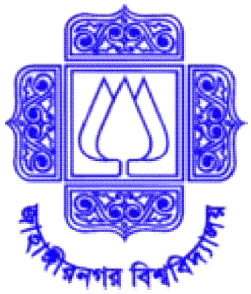
Curriculum

B.Sc. (Honours) in Biotechnology and Genetic Engineering



DEPARTMENT OF BIOTECHNOLOGY AND GENETIC ENGINEERING

JAHANGIRNAGAR UNIVERSITY

Vision, Mission and Program objectives of the Department of Biotechnology and Genetic Engineering

Vision:

To provide the state-of-art knowledge and skills in the field of Biotechnology and Genetic Engineering for sustainable development of society, industry and environment of Bangladesh

Mission:

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

Program objectives:

To provide solution-based education with cutting edge knowledge in Biotechnology and Genetic Engineering in order to harness the latest techniques, technologies and methodologies for the graduates in the field of:

- Medical and Pharmaceutical Biotechnology
- Molecular Biotechnology
- Nutrition and Food Biotechnology
- Microbial and Industrial Biotechnology
- Environmental Biotechnology
- Plant and Animal Biotechnology

Part –I (1st Year, Examination of 2021, 2022 and 2023)

Theory Courses

Course No.	Course Title	Credits	Marks	
BGE 101	Fundamentals of Biotechnology and Genetic Engineering	3	75	
BGE 102	Basic Biology	3	75	
BGE 103	Basic Chemistry	3	75	
BGE 104	Basic Physics	2	50	
BGE 105	Basic Biochemistry	3	75	
BGE 106	Microbiology-I	2	50	
BGE 107	Basic Mathematics	2	50	
BGE 108	English	2	50	
BGE 109	Economics	2	50	
Sub Total		**22**	**550**	

Practical Courses and Field Work

BGE 110	Biochemistry Practical	2	50	
BGE 111	Biology Practical	2	50	
BGE 112	Chemistry Practical	2	50	
BGE 113	Microbiology Practical	2	50	
BGE 114	**Viva-voce**	2	50	
Sub Total		**10**	**250**	
Year Total		**32**	**800**	

Part –I I (2nd Year, Examination of 2021, 2022 and 2023)

Theory Courses

Course No.	Course Title	Credits	Marks	
BGE 201	Basic Genetics	3	75	
BGE 202	Biophysical Chemistry	3	75	
BGE 203	Molecular Biology-I	3	75	
BGE 204	Enzymology	2	50	
BGE 205	Metabolism – I	2	50	
BGE 206	Human Physiology	3	75	
BGE 207	Microbiology-II	3	75	
BGE 208	Cell Biology	3	75	
BGE 209	Nutrition and Food Biotechnology	2	50	

BGE 210	Biostatistics	3	75	
BGE 211	Immunology- I	3	75	
Sub Total		**30**	**750**	

Practical Courses and Field Work

BGE 212	Human Physiology Practical	2	50	
BGE 213	Metabolism Practical	2	50	
BGE 214	Computer Basics and ICT Practical	2	50	
BGE 215	**Viva-voce**	2	50	
Sub Total		**8**	**200**	
Year Total		**38**	**950**	

Part –III (3rd Year, Examination of 2021, 2022 and 2023)

Theory Courses

Course No.	**Course Title**	**Credits**	**Marks**	
BGE 301	Microbial Genetics	3	75	
BGE 302	Genetic Engineering	3	75	
BGE 303	Immunology-II	3	75	
BGE 304	Molecular Biology-II	3	75	
BGE 305	Fermentation and Bioprocess Technology	3	75	
BGE 306	Developmental Biology	2	50	
BGE 307	Metabolism – II	3	75	
BGE 308	Analytical Methods in Biotechnology	2	50	
BGE 309	Biosafety, Ethics and Regulation in Biotechnology	2	50	
BGE 310	Bioinformatics	3	75	
BGE 311	Virology	3	75	
BGE 312	Research methodology	3	75	
Sub Total		**33**	**825**	

Practical Courses

BGE 313	Immunology Practical	2	50	
BGE 314	Molecular Biology Practical	2	50	
BGE 315	Bioinformatics Practical	2	50	
BGE 316	Plant Tissue Culture Practical	2	50	
BGE 317	Fermentation Technology Practical	2	50	
BGE 318	**Viva-voce**	2	50	

Sub Total	**12**	**300**	
Year Total	**45**	**1125**	

Part –IV (4th Year, Examination of 2021, 2022 and 2023)

Theory Courses

Course No.	Course Title	Credits	Marks	
BGE 401	Genomics and Proteomics	3	75	
BGE 402	Medical and Pharmaceutical Biotechnology	3	75	
BGE 403	Microbial Biotechnology	3	75	
BGE 404	Animal Biotechnology	3	75	
BGE 405	Plant Biotechnology	3	75	
BGE 406	Cell Signaling	3	75	
BGE 407	Environmental Biotechnology	3	75	
BGE 408	Molecular Diagnostics	3	75	
BGE 409	Downstream Processing	3	75	
BGE 410	Entrepreneurship in Biotechnology	3	75	
BGE 411	Fisheries and Marine Biotechnology	3	75	
Sub Total		**33**	**825**	

Practical Courses

BGE 412	Downstream Processing Practical	2	50	
BGE 413	Genetic Engineering Practical	2	50	
BGE 414	Plant and Animal Biotechnology Practical	2	50	
BGE 415	Genomics Practical	2	50	
BGE 416	Internship /Review Study/Project	2	50	
BGE 417	**Viva-voce**	2	50	
Sub Total		**12**	**300**	
Year Total		**45**	**1125**	
Grand Total	**32+38+45+45=160**		**4000**	

Part –I (1st Year, Examination of 2021, 2022 and 2023)

<table>
<tr><td colspan="2">Course: BGE-101</td><td colspan="2">Course title:
Fundamentals of Biotechnology and Genetic Engineering</td><td>Offered year: 1st</td></tr>
<tr><td colspan="2">Minimum course hour:
42h</td><td>Credit hour:
3</td><td>Final exam duration:
3h</td><td>Total marks: 75</td></tr>
<tr><td colspan="5">Rationale: The course is designed to provide the fundamental concepts of Biotechnology and Genetic Engineering and its scope of application in various fields of biological sciences.</td></tr>
<tr><td colspan="5">Course Objectives:
• Provide basic concepts of biotechnology and genetic Engineering
• Instruct sector-wise applications of biotechnology (microbial, plant, animal, medical and environmental biotechnology)
• Provide knowledge of the industrial applications and commercialization of biotechnology</td></tr>
<tr><td colspan="5">Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-
• Know the areas and scope of applications of biotechnology
• Learn basic genetic Engineering tools
• Know the microbial, plant and animal cell culture methods
• Produce microbial, plant and animal biotechnology products
• Realize environmental pollution and its protection measurements through biotechnology
• Understand biotechnological implication in medical sectors</td></tr>
<tr><td colspan="5">Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Field visit, etc.</td></tr>
<tr><td colspan="5">Assessment Strategy: Class participation (Attendance)
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A</td></tr>
<tr><td colspan="5">Course Content</td></tr>
<tr><td>1.</td><td colspan="4">Introduction:History and nature of biotechnology; applications of biotechnology and genetic engineering.</td></tr>
<tr><td>2.</td><td colspan="4">Microbial biotechnology: History, Different kinds of microbes, gene cloning, genetically modified microbes in modern research and diagnostics, value-added products, human nutrition and functional foods, probiotics.</td></tr>
<tr><td>3.</td><td colspan="4">Plant biotechnology: Major basics for plant tissue culture, plant tissue culture steps, kinds and advantages, application of biotechnology for production of bio-fertilizer, enhancement of biological nitrogen fixation, biocontrol of plant pathogens and production of transgenic plants, some examples ofplantbiotechnology products.</td></tr>
<tr><td>4.</td><td colspan="4">Animal biotechnology:Major basics for animal cell culture, maintenance of cellculture, kinds of cell culture, manipulation of cultured cells, animal cell cloning,</td></tr>
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	production of transgenic animals, contribution of transgenic animals in human welfare.
5.	**Medical and pharmaceutical biotechnology:** Antibiotics, vaccines, DNA probe, gene therapy, monoclonal antibody production, stem cell, tissue engineering, genetic testing, prenatal diagnosis.
6.	**Environmental biotechnology:** Waste treatment, bioremediation, oil, insecticide and heavy metal pollution control.
7.	**Basic concepts in genetic engineering:** Tools of recombinant DNA technology: restriction enzymes, DNA ligases, vectors, marker genes.
8.	**Biotech business and commercialization:** Role of biotechnology in developing countries, economic growth of biotech business in Bangladesh, current and future prospects of biotech sectors in Bangladesh, industrial production of biotech products.

Text Books:

1. Biotechnology. John E Smith, 5th Ed. Cambridge University press, UK. .
2. DNA and Biotechnology. Molly Fitzgerald-Hayes and Frieda Reichsman**.**Academic Press, UK. 2009.
3. Basic Biotechnology. Bullock, J. &Uritiansen, B. Academic Press, UK. 1995.
4. Introduction to Biotechnology. Dubey, R. C. 7thEdition. S. Chand & Co. Pvt. Ltd. India. 1995.
5. Introduction to Biotechnology and Genetic Engineering. AJ Nair. Infinity Science Press, Hingham, Massachusetts, USA. 2008.

Recommended References:

1. Molecular Biology of the Cell. Bruce Alberts, Alexander Johnson, Julian Lewis. 5th Edition. Garland Science. 2008.
2. A. Principles of Biotechnology, Wiseman, Surrey University Press and Chapman and Hall. New York. (1985).

Course: BGE-102	**Course title:** Basic Biology		**Offered year:** 1st
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to offer modern concepts in origin of life, diversities and functional aspects of plants and animals for welfare of human and nature and to develop the students' appreciation, understanding and practical capability in all aspects of plant and animal kingdom.

Course Objectives:

- To know the origin of life as well as plants on earth.
- To learn the tissue system, nutritional requirement and transport systems in plants.
- To elucidate general biological principles through the study of specialized or experimentally tractable systems.

- To familiarize students for knowledge of zoology at the systems and organism levels.

Intended Learning Outcomes (ILOs):

At the end of the course the students will be able to-

- Explain the structure and function of cells, tissues, organs and their organization in the whole plant.
- Understand the plant production systems and their impacts on the ecosystems.
- Recognize functional properties of plants and its biotechnological utilizations.
- Understand the diversity and evolutionary relationships among animals
- Be aware of the breadth of studies on the biology of animals as they relate to the evolution, function, behavior and ecology of animals.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:

Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Q/A

Course Content	
1.	**Origin, varieties of life and evolution:** What is life, theories of origin of life, nature of the earliest organism, Evolution; chemical and biological evolution of life, theories and their criticism, factors affecting evolution, evidences with example. A brief introduction of five kingdoms; Prokaryote, Protista, Fungi, Plantae and Animalia.
2.	**Tissue system:** Simple tissue (parenchyma, collenchymas, sclerenchyma); complex tissue (xylem and phloem); tissue systems (epidermal, ground, vascular); primary body and growth (root, stem, leaf); secondary growth. Animal tissues (Epithelial, connective, muscle and nervous) and their functions.
3.	**Nutrition:** Autotrophic Pigment systems, Chloroplast, light absorption by chlorophyll and transfer of energy, two pigment systems, photosynthetic unit, phosphorylation and electron transport system, Calvin-Benson Cycle (C3), Hatch Slack Pathway (C4), Crassulacan Acid Metabolism (CAM), factors affecting photosynthesis; Mineral nutrition in plants.
4.	**Transport:** Diffusion, osmosis, imbibitions, movement of water in flowering plants, uptake of water by roots, the ascent of water in xylem, apoplast symplast theory, Transpiration-structure of leaf and stomata in plants, opening and closing mechanism of stomata, formation of tissue fluids in animal, circulation of fluids through vessels in animal.
5.	**Coordination and control:** Plant movements (Tactic, Tropic, Nastic), plant growth substances (Auxins, Cytokinins, Gibberellins, ABA, Ethylene), phytochrome and effect of light on plant development, vernalisation and flowering, sensory receptors in animals, structure and function of receptors.
6.	**Ecology, Ecosystem and Biodiversity:** Concept of ecology and ecosystem, Habitat, community and ecological factors, niche, Structure and function of ecosystem, Ecosystem types, Biomass production and productivity, producers, consumers, decomposers, Food chain, food web, energy flow.

Text Books:

1. Biology: Concepts and Connections,Neil A. Campbell, Jane B. Reece, Martha R. Taylor, and Eric J. Simon. 6th Edition, Benjamin Cummins, (2008).
2. Biology: Concepts and Applications, Cecie Starr. 7th Edition. Brooks Cole, (2007).
3. Zoology, Stephen A Miller, John P Harley, Stephen Miller, and John Harley. 8th Edition. McGraw-Hill, USA, (2009).

Recommended References:

1. Cytology and Evolution, Bhamrah, H.S and Junijeak. Animal Publications Pvt. Ltd. India 1993.
2. Botany for Degree Students, Dutta, A. C. 4th Ed., Oxford University Press, Calcutta, (1974).

Course: BGE- 103	**Course title:** Basic Chemistry		**Offered year:** 1st
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide a firm foundation in the fundamentals and applications of Inorganic, Organic and Physical Chemistries that will further be applicable in later courses of Biotechnology and Genetic Engineering program.

Course Objectives:

- To provide knowledge of the key chemical concepts and models of structure, bonding, in physical, organic and inorganic chemistry.
- To describe the concept of thermodynamics, reaction kinetics and other associated terms and their applications in biology.
- To explain the role of acid-base reactions, buffer and pH in biochemical systems.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand fundamentals and applications of inorganic, organic and physical Chemistries
- Understand basic concept of Normality, Molarity, Molality, Periodic table
- Gather knowledge about acid, base, pH, buffer, conductivity, electrolysis
- Explain bonding patterns between atoms, bond energy; bond moment
- Gain information about different types of chemical reactions and their kinetics
- Learn different organic compounds (like Aliphatichydrocarbons: Petroleum and related products; Aliphatic alcohols; Aldehydes and ketones; Aromatic hydrocarbons) and metals structure, Chemistry, their transition pattern, formation of complexes.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy: **Tutorials**: Q/A, Quiz, Assignment, MCQ, Presentation, Viva **Final exams:** Q/A	
Course Content	
1.	**Physical Chemistry:** The basics; mole concept; Avogadro‘s number, Normality, Molarity, Molality, Periodic table. Acids andbases; The Bronsted-Lowry acids and bases; Arrnhenius concept, Lewis acids and bases, Physical properties of water, ionicproduct of water and pH scale; Ionization of acids and bases; Acid— base indicators common ion effect; Buffer solution Buffercapacity; Henderson—Hasselbach equation. Conductance; Faraday‘s law of electrolysis; conductivity and its measurement;Equivalent and molar conductance Variant of equivalent conductivity with concentrations of weak and strong electrolytes.
2.	**Inorganic Chemistry:** Ionization potential; Electron affinity; Electronegativity; Oxidation states,Ionic bonds (general characteristics), types of ions; Covalent bond (general characteristics; Coordinate covalent bond; Valenc bond approach; Sigmaand Pi bonds; Bond length; Bond order; Hydrogen bonds Van der Waal‘s forces; Metallic bond; Chemical reactions: Types ofreaction, acid-base reactions, concept of pH and buffer solution, oxidation-reduction reactions; balancing oxidation-reductionreactions, Redox potential and its significance, spontaneity of redox reactions; Concept of coordination complexes; Werner‘stheory; Bonding in coordination compounds. Role of inorganic elements in some vital complexes of coordination complexes, e.g. hemoglobin, cytochromes, ferredoxin, chlorophylls; Chemistry of elements: Chemistry of metal, nonmetallic elements and their compounds, transition metal chemistry and coordination compounds; chemistry of sulfur, phosphorus iron and copper.
3.	**Organic Chemistry:** Chemical bonding reconsidered; Atomic and molecular orbits; Polarity of bonds; Bond length and bondstrength: Bond energy; bond moment and dipole moment; Nucleophiles and electrophiles and their importance in biologicalsystems; Characteristics and type of organic reactions; Addition, elimination, substitution andrearrangement reactions. Aliphatichydrocarbons (Petroleum and related products); Aliphatic alcohols; Aldehydes and ketones; Aromatic hydrocarbons: Aromaticity,mechanism of orientation and substitution, structure of benzene, sources of aromatic hydrocarbons, industrially importantaromatic compounds, nomenclature of benzene derivatives, chemistry of aromatic-aliphatic compounds; Nitro-compounds andamines: Occurrence, nomenclature, synthesis, classification, properties, reactions, uses, diazonium compounds; Acids and theirderivatives. Basic principles of stereochemistry; Cis-trans isomers; Plane polarized light; Optical activity, Chirality and chiralmolecules; D & L designation; Absolute configuration.

Text Books:

1. General Chemistry. Atkins, 2nd Ed. W. H. Freeman and Company, New York, (1992).
2. Chemistry. Gillespie, Fitimpherys, Bairds and Robinson, Allyn and Bacon Inc. Boston, (1989).
3. Steriochemistry of carbon compounds. Eliel and Wilen. Wiley Interscience, (1994).
4. Organic chemistry: A short course, Atkins and Carey. McGraw Hill Publishing Company, (1991).
5. Organic Chemistry. I L Finar, (5th edition), John Wiley & Sons Inc. USA, 1997.
6. Organic Chemistry. Morrison & Boyd, (6th Edition) Allyn& Bacon Inc. USA, 2007
7. Organic Chemistry. SolomonsFryhle, 8th edition, John Wiley and sons, Inc. USA, 2006

Recommended References:

1. Peter Politzer, Jane S. Murray. Electrostatics and Polarization in σ- and π-Hole Noncovalent Interactions: An Overview. ChemPhysChem 2020, 21 (7) , 579-588.
2. Kasper Tolborg, Bo B. Iversen. Electron Density Studies in Materials Research. Chemistry – A European Journal 2019, 25 (66) , 15010-15029
3. Martin Rahm, Roberto Cammi, N. W. Ashcroft, Roald Hoffmann. Squeezing All Elements in the Periodic Table: Electron Configuration and Electronegativity of the Atoms under Compression. Journal of the American Chemical Society 2019, 141 (26) , 10253-10271.
4. Carey FA, Sundberg RJ. Advanced organic chemistry. Part A: structure and mechanism. 5th ed. New York: Springer; 2007.
5. Cahn RS, Ingold CK; Prelog V. Specification of molecular chirality. Angew. Chem. Int. Ed. 1966; 5(4): 385– 415.
6. Nasipuri D. Stereochemistry of organic compounds: principles and applications. 2nd ed. New Delhi: New Age International (P) Limited, Publishers; 1994, Reprinted 2005.

Course: BGE-104	**Course title:** Basic Physics		**Offered year:** 1st
Minimum course hour: 28 h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50

Rationale: This course is designed for serving the purpose of developing knowledge and understanding of the physics based techniques making important contributions to the Biotechnology.

Course Objectives:

- Basics of the light as detection technique applicable in biotechnology
- Imaging techniques, to understand the basics of the microscopes
- Basics of the fluid dynamics applicable in the fermentation process
- Energy and power system applicable in biotechnological processes

Intended Learning Outcomes (ILOs): After completion of the course, students will be able to-

- Describe the way of signal generation and transmission in biological systems
- Illustrate the different types of the motion and its application in fermentation process
- Outline the application of high speed ultrasonic in the detection techniques
- Illustrate the basics of mass spectrometric technique
- Demonstrate the different types of microscopic techniques

Teaching Strategy: Lecture, Projector display, Animationetc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction:** Branches of physics, Signal generation and transmission in biological systems, Importance of physics in Biology.
2.	**Mechanics:** Motion along a straight line, motion in two and three dimension, projectile motion, circular motion, relativemotion. Force, friction, work, energy and power. System of particles, collisions, rotational motion, combined rotational and translational motions.
3.	**Waves and Oscillations:** Types of wave, Wave-equation-power, intensity, principle of super position interference, standing waves - reflection, resonance. Sound-properties, interference, vibrating system and sources of sound, beats, doppler effect, effects at high speed ultrasonic's. Oscillatory systems, Harmonic motion, Simple harmonic oscillator, applications of simple harmonic motion. Types of oscillations, resonance.
4.	**Light:** Electromagnetic spectrum, Properties of light, Reflection, Refraction, Thick and thin lenses-Defects, Uses of lenses, Laser- principle, types, uses. Optical fiber, Interference-Thin film interference, Newton's rings, Air wedge, Michelson Interferometer, Holography, Diffraction- Single slit, double slit, multiple slit diffraction, grating. X-ray diffraction, Polarization-Types, production and detection of polarized light. Dichroism, polarizing sheets.
5.	**Imaging Techniques:** Microscopy: Electron Microscope - Dual nature of electron and its interaction with electric and magnetic fields, electron lens formation, Electron Microscope-construction, type, applications. Atomic Force microscope, Scanning Tunneling Microscope, Scanning Near field optical Microscope – an introduction. X- ray Crystallography: X-rays, X-ray scattering, general design of X-ray spectrometer
6.	**Spectrometry:** Mass spectrometry - General design of Mass spectrometers, Types of mass spectrometers, Mass spectrum.

Text Books:

1. Fundamentals of Physics. Halliday, Resnick and Walker, 8th Edition, Wiley & Sons, (2007).

2. Physics for Engineers Vol. 1 and Vol. 2. Dr. Giasuddin Ahmad.
3. The Feynman lectures on Physics. Feynman, Leighton and Sands, Addison Wesley Longman, (1970).
4. Waves and Oscillations. Subrahmanyam and Brijlal.
5. Mechanics, Wave Motion and Heat, Francis Weston Sears.
6. Optics. Subrahmanyam and Brijlal.
7. Basic Physics: A self-teaching guide. Carl F Kuhn. 2nd Edition. Wiley & Sons, (1996).

Course: BGE-105	**Course title:** Basic Biochemistry		**Offered year:** 1st
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide basic concepts and valuable insights of Prokaryotic and Eukaryotic Cells and also biomolecules such as carbohydrates, lipids, amino acids, proteins and nucleic acidsthat will further be applicable in later courses of Biotechnology and Genetic Engineering program.

Course Objectives:

- To describe detailed concepts of biochemistry.
- To explain the structural principles and properties of cells and biomolecules like-carbohydrates, lipids, amino acids, proteins and nucleic acids with relation to biological examples.
- To provide biochemically important aspects and function of the biomolecules.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Acquire knowledge on the cells, its structure, functions, organization and processes at molecular level.
- Gain in-depth knowledge on various macromolecules - monosaccharides, polysaccharides and lipids, their characteristics and roles in biological systems.
- Understand the structures of amino acids, their chemical properties and their 3D structural organization into polypeptides and proteins.
- Learn the structure and basic function of nucleotides, fundamentals of flow of information through replication, transcription and translation.
- Acquire knowledge on the system of important biological processes.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** History, Scopes, Significance of Biochemistry.

2.	**The Cell:** Concept of life and living processes; Identifying characteristics of a living matter; Historical background; Cell theory; Cell size and structure; Structure of Prokaryotic and Eukaryotic Cells.
3.	**Biochemical principles:** Atomic structure, Acids, bases and pH, important bio-macromolecules.
4.	**Cellular Organelles:** Structure and function of the following cellular organelles; Cell membrane, ribosome, nucleus, mitochondria, chloroplast, Golgi bodies, endoplasmic reticulum, lysosomes, vacuoles, peroxisomes, cytoskeleton, plant cell wall, Cell fractionation and distribution of cellular components.
5.	**Carbohydrates**: Monosaccharides, OligosaccharidesAnd Polysaccharides: Introduction, properties and derivatives.
6.	**Lipid**: Types and classifications, nomenclature: Structural lipids and storage lipids e.g. triacylglycerol, phospholipids, glycolipids, sphingolipids, waxes, sterols.
7.	**Amino acids**: Structural features, Optical properties, Classification of amino acids, Zwitter ions, Isoelectric properties.
8.	**Proteins**: General idea of primary, secondary, tertiary & quaternary structures. Structural protein and functional proteins. Conformational analysis and forces that determine protein structures and geometries; hydrogen bonding; disulphide bonds; hydrophobic interactions; alpha helices; beta sheets; helix to coil transition, general features and thermodynamic aspects of protein folding and folding kinetics, protein-ligand interactions, Relationship between the primary, secondary, and tertiary structure of proteins. Fibrous proteins; Quaternary structures: dimers, homo and hetero dimers, trimers, tetramers; Domain structures of proteins.
9.	**Nucleic Acids**: Physical and chemical properties of nucleosides and nucleotides; the central dogma; DNA and RNA as genetic material, Double helix, Primary, secondary and tertiary structure of DNA, Melting of DNA double helix (Hyper chromicity); Types of RNAs and their structures; Differences between DNA and RNA.

Text Books:

1. Lehninger Principle of Biochemistry, David L. Nelson, Michael M. Cox, 5th edition, W.H. Freeman.
2. Cell and Molecular Biology- E.D.P. De Robertis, 7th edition, Marcel and Dekker, NY.
3. Biochemistry, 5th edition, J. M. Berg, J.L. Tymoczko and L. Stryer, Freeman, (1995).
4. Harper's Illustrated Biochemistry, 28th Edition. Robert Murray, Victor Rodwell, David Bender, Kathleen M. Botham, P. Anthony Weil, Peter J. Kennelly, McGraw-Hill, (2009).

Course: BGE-106	**Course title:** Microbiology-I	**Offered year:** 1st

Minimum course hour:	Credit hour:	Final exam duration:	Total marks:
28h	2	**2**.5h	50

Rationale: This course provides a strong grounding in fundamental aspects of microorganisms. This course would enable the students to understand the fundamental scientific concepts and basic skills utilized in microbiology to expand their knowledge of the microscopic world.

