1st Year Curriculum

for

Bachelor of Science (Honours)

Session 2021-2022 onwards

Department of
Genetic Engineering and Biotechnology
University of Dhaka

First Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB 101	Fundamentals of Genetic Engineering and Biotechnology	4
GEB 102	Basic Biology	2
GEB 103	Basic Biochemistry	4
GEB 104	Basic Microbiology	4
GEB 105	Human Physiology	4
GEB 106	Chemistry for Biologists-1 (Extra-departmental course)	4
GEB 107	Mathematics for Biologists (Extra-departmental course)	2
GEB 108	Physics for Biologists (Extra-departmental course)	2
GEB 109	Laboratory Experiments	4
GEB 110	Viva voce	2
	Total	**32**

Course Profile: First Year

GEB 101 Fundamentals of Genetic Engineering and Biotechnology 4 Credit

Introduction to the Course:
This is a fundamental course covering various aspects and scope of biotechnology. Students will be introduced to the basic concepts/principles of different areas of biotechnology with an emphasis on the application of recombinant DNA technology. This course will describe the use of rDNA technology to solve agricultural/medical/ environmental problems.

Specific objectives:
The study of this course will

- Enable students to recognize the basic concepts of traditional and modern biotechnology.
- Equip students with an understanding of the recent advances in rDNA technology and its applications to improve human life and the environment.
- Enable students to know the basic tools used in genetic engineering.
- Provide opportunities to learn about ethical and social implications of biotechnology.

GEB 101 (Fundamentals of Genetic Engineering and Biotechnology) Course Content

1. Biotechnology

- Definition; traditional and modern biotechnology, multidisciplinary nature of biotechnology
- Scopes and applications of biotechnology
- Careers in biotechnology

2. Potential Areas of Biotechnology

- Agricultural biotechnology:
  -Applications, scopes and opportunities of agricultural biotechnology in Bangladesh
  -Genetic manipulation in plants; seed quality improvement, nitrogen fixation and bio-fertilizers
  -Genetically Modified (GM) crops: implications and concerns
  -Biocontrol of plant pathogens, insects, pests and weeds
- Medical biotechnology:
  -Scopes and applications
  -Commercial production of antibiotics, hormones, vaccines etc.
  -Gene therapy
  -Disease diagnosis
  -Monoclonal antibodies and their applications
  -Forensic applications
- Environmental biotechnology:
  -Scopes and applications
  -Pollution control; recalcitrant molecules and xenobiotics, use of specialized microorganisms to detoxify chemicals
  -Bioremediation of water, soil; waste disposal
- Other important biotechnology fields:
  -Livestock
  -Blue biotechnology

-Improvement of culturable fish species
-Feed improvement
-Improving dairy and meat animals
-Fermentation, cheese production
-Industrial uses of enzymes

- Commercialization in Biotechnology**:**
  -Industrial application of biotechnology, challenges and scopes of biotech product commercialization.

3. Introduction to Cell and Tissue Culture Techniques

- History and scope of animal and plant cell/tissue culture
- Laboratory facilities for animal/plant cell culture
- Culture media and culture procedures; primary culture and cell lines; scopes of cell and tissue culture
- Clonal and micropropagation of plant thalli, production of virus free thalli
- Production and uses of haploids; protoplast isolation and fusion

4. Recombinant DNA Technology and its Tools

- Basics of rDNA technology; scopes and applications
- Gene cloning—concept and basic steps
- Restriction endonucleases, ligases and other enzymes used in gene cloning
- Creation of genomic and cDNA libraries
- Application of bacteria and viruses in genetic engineering
- Uses of plasmids and phages as vectors
- Methods used to introduce foreign genes into host cells
- Uses of marker genes
- Uses of *Agrobacterium* for genetic engineering in plants
- Ethics and safety-related issues of genetically engineered products