Course Objectives:

- Demonstrate an understanding of historical development of microbiology.
- Provide the classification of microorganisms, microbial nutrition, cultivation, growth and maintenance.
- To offer basic concepts and applications of microscopes in microbiology.
- To be familiar with diversities of prokaryotes and eukaryotes, common bacterial, fungal and viral diseases.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Be familiar the structure and function of different microorganisms including bacteria, fungi and virus.
- Learn the concepts and theoretical knowledge of different microscopes used in the study of microorganisms.
- Familiarized about microbial growth and to control their growth by physical and chemical methods.
- Learn common bacterial, fungal and viral diseases.
- Know the prokaryotic and eukaryotic diversity of microorganisms.

Teaching Strategy: Lecture, Projector display, Animation, Discussion, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** History and Development of Microbiology, types of microorganisms, spontaneous generation and biogenesis, germ theory of diseases, pure culture concept, concept of Immunization, importance of microbiology in biotechnology.
2.	**Microscopic observations of microorganisms:** Principles and applications of dark field; bright field; phase contrast microscopy; fluorescent microscopy; and electron microscopy, preparation of specimens for light microscopy, staining; simple staining, differential staining, and special staining methods.
3.	**Cell structure and organization of bacteria:** Morphology, size, shape, and arrangement of bacterial cells, structures of flagella, pili, glycocalyx, cell-wall, nucleoid, ribosome, inclusions, and endospore.

4.	**Microbial nutrition, cultivation, growth and maintenance:** Nutritional requirements and nutritional categories of bacteria, culture media, physical conditions required for growth, the growth of bacterial cultures, quantitative measurement of bacterial growth, methods of maintenance and preservation of bacteria, and the control of microorganism by physical and chemical agents.
5.	**Prokaryotic diversity:** Domain: archaea,bacteria, actinomycetes, pathogenic microbes and human disease.
6.	**Eukaryotic diversity: Fungi:** Characteristics; classification and reproduction of fungi; fungal diseases; **Algae:** characteristics of algae; **Protozoa:** characteristics of protozoa; medically important protozoa, slime molds.
7.	**The viruses:** General characteristics, morphology, and classification of viruses, replication cycles viral multiplication, viral diseases in humans, viruses in plants, animals and microbes, virus and cancer, viroid.

Text Books:

1. Microbiology- Michael J. Pelczar, Noel R. Kreig and E.C.S Chan. 5th edition, Tata McGraw Hill Publishing Company Limited, New Delhi.
2. Microbiology: An Introduction- Tortora, BerdellR.Funkee& Case, 12th edition, Prentice-Hall.
3. Biology of Microorganisms- TD Brock, MT Madigan, JM Martinko, and J. Parker, 7th edition, Prentice-Hall, Englewood Cliffs.
4. Fundamental Principles of Bacteriology- A.J. Salle, 7th edition, McGraw Hill Book Company.
5. Essential Microbiology-Stuart Hogg, 2nd edition, John Wiley & Sons Ltd.

Recommended References:

1. Microbiology: Principles and Explorations. Jacquelyn G. Black, Laura J. Black. 9th Edition, Wiley; 2014.
2. Foundations in Microbiology.Kathleen Park Talaro and Barry Chess. 10thedition,McGraw-Hill; 2018.

Course: BGE-107	**Course Title:** Basic Mathematics		**Offered Year:** 1st
Minimum course hour: 28h	**Credit Hour:** 2	**Final Exam duration:** 2.5h	**Total Marks:** 50

Rationale: The course is designed to build students' confidence by helping them develop competence with mathematical concepts, methods and skills in numbers, patterns and relationships.

Course Objectives:

- To develop basic mathematical knowledge and build a strong emphasis on solving mathematical problems
- To learn the presentation and interpretation of the results
- To build a solid foundation to solve the mathematical problems to study biotechnology

Intended learning outcomes (ILOs): At the end of the course the students will be able to-

- Organize, interpret and present information in written, tabular, graphical and diagrammatic forms.
- Make calculations by suitable methods
- Perform some calculations without a calculator or know to use an electronic calculator
- Estimate, approximate and work to degrees of accuracy appropriate to the context
- Apply mathematical skills and techniques in biotechnological problem solving.

Teaching methods:

Lecture, Multimedia display, Animation, Handouts, Hands on demonstration, Visit, Seminar etc.

Assessment methods:

Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Q/A

Course Contents

1.	**Introduction to calculus:** Introduction, Basic concepts of functions, Graphing functions, combining functions, Inverse functions, Polynomial Functions, Limits and continuity.
2.	**Differential calculus:** Rules and techniques of differentiation of various functions, Concavity and convexity of a curve, Points of inflexion, Asymptotes and curvature, Partial derivatives, Maxima and Minima of functions.
3.	**Integral calculus:** Definite integrals, Properties of definite integrals, Rules and techniques of Integration, Simple application of integral calculus, Double and triple integrals.
4.	**Vector analysis:** Vector algebra- addition and multiplication of vectors, linear dependence and independence of vectors, dot and cross product of vectors.
5.	**Matrices:** Definition of various type of matrix; addition, subtraction and multiplication of matrices; transpose, adjoint and inverse of a matrix; rank and elementary-transformation of a matrix.
6.	**System of linear equations:** Basic definitions and solutions, Gaussian elimination method, Gauss-Jordan Elimination Method, Cramer's rule, Application of System of linear equations to Biological problems.

7.	**Differential equations:** Classification and formation of ordinary differential equations. Separation of variables, Homogeneous equations, Integrating factor, Exact equation, Linear equations, Bernoulli's equations, Modeling of Biological problems by ODEs.
8.	**Trigonometry:** De Moiver's theorem and its application, Gregory's series, summation of series.
9.	**Logarithm:** Log-log Plot, Semi Log Plot.

Text Books:

1. College Algebra by Jay Abramson, Arizona State University (2015). ISBN 13: 9781938168383
2. Trigonometry for Dummies (2nd Edition). Mary Jane Sterling (Author)
3. Calculus by Gilbert Strang, MIT

Recommended references:

1. Calculus and Analytic Geometry by George B. Thomas/ and Ross L. Finney.
2. Vector Analysis by Murry R. Spigel, Schaum's Outline Series.
3. Elementary Linear Algebra-Applications Version, Howard Anton, Chris Rorres, Ninth Edition, Wiley-India.
4. A First Course in Differential Equations with Modeling Applications, (Tenth Edition) Dennis G. Zill, Publisher: Brooks/Cole Cengage.

Course: BGE-108	**Course Title:** English		**Offered year:** 1st
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50

Rationale: The course is designed to practice specific points of grammar to consolidate and extend learner's existing knowledge; analysis of syntax; comprehension; skimming and scanning exercises develop the learners skills; comprehension questions interpretation and implication; the activities and games used to develop reading, listening, speaking, and writing skills through a communicative functional approach with suggested topics for discussion and exercises in summary writing and composition.

Course Objectives:

- To provide the learners with the skills and abilities to take an active and responsible role in their communities, in their workplace, and in educational settings.
- To be able to communicate in ways that make them effective and involved as citizens, operate confidently and to convey their ideas and opinions clearly in a wide range of contexts.
- To provide individuals with the essential knowledge, skills and understanding that will enable them to operate confidently, effectively and independently in life and at work.

Intended Learning Outcomes (ILOs): At the end of the course, the students will be able to-

- Be confident and capable when using the skills of speaking, listening and communication, reading and writing.
- Communicate effectively, adapting to a range of audiences and contexts that includes explaining information clearly and succinctly, and expressing a point of view reasonably and persuasively.
- Read and understand information and instructions, then use this understanding to act appropriately.
- Analyze how ideas and information are presented, evaluating their usefulness, for example in solving a problem.
- Make a presentation or report, contribute to discussions and use speech to work collaboratively to agree actions and conclusions.

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Reading:** Reading Comprehension for developing sub skills such as scanning, skimming, understanding contextual meaning, inference, vocabulary building and summarizing. Reading and reviewing short texts (articles and passages which are related with Genetic Engineering and Biotechnology & heath sectors). Important biotechnological terminologies and its application. Reading passage, checking comprehension through the questions mentioned and doing vocabulary exercises on the passage, processing information from academic and authentic sources (magazines, journals and the internet), logical organization of information, identifying same words but different meaning, & words frequently confused.
2.	**Writing:** Important factors of writing: prewriting, brainstorming, outlining (drafting), proofreading and plagiarism. Paragraph mapping: Paragraph structure (topic sentence thesis statement, introducer, developers, modulators, terminator etc.) Different types ofparagraphs (narrative, descriptive, argumentative, cause and effect compare and contrast, process analysis paragraph), transitional words/ devices. Essay writing/ report writing. Letter Writing/ Application writing/ Email writing: (Academic applications, Cover Letter, CV, Letter of requesting reference, Letter of seeking recommendation, Acceptance letter, letters to the editor of newspaper, memorandum writing. Interpreting and comparing data; describing tables, objects & graphs; stating and developing arguments/opinions; problem-solving; presenting information

	logically, coherently and cohesively.
3.	**Listening:** Listening to different forms of English TV news, Talk shows, Tape scripts. Extracting information from texts of varying lengths, e.g., university lectures, radio interviews, radio documentaries, conversations; learning what information to look for and what to exclude, understand the gist. Practice mapping: The listening module comprises four sections of increasing difficulty. Each section, which can be either a monologue or dialogue, begins with a short introduction telling the students about the situation and the speakers. Then they have some time to look through questions. The first three sections have a break in the middle allowing students to look at the remaining questions.
4.	**Speaking:** Social interactive and communicative English, Polite and formal expression (requesting, inviting, asking for help giving information, greetings key, introducing keys, seeking permission, asking for advice, giving (advice or suggestion, polite offer, saying bye of bidding farewell. English in workplaces and daily Conversation, asking and answering questions, extempore, providing information in a formal interview context; giving an extended talk on a given topic; taking part in a formal discussion; giving a formal presentation, dialogue & role play (situation & function based)
5.	**Grammar:** Components of syntax & semantic, tense, right form of verb, verb patterns, techniques of word formation (suffix-prefix, etymology), usage of modals, subject-verb agreement, articles, preposition, gerund, infinitive, usage of transitional/ linking words, voice change, parallel structure of sentence, fragments, modifiers, making questions/ questionnaire designing, conditionals, reported speech, paraphrasing, clauses, phrases, error analysis and correction.

Text Books:

3. A Practical English Grammar- A.J. Thomson and A.V. Martinet. (1993) Oxford University Press, New Delhi, India.
4. English Skills- John Langan, 7th edition, McGraw-Hill Publications.
5. From Paragraph to Essay- Maurice Imhoof and Herman Hudson.
6. Headway Advanced Student's Book with CD and workbook, Oxford University Press- John & Liz Soars.
7. Practical English Usage-Michael Swan.

Recommended References:

1. A guide to Pattern and Usage in English. Honorby A. S.
2. English Vocabulary in Use. McCarthy and Dell, O.
3. Cliff's TOEFL Preparation Guide. Michael, A. Pyle et al.
4. Intermediate English Grammar. Murphy, R. (1995). Cambridge University Press, New Delhi, India.
5. High School Grammar & Composition. Wren and Martin. (1995). S. Chand & Co. Ltd. New Delhi, India.

Course: BGE-109	**Course title:** Economics	**Offered year:** 1st

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
28 h	2	2.5 h	50

Rationale: This course aims to give students an overview of basics of economics. Macro and Micro economic theories, theory of production of biotechnology products; and of the insights regarding market economy.

Course Objectives:

- To introduce understanding of theories of economics; macro and micro economy; production economics and Bio-economy
- To enable to understand the market environment of biotechnology and non-biotechnology products
- To expose students understanding about money, banking, financing, loan, investment, interest and profit, and growth.
- To deliver the structure of Bangladeshi economy and world economy in general with some few reference countries

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know theories of economics; macro and micro economy; production economics and economic development of a country
- Understand functions of products for economic contribution in the short and long run
- Analyse market structure and implications for profit maximization
- Understand and apply different models and theories of economics.
- Learn basic characteristics of Bangladesh economy and major issues of development.

Teaching Strategy: Lecture, Projector display, Video and Animation, Visit, Seminar, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Basic concepts of economics:** The Fundamentals of Economics & Economic Organizations; Utility, Wealth, Production, Capital; Central Problems of an Economy; Theory of Production, Production Possibility Curve, Equilibrium; Theory of Demand and Supply, Cost of Production. Bio-economy.
2.	**Forms of market:** Various forms of market- monopoly, perfect competition, monopolistic competition, oligopoly, duopoly; Pricing strategies in various market.
3.	**National income:** Gross National Product, Net National Product, Measurement of

	National Income, Economic growth and fluctuations, Consumptions, Savings and Investment.
4.	**Money:** Definition and functions of money, Quantity theory of money, Inflation and effect of inflation on production and distribution of wealth, Control of Inflation, Money Supply, Liquidity preference and marginal efficiency, Rate of Interest and Investment.
5.	**Banking:** Definition, Functions and utility of Banking, Principles of Commercial Banking, Essentials of sound Banking system, Multiple credit creation, Functions of Central Bank, Measures of credit control and Money Market, National & International Financial Institutions.
6.	**Bangladeshi economy:** Meaning of an Underdeveloped Economy, Basic Characteristics of the Bangladeshi Economy, Major Issues of Development; Natural resources in the process of Economic Development; Resources - land; forest; water, fisheries, minerals; Economic development and Environmental Degradation, Global Climate Change and India, The role of Industrialization, pattern of Ownership of Industries; Role and Contribution of Industries in Economic development (with special reference to the following industries): Rice, Food (packed and beverages), Pharmaceuticals, Cotton, Textile and Garments, Jute, Sugar, Leather, Paper, Petrochemicals and Fertilizers, IT and Biotechnology.
7.	**Infrastructure of the Bangladeshi economy:** Overview, Infrastructure and Economic Development, Private Investment in Infrastructure, Public Private Partnership (PPP), Model in Infrastructure: Energy, Information Technology (IT) and ITES (Information Technology Enabled Services), Science and Technology, Biotechnology.

Text Books:

1. The Business of Bioscience, Craig D. Shimasaki, Springer, Spring Street, New York, USA
2. "Fundamentals of Economics and Management", Directorate of Studies, 2nd Ed. The Institute of Cost Accountants of India, Kolkata 2014.

Recommended References:

1. U.S. Congress, Office of Technology Assessment "Biotechnology in a Global Economy" OTA-BA-494 (U.S. Government Printing Office, Washington, DC, October 1991).
2. Lewis D "Bangladesh: politics, economy and civil society", Cambridge University Press 2011.
3. Dunn R M, Mutti J H "International Economics" 6th ed. Routledge, New York 2004.
4. Sowell T "Basic economics: a citizen's guide to the economy" 1st Ed, Basic Books, New York 2000.

Course: BGE-110	**Course title:** Biochemistry Practical	**Offered year:** 1st

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
28h	**2**	As required	50

Rationale: This course aims to give students a basic understanding of a laboratory, from safety to handle biochemicals and lab apparatus.

Course Objectives:

- To give hands on training of solution preparation, analytical skills and pipet calibration
- To provide knowledge for the estimation and separation techniques of biological macromolecules
- To be familiar with wavelength scanning of DNA, RNA, Protein and other materials.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the basic safety measures of laboratory
- Learn to determine protein content by spectrometric method
- Acquire various quantitative and analytical skills
- Learn wavelength scanning of standard samples of DNA, RNA, protein
- Know various separation of biomolecules

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	Safety measures in the laboratory
2.	Estimation of Glucose concentration by DNS method
3.	Determination of protein content by spectrometric method
4.	Wavelength scanning of standard samples (DNA, RNA, Proteins, and other materials)
5.	Determination of strength of a solution by titration method
6.	Separation of biomolecules
7.	Measurement of vitamin C in biological samples

Text Books:

1. Harper's Illustrated Biochemistry, 28th Edition. Robert Murray, Victor Rodwell, David Bender, Kathleen M. Botham, P. Anthony Weil, Peter J. Kennelly, McGraw-Hill, (2009).
2. Lehninger Principles of Biochemistry, Fourth Edition - David L. Nelson, Michael M. Cox, 4th edition, (2004).

3. Laboratory Exercises in Microbiology, Fifth Edition, Harley, J.P. and Prescott, L.M. The McGraw-Hill Companies. (2002)

Course: BGE-111	**Course Title:** Biology Practical		**Offered year:** 1st
Minimum course hour: 28h	**Credit hour:** 2	**Final Exam duration:** As required	**Total Marks:** 50

Rationale: The course is designed to provide well-designed studies of experimental and practical knowledge of biology. This course will provide worthwhile hands-on experience to develop the skills to carry out experimental and investigative work.

Course Objectives:

- To provide basic concepts of laboratory safety measures
- To evaluate, identify and observed the structure, size and shape of different cells and organisms.
- To gain practical knowledge on different biological ecosystem, their components and functions.

Intended learning outcomes (ILOs): At the end of the course the students will be able to-

- Learn efficient and safe practice of laboratory use
- Know the applications of microscope in cell studies
- Perform identification of cells, living organisms and different organs
- Be aware of the importance of beneficial and harmful living and non-living things and their impact on individual, community and the environment.
- Know the instruments and apparatus used in biology, including techniques of operation and aspects.

Teaching methods:
Lecture, Multimedia display, Animation, Handouts, Hands on training, field visit, Lab experiments etc.

Assessment methods:
Tutorials: Structured questions, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Structured questions, Advanced practical skills, viva, demonstration and presentation

	Course Contents
1.	**Introduction: F**undamentals of biology laboratory and demonstration of the laboratory facilities.
2.	**Sterilization:** Basic techniques of sterilization and proper maintenance of sterilized materials
3.	**Microscopy:** Introduction to microscope and its applications in cell studies
4.	**Observation of plant and animal cells**: Studies of the permanent slides, observation and identification of planktons from pond water, study of structure and functions of monocot and dicot plants.

5.	**Ecosystem:** Studies of components of ecosystems, collection and identification plants and animals from different ecosystem
6.	**Osmosis and photosynthesis:** Demonstration of osmosis and photosynthesis process, separation of photosynthetic pigments by paper chromatography
5.	Field visit and report preparation.

Text Books:

1. Practical Biology Student eText book by Dan Foulder. ISBN:9781398322752
2. Biology by Mary Jones, Oxford University Press
3. Textbook of Practical Microbiology by Subhas Chandra Parija. ISBN-13: 978-8189443061

Recommended references:

1. Practical handbook of Microbiology by Emanuel Goldman and Lorrence H Green. CRC Press

Course: BGE- 112	**Course title:** Chemistry Practical		**Offered year:** 1st
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: Chemistry practical is designed to improve student's laboratory skills regarding fundamental and basic chemistry and to improve their confidence level to safely work in laboratory. This course provides basic knowledge on laboratory basics, chemical safety measures, solutions preparation and calculation of impurities.

Course Objectives:

- To provide laboratory basics, chemical safety measures, MSDS and scientific notation.
- To build a strong knowledge on laboratory chemicals, solutes, solvents, buffers, solutions and calculation of impurities.
- To deliver clear concept of the Henderson-Hassel balchequation and Beer-Lambert law.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to demonstrate knowledge and understanding of:

- Laboratory basics, chemical safety measures, MSDS and scientific notation
- Moles, molarity, molality, normality, pH and pKa
- Henderson-Hassel balch equation and Beer-Lambert law
- Laboratory chemicals, solutes, solvents and buffers
- Mathematics involved in making solutions, calculation of impurities, calculation dilutions

Teaching Strategy: Lecture, Animation, Field visit, Experiment in lab

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Assignment, Lab report, Viva
Final exams: Q/A, Performing experiments in the Lab, Writing Report

	Course Content
1.	Laboratory basics and safety: Chemical safety measures, Understanding MSDS, Purity of chemicals and calculation of impurities, Buffers and solutions, Understanding laboratory chemicals, Solutes, solvents, preparation of solution.
2.	Scientific notation and metric prefixes: Introduction, Significant Digits, Exponents and Scientific Notation, Metric Prefixes.
3.	Solutions, mixtures, and media: Introduction, Calculating Dilutions: A General Approach, Concentrations by a Factor of X, Preparing Percent Solutions, Diluting Percent Solutions, Understanding of Moles and Molecular Weight, Normality, pH, pKa and The Henderson-Hassel balch Equation.
4.	Verification of Beer-Lambert law

Text Books:

1. Calculations in Molecular Biology and Biotechnology: A Guide to Mathematics in the Laboratory, Frank H. Stephenson (2003)
2. IUPAC, Compendium of Chemical Terminology, 2nd ed. (the "Gold Book"); Compiled by A. D. McNaught and A. Wilkinson. Blackwell Scientific Publications (1997).
3. General Chemistry. Atkins, 2nd Ed. W. H. Freeman and Company, New York, (1992).
4. Chemistry. Gillespie, Fitimpherys, Bairds and Robinson, Allyn and Bacon Inc. Boston, (1989).

Recommended References:

1. Mayerhöfer, Thomas Günter; Pahlow, Susanne; Popp, Jürgen (2020). "The Bouguer-Beer-Lambert law: Shining light on the obscure". ChemPhysChem. doi:10.1002/cphc.202000464. PMID 32662939.
2. Mayerhöfer, Thomas Günter; Popp, Jürgen (2018). "Beer's law - why absorbance depends (almost) linearly on concentration". ChemPhysChem. 20 (4): 511–515. doi:10.1002/cphc.201801073. PMID 30556240.

Course: BGE-113	**Course Title:** Microbiology Practical		**Offered year:** 1st
Minimum course hour:28h	**Credit hour:** 2	**Final Exam duration:** As required	**Total Marks:** 50

Rationale: The course is designed to provide well-designed studies of experimental and practical knowledge on microbiology. This course will provide worthwhile hands-on experience to develop the skills to carry out experimental and investigative work.

Course Objectives:

- To develop basic knowledge of using a microscope.
- To build a strong emphasis on culturing, counting and preserving microorganisms.
- To evaluate and identify the structure, size and shape of different microorganisms.
- To explain the staining procedure of gram positive and gram negative microorganisms

Intended learning outcomes (ILOs): At the end of the course the students should be able to demonstrate knowledge and understanding of:

- The application of microscope in microbial cell studies.
- Sample collection and identification of microorganisms from different sources.
- Staining procedure of gram positive and gram negative microorganisms.
- The awareness of the importance of beneficial and harmful microorganisms and their impact on individual, community and the environment.
- The instruments and apparatus used in microbiological experiments.

Teaching methods:

Lecture, Multimedia display, Animation, Handouts, Hands on training, field visit, Lab experiments etc.

Assessment methods:

Tutorials: Structured questions, Quiz, Assignment, MCQ, Presentation, Viva

Final exams: Structured questions, Advanced practical skills, viva, demonstration and presentation

Course Contents

1.	**Introduction:** Introduction to microbiology laboratory and demonstration of the laboratory facilities.
2.	**Sterilization:** Basic techniques of sterilization and proper maintenance of sterilized materials
3.	**Microscopy:** Introduction to microscope and its application in microbial cell studies
4.	**Culture media:** Preparation of various culture media for microbial cells
4.	**Isolation and identification of microbes:** sample collection from different sources, isolation of pure culture, serial dilution, and gram staining.
5.	**Enumeration of bacteria:** Bacterial cell count by pour plate, spread plate and streak plate method

Text Books:

1. Practical Biology Student eText book by Dan Foulder. ISBN:9781398322752
2. Biology by Mary Jones, Oxford University Press
3. Textbook of Practical Microbiology by Subhas Chandra Parija. ISBN-13: 978-8189443061

Recommended references:

1. Practical handbook of Microbiology by Emanuel Goldman and Lorrence H Green. CRC Press

Part –II (2nd Year, Examination of 2021, 2022 and 2023)

Course: BGE-201	**Course title:** Basic Genetics	**Offered year:** 2nd

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
42h	3	3h	75

Rationale: The course will cover the general area of genetics to provide basic concepts in heredity, inheritance patterns in plants, animals and microbes, and sex determinations mechanisms in various organisms.

Course Objectives:

- To provide the basic principles of Mendelian genetics.
- To demonstrate the relationship of allelic variation and gene function.
- To explain more complex modes of inheritance and compare the effects of linkage and crossing over on genetic outcomes and assess data

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand Mendel's rules of inheritance; gene segregation and independent assortment.
- Know the principles of extensions to Mendelian inheritance, including multiple allelism, lethal alleles, and gene interactions.
- Analyze the causes of sex determination in various organisms and understand methods of dosage compensation.
- Learn the analytical techniques for locating the relative positions of genes on chromosomes in diploid eukaryotic organisms and human chromosome.

Teaching Strategy: Lecture, Projector display, Animation, Discussion, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction to genetics:** Classical and Molecular Genetics; Genetics in genomics and proteomics era; Genetics and medicine, Agriculture and Society.
2.	**Mendelian genetics:** The basic principles of inheritance, Mendel's study of heredity, Application of Mendel's Principles; Formulating and testing genetic hypotheses; Mendelian principles in human genetics.
3.	**Extensions of mendelism:** Allelic Variation and Gene function; Gene action: from phenotype to genotype.
4.	**Inheritance of complex traits:** Complex pattern of inheritance; statistics of quantitative genetics; analysis of quantitative traits; inbreeding and resemblance between relatives.
5.	**The chromosomal basis of mendelism:** Sex-linked genes in human; Sex

	chromosomes and sex determinations; Dosage compensation of X-linked genes.
6.	**Variation of chromosome number and structure:** Cytological techniques, Polyploidy, Aneuploidy; Rearrangements of chromosome structure.
7.	**Linkage crossing over and chromosome mapping in eukaryotes:** Linkage, recombination and crossing over; Chromosome mapping; Recombination and evolution.
8.	**Advanced linkage analysis:** Detection of linkage in experimental organisms; Specialized mapping techniques; Linkage analysis in humans.

Text Books:

1. Essential Cell Biology. Bruce Alberts, D. Bray, K. Hopkin, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, Second Ed. Garland Science; 2003.
2. Molecular Biology of Cell. Bruce Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, J. D. Watson, Fourth Ed. Garland Science; 2002 .
3. Genes VI and VII. Benjamin and Lewin, Sixth Edition. Oxford University Press; 1997.
4. Molecular Biology of the Gene. Watson, J.D. and Hopkins, A.M., Roberts, J.W., Steitz, J.A. and Weiner, A.M., Benjamin/Cummings Scientific Publishing, Menlo Park, California; 1988.
5. Genomes. Brown, T. A. Second Edition. BIOS Scientific Publishers Ltd.; 2002.
6. Principles of Genetics.Snustad, D.P. Simmons, M.J. and Jenkins, J.B., Jacaranda/Wiely pub.; 1997.
7. Concepts of Genetics. Klung, W.S. and Cummings, M.R., Scott, Foresman and Co. USA; 1980.
8. Principles of Genetics. Robert Tamarin, 7th edition, The McGraw−Hill Companies; 2001.

Recommended References:

1. An Introduction to Genetic Analysis. Anthony JF Griffiths, Jeffrey H Miller, David T Suzuki, 7th edition,New York: W. H. Freeman; 2000.
2. Genetics: Analysis and Principles.Robert J. Brooker. 6th Edition,McGraw-Hill Education; 2017.

Course: BGE-202	**Course title:** Biophysical Chemistry		**Offered year:** 2nd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide basic concepts and valuable insights in Biophysical Chemistry that will further be applicable in later courses of Biotechnology and Genetic Engineering program.

Course Objectives:

- To provide detailed knowledge in the field of biophysical chemistry.
- To explain the principles and theories of physical chemistry with relation to

biological examples.

- To develop in-depth knowledge on different laws of thermodynamics and their applications in biological systems.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Learn different laws of thermodynamics and their applications in biological systems.
- Be familiar with various topics of physical chemistry such as electrolysis, colligative properties, protolysis of water, acid, bases and buffers, colloids, surface phenomena, etc.
- Gather basic in-depth knowledge on solutions and their various properties.
- Understand exothermic and endothermic reactions, enthalpy, entropy and free energy.
- Know the basic concepts of distribution law, Henry's law, chemical equilibrium and coupling of reactions.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** Scope, Importance of biophysical chemistry, relation to biotechnology
2.	**Properties of liquid and solution:** Introduction, kinetic molecular description, intermolecular forces in liquids, viscosity (definition, units of viscosity, measurement of viscosity by Ostwald viscometer, effect of temperature on viscosity). surface tension (definition, effect of temperature on surface tension, determination of surface tension by capillary – rise method, drop formation method and drop - number method), solution; definition, types of solution, concentration units and volumetric problems, polar and non-polar solvents.
3.	**Colloid:** General properties, lyophobic and lyophilic systems, dispersion, Brownian movement, origin of colloidal charge, coagulation, gel and emulsion, colloidal electrolytes and Zeta potential.
4.	**Colligative properties of solution:** Introduction, definition, dilute solution, real solutions, colligative properties, partial molar quantities, chemical potential, Raoult's law, Henry's law, activity and activity coefficient, osmosis and osmotic pressure, semi-permeable membranes, determination of osmotic pressure, determination of molecular weight, isotonic solution.

5.	**Thermodynamics:** First law; definition, system, state and state function, properties of thermodynamics first law of thermodynamics, nature of heat and work, pv work, maximum work, internal energy, molar heat capacity, isothermal and adiabatic changes and enthalpy; Second law of thermodynamics: Thermodynamic reversibility and irreversibility, spontaneous processes, entropy, thermodynamic efficiency and Carnot's theorem, statement of second law. Changes of entropy in various processes of ideal gases (at constant temperature, pressure and volume), Phase transition.
6.	**Thermochemistry:** Exothermic and endothermic reactions, standard enthalpy of formation, thermochemical equations, reaction enthalpy, dependence of temperature.
7.	**Free energy**: Variation with temperature, pressure, Gibbs Helmoholtz equation. Clausius Clapeyron equation. Application of thermodynamics to Biochemistry and Biotechnology.
8.	**Distribution law:** Introduction, Nernt's distribution law, solubility and distribution law, distribution law and molecular state, Henry's law, Determination of equilibrium constant.
9.	**Chemical equilibrium:** Nature of chemical equilibrium, law of mass of action, equilibrium constant, relationship between ΔG & $K_{eq.}$ Effect of temperature and pressure, ionization of water, Le chatteliar principle, equilibrium reaction involving protons, coupling of reactions.

Text Books:

1. Biological Physics, Philip Nelson. W.H. Freeman and Company, New York, (2004).
2. Physics for Engineers, Gr. Gias Uddin Ahmed, Part 1, Habib Book Center, Bangladesh, (2005)
3. Electricity and Magnetism, R. Murageshan, , S. Chand and Co. Ltd., New Delhi, India.
4. Modern Physics, R. Murageshan, S. Chand and Co. Ltd., New Delhi, India.
5. Modern Physics, B. L. Theraja,
6. A text book of Physical Chemistry, K. K. Sharma and L. K. Sharma,
7. Essential of Physical Chemistry, B.S. Bahl and G.D. Tuli, S. Chand and Company Ltd. (2006).
8. Physical Chemistry, V.M. Khanna, M.M. Kapur, and V.P. Sharma.

Recommended References:

1. Biologist's Physical Chemistry, Morris, J. G. A,

Course: BGE-203	**Course title:** Fundamentals of Molecular Biology		**Offered year:** 2nd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide the basic concepts on the structure, function and creation of biomolecules such as nucleic acids, proteins, carbohydrates and lipids in both prokaryotic and eukaryotic system.

Course Objectives:

- To provide the basic concepts of molecular biology.
- To demonstrate how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information.
- To explain the process, regulation and expression of biomolecules in living system.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Demonstrate knowledge and understanding of the molecular machinery of biological system.
- Understand how genetic information in the DNA is selectively expressed as functional proteins.
- Learn various topics of molecular biology such as structural and regulatory RNA, Protein localization and dynamics.
- Gain basic understanding of DNA replication, transcription, genetic code, translation and expression.
- Understand the process, regulation and expression of biomolecules in living system.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction to Biomolecules:** Nature of Organic Biomolecules in the Body; Carbohydrates; Lipids; Proteins; Nucleic Acids.
2.	**DNA Replication:** Semiconservative Manner of DNA Replication; Modes of Replication; Requirements of Replication; Direction of Replication; Bacterial Replication System; Fidelity of DNA Replication; Mechanism of Replication of Eukaryotic DNA; Replication in Archaea; Antibiotics that Target DNA Synthesis.
3.	**Transcription and RNA Processing:** Overview of Transcription Process; Process of Bacterial Transcription; Process of Eukaryotic Transcription; Antibiotics that Inhibit RNA Synthesis.
4.	**RNA Molecules and RNA Processing:** Gene Organization; Concept of Colinearity; Structure and Processing mRNAs, tRNA and rRNA; RNA Splicing Mechanisms; Alternative Processing Pathways; Diversity of Non-Coding RNA(ncRNA); Catalytic RNAs.
5.	**The Genetic Code:** The Triplet Code; Cracking the Genetic Code; Properties of the Genetic Code; Effect of Mutations; Expanded Genetic Code; Artificially Modified Genetic Code; Synthetic Biology.
6.	**The Process of Translation:** Stages of Translation Process - Binding of Amino

	Acids to tRNAs, Initiation, Elongation and Termination; RNA–RNA Interactions in Translation; Polyribosomes; Translation Systems in Bacteria, Archaea and Eukarya; The Posttranslational Modifications of Proteins; Translation and Antibiotics.
7.	**Protein Localization and Dynamics:** Post-Translational and Co-Translational Translocation of Proteins; Protein Targeting; Roles of Chaperones in Protein Folding, Transport and Degradation; Signal Sequences that Initiate Translocation; Translocon − Channel Through the Membrane; Protein Anchoring in the Membrane.
8.	**Organelle Genome:** Structures of Mitochondria and Chloroplasts; Genetics of Organelle-Encoded Traits; Endosymbiotic Theory; Mitochondrial Genome Organization; Evolution of Mitochondrial DNA and Human History; Chloroplast Genome Organization; Evolution of Chloroplast DNA; Consequences of Damage to Mitochondrial DNA.

Text Books:

1. Essential Cell Biology. Bruce Alberts, D. Bray, K. Hopkin, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. Second Ed. Garland Science, (2003).
2. Molecular Biology of Cell. Bruce Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, J. D. Watson, Fourth Ed. Garland Science, (2002).
3. Genes VI and VII. Benjamin and Lewin, Sixth Edition. Oxford University Press, (1997).
4. Lehninger Principle of Biochemistry, David L. Nelson, Michael M. Cox, 4th edition, W.H. Freeman (2004).
5. Genomes. Brown, T. A. Second Edition. BIOS Scientific Publishers Ltd. (2002).
6. Principles of Genetics Snustad, D.P. Simmons, M.J. and Jenkins, J.B., Jacaranda/Wiely pub. (1997).

Recommended References:

1. Molecular Biology of the Gene. Watson, J.D. and Hopkins, A.M., Roberts, J.W., Steitz, J.A. and Weiner, A.M., Benjamin/Cummings Scientific Publishing, Menlo Park, California, (1988).
2. Concepts of Genetics. Klung, W.S. and Cummings, M.R., Scott, Foresman and Co. USA, (1980).

Course: BGE-204	**Course title:** Enzymology		**Offered year:** 2nd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50

Rationale: This course provides the basic knowledge and information on enzyme. It will emphasize on enzyme based catalytic models, enzyme kinetics and factor affecting enzyme catalysis, enzyme regulation, inhibition, isolation and application of enzyme in different biotechnological sectors.

Course Objectives:

- To provide basic concepts of enzymology
- To explain the function and action of enzymes.
- To explain enzyme regulation and inhibition and their application in biotechnology.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the basic concepts and knowledge of enzyme
- Describe enzyme kinetics, regulation and inhibition
- Provide in-depth knowledge on various factors influencing the rate of enzyme catalytic reactions
- Learn various processes of enzyme isolation, purification and assay
- Know the industrial application of enzymes inbiotechnologyrelated industries.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction:** Definition, classification and nomenclature of enzymes, enzyme assay, apoenzyme and holoenzyme, coenzyme and prosthetic group, specific activity and enzyme activity units.
2.	**Enzyme kinetics:** Monosubstrate reactions, Michaelis-Menten equation and its linear transformations; Km and Vmax: definition, determination, and significance.
3.	**Factors influencing the rate of Enzyme-catalyzed reactions:** Substrate concentration, enzyme concentration, pH, temperature, co-enzyme and cofactors; factors affecting the catalytic efficiency of enzyme: proximity and orientation, covalent catalysis, acid-base catalysis, strain.
4.	**Regulation and mechanism of enzyme action:** Covalent modification; feedback inhibition, allosteric regulation, ATKase; mechanism of enzyme action: Examples – chrymotrypsin, ribonuclease A.
5.	**Inhibition of enzyme:** Reversible and irreversible inhibition, competitive, non-competitive and uncompetitive inhibition with specific examples.
6.	**Isoenzyme:** Characteristics, properties of LDH, CK, clinical and biological importance of isoenzymes.
7.	**Enzyme isolation, purification and assay:** Introduction, objectives and strategies in enzyme purification; primary clarification of the soluble enzyme; methods of concentrating enzymes; various chromatographicmethods for enzyme purification; examples of purificationprocedure;techniques of enzyme assay.
8.	**Industrial applications of enzymes:** Introduction, application of enzymes in biotechnology, economic significance, enzymes isolated on an industrial scale and their application.

Text Books:

1. Lehninger Principle of Biochemistry, David L. Nelson, Michael M. Cox, 4th edition, W.H. Freeman, (2004).
2. Fundamental of Enzymology, Nicholas C. Price and Lewis Stevens. 2nd edition. Oxford Science Publications, UK. (1990).

Recommended References:

1. A. Principles of Biotechnology, Wiseman, Surrey University Press and Chapman and Hall. New York. (1985).
2. Recombinant DNA Technology, Watson. J.D., Gilman. M., Witkowskli, J., Zoller, M. Scientific American Books. (1992).

Course: BGE-205	**Course title:** Metabolism-I		**Offered year:** 2nd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5 h	**Total marks:** 50

Rationale: The course is designed to develop student's knowledge and understanding of biochemical and molecular studies into metabolic pathways and processes occurring in living cells with a focus on human metabolism in health and disease.

Course Objectives:

- To provide basic knowledge of the biochemical conversions and molecular pathways of metabolism.
- To demonstrate the metabolic fates (synthesis/degradation/modification) of carbohydrate, and lipid.
- To explain the central mechanisms of molecular regulation and control of metabolism.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Understand the basic metabolic pathways (the energy-yielding and energy-requiring reactions in life)
- Know the diversity of metabolic regulationin different cells
- Understand the integrated control system of the biochemical processes
- Know the basic and alternative metabolic pathways
- Understand various aerobic and anaerobic metabolic processes

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction to metabolism:** Important differences and relationship between Anabolic & Catabolic mechanisms in cell, High-energy phosphate compounds and Biological oxidation-reduction reactions, ATP generation by different processes, ATP cycle.
2.	**Membrane and membrane transport system:** Structure and composition of membrane, Active transport, Passive transport, Facilitative diffusion, and Group translocation.
3.	**Glycolysis:** Glycolytic pathway, Importance and regulation of glycolysis.
4.	**Citric acid cycle and electron transport system:** Pathways of Citric acid cycle,The electron carriers of electron transport chain, Mitochondrial electron flow, Uncouplers of oxidative phosphorylation.
5.	**Alternative pathways for glucose catabolism:** Hexose monophosphate shunt, Entner-Doudoroff pathway, Methyl-glyoxal bypass.
6.	**Pathway for utilization of sugars other than glucose:** Fructose, Mannose, Maltose, Lactose, Sorbitol, Mannitol, Starch, Cellulose.
7.	**Metabolism of alternate carbon sources:** Glyoxylate cycle, Gluconeogenesis, Other anaplerotic reactions.
8.	**Aerobic metabolic processes:** Growth with organic acids (beta-oxidation), Amino acids, Aromatic compounds, Aliphatic hydrocarbons and CI compounds.
9.	**Anaerobic metabolic processes:** Fermentation of ethanol, Lactic acid, Acetate-butyrate, Acetone-butanol, and Methane.

Text Books:

1. Lehninger Principles of Biochemistry, Fourth Edition - David L. Nelson, Michael M. Cox, 4th edition, (2004).
2. Microbial Physiology, A.G Moat & J.F Foster.
3. Bacterial Metabolism, G. Gottschalk.

Recommended References:

1. Boiteux, A. & Hess, B. Design of glycolysis. Philos. Trans. R. Soc. Lon. Ser. B Biol. Sci 293, 5-22, 1981.

Course: BGE-206	**Course title:** **Human Physiology**		**Offered year:** 2nd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75
Rationale: This course is designed to provide students with an understanding of the function and regulation of the human body and physiological integration of the organ systems to maintain homeostasis.			

Course Objectives:

- To offer an in-depth presentation of the function of the major organs and organ systems of the human body
- To explain the molecular and cellular basis of physiological functions in human
- To integrate the regulation of organ system functions to explain homeostasis
- To demonstrate the structure-function relationships of different organs and systems

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Explain the homeostatic mechanisms, controls, and specific functions of the systems of the human body.
- Design, construct, and quantify experimental methods to evaluate human physiological systems.
- Interpret data and present findings of physiology laboratory experiments.
- Analyze and explain medical and health science-related scenarios of physiological system disruptions.
- Understand various functions of mammalian hormones, endocrine glands and maintenance of homeostasis.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**General Physiology:** Introduction to human physiology, branches of physiology, homeostasis, cell structure, membrane transport, cell membrane potential, action potential, excitation rhythmical.
2.	**Blood:** Composition, origin and functions; properties plasma proteins, erythrocytes-morphology, function, developmental fate, leukocytes-morphology, function, classification, properties, development; thrombocytes-morphology, function, development; hemoglobin-synthesis, structure, function, fate; homeostasis and coagulation-concept of coagulation, anti-coagulation; Blood grouping-ABO system; R^h factor, lymph-function circulation.
3.	**Endocrine system:** General Introduction, classification and chemistry, communication among cells and tissues; control of hormone secretion, mechanism for second messenger generation; Hormone action and phosphotidyl insotitol, mechanism of action of Epinephrin, Glucagon, Insulin and steroid hormone.
4.	**Cardiovascular system:** Structure and properties of cardiac muscle, generation and conduction of cardiac impulse, electro-physiology of cardiac muscle (ECG); events of cardiac cycle and cardiac output, blood pressure, heart rate, factors affecting heart rate, hemodynamic blood pressure and its regulation.
5.	**Respiratory system:** Introduction of respiratory apparatus and pulmonary

	circulation, mechanism of respiration, pulmonary ventilation, pulmonary volume, alveolar ventilation, capacities, gaseous exchange, ventilation-perfusion relationship, oxygen transport, oxygen dissociation saturation curve, carbon dioxide transport, oxygen carriage, regulation of respiration- nervous and chemical.
6.	**Nervous system:** Nerve cells, classification of nervous system, structure and function of neuron, synapse, neurotransmitter, membrane potential, action potential; the sense, sense receptors, and transmission of nerve impulse, control of sensory and motor function, reflex. Neural regulation of temperature, neural control of pituitary, adrenal, cortical and other systems.
7.	**Digestive system:** Anatomy and function of digestive system, composition, function and regulation of salivary, gastric, pancreatic, bile and intestinal juices, mechanism of secretion of gastric acid, physiology of digestion and absorption of foods. Digestive disorders (eg. Diarrhea, gastritis etc.).
8.	**Kidney and urinary excretory system:** Structure and function of kidney, renal circulation, urine formation-filtration, re-absorptions of different components of tubular fluid, secretion of substances by the kidney, concentration of urine, concept of plasma clearance, Acidification of urine.
9.	**Reproductive system:** Introduction to reproductive organs, puberty, menarche and menopause. Female Reproductive Organ: Structure and functional aspects of ovary and ovarian cycle, menstrual cycle,Male Reproductive Organ: Structure of testes, spermatogenesis steps and control, fertility, fertility control and sterility, Anatomy of primary organ and secondary organ of male and female reproductive system and their functions, composition, reproductive disorders.

Text Books:

1. Text Book of Medical Physiology, Arthur C. Guyton, M.D. & John E. Hall, W.B. Saunders Company, London, (2006).
2. Anatomy and Physiology- The Unity of Form and Functions. 3rd Edition. Keneth Saladin.
3. Review of Medical Physiology, William F. Ganong, 21st Edition, (2006).
4. Human Physiology, Dr. C.C. Chatterjee. Vollume.1 & 2.
5. Gray's Anatomy, Grays.

Recommended References:

1. Human Physiology, Shana and Ghosh.
2. Text Book of physiology, Smith. E. Pateson. C.R. Scratecherd. T. and Read. N.W. Hong kong (1988).
3. Human Anatomy and physiology, Elaine. N. 4th Ed. Benjamin/Cummings. Scientific publishing, California.
4. Albert L. Lehninger, David L. Nelson, Michael M. Cox (1993). Principles of Biochemisty, 2ndedn., CBS publishers and distributors, 485 Jain Bhawan, Bholanath Nagar, Shahdara, Delhi-110032, India.
5. William F Ganong (1998). Review of Medical Physiology, 18thed Prentice Hall International Inc. Canada.

Course: BGE-207	Course title: Microbiology II	Offered year: 2nd

Minimum course hour:	Credit hour:	Final exam duration:	Total marks:
42h	3	3h	75

Rationale: The course emphasizes the knowledge of microbiology and its application in various areas of life, environment and industry. This course also explains the mechanisms of microbial pathogenicity and host pathogen interaction.

Course Objectives:

- To provide basic concept of microbiology and its application in various sectors of life.
- To explain the role of microorganisms in the environment and industrial sectors.
- To explain the mechanisms of microbial pathogenicity and host pathogen interaction.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand microbial associations with other organisms
- Know the impact of microorganisms in the environment
- Understand the role of microorganisms in various industrial sectors
- Learn the mechanisms of microbial pathogenicity and host pathogen interaction.
- Get knowledge of viral pathogenicity and application of virus in synthetic biology

Teaching Strategy: Lecture, Projector display, Animation, Discussion,Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** Industrially importance microorganism, scope of using microbes in industries in Bangladesh; examples of industrially important microorganisms
2.	**Microbial associations:** Microbial associations with animals, plants, and other microorganisms.
3.	**Microorganisms in the environment:** The carbon cycle, the nitrogen cycle, the sulphur cycle, phosphorus, the microbiology of soil, the microbiology of freshwater, the microbiology of seawater, detection and isolation of microorganisms in the environment, beneficial effects of microorganisms in the environment, and harmful effects of microorganisms in the environment.
4.	**Appliedand industrial microbiology:** Food microbiology: the role of microorganisms in food production; the microbial spoilage of food, Industrial microbiology: fermentation technology; industrial products, alternative energy sources using microorganisms.
5.	**Microbial mechanisms of pathogenicity:** The spread of infection, How microorganisms enter a host, how bacterial pathogens penetrate host defenses, how bacterial pathogens damage host cells, pathogenic properties of viruses,

	pathogenic properties of fungi, protozoa, helminths, and algae, portals of exit.
6.	**Virus and pathogenicity:** Latent viral Infections, persistent viral infections, and prions.
7.	**Viral derived tool:** Virus as a tool for synthetic biology, virus based cancer therapy.

Text Books:

1. Microbiology. Michael J. Pelczar, Noel R. Kreig and E.C.S Chan. 5th edition, Tata McGraw Hill Publishing Company Limited, New Delhi.
2. Microbiology: An Introduction. Tortora, BerdellR.Funkee& Case, 12th edition, Prentice-Hall.
3. Biology of Microorganisms. TD Brock, MT Madigan, JM Martinko, and J. Parker, 7th edition, Prentice-Hall, Englewood Cliffs.
4. Fundamental Principles of Bacteriology. A.J. Salle, 7th edition, McGraw Hill Book Company.
5. Essential Microbiology. Stuart Hogg, 2nd edition, John Wiley & Sons Ltd.

Recommended References:

1. Microbiology: Principles and Explorations. Jacquelyn G. Black, Laura J. Black. 9th Edition, John Wiley & Sons Ltd; 2014.
2. Foundations in Microbiology. Kathleen Park Talaro and Barry Chess. 10thedition,McGraw-Hill; 2018.

Course: BGE-208	**Course title:** Cell Biology		**Offered year:** 2nd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course emphasizes on the in-depth knowledge of cell as it is the structural and functional unit of life. This course is intended to provide the basic concepts on fundamentals of cell cycle, cell division, cytoskeleton and their role in cell movement, mechanisms of cell-cell communication and adhesion.

Course Objectives:

- To provide basic concepts on cell, cell cycle and cell division.
- To explain fundamentals of cellular components and their functions.
- To develop knowledge on the cell-cell communication, cell birth, death and their regulation mechanisms.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the origin and evolution of cell
- Learn the basic components of cytoskeleton and their role in cell movement
- Understand fundamentals of cell cycle and cell division
- Know the components and mechanisms of cell-cell communication
- Gain in-depth knowledge eof regulations of cell birth and cell death

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Overview:** Origin and evolution of cells; the first cell, present day prokaryotes, eukaryotic cells, cells as experimental models.
2.	**The cytoskeleton and cell movement:** Structure, assembly and organization of actin filaments, association of actin filaments with plasma membrane, protrusions of the cell surface, role of actin and myosin in muscle contraction, regulation of muscle contraction, unconventional myosin, cell migration and crawling, intermediate filaments, structure, assembly and dynamic instability of microtubules, general features of microtubules, microtubules organizing centers, reorganization of microtubules during mitosis, microtubule motor proteins, organelle transport and intracellular organization, separation of mitotic chromosomes, and microtubules in cilia and flagella.
3.	**Cell cycle and division:** The eukaryotic cell cycle; phases of the cell cycle, regulation of the cell cycle by cell growth and extracellular signals, cell cycle checkpoints, regulators of cell cycle progressions, inhibitors of cell cycle progression, the events of M phase, cytokinesis, meiosis and meiosis vs. mitosis, fertilization.
4.	**Cell junctions, cell adhesion and the extracellular matrix:** Cell junctions and their role, cell adhesion, cell adhesion proteins and their role, cell-cell and cell-matrix adhesions, extra-cellular matrix of animals, matrix macromolecules, their synthesis and role, integrins.
5.	**Cell birth and stem cells:** Introduction, The birth of cells: stem cells give rise to stem cells and to differentiating cells, cultured embryonic cells can differentiate into various cell types, tissues are maintained by associated populations of stem cells, cell fates are progressively restricted during development; Origin and properties of embryonic stem cells, Pluripotent stem cells, Mesenchymal stem cells, Adult stem cells, Stem cell culture and application.
6.	**Cell lineage and cell death:** Cell death and its regulation: programmed cell death occurs through apoptosis, neurotrophins promote survival of neurons, a cascade of caspase proteins functions in one apoptotic pathway, pro-apoptotic regulators

	permit caspase activation in the absence of trophic factors, some trophic factors induce inactivation of a pro-apoptotic regulator, tumor necrosis factor and related death signals promote cell murder by activating caspases.

Text Books:

1. The Cell: a molecular approach. Geoffrey M. Cooper, Robert E. Hausman; (3rd Edition) ASM Press, Washington, D.C., 2004.
2. Molecular Biology of the Cell. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter; (4th Edition) Garland Science, New York, 2002.
3. Molecular Cell Biology, 4th Edition, by Lodish, A., et al. Fourth Edition, Freeman and Company, 2000.