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Familiarize the basic concepts of biotechnology.
- Acquainted with current applications of biotechnology and advances in different areas like agriculture, healthcare, industry and environment.
- Explain the concept and applications of animal/plant cell and tissue culture.
- Understand the principles and methods of modern rDNA technology.
- Provide examples on how to use microbes for the production of pharmaceutical products and for bioremediation of waste materials.
- Detect problems in the areas of agriculture/health/industry/environment and generate ideas to solve those by biotechnological approach.
- Acknowledge the ethical implications of biotechnology.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	No. of classes/unit
Biotechnology: Definitions; Applications	5
Potential Areas of Biotechnology: Agricultural Biotechnology, Medical Biotechnology and Environmental Biotechnology	25
Introduction to Cell and Tissue Culture Techniques:	15
Recombinant DNA Technology and its Tools:	15
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:

- Thieman WJ, Palladino MJ. *Introduction to Biotechnology.* Pearson (4th edition, 2020 or a later edition).
- Ratledge C, Kristiansen B. *Basic Biotechnology*. Cambridge Univ. Press (2006 or a later edition).
- Gupta PK. *Biotechnology and Genomics.* Rastogi Publications (2005 or a later edition).
- Glick BR, Pasternak JJ. *Molecular Biotechnology: Principles and Applications of rDNA*. ASM Press (4th edition 2009 or a later edition).
- Glazer AN, Nikaido H. *Microbial Biotechnology: Fundamentals of Applied Microbiology.* Cambridge University Press (2007 or a later edition).
- Watson JD, Myers RM, Caudy AA, Witkowski JA. *Recombinant DNA: Genes and Genomes- A Short Course.* W. H. Freeman (3rd edition 2006 or a later edition).
- Nicholl DS. *An Introduction to Genetic Engineering.* Cambridge University Press, (2008 or a later edition).
- Old RW, Primrose SB. *Principles of Gene Manipulation: an Introduction to Genetic Engineering.* Blackwell Scientific (3rd edition 2003 or a later edition).

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 102	Basic Biology	2 Credit

Introduction to the Course:
This is a basic course covering the introduction and aspects of general biological sciences. Students will be introduced with the different wings of biological sciences, especially with the plant, animal, and fungal kingdom, environmental biology, ecology and biodiversity, and biodiversity conservation from the perspective of Bangladesh.

Specific objectives:
The study of this course will

- Enable students to gain basic knowledge on life science, ecology, and evolution.
- Provide opportunities to the students so that they become familiar with kingdoms of living organisms, their basic structure, habitat, reproductive strategies, and potential application.
- Provide the students an introduction on fundamental principles of environmental biology, ecology, ecosystems, biodiversity, and ecological conservation strategies.

GEB 102 (Basic Biology) Course Content

1. Concepts of Life and Evolution

- Definition and key characteristics of life
- Theories on origin of life
- Oparin's hypothesis and Miller-Urey experiment on origin of biological micromolecules
- Formation of macromolecules from biological micromolecules
- Nucleic acids as early functional biomolecule
- Formation of protocell
- Origin and evidence of early prokaryotes and eukaryotes
- Geological time scale of life
- Microevolution and macroevolution

2. Protists and Fungi

- Types, characteristics and economic importance of protists
- Slime molds
- Fungi
- Endophytes
- Lichens

3. Green plants

- Green algae
- Bryophytes
- Pteridophytes
- Gymnosperms
- Angiosperms

4. Animals and model organism

- Major phyla of animals
- Definition, characteristics, and advantages of model organisms
- *Drosophila melanogaster*: maintenance of fly stocks, identification, virgin female flies
- *Mus musculus*: husbandry, breeding and pup identification

5. Ecology and Environmental Biology

- Structure and components of ecosystem
- Flow of energy and matters within an ecosystem
- Ecological niche
- Predator-prey interaction
- Symbiosis: Types and examples
- Population and factors affecting population

6. Biodiversity and Conservation Biology

- Concepts of biodiversity and conservation
- Elements of biodiversity
- Biomes
- Biodiversity of Bangladesh (flora & fauna)
- NBSAP objectives and efforts in Bangladesh