Recommended References:

1. Cooke, R. Motor proteins. *Encyclopedia Life Sciences.* Nature Publishing Group, 2001.
2. Spudich, J. A. The myosin swinging cross-bridge model. *Nature Rev. Mol. Cell Biol.* **2**:387–392, 2001.
3. Vale, R. D., and R. A. Milligan. The way things move: Looking under the hood of molecular motor proteins. *Science* **288**:88–95, 2000.

Course: BGE-209	**Course Title:** Nutrition and Food Biotechnology		**Offered Year:** 2nd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total Marks:** 50

Rationale: The course is designed to provide the knowledge and understanding of nutrition and various biotechnological applications in food sector. This course is intended to furnish a student with knowledge and understanding of the basic biological and chemical processes for the production, processing and preservation of food and related products.

Course Objectives:

- To explain the role of microorganisms in food production, processing and preservation.
- To demonstrate the role of nutrition in gene regulations and production of microbial proteins.
- To develop basic knowledge on food safety and regulations.

Intended learning outcomes (ILOs): At the end of the course the students will be able to-

- Get basic knowledge about nutrition and food biotechnology
- Know the role of microorganisms in food production, processing and preservation
- Learn the applications of microorganisms in various food biotechnological systems
- Know the implementation of molecular biotechnological techniques for nutraceutically enriched food

- Gain knowledge of national and international regulations on food biotechnology

Teaching methods:
Lecture, Multimedia display, Animation, Handouts, field visit, Seminar, Case Study etc.

Assessment methods:
Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva
Final exams: Structured questions

	Course Contents
1.	**Introduction**: Definition of Food, Food source, calorific value of food, Food Safety and security. Scope of Food Biotechnology and Industrial Biotechnology, Aspects of molecular biology and bioinformatics of relevance in food and industrial biotechnology.
2.	**Nutrition:** Concepts of nutrition, Nutritional requirements, Biological value of proteins, essential and non-essential amino acids, essential and non-essential fatty acids; Sources, nutritional importance and deficiency disorders of vitamins.
3.	**Genomic Basis of food**: Genomic basics of food improvement, metabolic engineering of bacteria for food ingredients, Genetic modification of plant starch, Biotechnology of sweeteners microbial biotechnology of food flavor production, pectinases in food processing, Food grade bio-preservatives.
4.	**Dairy products**: Diversity of dairy products, Milk constituents, Milk processing, genetically engineered milk or Designer milk, Dairy enzymes.
5.	**Food microbiology**: Fermentation technology in foods, Starter culture, Genetic manipulation of starter culture, Production of fermented food and food products: beer, wine, bread, cheese, yogurt, cocoa, soy milk, Detail production and safety procedures for single-cell proteins, yeasts and yeast products, ddifferent fermented foods, vegetables, fruits and meat products.
6.	**Nutraceuticals**: Nutrition, health sustaining and health enhancing ingredients. Molecular biotechnology for Nutraceutical enrichment of food crop. Functional phytochemicals, Probiotics, Bioactive peptides, LAB.
7.	**Industrial food biotechnology**: Biotechnological approaches for the production of Carotenoids, Amino acids, Wine yeast, Citric acid, Food flavors, Oils and fat.
8.	**Microbial safety of food and food products**: Food allergies, Clinical symptoms of food allergies, Sea food allergies, Biogenic amines in food, detection of emerging bacterial food-borne pathogen, Biosensors for sensitive detection of agricultural contaminants, pathogens and food-borne toxins. Genetic modification of food crop against food allergy.

Text Books:

1. Perry Johnson-Green (2002). Introduction to Food Biotechnology. Author. CRC Press.
2. Stanbury, P.F, S Whitake, A. (1984). Principles of Fermentation Technology. Pergamon Press: Oxford
3. Hutkins, Robert (2006). Microbiology and Technology of Fermented Foods,

Blackwell Publishing

Recommended references:

1. Modern Industrial Microbiology and Biotechnology, Nduka Okafor, Scince Publishers, USA. ISBN: 978-57808-434-0.
2. Food Biochemistry and Food Processing, Benjamin K Simpson, Wiley-Blackwell, USA. ISBN: 978-0-8138-0874-1
3. Food Biotechnology (Eds: Kalidash Shetty et al.) Taylor and Francis Group. ISBN: 10:0-8247-5329-1

Course: BGE-210	**Course title:** Biostatistics		**Offered year:** 2nd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course intended to demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation. Biostatistics introduces to the terminologies, methods and software used for the analysis of biostatistical data.

Course Objectives:

- To demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation.
- To give students an appreciation of a statistical perspective on information arising from the health arena and basic critical appraisal skills to assess the quality of research evidence.
- To introduce various terminologies, methods and software for the analysis of biostatistical data.

Intended Learning Outcomes (ILOs): At the end of the course, the students will be able to-

- Select from, use, and interpret results of descriptive statistical methods and the principal methods of statistical inference and designeffectively,
- Demonstrate an understanding of the central concepts of modern statistical theory and their probabilistic foundation
- Communicate the results of statistical analyses accurately and effectively,
- Read and learn new statistical procedures independently,
- Make appropriate use of statistical software.

Teaching Strategy: Lecture, Projector display, Animation, Case study, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction to biostatistics:** Definition, application and scope of statistics and biostatistics; basic statistical principles and terminologies- population, sample, parameter, statistic, variable, Statistical characterization of samples, Distributions, Statistical concepts pertaining to interpretation and decision, etc.
2.	**Frequency distribution:** Frequency distribution; necessity of frequency distribution, principles of classification, numerical examples.
3.	**Graphical representation of data:** Histogram; bar-diagram; pie chart; line-graph; Ogive.
4.	**Descriptive statistics: Central tendency-** Concept, objectives of measure of central tendency and different measures as arithmetic mean, geometric mean, harmonic mean, median, quartiles, percentiles, deciles, mode; properties of different measures and their uses; **dispersion-** concept, objectives of measures of dispersion, different measures- absolute measures, relative measures, range, quartiles deviation, standard deviation, variance, co-efficient of variation, propertiesof different measures of dispersion and their uses.
5.	**The relationship between variables – sample correlation and linear regression: correlation analysis-** concept, definition and properties of correlation co-efficient, different methods of studying correlation co-efficient, uses of correlation co-efficient; **regression analysis-** concept, definition, properties and confidence limit of regression co-efficient, Significance of a difference between regression coefficient; Least square method to estimate the parameters of simple linear regression model, Test of linearity of a regression, uses of regression analysis.
6.	**Sampling techniques:** Concept; sampling frame; sampling design; simple random sampling; stratified random sampling.
7.	**Probability and probability distribution:** Definition of probability; different approaches of probability; conditional probability; definition of random variable; probability distribution, binomial distribution, Poisson distribution and normal distribution; concept and different measures of skewness and kurtosis.
8.	**Hypothesis testing:** Concept; tests of hypotheses; statistical hypothesis; null hypothesis; alternative hypothesis; level of significance; type 1 error; type 2 error; Mean test- test of hypothesis about single mean, test of hypothesis about quality of two means; proportion; confidence interval. **Test of significance: Measurement data** **T-test** in paired and non-paired experiments, selection of appropriate method of calculating t, confidence limits of a difference between means; general test of independent in one rxe contingency level; p-value; Z-score; non-parametric test; **Analysis of variance: The F test -**Single characterization data, Single classification data with subgroups, Multiple classification data, Ducan's multiple range test: Least significance difference test, The relationship between t and F test. **Analysis of variance (ANOVA) test**- one-way and two-way classifications.

	Test of significance: Enumeration data **The chi-square (x2) test** - The 1 x n table, the 2 x n table, use of x2 with occurrence-non-occurrence data, x2 analysis of a 2 x 2 or four fold table, Alternate methods of calculating x2, Tests of significance when cell frequencies are small.
9.	**Use of software in biostatistics:** Basics, advantages, limitations, and Hands-on training using, Microsoft Excel, SPSS/SAS and R; Problem/Analysis: representation and observation.

Text Books:

1. Basic Biostatistics for Geneticists and Epidemiologists: A Practical Approach by Robert C. Elston, William D. Johnson. 2008. Publisher-John Wiley & Sons, Ltd.
2. Statistics for Biologist (3rd edition) by R.C. Campbell. 1989, Publisher-Cambridge University press.
3. Epidemiology and Biostatistics. Kestenbaum& Bryan 2009. Publisher-Springer.
4. Fundamentals of Biostatistics (7th edition). Bernard Rosner. 2010, publisher-Cengage Learning.
5. Text Book of Biostatistics. A.K. Sharma. 2005, Publisher-Discovery Publishing House.

Recommended References:

1. Principles and procedures of statistics. Steel, R.D.G and Torry, J.H. 1960, McGraw Hill Book Co. Inc. NewYork
2. Introduction to Statistics. Mian, M. and Miyan, Alimullah, M. 1984
3. Experimental Designs. Cochraan W.G. and Cox. G. M.
4. Introduction to Statistics. Shill and R Debnath
5. Method of statistic. Mostafa M. N. Bangladesh
6. Introduction to statistic and probability (3rd edition). Islam M.N.

Course: BGE-211	**Course title:** Basic Immunology		**Offered year:** 2nd
Course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The history and basic concepts of immunology will be introduced with a special emphasis on components of immune system and their role in immunity. Lectures are designed to give students hands on training with the techniques related to antigen antibody interactions.

Course Objectives:

- To explain the basic principles and components of immune system
- To develop basic concepts of inflammation, immunity and immune effector mechanisms.
- To demonstrate various techniques involve in immunology research.

Intended Learning Outcomes (ILOs): At the end of the course, the students will be able to-

- Know the modern perspective of inflammation, immunity and immune effector mechanisms
- Know the various terminologies and determining factors of immunogenicity
- Learn about immunoglobulins structures, types and their functional properties
- Understand the antigen-antibody interactions, immune complex reactions, specificity and cross-reactivity
- Gain knowledge of complements and their functions in immune response.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Immune System:** Introduction and Historical Perspective; The Immune System Includes Innate and Adaptive Components: innate immunity, adaptive immunity; Humoral immunity but not cellular immunity is transferred with antibody; The Major Histocompatibility Molecules Bind Antigenic Peptides; Complex Antigens Are Degraded and Displayed with MHC Molecules on the Cell Surface; Clonal Expansion; Collaboration of Innate and Adaptive Immune Systems; Comparative Immunity; Immune Dysfunction and Its Consequences.(Add plant, microbial and animal immune system in brief)
2.	**Cells and organs of the immune system:** Hematopoiesis; Cells of the Immune System; Organs of the Immune System; Systemic Function of the Immune System.
3.	**Antigens:** Immunogenicity versus Antigenicity; Factors That Influence Immunogenicity, Epitopes; Haptens and the Study of Antigenicity; Pattern-Recognition Receptors.
4.	**Antibody:** Basic Structure of Antibodies; Immunoglobulin Fine Structure; Antibody-Mediated Effector Functions; Antibody Classes and Biological Activities; Antigenic Determinants on Immunoglobulins; TheB-Cell Receptor; The Immunoglobulin Superfamily; Monoclonal Antibodies.
5.	**Organization and expression of immunoglobulin genes:** Genetic Model Compatible with Ig Structure; Multigene Organization of Ig Genes; Variable-Region Gene Rearrangements; Mechanism of Variable-Region DNA Rearrangements; Generation of Antibody Diversity; Class Switching among Constant-Region Genes; Expression of Ig Genes Synthesis, Assembly, and Secretion of Immunoglobulins; Regulation of Ig-Gene Transcription; Antibody Genes and Antibody Engineering.
6.	**Antigen-antibody interactions:** Strength of Antigen-Antibody Interactions; Cross-Reactivity; Precipitation Reactions; Agglutination Reactions; Radioimmunoassay; Enzyme-Lin Western Blotting; Immunoprecipitation;

	Immunofluorescence; Flow Cytometry and Fluorescence; Alternatives to Antigen-Antibody Reactions; Immunoelectron Microscopy.
7.	**Complement:** The Functions of Complement; The Complement Components; Complement Activation; Regulation of the Complement System; Biological Consequences of Complement Activation; Complement Deficiencies.

Text Books:

1. Basic Immunology - Abul K Abbas, Andrew H Lichtman
2. Immunology - David Male, Jonathan Brostoff , David B Roth, Ivan Roit
3. Kuby Immunology - Thomas J Kindt, Richard A Goldsby, Barbara A Osborne
4. Immuno Biology - Charles A, JanewayJr, Paul Travers, mark Walport, Mark J Shlomchik
5. Essential Immunology – Ivan M. Roit et al.
6. Cellular and Molecular Immunology – Abul K. Abbas, Andrew H. Lichtman.

Course: BGE-212	**Course title:**	Human Physiology Practical	**Offered year:** 2nd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: Human Physiology Practical is a course that will provide practical knowledge on body functions, general anatomy, and physiological processes of the human body.

Course Objectives:

- To provide basic knowledge of anatomical body structures, organs and organ systems within the body.
- To provide knowledge of the physiological processes associated with the body and their interaction and function.
- To provide basic concepts of clinical biochemistry

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the anatomical body structures, organs and organ systems
- Acquire practical knowledge of physiological techniques
- Learn the biochemical analysis of blood samples.
- Know various techniques of clinical biochemistry such as liver function tests, renal function tests.
- Gain knowledge of X-Ray and MRI.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	Measurement of normal blood pressure and effect of posture/ exercise on it.
2.	Electrocardiography.
3.	Total count of B. R. C; W. B. C & Platelets, differential count of W. B. C.
4.	BMI estimation.
5.	Estimation of hemoglobin and serum creatinine.
6.	Respiratory volume and capacity estimation.
7.	X-Ray and MRI study.

Text Books:

1. Text Book of Medical Physiology, Arthur C. Guyton, M.D. & John E. Hall, W.B. Saunders Company, London, (2006).
2. Anatomy and Physiology- The Unity of Form and Functions. 3rd Edition. Keneth Saladin.
3. Review of Medical Physiology, William F. Ganong, 21st Edition, (2006).
4. Human Physiology, Dr. C.C. Chatterjee. Vollume.1 & 2.
5. Gray's Anatomy, Grays.

Recommended References:

1. Human Physiology, Shana and Ghosh.
2. Text Book of physiology, Smith. E. Pateson. C.R. Scratecherd. T. and Read. N.W. Hong kong (1988).
3. Human Anatomy and physiology, Elaine. N. 4th Ed. Benjamin/Cummings. Scientific publishing, California.
4. Albert L. Lehninger, David L. Nelson, Michael M. Cox (1993). Principles of Biochemisty, 2nd edn., CBS publishers and distributors, 485 Jain Bhawan, Bholanath Nagar, Shahdara, Delhi-110032, India.
5. William F Ganong (1998). Review of Medical Physiology, 18thed Prentice Hall International Inc. Canada.

Course: BGE-213	**Course title:** Metabolism Practical		**Offered year:** 2nd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: This course aims to provide a fundamental understanding of the microbial growth, metabolism, fermentation, and isolation and characterization process of novel microbial species in an experimental way to enable students to acquire a specialized knowledge to understand the basics of metabolism.

Course Objectives: The course is aimed

- To teach the students to identify and quantify different microbial enzymes,
- To isolate and grow novel bacterial species in the laboratory
- To provide hands on training on the microbial metabolism.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Estimate the amount of various enzymes from microbial sources
- Isolate and detect bacterial species
- Understand microbial metabolism
- Perform fermentation test in the laboratory
- Isolate pure culture from different sample

Teaching Strategy: Lecture, Animation, Field visit, Experiment in lab

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Assignment, Lab report, Viva
Final exams: Q/A, Performing experiments in the Lab, Writing Report

	Course Content
1.	Extracellular enzymatic activities of microorganisms.
2.	Carbohydrate fermentation.
3.	TSI test.
4.	IMViC test.
5.	Hydrogen sulfide test.
6.	Urease test.
7.	Nitrate reduction test.
8.	Catalase test.
9.	Oxidase test.
10.	Utilization of amino acids.
11.	Identification of unknown bacterial cultures.

Text Books:

1. Laboratory Exercises in Microbiology, Fifth Edition, Harley, J.P. and Prescott, L.M. The McGraw-Hill Companies. (2002)
2. Lehninger Principles of Biochemistry, Fourth Edition - David L. Nelson, Michael M. Cox, 4th edition, (2004).
3. Microbial Physiology, A.G Moat & J.F Foster.
4. Bacterial Metabolism, G. Gottschalk.

Course: BGE-214	**Course title:**	Computer Basics and ICT Practical	**Offered year:** 1st
Minimum course hour: 28 h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: The course is designed for developing the knowledge on information and communication technology and the basics of the computer system.

Course Objectives:

- To provide basic computer skills required for the daily office and lab work
- To teach developing programming skill to generate some basic computer programs applicable in Bioinformatics
- To Teach basic bioinformatics tools and techniques

Intended Learning Outcomes (ILOs): After completion of the course, students will be able to-

- Maintain the computer and its security issues
- Demonstrate any types of Microsoft word, excel and power-point documents
- Describe the organization of the Hardware and the software of computer
- Perform any spreadsheet analysis
- Create, add and remove any information from any type of the database
- Develop computer program with the visual tools and C++
- Demonstrate different types of the Bioinformatics tools and techniques

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction to computer systems:** Types of computer, application areas, concept of CPU, keyboard, mouse, hard disk. Windows and the like peripheral, working principles of computer systems.
2.	**Hardware and software:** Organization and structure motherboard and microprocessor system, memory and other devices, classification of software‘s importance, components, basic functions. DOS, Windows, Unix, Linux etc.
3.	**File Management and word processing:** Concept of file and folder, creation of file, saving, editing and deleting file/ document. File copy, file move, layout, formatting, page setup and printing, tables and graphs etc.
4.	**Spreadsheet analysis:** Mathematical and statistical function: frequency, standard deviation, variance, mean, medium, line, bar, pie graph, correlation, regression etc. Creating and formatting chart, printing sheet, problem solving using formulas, data consolidation.
5.	**Power point presentation:** Preparation of slides, tables, graphs, editing, copying.
6.	**Database:** Concept of field, record, table, database and database management system. Creating and adding information to adatabase, editing and viewing the data, designing and viewing/ printing reports, understanding sorting and indexing.
7.	**Introduction to ICT:** Computer networking, basic concept of LAN, MAN and WAN; email and www. How to use a searchengine.
8.	**Computer maintenance and security:** Power supply, stability, grounding, handling and protection. Protecting privacy and data; Ergonomics. Computer

	viruses and troubleshooting.
9.	**Programming with visual tools:** Basic methods, object, method, event, event-driven programming. Working with forms, basicactive control, text box control, list-box control, command button, MS Flex grid control. Visual basic language, variable, constants, arrays, collections, procedures, subroutines, functions, calling procedures, arguments, control flow statements, if---then, if—then---else, select case. Loop statements: Do loop, for…next, nested control structures, the exit statement.
10.	**Programming with C/C++:** Constants, variables, data types, operators, expression, input and output operations, branching, looping, arrays, pointer, functions, structures and union, files, dynamic memory allocation.
11.	**Database programming:** Database, DBMS, relational concepts, keys, referential integrity, introduction SQL, basic structure, joins, attaching queries to a database, the data control, advanced data bound controls, the ADO data control, entering data ,accessing fields in record sets. HTML and front page
12.	**Applications:** Introduction and applications of WINBOT, BLAST, PDB, Perl and Linux programs.
Text Books: 1. Introduction to Information Technology. 3rd Ed. V. RAJARAMAN. PHI Learning Pvt. Ltd., India	
Recommended References: 1. Information Technology: An Introduction for Today's Digital World. 2nd edition. Richard Fox. Chapman and Hall/CRC.	

Part –III (3rd Year, Examination of 2021, 2022 and 2023)

Course: BGE-301	**Course title:** Microbial Genetics		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course is designed to introduce different aspects of microbial genetics. It starts with origin, structure, basic features, life cycle, mechanism of gene transmission, recombination of microbial and phage genetics which extends to their particular applications.

Course Objectives:

- To provide basic in-depth knowledge on microbial genome and genetics.
- To familiarize with fundamental organization and processes of fungi, yeast, plasmids, bacterial genome and gene transfer.
- To introduce phage genetics, transposable elements, recombination process and

molecular cloning.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Learn about microbial genome, plasmids, and gene transfer processes such as conjugation, transduction and transformation
- Be familiar with phage genetics, transposable elements and use of molecular cloning
- Know molecular basis of recombination process
- Learn genetics, structure and life cycle of Viruses
- Know the commercial importance of fungi and yeast

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Genetics of Bacteria:** Bacteria their origin and structure, kinds of bacteria, differences between eukaryotic and prokaryotic genetics, bacterial life cycle, replication.
2.	**Mechanism of gene transmission:** **Transformation***:* Molecular mechanism of transformation, competence; natural and artificially induced competence, uptake of DNA, transfection of plasmid, consequences of recombination; gene mapping; mosaic genes and chromosome plasticity. **Conjugation:** Mechanism of conjugation, F and F like plasmids, tra-operon, sex pilli, formation of Hfr strain, plasmid mobilization, conjugation in other bacteria **Transduction:**Generalized transduction, origin of generalized transducing phages, specialized transduction, origin of specialized transducing phage particle, genetic mapping by different transductant classes.
3.	**Recombination:** Types of recombination; molecular basis of homologous, non-homologous recombination and site-specific recombination.
4.	**Plasmids:** Introduction, basic features, size and copy number, structure and replication, types of plasmid, plasmid incompatibility, replication of Col El, control of plasmid replication, plasmid curing, r-plasmid and antibiotic resistant plasmid, mechanism of antibiotic resistance.
5.	**Genetics of Viruses:** The discovery and origin of viruses; kinds of bacteriophages, bacteriophage structure; ssDNA bacteriophage; RNA containing phages; dsDNA phages; lytic and lysogenic cycle of λ (lambda) phage; HIV Virus, it's structure and life cycle.
6.	**Genetics of Fungi:** Characteristics of fungi, life cycle, reproduction, economic importance of commercially important fungi; **Yeast:** Yeast as a model organism, advantages, life cycle, mating type switching in yeast.

Text Books:

1. Molecular Genetics of Bacteria: Dale and Park. John Wiley & Sons Ltd,
2. Principles of Genetics. Gardner, E. J., Simmons, M.J. and D.P. Snustad. 8th Edition. John Wiley and Sons Inc. Singapore, NY., (1997).
3. Molecular Genetics of Bacteria: Jeremy W Dale and Simon F Park. Fourth Edition. John Wiley and Sons.

Recommended References:

1. Gene IX, Benjamin Lewin: Ninth Edition. Jones and Bartlett Publishers.
2. Lehninger Principles of Biochemistry. Nelson and Cox. W. H. Freeman.
3. Molecular Biology of the Gene. James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick. Sixth Edition. Benjamin Cummings.
4. Molecular Biology. David Freifelder. Second Edition. Jones and Barlett Publishers.
5. Cells: Principles of Molecular Structure and Function. David M. Prescott. Jones and Barlett Publishers.

Course: BGE-302	**Course title:** Genetic Engineering		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide advanced concepts in genetic engineering. Lectures will cover the methods of PCR amplification, DNA manipulative enzymes, gene cloning, vectors, and introduction of rDNA, cloned gene selection and expression in various biological systems.

Course Objectives:

- To familiarize with fundamental knowledge and understanding of genetic engineering, the basic principles of recombinant DNA technology, gene manipulation and genetic transformation in living cells.
- To provide general techniques used in genetic engineering and its application in biotechnology and genetic engineering.
- To elucidate the process, regulation and expression of genes in prokaryotic and eukaryotic system.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Recognize the scope and importance of genetic engineering
- Learn the purification of DNA from living cells
- Choose a suitable method of recombinant DNA technology for gene manipulation
- Learn to construct recombinant gene, clone and transfer into suitable host system to produce valuable compounds
- Know the various types of vector used in gene cloning

• Gain in-depth idea about the applications of gene cloning and genome engineering	
Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.	
Assessment Strategy: **Tutorials:** Q/A, Quiz, Assignment, MCQ, Presentation, Viva **Final exams:** Q/A	
Course Content	
1.	**Introduction to Genetic Engineering:** Historical Milestones in Genetic Engineering; Emergence of Recombinant DNA Technology; Biotechnological Application of Recombinant DNA Technology; Techniques Used for Gene Cloning; The NIH Guidelines.
2.	**Purification of DNA from Living Cells:** Preparation of Total Cell DNA, Plasmid DNA, and Bacteriophage DNA; Preparation of Non-Lysogenic λ Phages; Purification of DNA from λphage and M13 DNA particles.
3.	**DNA Manipulative Enzymes:** Range of DNA Manipulative Enzymes; Type II Restriction Endonucleases; Performing a Restriction Digest in the Laboratory; Separation and Estimation of the Sizes of DNA Fragments; Ligation Strategies.
4.	**Introduction of Recombinant DNA into Living Cells:** Uptake of DNA by Competent Bacteria; Selection for Transformed Cells; Identification of Recombinants; Introduction of Phage DNA into Bacterial Cells; Identification of Recombinant Phages; Introduction of DNA into Non-Bacterial Cells; Transformation of Whole Organisms.
5.	**Vectors for Gene Cloning:** Plasmids and Bacteriophages as Cloning Vectors; Plasmid-Based Cloning Vectors for *Escherichia coli*; Cloning Vectors Based on λBacteriophage; Insertion and Replacement Vectors; Cosmid; Vectors Based on M13 Bacteriophage; Phagemid Vectors; High-Capacity Cloning Vectors
6.	**How to Obtain a Clone of a Specific Gene:** Problem in Getting Positive Clones; Direct Selection for the Desired Gene; Identification of the Clone from a Gene Library; Methods for Clone Identification; Methods for Labeling Nucleic Acids; Hybridization Probing.
7.	**Production of Protein from Cloned Genes:** Recombinant DNA Technology in Biotechnology; Vectors for Expression of Foreign Genes; Selection of Promoters; Expression Cassettes; Gene Fusion Systems; General Problems with the Production of Recombinant Protein; Production of Recombinant Protein by Eukaryotic Cells; Pharming; *In Vitro* Translation Systems.
8.	**Application of Gene Cloning and Genome Engineering:** Methodology for Sequencing Genes and Genomes; Sequence a Genome; Identifying and Studying the Translation Product of a Cloned Gene; Studying Protein–Protein Interactions - phage display, the yeast two-hybrid (Y2H) system, and yeast three-hybrid (Y3H) system; 8.4.5 Protein Engineering; Site-Directed Mutagenesis.
9.	**Genome Engineering Using CRISPR-Cas Technology:** CRISPR-Cas Systems;

	CRISPR Timeline; Diversity of crRNA-Cas Effector Complexes; Mechanism of CRISPR-Cas Immune Systems; Genome Engineering Using the Class 2 CRISPR-Cas Systems; Guide RNAs (gRNAs) and Single Guide RNA (sgRNA); Delivery of CRISPR-Cas Plasmid Construction into Target Cells; Use of Deactivated Cas9 to Regulate Gene Transcription.

Text Books:

1. Molecular biology of the Gene-Watson, Hopkins Roberts, Steitz and Weiner.
2. Genetic Engineering, Kingsman&Kingsman.
3. Principles of genetics,D.PSnustad, M.J Simmon& J.B Jenkins.
4. Gene Cloning, An Introduction, T.A Brown.
5. Biology of Microorganism, Brock, T.D., Madigan, M.T., Martinco, J.M. and Parker, J., (1990).
6. Genetics, Avers, C.J., Freeman and Co. NY. (1990).
7. Genetics, Strickberger, M.W., Macmillan pub. Co. NY. (1990).

Recommended References:

1. Principles of Gene Manipulation, R.W Old & Primrose
2. Introduction to Genetic Analysis, Suzuki, Griffith and Miller, W.H. freeman and Co. USA, (1986).
3. Bacterial Plasmid, Hardy, K.M., Published by American Society of Microbiology, (1986).

Course: BGE-303	**Course title:** Immunology-II		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course will provide a basic understanding of immune response to infections and immunological disorders. Emphasis is given to the basic mechanism of immune cell maturation and differentiation, hypersensitivity, immune manipulation such as grafting, tolerance etc.

Course Objectives:

- To elucidate basic mechanism of immune cell maturation and differentiation.
- To provide basic idea about the principles of hypersensitivity and unresponsiveness from standpoint of pathology.
- To explain basics of immunological disorders and therapeutic approaches to diagnose and treat them.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know about immune cells maturation and development process
- Gain detail knowledge about genetic organization of major histocompatibility complex (MHC)
- Know basics of cytokines and its receptor medicated signal transduction mechanism.
- Gain knowledge about transplantation and rejection mechanisms of cells, tissues, and organs to correct immune disorders. Discuss more detail on graft acceptance, rejection, and other post-grafting events.
- Know various factors involved in autoimmune disorders and hypersensitivity reactions
- Gain knowledge of immunobiology of host microbe interactions and immune response to tumors and cancer immunotherapy.

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Activation of T and B cells:** Maturation of T-Cell; Thymic Selection of the T-Cell Repertoire; T_H-Cell Activation; T-Cell Differentiation; B-Cell Maturation, Activation, and Proliferation; B-Cell Differentiation; Regulation of B-Cell Development.
2.	**Major Histocompatibility Complex (MHC):** General Organization and Inheritance of the MHC; Detailed Genomic Map of MHC Genes; Cellular Distribution of MHC Molecules; Regulation of MHC Expression; Production of inbred mouse strains; MHC and Immune Responsiveness; MHC and Disease Susceptibility.
3.	**Cytokines:** Properties of Cytokines; Cytokine Receptors; Cytokine Antagonists; Cytokine Secretion by T_H^1 and T_H^2Subsets; Cytokine-Related Diseases; Therapeutic Uses of Cytokines and Their Receptors; Cytokines in Hematopoiesis; Role of cytokines in B and T cells activation.
4.	**Transplantation Immunology:** Barriers of transplantation; Host vs graft response; Graft vs host reactions; Immunologic Basis of Graft Rejection; Clinical Manifestations of Graft Rejection; General Immunosuppressive Therapy; Specific Immunosuppressive Therapy; Immune Tolerance to Allografts; Clinical Transplantation.
5.	**Hypersensitive Reactions:** Gell and Coombs Classification; IgE-Mediated (Type I) Hypersensitivity; Antibody-Mediated Cytotoxic (Type II) Hypersensitivity; Immune Complex–Mediated (Type III) Hypersensitivity; Type IV or Delayed-Type Hypersensitivity (DTH).
6.	A**utoimmunity:** Organ-Specific Autoimmune Diseases; Systemic Autoimmune

	Diseases; Animal Models for Autoimmune Diseases; Evidence Implicating the CD4+ T Cell, MHC, and TCR in Autoimmunity; Proposed Mechanisms for Induction of Autoimmunity; Treatment of Autoimmune Diseases.
7.	**Immune Response to Infectious Diseases:** Viral Infections; Bacterial Infections; Protozoan Diseases; Diseases Caused by Parasitic Worms (Helminths); Emerging Infectious Diseases.
8.	**Cancer and the Immune System:** Cancer: Origin and Terminology; Malignant Transformation of Cells; Oncogenes and Cancer Induction; Tumors of the Immune System; Tumor Antigens; Immune Response to Tumors; Tumor Evasion of the Immune System; Cancer Immunotherapy.

Text Books:

1. Basic Immunology - Abul K Abbas, Andrew H Lichtman
2. Immunology - David Male, Jonathan Brostoff , David B Roth, Ivan Roit
3. Kuby Immunology – Owen, Punt, Stranford (7^{th} edition). W.H. Freeman and Company, New York 2013
4. Essential Immunology – Ivan M. Roit (5^{th} edition) Blackwell Scientific Publication. London 2002

Recommended References:

1. Cellular and Molecular Immunology – Abul K. Abbas, Andrew H. Lichtman.
2. Immuno Biology - Charles A, JanewayJr, Paul Travers, mark Walport, Mark J Shlomchik

Course: BGE-304	**Course title:** Molecular Biology-II		**Offered year:** 3^{rd}
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide the basic and advance concept of gene, gene expression and their regulation, mutation, molecular basis of mutagenesis, DNA repair mechanisms, genetic elements of disease and treatment in both prokaryotic and eukaryotic system.

Course Objectives:

- To provide the basic and advanced concepts of molecular biology
- To elucidate the process, regulation and expression of genes in prokaryotic and eukaryotic system.
- To explain the mechanisms of DNA modification and its consequence in living system.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the molecular mechanisms of gene expression in biological system
- Learn regulation of gene expression in prokaryotic and eukaryotic cells
- Know various topics of molecular biology such as mutation, molecular basis of mutagenesis, DNA repair mechanisms and recombination, transposable genetic elements, molecular biology of the telomere.
- Learn about the molecular machines of disease and treatment
- Gain knowledge of epigenetics and regulation of gene expression in heterologous system

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction: Concept of Gene and Gene Expression:** Flow of Information from DNA to RNA to Protein; Science of Omics and Its Scope; Differences in Gene Expression between Prokaryotes and Eukaryotes; Regulation of Gene Expression; Genes and Regulatory Elements; DNA-Binding Proteins.
2.	**Regulation of Gene Expression in Prokaryotes:** Principles of Gene Regulation; Gene Regulation in Bacterial Cells; Operon Structure; Lac Operon and Catabolite Repression; Trp Operon and Attenuation; RNA Molecules Control the Expression - Antisense RNA, Riboswitches and Ribozymes.
3.	**Organization of Eukaryotic Genome:** Genome Sequencing and Mapping; Composition of the Eukaryotic Genomes; Packing DNA; Unique Animal Chromosomes; Eukaryotic Genome Complexity; Genome Evolution.
4.	**Control of Gene Expression in Eukaryotes:** Regulation of Transcription and Gene Expression in Eukaryotes; *cis*-Acting Regulatory Regions; *trans*-Acting Proteins; Epigenetic Effects on Gene Expression; Transcriptional Regulation Systems; RNA Processing and Degradation; RNA Interference; Translational and Post-Translational Control Mechanisms.
5.	**Mutation:** Definition and Classification; Genotypic and Phenotypic Effects of Mutations; Mutation Rates and Frequency; Molecular mechanisms of Spontaneous and Induced Mutation; Detection of Mutations.
6.	**DNA Repair Mechanisms:** Sources and Types of Damage; DNA Repair Mechanisms - Direct Repair, Mismatch Repair, Excision Repair, Recombination Repair, Repair of Double-Strand Breaks, Translesion Synthesis and SOS Response; Genetic Disease and Faulty DNA Repair.
7.	**Transposable Elements:** Nature of Transposable Elements; Mechanism of Transposition; Mutagenic Effects of Transposition; Different Types of Transposable Elements in Bacteria and in Eukaryotes; Transposable Elements and

	Genome Evolution.
8.	**Molecular Biology of the Telomere and Telomerase:** Telomere Sequences and Telomerase; Shelterin Complex; Telomerases Synthesis; Molecular Mechanism of Telomerase Action; Impact of Telomere Dysfunction on Cancer and Aging.
9.	**Epigenetics:** Definition; Functional Coupling Among Writers, Erasers and Readers; Mechanisms of Epigenetic Inheritance Systems - DNA Modifications, Histone Code, Non-Coding RNAs (ncRNA), Non-Genic DNA and Prion-Based Epigenetic Inheritance; Techniques Used to Study Epigenetics; Epigenetics and the Environment; Clinical Applications.

Text Books:

1. Essential Cell Biology. Bruce Alberts, D. Bray, K. Hopkin, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, (2003). Second Ed. Garland Science.
2. Molecular Biology of Cell. Bruce Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, J. D. Watson, Fourth Ed. Garland Science, (2002).
3. Genes VI and VII. Benjamin and Lewin, Sixth Edition. Oxford University Press, (1997).
4. Lehninger Principle of Biochemistry, David L. Nelson, Michael M. Cox, 4th edition, W.H. Freeman, (2004).
5. Principles of Genetics Snustad, D.P. Simmons, M.J. and Jenkins, J.B., Jacaranda/Wiely pub. (1997).

Recommended References:

1. Molecular Biology of the Gene. Watson, J.D. and Hopkins, A.M., Roberts, J.W., Steitz, J.A. and Weiner, A.M., Benjamin/Cummings Scientific Publishing, Menlo Park, California, (1988).

Course: BGE-305	**Course title:** Fermentation and Bioprocess Technology		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour: 3**	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course is designed for understanding the variety of fermentation and subsequent processing approaches in order to manufacture the biological products and the design, operation and selection of these fermentation systems.

Course Objectives:

- To explain substrate preparation, control of fermentative process and isolation of products.
- To provide knowledge on required environmental condition for microorganisms to survive and also the chemical transformation they occur in order to produce biologically important products.
- To elucidate the application of microorganisms and enzymes in technological operation.

Intended Learning Outcomes (ILOs):

After completion of the course, the students will be able to-

- Be familiar with the industrial aspect of the field of Microbiology, and also learn about growth pattern of microbes in different industrial systems.
- Select a suitable fermentation system to produce valuable microbial products.
- Acquire knowledge of experimental procedure of microbial production of various industrial products such as enzymes, alcohol etc.
- Learn processes involved in the recovery and purification of the produced products
- Gain knowledge on the sterilization procedure of the both fermentation media and the fermenter.
- Get some ideas on the troubleshooting in the fermentation industries.

Teaching Strategy: Lecture, Projector display, Animation etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction to fermentation processes:** Definition, scope and importance of fermentation technology, range of fermentation processes, Chronological development of fermentation industry, Component parts of fermentation industry, Importance of bioprocess engineering in biotechnology, Overview of fermentation industry, Microbial Fermentation.
2.	**Configuration of bioreactor and ancillaries**: Control of pH, temperature, dissolved oxygen and other environmental parameters, Agitation, Mode of heat transfer and Heat exchange.
3.	**Fermenter design:** Introduction, Equipment and Space Requirements, General Design Data, Continuous Sterilizers, Fermenter Cooling, The Design of Large Fermenters (Based on Aeration), Trouble Shooting in a Fermentation Plant
4.	**Requirements of a fermentation process:** Fermentation media, Types of fermentation media, Effect of nutrient concentration on growth rate, Design and optimization of media by response surface methodology, oxygen requirements of microbial growth, mass transfer and determination of Kla, Factors affecting Kla.
5.	**Sterilization:** Thermal death kinetics of microorganisms, Batch and continuous heat, Sterilization of liquid media, Filter sterilization of liquid media, Air sterilization, Design of sterilization equipment.
6.	**Inocula preparation and development:** Criteria used for inocula preparation, different processes of preparation, bacterial and fungal inocula preparation and development.
7.	**Strain Improvement:** Necessity of strain improvement, Classical and recent strain improvement approaches, methods for identification of improved strains.
8.	**Kinetics of cell growth:** Unstructured kinetic models for microbial growth, Monod model, Product formation kinetics, Different modes of cultivation systems,

	Batch, Continuous and Fed batch, Introduction to structured models for growth and product formation.
9.	**Stoichiometry of cell growth and product formation:** Elemental balances, Degrees of reduction of substrate and biomass, Yield coefficients of biomass and product formation, Maintenance coefficients, Oxygen consumption and heat evolution in aerobic cultures.
10.	**Recovery and purification of fermentation products:** Methods of recovery and purification.

Text Books:

1. Fermentation and Biochemical Engineering Handbook, H. C. Vogel, C. C. Haber. 2nd Ed. Principles, Process Design and Equipment. Noyes Publications, New Jersey, U.S.
2. Biochemical Engineering Fundamentals, J. E. Bailey and D.F. Ollis, 2nd Edn., McGraw Hill Publishers, (1986).
3. Bioprocess Engineering-Basic Concepts, M. L. Shuler and F. Kargi, 2nd Edn., Prentice Hall, (2004).
4. Bioprocess Engineering Principles, P. M. Doran, 2nd Edition, Academic Press, (2005).
5. Principles of Fermentation Technology, P. F. Stanbury, S. J. Hall, and A. Whitaker, 2nd Edn., Elsevier, Science & Technology Books, (2005).
6. Biochemical Engineering, J. M. Lee, 1st Edn., Prentice Hall, (1991).
7. Principles, Process, Design and Equipment, Noyes Publications, New Jersey, USA
8. Fermentation and enzyme technology, Wang, D. et al (1979). John Wiley & Sons, New York, USA
9. Biotechnology: A Textbook of Industrial Microbiology, Crueger W. and Crueger A (1990), ed Thomas D. Brock sinaure Associates, Inc. Sunderland, MA.
10. Heat Transfer, Holman. J. P. (1992), 7th edition, McGraw-Hill Book Co. Singapore.
11. Unit Operations of Chemical Engineering, McCabe, W. L. Smith, J. C. and harriot, P. (1993), Fifth edition McGraw-Hill, Inc; Singapore.

Course: BGE-306	**Course title:** Developmental Biology		**Offered year:** 3rd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50

Rationale: The course is designed to offer basic and modern concepts of cellular growth, apoptosis, diversities of embryonic developmental stages, stem cell engineering, cellular reprogramming, and development of different parts of plant for welfare of human and nature.

Course Objectives:

- To provide basic concepts of embryology, cell fate and apoptosis.
- To explain early and later stages of embryonic development of *Drosophila*, *Xenopus* and mammals.
- To be familiar with stem cell engineering and cellular reprogramming technologies.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the basic concepts of cell fate and apoptosis.
- Learn various steps of early and later embryonic development of *Drosophila melanogaster.*
- Be familiar with early and later embryonic development of *Xenopus laevis.*
- Learn various steps of mammalian early and later embryonic development.
- Know stem cell engineering and cellular reprogramming techniques

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** Origin and history of development, Basic anatomical feature, Regulation of the program of development, Developmental decisions of cell/cell fate, Positional values, Genes controlling developmental processes, Programmed cell death/ Apoptosis
3.	**Development of *Drosophila melanogaster:*** Syncytium development, genes responsible for early development of *Drosophila*, role of egg- polarity genes, effect of mutations on gene, anterior/posterior patterning, *Hox* genes, signal pathway of wing disc, lateral inhibition, central nervous system.
4.	**Development of *Xenopus laevis:*** Asymmetries of *xenopus* egg, Formation of blastula, gastrulation, convergent extension, axis formation, central nervous system.
5.	**Mammalian development:** Formation of central nervous system, Development of Ectoderm: eye, epidermis, hair, neural crest cell, Development of Mesoderm: somites, muscle, bone, Kidney, Development of Endoderm: Heamatopoiesis.
6.	**Post-embryonic development:** Sex determination in *Drosophila* Sex determination in mammals, X-inactivation.
7.	**Specialized tissues, stem cells and tissue renewal:** Stem cell, Kinds of Stem Cell, Renewal of Epidermis, Blood, Stem Cell Engineering, IPS cell.

Recommended Text Books/ References:

1. Developmental biology. Scott F. Gilbert, Sinauer Associates Inc. USA, (2003).
2. Molecular Biology of the Gene (7th edition) by James D. Watson, Tania A. Baker, Stephen p. Bell,Alexander Gann, Michael Levine & Richard Losick. 2013. Publisher-Benjamin Cummings.
3. Molecular Biology of the Cell (5th edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roderts& Peter Walter.2007. Publisher-Garland Science.
4. Molecular Cell Biology (6th edition) by Harvey Lodish, Arnold Berk, Chris A. Kaiser & Monty Kreger. 2007. Publisher- W. H. Freeman

Course: BGE-307	**Course title:** Metabolism-II		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to develop student's knowledge and understanding of biochemical and molecular studies into metabolic pathways and processes occurring in living cells with a focus on human metabolism in health and disease.

Course Objectives:

- To explain the basic metabolic pathways of human.
- To provide knowledge of inborn errors of metabolism and the application of DNA technology to their study.
- To explain the control and integration of metabolism.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Know the principles of metabolism and the differences between anabolism and catabolism.
- Outline the metabolic pathways involving glucose, fatty acids and amino acids.
- Learn the various types of genetic mutation and inborn errors of metabolism.
- Describe the methods for detecting and correcting inborn errors of metabolism.
- Outline the hormonal regulation of metabolism and discuss the role of protein phosphorylation in this context.
- Learn the regulation of metabolism in physiological and pathological situations (e.g. exercise, starvation and diabetes).

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Amino acid metabolism:** Types of amino acids, deamination, urea cycle, amino acid biosynthetic precursors; the glutamate or ketoglutarate family; the aspartate and pyruvate families; the serine-glycine family; aromatic amino acids; regulation of amino acid biosynthesis.
2.	**Lipid metabolism:** Fatty acid oxidation and biosynthesis, role of cofactors in fatty acid biosynthesis; regulation of fatty acid metabolism; biosynthesis of triacylglecerol, phospholipid, mevalonate, squalene, cholesterol and wax.
3.	**Nucleotide metabolism:** Synthesis of purine and pyrimidine nucleotides, formation of deoxyribonucleotides, degradation of purines and recycle of purines pyrimidines, regulation of purine and pyrimidine biosynthesis.
4.	**Heterotrophic metabolism:** Hydrolysis of polymers-starch and cellulose hydrolysis; utilization of sugars-hexose and pentose utilization; organic acid utilization-fatty acid utilization; utilization of alcohols and ketones.
5.	**Bacterial fermentation:** Alcohol fermentation, lactate fermentation, mixed acici and butanediol fermentation, acetate fermentation, methane fermentation, fermentation of nitrogenous compounds.
6.	**Regulation of bacterial metabolism:** Regulation of enzyme synthesis by induction and repression; regulation of enzyme activity.
7.	**Chemolithotrophic and phototrophic metabolism:** Chemolithotrophic metabolism, assimilation of CO_2, phototrophic metabolism.
8.	**Fixation of molecular nitrogen:** Inorganic nitrogen metabolism; assimilation of inorganic nitrogen; fermentation of nitrogenous compounds; regulation of biological nitrogen fixation.

Text Books:

1. Microbial Physiology. A.G Moat, J.F Foster and Michael P. Specter. Fourth Edition. John Wiley & Sons Inc.
2. Bacterial Metabolism. G. Gottschalk. Second Edition. Springer. ISBN-13: 978-0387961538.
3. Bacterial Physiology and Metabolism. Byung H. Kim and Geoffrey M. Gadd. Cambridge University Press. ISBN-13 978-0-521-71230-9.
4. Lehninger Principles of Biochemistry (4th edition). Nelson and Cox. W. H. Freeman. ISBN-13: 978-0716743392.

Course: BGE-308	**Course Title:** Analytical methods in Biotechnology		**Offered year:** 3rd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50

Rationale: The course is designed to provide, the knowledge and understanding in learning the mathematical techniques useful in biotechnology. Concepts will always be explained in the simplest possible way and in the context of examples in general lab uses, many of which will be worked out in detail in the laboratory classes. The overall goal of this course is to give the students the analytical concepts to analyze and interpret biotechnological data correctly with confidence.

Course Objectives:

- To explain the basic principles of frequently used analytical tools in biotechnology.
- To provide in-depth knowledge on the isolation, quantification, kinetics and applications of nucleic acid.
- To demonstrate different types of PCR techniques and their principles, primer design, calculation for protein quantification and separation.

Intended learning outcomes (ILOs): At the end of the course the students should be able to demonstrate knowledge and understanding of:

- Different analytical techniques, their principle and instrumentation used in regular experimentation in biotechnology
- Optimize the separation methods; chromatography, spectroscopy, and quantitative and qualitative analysis in the area of bio-analysis
- The effect of the biological sample on analysis methodology
- Nucleic acid, their quantification, kinetics, blotting and separation procedures and their applications
- Different PCR techniques, template preparation, primer design and their amplification
- The principles of molecular methods in a design to sense, study or control a biological system
- Design of a quantitative molecular application used in biotechnology

Teaching methods:
Lecture, Multimedia display, Animation, Handouts, field visit, Seminar etc.

Assessment methods:
Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva
Final exams: Structured questions

Course Contents	
1.	**Spectroscopic techniques:** Spectrum, visible, ultraviolet and infrared spectrophotometers, spectrofluorimetry, luminometry, NMR, mass spectrometry.
2.	**Chromatographic techniques:** Principle of chromatography, column, thin-layer and paper chromatography, adsorption, gas-liquid, ion exchange, exclusion, affinity and high performance liquid chromatography.
3.	**Centrifugation:** Principle of sedimentation, centrifuges and their use, density gradient centrifugation and ultracentrifuge. RPM and RCF, Sedimentation time calculation.
4.	**Nucleic acid quantification and labeling:** Quantification of nucleic acids by UV-Spectroscopy, Molecular weight Molarity and Nucleic acid length, Labeling nucleic

	acids with Radioisotopes, Oligonucleotide synthesis. Physico-chemical properties of DNA such as T_m value, Cot value, different conformations of DNA hybridization kinetics, DNA-DNA & DNA-RNA hybridization, DNA and RNA isolation and purification, quantification; fractionation of RNA; electrophoresis southern and Northern blot, DNA sequencing
5.	**PCR:** Template and Exponential amplifications, Primer Tm, DNA polymerese, Quantitative PCR, Real-Time PCR. Applications of Real-Time PCR in disease diagnostics. Add some Non-PCR Techniques
6.	**Recombinant DNA:** Restriction endonuclease, Calculation of the amount of fragment ends, ligation, genomic libraries, expression libraries, Sizing DNA fragments and discrimination, DNA typing, Multiplication rules, Paternity index.
7.	**Protein:** Calculation of proteins molecular weight, Protein measurement by colorimeter, Protein quantification using different spectrum, labeling of proteins, TLC and Rf value, DNA polymerese activity, Isoelectric point of protein.
8.	**Forensics and paternity:** Alleles and genotypes, The Hardy–Weinberg Equation and Calculating Expected Genotype Frequencies, the chi-squre test, the power of inclusions, Forensics and paternity test using molecular tools. Add: Electrophoresis

Text Books:

1. Frank H Stephenson (2016). Calculations for molecular biology and biotechnology. Academic Press.
2. Friedrich Lottspeich, Joachim W. Engels (2018). Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH

Recommended reading:

1. Molecular Genetics of Bacteria: Dale and Park. John Wiley & Sons Ltd,
2. Analytical Techniques in Biochemistry and Molecular Biology, Katoch, Rajan. Springer. Germany
3. Analytical Techniques In Agriculture, Biotechnology And Environmental Engineering, Ahindra Nag. Prentice-Hall. India

Course: BGE-309	**Course title:** Biosafety, Ethics and Regulations in Bangladesh		**Offered year: 3rd**
Minimum course hour: 28 h	**Credit hour:** 2	**Final exam duration:** 2.5h	**Total marks:** 50
Rationale: This course is designed to provide an understanding on biosafety, regulation, risk assessment and biosecurity practices relevant to the bio industries and field of research. This course also provides analysis on ethical aspects related to biological, biomedical, health care and biotechnology research.			

Course Objectives:

- To provide basic knowledge of biosafety, biosecurity and regulations in biotechnology.
- To analyze ethical aspects related to biological, biomedical, health care and biotechnology research.
- To adopt safe handling and working practices relevant to the bio industries and field of research.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Acquire adequate knowledge in the use of genetically modified organisms and its effect on human health.
- Understand the current trends in biosafety and national and international regulations in biotechnology.
- Learn risk analysis methods of new products derived from recombinant DNA technology.
- Know national and international regulations of genetically modified organisms.
- Gain knowledge about transboundary movement of GMOs.
- Perceive knowledge about different biosafety protocols.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction:** Concepts of biosafety and ethical issues, Biosafety guidelines of Bangladesh.
2.	**Hazard analysis:** **a. Risk for animal health:** Toxicity and food quality/safety, allergies; Pathogen drug resistance (antibiotic resistance).
	b. Risk for agriculture: weeds or super weeds, alteration of nutritional value (attractiveness of the organism to the pests), reduction of cultivars (increase of susceptibility), Genetic pollution through pollen or seed disposal, horizontal gene transfer (transgene or promoter dispersion) and loss of biodiversity.
	c. Risk for the environment: Persistency of gene or transgene or transgene products, resistance/tolerance of target organism or susceptibility of non-target organisms, increased use of chemicals in agriculture, unpredictable gene expression or transgene instability.