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Recognize biology as a natural science and conceptualize the nature and origin of life.
- Explain the similarities and differences among different groups of living things.
- Investigate diverse species of microbes, protists, plants and animals.
- Observe the interactions of different species among themselves, other species and the environment.
- Evaluate the effects of human activities on biodiversity and the ecosystem.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Concepts of Life and Evolution	5
Protists and Fungi	3
Green plants	5
Animals and model organism	7
Ecology and Environmental Biology	5
Biodiversity and Conservation Biology	5
Total	**30**

Instructional Strategies:

- Lecture with traditional method

- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:

- Mason K, Duncan T and Losos J. Understanding Biology. McGraw-Hill. (3rd Edition. 2021. or a later edition).
- Urry LA, Cain ML, Wasserman SA, Minorsky PV, Jackson RB. Campbell Biology. Pearson. (12th Edition, 2020 or a later edition).
- Solomon E, Martin C, Martin DW, Berg LE. Biology. Cengage Learning. (11th Edition, 2018 or a later edition).
- National Biodiversity Strategy and Action Plan of Bangladesh 2016-2021. Department of Environment. Ministry of Environment and Forest. Government of the People's Republic of Bangladesh. 2016.
- 6th National Report for the Convention of Biological Diversity. Government of the People's Republic of Bangladesh. 2019.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 103	**Basic Biochemistry**	**4 Credit**

Introduction to the Course:

Biochemistry is the study of living organisms at the cellular and molecular level. The course is broadly–based and is devoted to the structure and function of macromolecules, gene expression, and molecular aspects of cell structure and function, discussed in the context of prokaryotic and eukaryotic organisms. With a detail description about the double helical structure of DNA, this course will impart elementary ideas about DNA sequence and mutations. As a whole, this course will implant in-depth knowledge on molecular and cellular aspects of living systems preparing students for implementation in Biotechnology.

Specific objectives:

The study of this course will

- Enable students to understand the cell: structural & functional units of life, their organization and processes at molecular level.
- Students will recognise the special properties of water and how the aqueous environment influences the behaviour of biological macromolecules.

- 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 & translation
- Learn the structure of fundamental monosaccharides, polysaccharides and lipids and their roles in biological systems
- Emphasise on learning about the central aspects of the flow of information from DNA, RNA to protein & apply them in genetic engineering.

GEB 103 (Basic Biochemistry) Course Content

1. Structure and Organization of the Cell

- Distinguishing features of living organisms, Discovery of cells, Cell theory
- Structural features and comparison of prokaryotic, eukaryotic, plant and animal cells
- Isolation of subcellular organelles, Characteristic features and functions of nucleus, ribosomes, endoplasmic reticulum, Golgi apparatus, Lysosomes, Vacuoles, Peroxisomes, Glyoxysomes, Mitochondria and Chloroplast
- Biological membranes, Cytoskeleton, Cell coverings, Cell junctions
- Cell cycle, Mitosis and Meiosis

2. Amino acids, Peptides and Proteins

- Amino acids: structural features, nomenclature, classification, zwitterion, pK_a and pI
- Peptides: peptide bond, biologically active peptides
- Proteins: classification, primary structure, secondary structure, tertiary structure, quaternary structure

3. Carbohydrates

- Biological importance, classification and abundance
- Monosaccharides: structural features, stereoisomers and derivatives
- Disaccharides: examples, glycosidic bond, reducing and non-reducing sugars
- Polysaccharides: structural features and biological roles of homopolysaccharides and heteropolysaccharides
- Glycoconjugates: proteoglycans, glycoproteins, glycolipids

4. Lipids

- Fatty acids, Triacylglycerols
- Membrane lipids
- Lipids as signals, cofactors and pigments

5. Nucleic Acids

- Nucleotides: classification, structures, phosphodiester linkage
- DNA: evidence of DNA as hereditary material, double-helix structure, Watson-Crick model, different three-dimensional forms, unusual secondary structures
- RNA: structural features, classification, mRNA, rRNA, tRNA and other non-coding RNAs

- Nucleic Acid Chemistry: heat denaturation, annealing, DNA hybridization, methylation
- Functions of nucleotides as energy carriers, enzyme cofactors and secondary messengers