3.	**Bioethics and Legal Issues:** Ethical issues; Public perception related to Biotechnology from developed and developing countries. Legal and socio-economic impacts of biotechnology, public awareness on genetically modified life forms (case study). Ethical implication of biotechnological products and technique. Social and ethical implication of biological weapons, Intellectual Property, Types of IP: Patents, Trademarks, Copyright & Related Rights,
4.	**Biosecurity:** Biosafety andbiosecurity in lab, different Biosafety levels.Physical security, Personnel security, Transport security, Information security, biological terrorism.
5.	**Regulations:** Cartagena Protocol, Biosafety regulations to protect nature, growers and consumers interest and national interest, International agreements and guidelines, trans boundary movements.

Text Books:

1. The Ecological Risks of Engineered Crops, Rissler, J. and Mellon, M., Cambridge, USA: The MIT Press, (1996).
2. Genetic Engineering in Agriculture and the Environment: Assessing risk and benefits, Maurizio G. Paoletti and David Pimentel, http:\\www.ag.auburn.edu/biotech/genetic.html.

Recommended References:

1. Biosafety guidelines of Bangladesh. Ministry of Environment and Forest, Government of the People's Republic of Bangladesh.
2. Laboratory biosafety manual (Third edition, 2004) By World Health Organization.
3. Eigner WW 1994. Just Technology? CACL, York Univ. Ontario
4. Moe-Wan Ho 1997. Genetic Engineering – Dreams or Nighmares? RFSTE/TWN, New Delhi
5. Melchias G 2000. Biodiversity and Conservation. Science Publ. Inc. New Hampshire, USA.
6. Mulongoy KJ 1997. Transboundary Movement of Living Modified Organisms, Int. Acad. Envir. Geneva.
7. Pistorius R 1997. Scientist. Planta and Politics. IPGRI, Rome.
8. TWN 1996. Biosafety – Scientific Findings and Elements of a Protocol, Malaysia.

Course: BGE-310	**Course title:** Bioinformatics		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course aims to guide students in the use of bioinformatics applications available for the use of the information derived from the study of genomics and proteomics to generate knowledge and make discoveries based on informed

interpretation.

Course Objectives:

- To explain the application areas of bioinformatics
- To provide different types of data and the processes of collect, store, organize, manage, distribute and retrieve genomic data (DNA/RNA and protein sequences)
- To develop basic knowledge of different approaches to sequence alignment, BLAST tools, phylogenetic tree analysis and structure determination of promoter, protein and RNA.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Know the difference between databases, tools, repositories and be able to use each one to extract specific information
- Learn alignment of DNA and protein sequences following proper process
- Understand the differences between homologues, paralogues and orthologues
- Gain the knowledge of predicting of RNA secondary structure
- Explain the effect of changing parameters such as scoring matrices, gap penalties etc.
- Gain in-depth concepts of evolutionary trees and various methods of phylogenetic analysis
- Learn to predict gene and protein structure

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction and overview:** Definition, goal, history and scope of Bioinformatics, Major areas of applications and limitations.
2.	**Databases:** Definition, types of databases, Major databases, pitfalls of biological databases, sequence retrieval from biological database, global bioinformatics centers and servers.
3.	**Alignment of DNA and protein sequences:** Pairwise sequence alignment, sequence similarity versus sequence identity, alignment methods, scoring matrices, statistical significance of sequence alignment, database similarity searching, exhaustive algorithms, heuristic algorithms, Dynamic Programming, Basic Local Alignment Search Tool (BLAST), FASTA, Multiple Sequence Alignment, ClustalW/ ClustalX, position-specific scoring matrices, profiles, markov model and hidden markov models.
4.	**Prediction of RNA secondary structure:** Basics, features of RNA secondary structure, limitations of prediction, various prediction methods: minimum free energy method, suboptimal structure prediction by MFOLD, using sequence co-

	variation to predict structure, stochastic context-free grammars for modeling RNA secondary structure, searching genomes for RNA splicing genes, applications of RNA structure modeling.
5.	**Phylogenetic prediction:** Relationship of phylogenetic analysis to alignments, the concepts of evolutionary trees, various methods: Maximum parsimony method, Distance methods, the maximum likelihood approach, sequence alignment based on evolutionary model, reliability of phylogenetic predictions, complications from phylogenetic analysis.
6.	**Gene prediction:** microbial genomes, eukaryotes, evaluation of prediction, promoter prediction in pro- and eukaryotes, categories of gene prediction programs, prediction algorithms.
7.	**Protein structure prediction:** Protein structure basics, amino acids, peptide formation, dihedral angles, hierarchy, secondary structures, tertiary structures, review of terminology, methods: viewing protein structures, protein structure classification databases, alignment of protein structures, structural prediction: secondary structure prediction of globular, transmembrane, coiled coil proteins, protein tertiary structure prediction, methods, homology modeling, threading and fold recognition, *Ab initio* protein structural prediction, CASP evaluation, structural modeling, future prospects. Scanning or searching for patterns, motifs, profiles, domains and families, finding post-translational modifications, designing proteins.

Text Books:

1. Bioinformatics: Sequence and Genome Analysis. David W. Mount. Cold Spring Harbor Laboratory Press.
2. Essential Bioinformatics. JinXiong. Cambridge University Press, (2006)
3. Introduction to Bioinformatics. Arthur M. Lesk. Oxford University Press, (2002)
4. Bioinformatics: From Genomes to Drugs. Edited by Thomas Lengauer. Wiley-VCH. (2002).
5. Lecture Notes on Biological Sequence Analysis. Martin Tompa. (2000)
6. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis. 2nd Edition. Wiley Interscience. (2002)

Recommended References:

1. Bioinformatics Computing. Bryan Bergeron. Prentice Hall PTR. (2002)
2. Blast. Joseph Bedell. Ian Korf, Mark Yandell. O'reilly. (2003)
3. Developing Bioinformatics Computer Skills. Cynthia Gibas, Per Jambeck. O'reilly. (2001)
4. Discovering Genomics, Proteomics, and Bioinformatics. Campbell andHeyer (2003) Pearson Education, ISBN: 0-8053-4722-4
5. Bioinformatics, Methods of Biochemical Analysis Series Vol. 43, Baxevanisand Ouellette (2001) John Wiley and Sons, ISBN 0-471-38391-0.

<table>
<tr><td colspan="2">Course: BGE-311</td><td colspan="2">Course title: Virology</td><td>Offered year: 3rd</td></tr>
<tr><td>Minimum course hour:
42h</td><td>Credit hour:
3</td><td colspan="2">Final exam duration:
3h</td><td>Total marks:
75</td></tr>
<tr><td colspan="5">Rationale: The course is designed to provide basic knowledge on viruses. It will emphasize on host-virus interactions, host defense strategies against viral infection in viral diseases. Students will be introduced theoretically with relationship between virus and cancer and how cancer and viral cells survive in human body escaping immune system.</td></tr>
<tr><td colspan="5">Course Objectives:
• To demonstrate an understanding of basic virology principles.
• To emphasize on host-virus interactions, host defense strategies against viral infection.
• To explain viral mechanism of pathogenicity and treatments of viral diseases.</td></tr>
<tr><td colspan="5">Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-
• Explicate major groups of viruses, their structure and interaction with the host.
• Elucidate viral diseases and the host defense strategies against viral infection.
• Discuss the concepts of oncogenes and tumor suppressor genes.
• Learn the vaccination and therapeutic approaches against viral diseases.
• Gather detailed knowledge on viruses-promise and problems</td></tr>
<tr><td colspan="5">Teaching Strategy: Lecture, Projector display, Animation, etc.</td></tr>
<tr><td colspan="5">Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A</td></tr>
<tr><td colspan="5">Course Content</td></tr>
<tr><td>1.</td><td colspan="4">Introduction: Virus structure and morphology, Major groups of viruses (Bacterial, plant and animal viruses with their nomenclature and classification).Structure of discovery of viral receptors (polio, herpes, VSV, HIV), Kinetics of receptor binding.</td></tr>
<tr><td>2.</td><td colspan="4">Virus-host interaction: Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms. Nuclear localization signals andnuclear pore transit, virus–cytoskeletal interactions, transport of viral proteins. Host cell ‘shut off’, apoptosis, necrosis, stress response, alteration of signaling pathways, cellular basis of transformation, types of cenotaphic effects, ultrastructural cytopathology. Cellular injury associated markers, mechanism of viral persistence and latency—in vivo and in vitro models (JE, measles, LCM and HIV).</td></tr>
</table>

3.	**Host defense strategies against viral infection:** Anti-viral agents: **Natural:** Induction of interferon synthesis and development of antiviral state by interferon, molecular basis of interferon action, viral interference not mediated by interferon; **Artificial:** Immunization with vaccines and use of chemotherapeutic agents.
4.	**Viral diseases:** Diagnosis and therapeutic intervention of Viral diseases (Enteric Diseases, Viral Hepatitis, Viral Respiratory Diseases, Viral Haemorrhagic Fevers, Viral Encephalitis, HIV / AIDS), SWAN/Bird Flu, NIPA.
5.	**Prevention and treatment of viral infection:** Vaccination strategy; chemotherapy of viral diseases; interferon-its induction and action.
6.	**Viruses-promise and problems:** Cloud of horizon-emerging disease; source and caused of emergent virus diseases; silver linings-virus as therapeutic agent; viruses for gene delivery.

Text Books:

1. Principles of Virology, S. Jane Flint
2. Virology Methods Manual, Hillar O Kangro
3. Fundamentals of Virology, Bernard N. Fields, David M
4. Virology, Molecular Biology and Pathogenesis, Leonard C. Norkin
5. Introduction to Modern Virology, N. J. Dimmock
6. Basic Virology, Edward K. Wagner & Martinez J. Hewlett
7. The Biology of Cancer, Robert A. Weinberg (2nd Edition)
8. The Molecular Biology of Cancer, Pelengaris S, Khan M
9. Cancer Medicine, Holland
10. Cancer Biology, Raymond W. Ruddon
11. Cancer Biology, Roger John Benjamin King

Recommended References:

1. Biology of Microorganisms. Brock, T.D.
2. Review of medical microbiology. Jawetz, E. J. *et al.*

Course: BGE-312	**Course Title:** Research Methodology		**Offered year:** 3rd
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course is aimed to understand students to grasp about the research, how it is conducted and its importance in academic endeavor. The focus will be on assisting students in developing practical research skills and strategies to enhance academic and professional success. Major emphasis will be on helping students understand the basic concepts of research and research methodology as well as the different research paradigms and their implications for doing research.

Course Objectives:

- Guide students towards achieving competence and proficiency in the theory and practice to research
- Develop skills required in writing research proposals, research article, research reports, and dissertation
- Develop the ability to effectively prepare a research proposal
- To explain about research designs and methodology.

Intended learning outcomes (ILOs): At the end of the course the students should be able to demonstrate knowledge and understanding of:

- Understand research concepts and process
- The capacity for scholarly analysis and synthesis
- The capacity to review and assess new and complex phenomena, issues and situations autonomously and critically
- Draw on the literature in the field, analyze and interpret research evidence published on a topic to establish a suitable research problem/issue or opportunity to explore further.
- Identification of a suitable research problem/issue or opportunity, design the research study using a suitable paradigm, associated methodologies and methods of data collection and analysis.

Teaching methods:

Lecture, Multimedia display, Animation, Handouts, field visit, Seminar etc.

Assessment methods:

Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva

Final exams: Structured questions

Course Contents	
1.	**Overview of research process:** Meaning of research; Types of Research; Steps in research; Identification; Selection and formulation of research problem; Research design; Formulation of Hypothesis. Literature survey: Review of literature, review process and bibliography, Research Objectives and hypothesis, Data collection and analysis plan, Research budget and resources.
2.	**Scientific writing:** Scientific document: Organization and writing of a research paper, short communications, review articles, monographs, technical and survey reports, authored books and edited books, and dissertation. Research ethics: legal issues, copyright, plagiarism.
3.	**Experimental design:** research purpose selection, hypothesis development, target population selection, research methodology development, assessment of the intervention conditions, variable selection, random assignment and manipulation, data recording and analysis tools selection.
4.	**Research ethics:** Fundamentals of bioethics, ethical issues in conducting research, conflict of interest and publishing biases, ethical design of research, animals in research.

5.	**Research and development of projects in biotechnology:** • Funding agencies: National and international funding agencies for R & D projects, • Preparation of R & D projects for funding: Organization of a research project, identification of gap areas in the subject, aims and objectives of the projects, possible outcome of the project, funds requirements and justification(s), • Patents and patents writing: Parts of Patent applications characteristics of the disclosure for a biotechnology invention, marketing of biotechnological invention.

Text Books:

1. Sing, A.K.: Measurements and Research Methods In Behavioral Sciences.
2. Information Resources and Technology Transfer Management in Developing Countries By Richard Onyango (2020). ISBN 9780815355052.
3. Technology Transfer in a Global Economy. Editors: Audretsch, D.B., Lehmann, E.E., Link, A.N., Starnecker, A. (Eds.). Springer
4. Research Methodology: A Guide for Researchers In Agricultural Science, Social Science and Other Related Fields. Authors: Sahu, Pradip Kumar. Springer

Recommended references:

1. BARI/BARC (1990). Resource Manual of Research Planning and Evaluation Training course, BARI,Joydebpur, Gazipur-1701.
2. Kotari, C. R. (1990). Research Methodology: Methods and Techniques. Wiley Eastern Ltd., India.
3. Singh, A. K. (1993). Tests, Measurements and Research Methods in Behavioral Sciences. Tata McGraw-Hill Pub. Co. New Delhi, India.

Course: BGE-313	**Course title:** Immunology Practical		**Offered year:** 3rd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: The Immunology practical course is designed to provide a foundation on the basic concepts and hands on training of various immunological techniques and assays.

Course Objectives:

- To provide basic concepts and hands on training of various immunological techniques
- To explain various immune assay techniques such as agglutination, immunoprecipitation, immunofluorescence, radioimmunoassay, and enzyme-linked assay.
- To elucidate the methods of isolation of pure antibodies and Lymphocytes.

Intended Learning Outcomes (ILOs): At the end of the course students will be able to-

- Understand antigen antibody interaction and precipitation reaction in gel.
- Explain the procedure of hemagglutination and complement fixation test.
- Perform various assay techniques such as Radioimmunoassay, Enzyme-linked Immunosorbent assay and Effectors' Cell Assay.
- Isolate pure antibodies and Lymphocyte population.
- Identify cancer cells in different stages.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Assignment, Lab report, Viva
Final exams: Q/A, Performing experiments in the Lab, Writing Report

Course Content

1.	Immunological Techniques: Precipitation reactions; Immunodiffusion, Immuno-electrophoresis, Agglutination, co-agglutination and haemagglutination; Complement fixation; Direct and indirect immunofluorescence; Immunoassay; Immunoblotting; Immunoprecipitation; Fluorescence activated cell sorter (FACS); radioimmune assay (RIA), enzyme linked immunosorbent assay (ELISA); immunofluorescence.
2.	Antigens, Antibodies and Immunoglobulin.
3.	Histological observations of cancer cells in different stages.

Text Books:

1. Kuby Immunology. Owen, Punt, Stranford; (7th Edition) W. H. Freeman and Company, New York 2013.
2. Immunology. Ivan Roitt, Jonathan Brostoff, and David Male; (6th Edition) Mosby-Elsevier Science Ltd, London, 2002.
3. Essential Immunology. I. M. Roitt (5th edition) Blackwell Scientific Publication. London 2002.

Recommended References:

1. Bendelac, A., M. N. Rivera, S-H. Park, and J. H. Roark. Mouse CD1-specific NK1 T cells: Development, specificity and function.*Annu. Rev. Immunol.* **15:**535, (1997).

Course: BGE-314	**Course title:** Molecular Biology Practical		**Offered year:** 3rd
Minimum course hour: 28	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** **50**
Rationale: This is a laboratory course designed to provide basic practical knowledge in molecular biology techniques which will help the students to enhance their confidence			

and research skills.

Course Objectives:

- To provide basic practical knowledge in molecular biology techniques such as identification, isolation, analysis of DNA, RNA and protein.
- To explain visualization techniques of isolated DNA, RNA and protein by agaroge and polyacrylamide gel electrophoresis.
- To provide hands on training for the isolation of PCR product from gel and PCR amplification process.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Carry out the experiments of molecular biology and interpret the results.
- Design a strategy to circumvent potential experiments.
- Gain basic practical knowledge for the identification, isolation, analysis of DNA, RNA and protein.
- Apply agaroge and polyacrylamide gel electrophoresis techniques for the visualization of isolated DNA, RNA and protein.
- Learn various PCR amplification process.

Teaching Strategy :PPT Lecture, Lab Experiment, etc.

Assessment Strategy:
Tutorials:Q/A, Quiz, MCQ, Assignment, Presentation
Final exams: Q/A, Short Question, MCQ, Lab Report, Viva, etc.

Course Content

1.	Isolation of genetic material (plasmid and genomic DNA)
2.	DNA quantification using spectrophotometer
3.	Restriction digestion of plasmid DNA
4.	Observation of DNA by Agarose gel electrophoresis
5.	PCR amplification
6.	Isolation of PCR product DNA from gel
7.	Competent cell preparation
8.	Polyacrylamide gel electrophoresis

Recommended text book and references:

1. A Biologist's Guide to Principles and Techniques of Lab. Biochemistry, 3rd edition: K. Wilson and K. H. Goulding.
2. Lab. Skills in Biomolecular Sciences: Rob Reed, David Holmes, Jonathan.
3. DNA and Biotechnology. Molly Fitzgerald-Hayes and Frieda Reichsman**.**Academic Press, UK. 2009.
4. Basic Biotechnology. Bullock, J. &Uritiansen, B. Academic Press, UK. 1995.

Course: BGE-315	**Course title:** Bioinformatics Practical	**Offered year:** 3rd

Minimum course hour: 28	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: This course is intended to be familiar with vast amounts of biomedical and genomic data and tools of bioinformatics. It also Introduce students to the current bioinformatics algorithms, concepts and their implementations in life.

Course Objectives:

- To introduce students to databases, bioinformatics tools, software, and analysis methods.
- To be familiar with vast amounts of biomedical and genomic data and tools of bioinformatics.
- To provide sequence alignment methods, phylogenetic tree development method.

Intended Learning Outcomes (ILOs):

After completion of the course, the students will be able to-

- To be familiar with vast amounts of biomedical and genomic data and tools of bioinformatics.
- Design and evaluate research methodology in basic bioinformatics
- Analyze and interpret data, and assemble and evaluate information in advanced bioinformatics
- Construct and evaluate estimates of phylogenetic relationships
- Create new ideas and methods in advanced bioinformatics

Teaching Strategy: PPT Lecture, Projector display, Hands-on experiment, Problem Solving, etc.

Assessment Strategy:

Tutorials:Q/A, Quiz, MCQ, Assignment, Presentation

Final exams: Q/A, Short Question, MCQ, Lab Report, Viva, etc.

	Course Content
1.	Analyzing Protein, DNA and RNA sequences
2.	Sequence alignment
3	Use of Gene Bank
4.	Using Protein and specialized sequence databases
5.	Working with single DNA sequence
6.	Working with single protein sequences
7.	Working with protein 3D structures
8.	Working with RNA structures
9.	Building phylogenetic trees

Text Books:

1. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis. 2nd Edition. Wiley Interscience. (2002)

2. Bioinformatics: Sequence and Genome Analysis. David W. Mount. Cold Spring Harbor Laboratory Press.

Recommended References:

1. Bioinformatics Computing. Bryan Bergeron. Prentice Hall PTR. (2002)
2. Bioinformatics: A Lab. Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis and B. F. Francis Ouellette (2004). 3rd Edition. Wiley and Sons, ISBN: 0-471-47878-4

Course: BGE 316	**Course Title:** Plant Tissue Culture Practical		**Offered year:** 3rd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: Plant tissue culture is the science of growing plant cells, tissues or organs isolated from the mother plant, on artificial media. The purpose of this course is to give students a practical experience in techniques in plant tissue culture and crop development. Students will get hands on training of media preparation, sterilization, explants selection, micro propagation, callus culture, protoplast fusion etc.

Course Objectives:

- To provide hands on training of basic tissue culture concepts such as media preparation, sterilization, explants selection, maintenance of aseptic condition etc.
- To give a clear knowledge on micropropagation of different plant parts like protoplast, somatic embryo, ovule, pollen, and anther etc. for the production of important commercial variety.
- To explain the techniques of cryopreservation and artificial seeds production

Intended learning outcomes (ILOs): At the end of the course the students should be able to-

- Understand the importance of sterile techniques
- Prepare culture medium from reagent grade chemicals and stock solutions, routinely transfer cultures without contamination.
- Sterilize instruments, lab wares, culture media and explants
- Design and prepare various culture media, stock solutions of inorganic salts, growth regulators
- Identify appropriate explant and learn inoculation techniques into suitable culture media under sterile condition.
- Determination of appropriate stages of anther and pollen useful for anther/pollen culture

Teaching methods:

Lecture, multimedia display, animation, hands on training, field visit etc.

Assessment methods:
Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva
Final exams: Demonstration, experiment

Course Contents	
1.	Sterilization of plant materials.
2.	Medium preparation.
3.	Establishment of callus culture from different plant explants.
4.	Establishment of shoot culture through efficient regeneration.
5.	Establishment of cell culture.
6.	Inducing adventitious shoot and roots.
7.	Somatic embryogenesis and plant regeneration.
8.	Acclimatization and hardening of in vitro grown shoots.

Text Books:

1. Bhojwani, S. S. (1990). Plant Tissue Culture. Oxford, NY. Gamborg, O. L. and G. C. Phillips (1996).
2. Plant Cell, Tissue and Organ Culture: Fundamental Methods. Narosa Publishing House, New Delhi, India.
3. Razdan, M. K. (1994). An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi. India.

Recommended reading:

1. Reinert, J and Y. P. S. Bajaj (1995). Plant Tissue and Organ Culture: Applied and fundamental aspects. Narosa publishing House, New Delhi, India.
2. Vasil, I. K. and T. A. Throp (1994). Plant Cell and Tissue Culture. Kluwer Academic publishers. London. U.K.

Course: BGE-317	**Course title:** Fermentation Technology Practical		**Offered year:** 3rd
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: The course will provide the practical knowledge of fermentation processes and kinetics. To make students acquainted with principles of using of microorganisms in fermentation process.

Course Objectives:

- To familiar with the various types of microorganisms involved in fermentation, control environmental condition requires to survive the microorganisms along with the product formation.
- To explain various fermentation areas through hands on training.
- To provide experience of the most common fermentation techniques in labs and demonstrations of more advanced or uncommon techniques.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Recognize the fundamentals of fermentation technology.
- Measure bacterial growth and construct growth curve of bacteria.
- Experience real world of fermentation production systems and control mechanisms.
- Choose a proper fermentation system to produce valuable compounds.
- Control of flow rates, pH and pressure in a bioprocess.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Field visit, Experiment in lab, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A, Assignment, MCQ, Presentation, Viva, Lab report, lab work, case study, performance, etc.

	Course Content
1.	Construction of growth curve of bacteria – estimation of biomass, calculation of specific growth rate, yield coefficient, utilization and product formation kinetics in shake flask culture.
2.	Control of pH and temperature in a bioprocess.
3.	Control of flow rates and pressure in a bioprocess.
4.	Determination of volumetric oxygen transfer co-efficient (Kla) in a fermentor by static gassing out and sulphite oxidation methods.
5.	Determination of Residence Time Distribution (RTD) of CSTR.
6.	Determination of mixing time in stirred tank reactor with Newtonian and Non-Newtonian fluids.
7.	Determination of thermal death kinetics.
8.	Fermentation process of some biomolecules using SMF and SSF.
9.	Measurement of ethanol production in a fermentor.

Recommended Text book and References:

1. Fermentation and Biochemical Engineering Handbook, H. C. Vogel, C. C. Haber. 2nd Ed. Principles, Process Design and Equipment. Noyes Publications, New Jersey, U.S.
2. Biochemical Engineering Fundamentals, J. E. Bailey and D.F. Ollis, 2nd Edn., McGraw Hill Publishers, (1986).
3. Bioprocess Engineering-Basic Concepts, M. L. Shuler and F. Kargi, 2nd Edn., Prentice Hall, (2004).
4. Bioprocess Engineering Principles, P. M. Doran, 2nd Edition, Academic Press, (2005).
5. Principles of Fermentation Technology, P. F. Stanbury, S. J. Hall, and A. Whitaker, 2nd Edn., Elsevier, Science & Technology Books, (2005).
6. Biochemical Engineering, J. M. Lee, 1st Edn., Prentice Hall, (1991).
7. Principles, Process, Design and Equipment, Noyes Publications, New Jersey, USA

Part –IV (4th Year, Examination of 2021, 2022 and 2023)

Course: BGE-401	**Course title:** Genomics and Proteomics		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course aims to introduce students with the techniques used in genomics and proteomics, their analysis and application.

Course Objectives:

- To discuss the theory and practice of computational methods used in the field of genomics, proteomics
- To explain the test procedures of scientific hypotheses on structure-function of biological molecules and systems
- To interpreted results of various experimental data using computational analysis and modeling

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Learn the fundamental knowledge of genome, transcriptome, proteome and metabolome.
- Gain the knowledge of omics technologies, with emphasis on advanced genomics and proteomics technologies
- Synthesize information to discuss the key technological developments that enabled modern genomic and proteomic studies
- Know the different types of genome variation and their relationship to human diseases.
- Learn how biological systems information relating to genes, proteins and cellular structures can be used to model living cells, and even to create new synthetic cells.

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** The definition and principle: "omes" genome, transcriptome, proteome, metabolome; Omics; Organization, structure and mapping of genomes.
2.	**Genome sequences analysis:** Definition of gene, genomes, and genomics, brief introduction of genetic mapping, features of human genome sequence, evolution of genomes, genomic identifications, genomic variations. Sequence methods and strategies: Automated sequencing, large-scale genome sequencing and analysis, NextGen sequencing, Sequencing and individual variation, examples; assembly and finishing methods, comparative genome analysis

3	**Genome expression:** DNA microarray: Principle, basic clustering algorithms, normalization, applications of microarray (identification of complex genetic diseases: drug discovery, mutation, polymorphism detection, and so on); Introduction to gene networks and epigenetic analysis (i.e., DNA methylation); Next-generation Multiplex Assay Technology for genomics. Hybridization principles. Array platforms, Transcript arrays, RNA versus DNA, In-depth analysis of gene expression; *in vivo* technologies for assessing gene expression, analysis/visualization, and issues with imaging. Forward and reverse genetic approaches for studying gene function.
4.	**Genomic circuits in single genes:** Genomes controlling individual genes, how gene controls location, timing, and transcriptome, integrating single gene circuits. Simple integrated circuits, complex integrated circuits, modeling whole-genome circuits.
5.	**Overview of proteomics:** Introduction, methods used in proteome analyses.
6.	**Protein sequencing:** Protein sequencing by Edman degradation and protein sequence analyses.
7.	**Electrophoresis in proteomics:** Isoelectric focusing, Spot identification, 2D Gel Electrophoresis, drawbacks, and limitations; 2D gel data analysis, SDS-polyacrylamide gel electrophoresis, Differential in-gel electrophoresis (DIGE), Applications of 2D-PAGE.
8.	**Mass spectrometry and proteomics:** Characterization and identification of proteome using mass spectrometry, MALDI (Matrix-assisted Laser Desorption/Ionization), nESI (nano-electrospray ionization), MALDI-TOF (time of flight), Mass Spectroscopy, Tandem mass spectrometry (MS/MS), Surface-enhanced laser desorption ionization (SELDI).
9.	**Application of proteomics:** Protein Arrays: Types of protein Arrays, Data analysis, Applications of protein microarrays; Organelle and cellular proteomics; Protein and Enzyme Assays; Next-generation multiplex Assay Technology for Proteins. Immunoassay principles. Antibody validation, Particle and bead assays, Biosensors, Plasmon Resonance, Flow Cytometry.

Text Books:

1. Discovering Genomics, Proteomics and Bioinformatics, A. Malcolm Campbell, Laurie J Heir. Pearson Education, 2nd ED, (2007).
2. Data mining for genomics and proteomics, Darius M Dziuda, Wiley and Sons Inc, (2010).
3. Plant genomics and proteomics, Christopher A. Cullis. Wiley and Sons Inc. (2004).
4. Genome Transcriptome and proteome Analysis, Alain Bernot, Wiley and Sons Inc. (2004).

Course: BGE-402	**Course title:** Medical and Pharmaceutical Biotechnology	**Offered year:** 4th

Minimum course hour: 42h	Credit hour: 3	Final exam duration: 3h	Total marks: 75

Rationale: This advanced course is designed to introduce pharmaceuticals and biopharmaceuticals products and to cover the recent advancements in medical and pharmaceutical biotechnology. This course will help the graduates to find employment in a range of areas including the pharmaceutical, biomedical industries, biotechnology companies, research institutes, hospitals and universities.

Course Objectives:

- To familiarize with fundamental process and practices in pharmaceutical industries.
- To provide updated knowledge of medical applications e.g. therapies of prominent diseases.
- To instruct the knowledge of biopharmaceutical products, drug development and discovery process.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Learn about general procedure and practices needed for pharmaceutical setup.
- Know the recent advances related to pharmacodynamics and pharmacokinetics, pharmacogenetics and pharmacogenomics.
- Understand the gene therapy and synthetic therapy issues of medical and biotechnological research and innovations.
- Know the modern improvements in medical and pharmaceutical biotechnology.
- Learn advanced drug delivery and drug development mechanisms.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction to medical and pharmaceutical biotechnology:** Biotechnology, Medical and Pharmaceutical Biotechnology, Historical perspective of pharmaceutical biotechnology, Traditional pharmaceuticals of biological origin: Pharmaceuticals of Animal, Plant and Microbial origin- brief study and therapeutic uses, Introduction to drug dosage forms.
2.	**Sources of biopharmaceuticals**: Bacteria, yeasts, animal cells, transgenic animals, transgenic plants, Insect-cell based systems, production of final product and analysis of biopharmaceuticals.
3.	**Therapeutics based on biotechnology:** Brief study, production and purification, applications of Hormones, Enzymes, Antibiotics, Antibodies, Blood products- Cytokines- Interferons, Interleukins I and II, Tumor Necrosis Factor (TNF), Nucleic acid therapies.
4.	**Vaccine Production:** Introduction, Classification of vaccines, Cultivation of

	virus, Amplification, Harvesting and Assay techniques. Adjuvant technology.
5.	**Pharmacodynamics and pharmacokinetics:** Dose-effect relationships, drug receptor theory, mechanism of drug action. Principles of Pharmacokinetics: Biological half-life, Renal clearance, Absorption, Distribution of drugs, Biotransformation and bioavailability of drugs.
6.	**Pharmacogenetics and pharmacogenomics:** Historical perspective Metabolism and transport, Therapeutic response.
7.	**Drug development and discovery:** Drug discovery, impact of genomics, Proteomics and related technologies upon drug discovery; Transforming new molecular entities into drug, Application of biotechnologies in drug development; Biologic drug development and approval: pre-clinical and clinical trials.
8.	**Advanced drug delivery:** Different routes of drug delivery, Basic principles; Controlled and sustained release: Polymer-based drug carriers, Lipid-membrane-based drug carriers: Permeation enhancement; Molecular approaches of drug delivery.
9.	**Gene therapy:** Background, types of gene therapy (ex vivo & in vivo), choosing targets for gene therapy, Gene Delivery methods–Viral delivery (Retroviral vectors, Adenoviral and Adeno-associated viral vectors), Non-viral delivery, Antibody engineering, Weismann barrier (soma-to-germ line barrier), epigenetic inheritance, problems & ethics. Gene therapy Models – Liver diseases, Lung diseases, Hematopoietic diseases, Circulated gene products, Cancer & Auto-immune diseases.
10.	**Synthetic therapy:** Synthetic DNAs, therapeutic Ribozymes, synthetic drugs.

Text Books:

1. Biopharmaceuticals-Biochemistry and Biotechnology, Gary Walsh, 2nd Edn., John Wiley, (2002).
2. Biotechnology and Biopharmaceuticals, Rodney J.Y. Ho and Milo Gibaldi.
3. Pharmaceutical Microbiology. Edited by W.B, Hugo & A. D. Russel, (1993).
4. Pharmaceutical Biotechnology, AanCrommelin, Robert D Sindelar, Tailor and Francis Publications, New York, (2002).
5. Hand book of Pharmaceutical Biotechnology, Jay P Rho, Stan G Louie, Pharmaceutical products press, New York, (2003).
6. Molecular Biotechnology: Principles and Application of recombinant DNA, Glick BR and Pasternak J.J.(1998) 2nd ed. ASM press, Washington,
7. Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems, Loyd V. Allen, Nicholas G. Popovich and Howard C. Ansel, (2011), Lippincott Williams and wilkins, Baltimore, MD

Recommended References:

1. Preservatives in pharmaceutical, food and environment industries. Edited by R.G. Board M.C. Allowodd and .J. G. Bank Blackwell Scientific Publication, (1987).
2. Assays in Applied Microbiology, Noris, J.R. and Richmond, M.H.(2001), John Wiley & Sons.UK.

Course: BGE-403	**Course title:** Microbial Biotechnology	**Offered year: 4 th**

Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 52.5

Rationale: Microbial Biotechnology intends to introduce different agriculturally and industrially important microorganisms. The course is designed to offer modern concepts and functional aspects of microorganisms for welfare of human and nature.

Course Objectives:

- To provide modern concepts on different agriculturally and industrially important microorganisms.
- To explain the various techniques of agricultural bioinoculants preparation, biomass utilization and renewable energy production.
- To explain the techniques of recombinant protein production in *Bacteria* and *yeast* system.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand the modern concepts on microbial biotechnology
- Know various agriculturally and industrially important microorganisms.
- Realize the diversities of agricultural bioinoculants.
- Produce renewable energy from different sources.
- Manufacture recombinant protein from *Bacteria* and *yeast.*

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction:** Historical development scope and major classes of microbial products and process, microbes as cell factory, single cell protein, spirulina.
2.	**Production of agricultural bioinoculants:** Screening and selection of plant growth promoting bacteria**,** mechanism of plant growth promotion, bioinoculant preparation, bacterial inoculants, rhizobacterial inoculants, fungal inoculants, composite inoculants, inoculation techniques, algalization of blue green algae, agronomic importance of bioinoculants.
3.	**Production of industrial biochemicals:** Production of small biomolecules-Ascorbic acid, amino acids, enzymes, antibiotics, biopolymers.
4.	**Biofuel and renewable energy:** Biology of biogas formation, biogas production from waste materials, biofuel production from algae, waste materials and cereals, Biological fuel cell for electricity production.
5.	**Recombinant protein production in Bacteria:** Advantages and limitations of protein production in bacteria, vectors for recombinant protein production,

	production of insulin, somatotropin, somatostatin, factor VIII.
6.	**Recombinant protein production in Yeast:** Advantages and limitations of protein production in yeast, *Saccharomyces cerevisiae* expression systems; vectors for recombinant protein production, production of recombinant proteins (tumor necrosis factor, streptokinase, erythropoietin etc).

Recommended Text Books/ References:

1. A text Book of Biotechnology, Dubey, R. C., S. Chand & Co. Ltd. New Delhi-110055, (2004).
2. Biological Nitrogen Fixation, Gary Stacey, Robert H. Burris and Harold J. Evans First Indian edition, CBS Publishers & Distributors, New Delhi, India, (1997).
3. Fuels from Biomass and Waste, Klass, Donald E., Emert, George 11, Ann Arbor Science Pub. Ins. USA, (1981).
4. Biomass System-Principles and applications, Mital, K. M., New Age international (P) Ltd. India, (1996).
5. The Fundamentals on Nitrogen Fixation, Postagate J. R., First Edition, Cambridge University Press, Cambridge CB21RP, (1982).
6. Principles of Gene Manipulation, R.W Old & Primrose. Blackwell publishing company, UK (2001)
7. Molecular biology of the Gene, Watson, Hopkins Roberts, Steitz and Weiner. Benjamin/Cumming Publishing Co., (1987).
8. Biology of Microorganism, Brock, T.D., Madigan, M.T., Martinco, J.M. and Parker, J., Benjamin Cummings; 13 edition (2010).
9. Bacterial Plasmid, Hardy, K.M., Published by American Society of Microbiology, (1986).

Course: BGE- 404	**Course title:** Animal Biotechnology		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course aims to improve the knowledge of use and potential of biotechnology in the area of animal production and products, pharmaceuticals and biological molecules for human and animal health care.

Course Objectives:

- To provide scientific understanding of animal biotechnology.
- To acquire general knowledge on animal cell culture and breeding.
- To develop an understanding to the *IVF* and embryo transfer techniques, animal cloning and the transgenic animal production.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Explain the scope and importance of study of animal biotechnology
- Acquire general knowledge on animal cell culture and breeding
- Learn embryo transfer techniques in domesticated animals.
- Understand the *IVF* techniques, cloning and other general techniques used in animal biotechnology
- Be acquainted with techniques and applications of transgenic animals.

Teaching Strategy: Lecture, Projector display, Animation, Discussion, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**Introduction:** History, scope and application of animal biotechnology
2.	**Concepts on animal breeding:** **Selection:** natural and artificial selection, selection objectives and selection criteria, selection methods**.** **Breeding:** inbreeding, outbreeding, topcrossing, grading, cross-breeding, criss-crossing, triple crossing, breeding guidelines, conservation of endangered animal genetic resources.
3.	**Media used for animal cell culture:** Media composition, media preparation and sterilization.
4.	**Culture of animal cells:** Major Basics for animal cell culture, cell culture environment, required media and reagents, culture of mammalian cells, tissues and organs, common cell culture contaminants, application of animal cell culture.
5.	**Culture of specific cell type:** Primary culture, secondary culture, suspension cultures, development of continuous cell lines, characterization and maintenance of cell lines, commercial scale production of animal cells.
6.	***In Vitro* fertilization and embryo transfer:** Collectionandcryo-preservation of semen; Semen processing; Separation of X and Y chromosomes, harvesting of oocyte; maturation of oocytes; *In vitro* fertilization and development of embryos, steps of embryo collection, cryopreservation of embryos; advantages and limitations of *In vitro* fertilization and embryo transfer techniques.
7.	**Animal cloning:** Animal viral vectors; animal cloning basic concept; cloning from- embryonic cells and adult cells; characterization of embryonic stem cells; different applications of embryonic stem cells; cloning of different animals; cloning for conservation of endangered species; ethical, social and moral issues related to cloning.
8.	**Transgenic animals:** Transgenic manipulation of animal embryos and gene

	knockout technologies; methods for production of transgenic animals for a) pharmaceutical use, b) improving desired characteristics of domestic animals and c) production of animal models for human or animal disease.

Text Books:

1. Culture of Animal Cells. Freshney RI. Wiley Liss; 2005.
2. Animal Cell Biotechnology.Portner R. Humana Press; 2007.
3. Reproductive Techniques in Farm Animals. Gordon I. CABI; 2005.
4. Advanced Molecular Biology. Twyman RM. Bios Scientific; 2003.

Recommended References:

1. A Textbook of Biotechnology. RC Dubey. S Chand ;2007.
2. Animal Biotechnology 2: Emerging Breeding Technologies. HeinerNiemann, Christine Wrenzycki Springer International Publishing; 2018.
3. Animal Transgenesis and Cloning. Louis-Marie Houdebine. Wiley; 2003.

Course: BGE-405	**Course Title:** Plant Biotechnology		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide, the knowledge and understanding in learning a broad exposure to molecular techniques behind the improvement of plants/crops for yield and quality. This course presents an overview of the techniques and underlying theory of plant biotechnology and genetic engineering, research and commercial applications, and issues/challenges in the area of plant biotechnology and Genetic Engineering.

Course Objectives:

- Provide basic and advanced knowledge and understanding of plant biotechnology and genetic engineering.
- Give explanation of the techniques of plant genetic manipulation and their applications and conservation.
- Explain the application of biotechnology for plant improvement and discuss the ethical issues related to GM plants.

Intended learning outcomes (ILOs): At the end of the course the students will be able to-

- Explain the basics of the plant biotechnology, history, applications and future aspects.
- Use various basic techniques to explore molecular biology of plants
- Understand the processes involved in the planning, conduct and execution of plant biotechnology experiments
- Learn the techniques of plant genetic manipulation and their applications and conservation
- Produce transgenic plant and various plant biotech products.

Teaching methods:
Lecture, Multimedia display, Animation, Handouts, field visit, Seminar etc.

Assessment methods:
Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva
Final exams: Structured questions

	Course Contents
1.	**Introduction**: Definition, concept of plant biotechnology, history and origin of plant biotechnology, scopes, tools of plant genetic engineering, application of biotechnological methods for plant development, DNA fingerprinting and molecular farming, Genome editing, early history of genome editing, progress and prospects in plant genome editing.
2.	**DNA markers for plant genome analysis**: DNA based molecular markers and its properties, types of molecular markers, types and description of DNA markers, multi locus probes, applications of molecular markers in plant improvement, QTL mapping with molecular markers, marker assisted selection and crop improvement.
3.	**Plant genomics**: Introduction to plant genomics, plant genome and its organization, sequencing and assembling plant genomes, integration of next generation sequencing with comparative genomics in plants, regulation of plant genomes by small RNA, genomics of plant stress tolerance.
4.	**Transgenesis in plants**: Gene transformation mechanism, gene transfer in plants, gene transfer through vectors: Biology of vectors used –Ti and Ri plasmids, binary vectors, binary vectors, co-integrative vector, viral vectors; cloning strategy and method of gene transfer; Vector less gene transfer: electroporation and gene gun method.Ti -plasmid, organization of Ti- plasmid, transfer of T-DNA in to host genome, advantage and disadvantages of A*grobacterium* mediated gene transfer.
5.	**Transgenic plants:** Transgenic plants for crop improvement, monocot system, dicot system, advantages and disadvantages of monocot and dicot system, development of resistance plants to biotic stress (insect resistance, virus resistant, disease resistant), resistant to abiotic stress, herbicide resistance, applications of

	transgenic plants. Detection of transgenes by molecular techniques. Case studies.
6.	**Epigenetic regulation in plants:** Epigenetics, molecular components of chromatin in plants, mechanisms of RNA mediated gene silencing pathways, amplification and spreading of siRNA mediated silencing, virus induced gene silencing, mobile silencing, transient epigenetic regulation in response to stress, epigenetic effects on genome structure. Case studies.
7.	**Genome editing in plants:** Mechanism of genome editing system in plants, Oligo nucleaotide Directed Mutagenesis (ODM), Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), Precision genome editing in plants, Single base editing, Simplex and Multiplex genome editing, Homology directed transgene free genome editing, Safety assessment aspect of genome editing. Case studies.

Text Books:

1. A Text book of Biotechnology, R.C Dubey.
2. Introduction to Plant Biotechnology, H.S Chawla.
3. Molecular Plant Biology: A practical approach, Gilmartin and Bowler, (Vol. I and II).
4. CRISPR-Cas Methods. Springer Protocol. M Tofazzal Islam, Pankaj K Bhowmic and Kutubuddin A. Mollah eds.

Recommended reading:

1. Plant Biotechnology, Mantel and Smith.
2. Genome editing Edited by KursadTurksen. Springer Publishing
3. Plant Genomics, Edited by Ibrokhim Y. Abdurakhmonov, Published by InTech, JanezaTrdine 9, 51000 Rijeka, Croatia

Course: BGE-406	**Course title:** Cell Signaling		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to explore the mechanisms of cellular communication and signal transduction in mammalian cells. Selected signaling pathways are highlighted and will be discussed in detail.

Course Objectives:

- To provide concept of cell to cell communication and basic principles of signal transduction mechanisms.
- To demonstrate the experimental design leading to various cell signaling pathways.
- To explain the components of mammalian signaling machinery and their mechanism of action.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Learn the detail mechanisms of cell signaling through which various cells can communicate to each other
- Know the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, signal integration and intracellular location
- Learn different types of extracellular signals and receptors and the mechanisms by which different receptors activated by their respective ligands
- Gain knowledge about quantitative properties of G-protein signaling networks and their regulation
- Know the structure and properties of the major components of signal transduction pathways

Teaching Strategy: Lecture, Projector display, Animation, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

	Course Content
1.	**General principles of cell signaling:** Extracellular signaling molecules and their receptors; Receptor specificity, Action of signaling molecules, Cellular response to different signal molecules and by different cell types, Mechanism of signal transductions, Signaling by nitric oxide (NO), Nuclear receptor, Ion channel linked, G-protein linked and enzyme linked receptors, Relay of signal by cell surface receptors; Intracellular signaling proteins as molecular switches; Localization of signaling proteins; Role of scaffold proteins, Protein-protein interactions in signal transduction; Modular binding domain and signaling protein interaction, Desensitization to signal molecules.
2.	**Signaling through G-protein-coupled receptors:** Structure of G-protein and G-protein-coupled receptors, Activation of G-proteins; cAMP and G-protein signaling, Regulation of G-protein activity, c-AMP dependent protein kinase (PKA)-mediated signaling, Lipid modifying enzymes; Phophatidylinositol 3-kinase (PI 3-kinase); Phopholipase C (PLC); Inositol phospholipids signaling pathway, Ca^{2+} as a intracellular messengers, Ca^{2+}/Calmodulin-dependent protein kinase (CaM kinase) signaling, Regulation of ion channels by G-proteins, Sensory transduction in vision, olfactory, and gestation, Amplification of extracellular signals, Desensitization of G-protein linked receptors.
3.	**Signaling through enzyme-coupled receptors:** Classification of enzyme-coupled receptors, Receptor tyrosine kinases (RTKs), Docking sits for proteins, Monomeric G proteins; Activation and regulation of Ras, Protein kinases; MAP kinase pathway, PI3-kinase/protein kinase B signaling pathway, Insulin receptor-mediated

	signaling, Cytokine receptors and the JAK-STAT pathway, Receptor Ser/Thr kinase and TGF-βsignaling pathway, Protein phosphatases.
4.	**Signaling pathways depends on regulated proteolysis:** Activation of Notch receptor by cleavage, Wnt signaling and its receptors, Hedgehog signaling in *Drosophila*; NFκB-dependant signaling pathway, Cleavage of signaling proteins by matrix metallo-proteinases, Cleavage of amyloid precursor and Alzheimer's disease.
5.	**Signaling in microorganism and plants:** Quorum sensing, Two component signaling pathway of bacterial chemotaxis, Detection of ethylene by plants through two-component systems and MAPK cascade.
6.	**Environmental approaches of signal induced responses:** Evolutionary conservation and proliferation of genes encoding signals and regulators, Glucose metabolism: an example of integration of signaling pathways.

Text Books:

1. Molecular Cell Biology. Darnell J, Lodish H, Baltimore D, W.H. Freeman and Company, New York, 1986.
2. Molecular Biology of the Cell. Alberts B Bray, D Lewis J. Garland Publishing Inc. New York, 1989
3. Molecular Biology of the Cell. Alberts, Johnshon, Lewis, Raff, Roberts and Walter.
4. Molecular Cell Biology. Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott, Zipersky and Darnell.

Course: BGE-407	**Course title:** Environmental Biotechnology		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide theoretical knowledge for the study of biotechnology to solve global environmental problems including microbes and their interaction with the environment, xenobiotics and their remediation, waste water treatment, biomining and biosensors.

Course Objectives:

- Explore the scopes and importance of study environmental biotechnology.
- Discuss the role of microorganisms in the environment.
- Describe biotechnological solutions to address environmental issues including pollution, and recovery of minerals.
- Utilize environmentally friendly technology.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Investigate different types of environmental pollutions and their impacts.
- Distinguish the role of potential microorganisms as biotechnological agents.
- Identify biotechnological approaches of waste water treatment.
- Be familiar with different technologies and tools for the purposes related to remediation, recovery of resources, and environmental monitoring.
- Acknowledge the environmental law and ethics

Teaching Strategy: Lecture, Projector display, Animation, Discussion, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** Global environmental problems – pollution, ozone depletion, greenhouse effect, acid rain, depletion of natural resources, waste disposal, deforestation and loss of biodiversity due to anthropogenic activities; scope of environmental biotechnology; VBNC organisms.
2.	**Environmental pollution and biotechnological control:** Pollution of air, water and soil and their mitigation by biotechnological means- use of commercial blends of microorganisms and enzymes in pollution control, immobilized cells in pollution control, novel biotechnological approaches like use of genetic manipulation, enzymes and specialized bacteria.
3.	**Recalcitrant molecules in the environment and control:** Types of recalcitrant molecules, Characterization of microbial activity and biodegradation of recalcitrant substances including pesticides in soil; Persistence and biomagnification of xenobiotic molecules.
4.	**Biodegradation:** Concept, application, biodegradation and metabolism of chemical pesticides, phenols, dyes, petrochemicals.
5.	**Bioremediation:** Heavy metal pollution, metal bioavailability in the environment, mechanisms of microbial metal resistance and detoxification, effects of metal-microbes interaction, approaches to bioremediation- environmental modification for bioremediation, microbial seeding and bioengineering approaches, DNA and RNA based methods.
6.	**Biotechnological approaches of industrial waste management:**Introduction on wastewater, Domestic and Industrial Waste water treatment, ETP and STP, Disposal.
7.	**Bioleaching:** Definition, Application, Example Cu-bioleaching, Prospect: Au-Bioleaching.
8.	**Biosensor:** Principle, transducers, biocomponent of biosensor, application of enzyme based and organelle-based biosensors, affinity binding assay, biological reactant pairs, application of immunosensor and receptor-based sensor,

	environmental biosensor.
9.	**Environmental laws**: Environmental legislation and regulation, environmental ethics.

Text Books:

1. Biotechnology and Environment. Trivedi, R N, Yadav, Seema. Anmol Publications.
2. A Textbook of Environmental Chemistry and Pollution Control. Dogra S S. Swastik Publishers.
3. Environmental Biotechnology. Young, M.M., Elsevier Pub. Ltd. Netherlands; 1997.
4. Molecular Approaches to Environmental Microbiology. Pickup RW and Saunders IJR. Ellis Horwood.
5. Environmental Biotechnology by S.N. Jogdand. Himalaya Publishing House. Bombay
6. Wastewater Engineering – Treatment, Disposal and Reuse. Metcalf and Eddy, Inc., Tata McGraw Hill, NewDelhi.
7. Introduction to Biodeterioration. D. Allsopp and k.J. Seal, ELBS/Edward Arnold.

Recommended References:

1. Theory and Practice of Water and Wastewater Treatment. Ronald L. Droste and Ronald L. Gehr. 2nd Edition.Published by John Wiley & Sons Inc.; 2019.
2. MicrobialBiotechnology:FundamentalsofApplied Microbiology .A. N. Glazer and H. Nikaido. 2nd edition,Cambridge University Press; 2007.

Course: BGE-408	**Course title:** Molecular Diagnostics	**Offered year:** 4th

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
42h	3	3h	75

Rationale: The course provides theoretical knowledge to the graduate in the area of molecular diagnosis for acquired, inherited, and infectious diseases and forensic science.

Course Objectives:

- To provide the basic principles of molecular biology and their relevance to the identification of disease-causing genes/mutations and the diagnosis of genetic disorders.
- To be familiar with modern tools employed to study DNA structure, identify variations in structure among individuals and the molecular basis of human diseases.
- To describe the structure and organization of genes, chromosomes, genetic mutations and abnormalities related to genetic diseases.

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Demonstrate knowledge and understanding of a range of concepts and issues in Forensic science.
- Show proficiency in assessing, evaluating, analyzing, and synthesizing scientific information and data interpretation from a variety of sample sources.
- Work cooperatively with others, while demonstrating an increasing understanding of how to be an independent learner.
- Define the various mutations and genetic abnormalities which can result in genetic diseases.
- Relate modern DNA technology to the application of disease gene identification and analysis.
- Explain human genome variation and its effect on disease.
- Perform a range a molecular genetics techniques and analyze the experimental results.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content	
1.	**Introduction:** History, concepts and application of molecular diagnostics.
2.	**Tandem repeats:** satellite DNA, variable number of tandem repeats/ mini satellite sequences, short tandem repeats/ microsatellite sequences, polymorphism of some genetic locus in relation to disease (HLA, APO and ACE gene).
3.	**DNA fingerprinting:** Hybridization based DNA fingerprinting (RFLPs) method; detection methods in RFLP: Isotopic labeling/ Radiolabeling, non-isotopic labeling (Direct: fluorescent; Indirect: colorimetric, fluorescent and chemiluminescent method); RFLP based disease diagnosis. PCR based DNA fingerprinting (STR analysis); Applications of DNA fingerprinting: Criminal investigation, personal identification, immigration, paternity dispute, identification of missing baby, bodies found in plane crash & road accident.
4.	**Various molecular methods using in disease diagnosis:** PCR: multiplex PCR, reverse transcription PCR, real time PCR, nested PCR. ELISA: Principle, classification:direct, indirect, sandwich, and competitive. Microarray: DNA microarray, mRNA microarray, protein microarray, forward phase and reverse phase assay, planar microarrays, bead based microarrays, Luminex xMap technology. FISH: principle, methods: single probe, dual color dual fusion probe.

	CRISPER: principle, method, various crisper protein. TALEN: principle, method. Nano technology: nanoparticle based disease diagnosis. Lateral flow technique: principle, design. Biosensor: principle, method, example.
5.	**Detection of various genetic disorder:** Cystic fibrosis: causes and clinical significance, diagnosis method. Fragile X syndrome: causes and clinical significance, diagnosis method. Philadelphia chromosome: causes and clinical significance, diagnosis method (FISH, RT PCR).
6.	**Detection of various viral and bacterial disease:** Hepatitis CVirus, Hepatitis B Virus, COVID, Tuberculosis (Mycobacterium tuberculosis Complex).
7.	**Detection of blood disorders:** ß-thalassemia: molecular basis, clinical significance, detection of mutation by molecular diagnosis method. Hemophilia: molecular basis, clinical significance, detection of mutation by molecular diagnosis method.
8.	**Development of Diagnostic kit:**steps involved in diagnostic kits development, various diagnostics kit for detection of various diseases.

Text Books:

1. From Genes to Clones, Introduction to Gene Technology by Ernst-L. Winnacker. VCH Publishers. (1987).
2. Principles of Gene Manipulation. An Introduction to Genetic Engineering. R. Old, S.B. Primrose. Blackwell Sci Pub. (1985).
3. Gene Cloning and DNA Analysis: An Introduction (4^{th} edition) by T.A. Brown.
4. From Genes to Genomes: Concepts and Applications of DNA Technology by J.W. Dale and M.V. Schartz.
5. DNA Science, Micklos, Davod A. and Frayer, Greg A., Cold Spring Harbor Laboratory press and Carolina Biological; Supply Company, (1990).
6. A Text Book of Biochemistry with Clinical Correlation, Devlin.
7. Principle of Biochemistry, Lehninger, Albert., M/S Worth Publishers Inc., New York.
8. Medical Microbiology, Edited by Greenwood. D, Slack. R and Peutherer. J, ELST Publishers, (1997).
9. Bailey and Scott's Diagnostic Microbiology, Betty A. Forbes, Daniel F. Sahm, Alice S. Weissefeld, Ernest A Trevino. Published by C.V. Mosby, (2002).
10. Fundamental of Molecular Diagnostics, David E. Bruns, Edward R. Ashwood, Carl A. Burtis. Sauders group, (2007).

Recommended References:

1. Banchereau J., F. Briere, C. Caux, J. Davoust, S. Lebecque, Y. J.Liu, B. Pulendran, and K. Palucka.Immunobiologyofdendriticcells.*Annu. Rev. Immunology.* **18:**767, (2000).

Course: BGE-409	**Course title:** Downstream Processing	**Offered year:** 4th

Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to provide a firm foundation in the fundamentals and applications of downstream processing for the production of bioproducts in the area of industrial biotechnology.

Course Objectives:

- To provide knowledge of bioproduct separation and purification techniques used in biotechnology focusing real industrial products.
- To explain the principles and theories of various bio separation processes and how to improve or customize the processes
- To offer knowledge to solve the real problems in industrial design and improve productivity.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Have an overview of bioproduct separation and purification techniques.
- Know various theories and principles of various bioseparation processes.
- Learn critical aspects in operating various downstream techniques.
- Improve their skills in problem solving with respect to designing separation and purification processes.
- Design unique separation process which will cost worthy than the existing one.
- Improve or customize separation process to improve productivity.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** Bioproducts, Definition, Selection criteria, Basis of separation, Broth characteristics, Operational stages.
2.	**Filtration:** Principle, classification, Pretreatment, Theory and Problems
3.	**Centrifugation:** Principle, classification, Centrifuge design, Equipment, Problem solution
4.	**Disruption of microbial cell:** Composition and structure of different cell wall (bacteria, yeast, other fungi), analysis of disruption, laboratory-scale and large-scale disruption techniques.
5.	**Extraction:** Principle and Chemistry of Extraction, Extraction Methods.
6	**Adsorption:** Theory of Adsorption, Classificationand Adsorption processes.

7	**Chromatography:** Chromatographic process, classification, yield and Purity.
8	**Precipitation:** Concept of solubility, Theory and Classification of Precipitation, Problem solving.
9	**Ultrafiltration:** Definition, Osmosis and Osmotic Pressure, UF Theory, Membrane Characteristics, Preparation of Membrane, Development of semi-permeable membrane, methods of preparation, membrane characteristics and performances, membrane fouling and treatment, UF equipment and processes.
10	**Crystallization:** Basic concepts, saturation, nucleation, crystal growth.

Text Books:

1. Belter, P. A. et al. Bioseparations: Downstream Processing for Biotechnology, Latest edition. Wiley-Interscience Publication.
2. Standbury P. F. and Whitaker A. Principles of Fermentation Technology, Latest edition. Pergamon Press, UK.
3. Moo-Young, M. (ed.). Comprehensive Biotechnology, Volume- 2 and 3, Pergamon Press, UK.
4. Bailey, J. E. and D. F. Ollis, (1986). Biochemical Engineering Fundamentals, second ed., McGraw-Hill Book Co., Singapore.
5. Ahuja S. (2000) Handbook of Bioseparations. Academic Press, San Diego.

Recommended References:

1. Laffend, L.A. et.al. (1997) Bioconversion of a fermentable carbon source to 1,3-Propanediol by a single microorganism. US patent 5686276, E.I. DuPont de Nemours and Company
2. Laffend, L.A. et.al. (1997) Bioconversion of a fermentable carbon source to 1,3-Propanediol by a single microorganism. US patent 5686276, E.I. DuPont de Nemours and Company
3. Schurr, G. *et al.* (2000) Focusing powder technology on processing biologically produced products, *14th Int. Congress of Chemical and Process Engineering*, Praha, Czech Republic
4. Laffend, L.A. et.al. (1997) Bioconversion of a fermentable carbon source to 1,3-Propanediol by a single microorganism. US patent 5686276, E.I. DuPont de Nemours and Company

Course: BGE-410	**Course title:**	Entrepreneurship in Biotechnology	**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: The course is designed to examine the entrepreneurial process in biotechnology from idea generation through economic viability. Biotechnology companies are unique in that they often need a decades-long period of incubation prior to becoming self-sustaining. Topics of this course include an overview of the global biotechnology industry, idea generation, business plan formulation, intellectual property protection, funding, personnel management including board composition, regulatory body interaction and company exits.

Course Objectives:

- To familiarize students with the scope of issues to understand entrepreneurial process in biotechnology from idea generation through economic viability.
- To give students the vocabulary to participate and contribute to the business side of scientific enterprises.
- To provide a general procedural road map for bioscience students who are interested in starting their own companies.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Understand entrepreneurial process in biotechnology from idea generation through economic viability.
- Combine the knowledge of biotechnology with business skills – a key driver of employ ability.
- Learn about the fundamental points of GLP; Resources, Characterization, Rules, Results, Quality Assurance and Good manufacturing practices.
- Learn the prospects, limitation and global market of biotech products.
- Be aware of public perceptions of biotech products.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, Visit, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	**Introduction:** Entrepreneur, Entrepreneurship, Entrepreneurship related characteristics for different sectors in biotechnology.
2.	**GMP and GLP:** The fundamental points of GLP; Resources, Characterization, Rules, Results, Quality Assurance, Good manufacturing practices for pharmaceutical products, Pharmaceutical quality system.
3.	**Biotech products:** Introduction, Public perceptions of Biotech products; The Global marketplace for Biotech products, Prospects and limitation of Biotech products in Bangladesh.
4.	**Major considerations in establishment of biotechnological startup:** The business potential of a Biotechnological company, Entrepreneurship, The Company, Seed capital raising for a Biotechnological start-up company, Stakeholders, Venture capital, Corporate strategies, Licensing, Alliances, and

	Mergers.
5.	**Market survey techniques:** Market survey, cost analysis, Price estimation, COGS, SWOT analysis, product positioning, marketing strategies.
6.	**Business regulations in biotechnology:** Laws, Regulations, and politics involved in Biotechnology; Ethical concerns regarding the use of Biotechnology.
7.	**Commercialization of biotech products:** Fundamentals of marketing and selling of Biotech products. Creating and marketing the image of the biotech company, The Art of negotiation. Effective advertising and marketing, Opportunities of international marketing.
8.	**Intellectual property rights in biotechnology:** Introduction, Collaborative research, Competitive research, Invention as intellectual property, Ownership of intellectual property, Basic requirements of patentability, Special issue in Biotechnology patents, Recent developments in patent system and patentability of Biotechnological invention.

Text Books:

1. Science Business: The Promise, the Reality, and the Future of Biotech, Pisano, Gary P. Harvard Business School Press, USA
2. Building Biotechnology: Business, Regulations, Patents, Law, Politics, Science, Yali Friedman, Logos Press. USA
3. The coming biotech age: The business of biomaterials. By Richard Oliver. NY : McGraw Hill, (2000).

Recommended References:

1. Handbook of Good Laboratory Practice (GLP), World Health Organization (WHO), 2001
2. Good manufacturing practices for pharmaceutical products: main principles, World Health Organization (WHO), 2014

Course: BGE-411	**Course Title:** Fisheries and Marine Biotechnology		**Offered year:** 4th
Minimum course hour: 42h	**Credit hour:** 3	**Final exam duration:** 3h	**Total marks:** 75

Rationale: This course is most important for the development of fisheries sector in Bangladesh as Bangladesh is aquatic resources rich country and earns lots of foreign currency. This course will introduce the student to the biology of the non-vertebrate marine and aquatic animals that humans harvest or culture. Risk analysis and food safety issues regarding aquatic organism.

Course Objectives:

- To provide basic knowledge on different biotechnological approaches and their applications in fisheries sector of Bangladesh.
- To explain about value added products and production procedure of different value added products and bi-products.
- To be familiar with the biology of marine and freshwater invertebrates that are important in fisheries or aquaculture.

Intended learning outcomes (ILOs): At the end of the course the students should be able to –

- Know basic knowledge of different biotechnological approaches and their applications in fisheries sector of Bangladesh.
- Learn various intensive and extensive aquaculture techniques.
- Identify the principal impacts of aquaculture (habitat destruction, over exploitation of feed stocks, pollution, introduction of exotics, spread of disease, competition for resources, social and economic impacts).
- Retrieve and present scientific information about aquaculture and fish genetics.
- Appreciate the multidisciplinary aspect of marine sciences and engage positively with people and ideas beyond their discipline area.

Teaching methods:

Lecture, Multimedia display, Animation, Handouts, field visit, Seminar etc.

Assessment methods:

Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva

Final exams: Structured questions

Course Contents

1.	**Introduction:** Aquaculture, Blue economy, fish physiology, fresh and marine water fish, History of genetic biotechnology and selective breeding in aquaculture and fisheries, phenotypic variation and environmental effects in aquaculture, Genetic conservation, gene banking, Future prospects of blue economy in Bangladesh, Constrains and limitations of aquatic genetic biotechnology.
2.	**Products from Aquatic organisms:** Culture aspects, Organisms (porifera, bryozoa, mollusks others), marine cements, bio minerals, antifouling compounds, Agar and agarose.
3.	**Transgenic Fish:** Gene expression, Isolation and Cloning of potential genes, Gene transfer techniques in fish, Transgenic expression and reporter gene, Pleiotropic effects of transferred genes, Mitochondrial DNA transfer.
4.	**Commercial application of aquatic biotechnology:** Polyploidy, Sex reversal and breeding, Gene knockout technology, Transgenic production of pharmaceuticals, Dramatic growth of transgenic fish.
5.	**Ethics, environmental risk and food safety of aquatic organism:** Environmental ethics and animal welfare, Theoretical risk, Environmental risk on transgenic fish,

	Genetic sterilization, International guidelines on food safety, Labeling.
6.	**Case studies:** Safety of consumption of transgenic salmon potentially containing elevated levels of growth hormone and Insulin-like Growth Factor.
7.	**Marine biodiversity:** Brief discussion on marine biodiversity and their prospects, DNA barcoding of marine genetic resources, improvement and utilizations of marine resources.

Text Books:

1. Food Biochemistry and Food Processing, Benjamin K Simpson, Wiley-Blackwell, London, ISBN: 978-0-8138-0874-1
2. Aquaculture and Fisheries Biotechnology (2nd Ed), Rex A Dunham, CABI Publishing, UK. ISBN: 13: 978-1-84593-651-8
3. Marine Biotechnology II, T Scheper, Springer-Verlag Berlin Heidelberg.

Recommended reading:

1. Ranga,M.M. and Q.J.Shammi (2005). Fish Biotechnology. Agrobios, India.
2. Itami, T, *et. al*. (1998). Advanced in shrimp biotechnology. National Centre for Genetic Engineering and Biotechnology. Bangkok.
3. Gjedren, T. (1990). Genetics in Aquaculture III Ed., Elsevier.

Course: BGE-412	**Course title:** Downstream Processing Practical		**Offered year:** 4th
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: The course is designed to provide a hands on experience of the fundamentals and applications of downstream processing for the production of bioproducts in the area of industrial biotechnology.

Course Objectives:

- To develop students' understanding of detailed processes for bioproduct separation and purification techniques used in biotechnology focusing real industrial products.
- To provide the principles and theories of various bioseparation processes and how to improve or customize the processes to solve the real problems in industrial design and improve productivity.
- To explain various theories and principles of various bioseparation processes.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to-

- Have an overview of bioproduct separation and purification techniques.
- Know various theories and principles of various bioseparation processes.
- Learn critical aspects in operating various downstream techniques.
- Improve their skills in problem solving with respect to designing separation and purification processes.
- Design unique separation process which will cost worthy than the existing one.

- Improve or customize separation process to improve productivity.

Teaching Strategy: Lecture, Animation, Field visit, Experiment in lab

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Assignment, Lab report, Viva
Final exams: Q/A, Performing experiments in the Lab, Writing Report

Course Content

1.	Solid-liquid separation.
2.	Cell disruption.
3.	Aqueous two phase extraction.
4.	Chromatographic separation.
5.	SDS-PAGE.
6	Measurement of product formation in a fermentation process.
7	Lyophilisation and Drying.
8	Crystallization

Text Books:

1. Belter, P. A. et al. Bioseparations: Downstream Processing for Biotechnology, Latest edition. Wiley-Interscience Publication.
2. Standbury P. F. and Whitaker A. Principles of Fermentation Technology, Latest edition. Pergamon Press, UK.
3. Moo-Young, M. (ed.). Comprehensive Biotechnology, Volume- 2 and 3, Pergamon Press, UK.
4. Bailey, J. E. and D. F. Ollis, (1986). Biochemical Engineering Fundamentals, second ed., McGraw-Hill Book Co., Singapore.
5. Ahuja S. (2000) Handbook of Bioseparations. Academic Press, San Diego.

Recommended References:

1. Abd El-Hady, D., and Albishri, H. M. (2018). Temperature controlled ionic liquid aqueous two phase system combined with affinity capillary electrophoresis for rapid and precise pharmaceutical-protein binding measurements. Methods. 146, 120–125. doi: 10.1016/j.ymeth.2018.02.007
2. Abdolrahimi, S., Nasernejad, B., and Pazuki, G. (2015). Influence of process variables on extraction of Cefalexin in a novel biocompatible ionic liquid based-aqueous two phase system. Phys. Chem. Chem. Phys. 17, 655–669. doi: 10.1039/C4CP02923B
3. Laser E.W., J.A. Aenjo, et al (1992) "Rational design of purification processes for recombinant proteins", Journal of Chromatography, 584, pp. 43-47.

Course: BGE-413	**Course title:** Genetic Engineering Practical	**Offered year:** 4th

Minimum course hour:	**Credit hour:**	**Final exam duration:**	**Total marks:**
28h	**2**	As required	50

Rationale: The course is designed to provide basic concept and advanced molecular biology techniques including gene cloning, PCR, real-time PCR, and sequencing reactions etc.

Course Objectives:

- To provide basic molecular biology techniques which include analytical skills, quantitative and statistical analysis
- To introduce the modern and advanced molecular biology techniques including gene cloning, PCR, real-time PCR, and sequencing reactions.
- To develop expertise in experiment design and improving scientific writing skills.

Intended Learning Outcomes (ILOs): At the end of the course the students will be able to learn-

- Basic molecular biology techniques, which include analytical skills, quantitative and statistical analysis
- Solving problem through group work
- Laboratory exercises and individual team-based original laboratory projects that focus on molecular biology
- Learn modern and advanced molecular biology techniques including gene cloning, PCR, real-time PCR, and sequencing reactions.
- Develop expertise in analytical skills, statistical analysis and experiment design.

Teaching Strategy: Lecture, Projector display, Animation, Hands on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, MCQ, Presentation, Viva
Final exams: Q/A

Course Content

1.	Restriction digestion and ligation of DNA
2.	Preparation of competent bacterial cells
3.	Transformation of Gram Negative and Gram Positive bacteria with Plasmid DNA
4.	DNA cloning
5.	RT PCR
6.	Colony PCR
7.	DNA sequencing

Text Books:

1. Laboratory Exercises in Microbiology, Fifth Edition, Harley, J.P. and Prescott, L.M. The McGraw-Hill Companies. (2002)
2. Lehninger Principles of Biochemistry, Fourth Edition - David L. Nelson, Michael M. Cox, 4th edition, (2004).

Course: BGE-414	**Course Title:** Plant and Animal Biotechnology Laboratory		**OfferedYear:** 4th
Minimum course hour: 28h	**Credit hour:** 2	**Final exam duration:** As required	**Total marks:** 50

Rationale: The course is designed to provide, the knowledge and understanding in learning an overview of the techniques and underlying theory of plant biotechnology and genetic engineering, research and commercial applications, and related bio-safety/ethics related issues/challenges in the area of plant/animal biotechnology and genetic engineering. Applications of biotechnological techniques in the laboratory will provide students with the basic understanding of the molecular mechanisms that underline cellular processes in plants/animals, with reference examples utilized in advanced Agricultural / Horticultural and Pharmaceutical Industry.

Course Objectives:

- To provide knowledge of biosafety, biosecurity, ethics and understanding of preparation of SOPs.
- To develop multi tasking skills for encouraging students to take charge of their learning.
- Encourage teamwork and accountability among the students which will help them to work in a research group in the sophisticated laboratories in abroad.

Intended learning outcomes (ILOs): At the end of the course the students should be able to-

- Gain knowledge of biosafety, biosecurity, ethics and regulatory issues on plant and animal biotechnology research.
- Learn to preparation SOP for the instruments and experiments.
- Learn broad understanding of plant secondary metabolites and their quantification.
- Know plant and animal cell culture techniques.
- Gain proper genetic transformation skill.

Teaching methods:

Lecture, multimedia display, animation, hands on training, field visit etc.

Assessment methods:

Tutorials: Structured questions, quiz, example sheets, problem solving, assignment, MCQ, verbal presentation, Viva

Final exams: Demonstration, experiment

Course Contents

	Plant Biotechnology:
1.	General lab safety, biosafety, bisecurity practices and preparation of SOP.
2.	Preparation of cell suspension culture medium and sterilization.
3.	Explants inoculation for Cell Suspension culture.
4.	Proto Biomass harvesting and determination of fresh weight, dry weight.
5.	Extraction and studies of different secondary metabolites in plants (Phenolics, flavonoids, antioxidants).
6.	Culture and maintenance of Agrobacterium spp.
7.	Demonstration of gene transfer, Direct and Indirect methods.
8.	Transgene validation through molecular techniques.
9.	Basic demonstration of plant genome editing.
	Animal Biotechnology:
1.	Understanding about the ethics, regulation and biosafety issues regarding animal biotechnology research.
2.	Preparation of animal cell culture medium and sterilization.
3.	Organ culture and fibroblast culture techniques.
4.	Live animal cell count.

Text Books:

1. Robertson, D.: Shore, S. and Miller, D.M. (1997). Manipulation and Expression of DNA; A Laboratory Manual. Academic Press. London. NY.
2. Skerrit, J. H. and R. Apples (1995). New Diagnostics in Crop Sciences. Biotechnology in Agriculture Series No. 13 CAB International, UK.
3. Gelvin, S. B.; Schilperoot, R. A and Verma, D. P. S. (1989). Plant Molecular Biology Manual. Kluwer Academic Publisher, Dordrecht, London. Benjamin, B.G. (1981).
4. New Technologies in Animal Breeding, Academic Press, NY, London, Tokyo, Sydney.

Recommended reading:

1. Tzotzos, T, G. (1995). Genetically Modified Organisms: A Guide to Biosafety. CAB International, UK.
2. Hafez, E. S. E. (1987). Reproduction in Farm Animals. LEA and Fibiger, Philadelphia.

Course: BGE-415	**Course title:** Genomics Practical		**Offered year: 4th**
Minimum course hour: 28h	**Credit hour: 2**	**Final exam duration:** as required	**Total marks: 50**

Rationale: This is a laboratory course designed to enable the students to apply and investigate conceptual knowledge of Genomics to generate knowledge and make informed interpretations and enhance their research skills.

Course Objectives:

- To introduce Unix commands, with a focus on the topics that will be taught in the course
- To broadly introduce NGS technologies, NGS data formats, and tools, NGS sequence alignment SNP/Indel detection, sequence assembly, and visualization
- To outline the basics of Transcriptomics, differential expression analysis, and Cancer informatics

Intended Learning Outcomes (ILOs): After completion of the course, the students will be able to-

- Carry out basic experiments of Genomics and interpret the results
- Carry out experiments to identify sets of co-regulated genes
- Design microarray experiments for evaluating normal and diseased cell specific mRNA expression
- Plan a strategy to circumvent potential experiments
- Design special ligand or protein to treat cancer

Teaching Strategy: Lecture, Projector display, Animation, Hands-on experiment, etc.

Assessment Strategy:
Tutorials: Q/A, Quiz, Assignment, Presentation, Viva
Final exams: Q/A

Course Content

1. **Genomics:** Introduction to NGS technologies. NGS data formats and tools. NGS sequence alignment and QC. SNP/Indel detection, sequence assembly. Sequence viewing with IGV.
2. **Genome Expression:** Design microarray experiments & the analysis of DNA microarray data; differing expression of genes over time, between tissues and disease, states, identifying sets of co-regulated genes; data processing: image analysis
3. **Cancer Genomics:** Unfolding the prognostic significance of a protein of interest in a particular cancer

Text Books:

1. Bioinformatics: Sequence and Genome Analysis. David W. Mount. Cold Spring Harbor Laboratory Press.
2. Essential Bioinformatics. JinXiong. Cambridge University Press, (2006)
3. Bioinformatics: From Genomes to Drugs. Edited by Thomas Lengauer. Wiley-VCH. (2002).
4. Lecture Notes on Biological Sequence Analysis. Martin Tompa. (2000)
5. Bioinformatics. A Practical Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanis. 2nd Edition. Wiley Interscience. (2002)

Recommended References:

1. Bioinformatics Computing. Bryan Bergeron. Prentice Hall PTR. (2002)
2. Developing Bioinformatics Computer Skills. Cynthia Gibas, Per Jambeck. O'reilly. (2001)
3. Discovering Genomics, Proteomics, and Bioinformatics. Campbell andHeyer (2003) Pearson Education, ISBN: 0-8053-4722-4
4. Computational Molecular Biology. Pevzner, P.A. (2000) MIT Press, ISBN: 0262161974
5. Bioinformatics: A Lab. Guide to the Analysis of Genes and Proteins. Andreas D. Baxevanisand B. F. Francis Ouellette (2004). 3rd Edition. Wiley and Sons, ISBN: 0-471-47878-4