6. Central Dogma of Molecular Biology

- Details of central dogma
- DNA Replication: proof of semiconservative replication, overview of replication
- Transcription: brief overview of transcription, reverse transcription
- Translation: genetic code, overview of protein synthesis

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Familiarize the basic concepts of biochemistry.
- Understand the molecular and cellular organization of living cells, cellular organelles, membranes and Cell division
- Obtain profound knowledge on the structure and biological functions of biomolecules of life - Carbohydrates, Lipids, nucleic acids and proteins.
- Understand the principles of protein structure and function from the detail perception of amino acid composition and sequence determination methods
- Acquainted to basic cellular genetic information pathways: DNA replication, transcription and translation

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Structure and Organization of the Cell	12
Amino acids, Peptides and Proteins	10
Carbohydrates	10
Lipids	8
Nucleic Acids	8
Central Dogma of Molecular Biology	12
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any

- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:
- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:
- Nelson, D., Cox, M., & Hoskins, A. (2021). *Lehninger Principles of Biochemistry*. 8th edition or a later edition, Macmilan Learning.
- McKee, J., & McKee, T. (2019). *Biochemistry: The Molecular Basis of Life.* 7th edition or a later edition, Oxford University Press.
- Voet, D., Voet, J., & Pratt, C. (2016). *Fundamentals of Biochemistry: Life at the Molecular Level.* 5th edition or a later edition, John Wiley & Sons, Inc.
- Solomon, E., Martin, C., Martin, D., & Berg, L. (2019). *Biology.* 11th edition or a later edition, Cengage.
- Raven, P., Johnson, G., Mason, K., Losos, J., & Duncan, T. (2020). *Biology.* 12th edition or a later edition, Mc Graw Hill Education.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 104	Basic Microbiology	4 Credit

Introduction to the Course:
Basic Microbiology is an appropriate course for students with background in biology and chemistry. This course will introduce the students about the nature and diversity of microorganisms and their potential implications. The course will cover comparative properties of prokaryotic microbes, as well as their roles as disease agents, ecological agents and model systems used to understand the fundamental biological processes at the molecular level. Lecture topics will also explore the basic principles of microbiology and their applications.

Specific objectives:
The study of this course will
- Explain the basic principles of microbiology.
- Identify the structures of microorganisms and describe the functions of each structure.
- Explain microbial growth, diversity and ubiquity.
- Explain both beneficial and harmful interactions between microbes and other forms of life.
- Explain the basic of microbiology laboratory methods, with an emphasis on safety and aseptic technique.
- Enable students to know the importance of microorganisms in biotechnology industries.

GEB-104 (Basic Microbiology) Course Content

1. Historical development

- The theory of spontaneous generation;
- the First Golden age of microbiology: contributions of Pasteur, Koch, Lister, Fleming and Waksman and others; the Second Golden age of microbiology: advent of molecular biology and recombinant DNA technology of microbiology.
- Brief introduction to the modern era of microbiology

2. Microscope and observing microorganisms:

- Development and characteristics of microscopes, different types of microscopes; sample preparation for microscopic observations
- Principle of staining, types of staining.

3. Bacteria

- Structure and anatomy of bacterial cell;
- Identification of common bacteria;
- Classification of bacteria;
- Common groups of eubacteria and their economic importance

4. Microbial growth and control

- Bacterial cell division and growth; growth curve; Factors affecting bacterial growth;
- Methods of estimation and enumeration of bacteria;
- Culture media;
- Establishment and maintenance of pure culture, preservation of culture;
- Disinfection and sterilization; physical and chemical methods of controlling microbial growth.

5. Virus

- Structural features and general characteristics of virus particles
- Isolation, cultivation and identification of viruses
- Multiplication of viruses, one-step growth curve
- Bacteriophages
- Classification of animal and plant viruses
- Common human viral pathogens
- Viroids and prions

6. Algae and Fungi

- Characteristics of algae and fungi
- Sexual and asexual reproduction of fungi
- Fungal diseases
- Economic importance of algae and fungi

7. Actinomycetes

- Characteristics of actinomycetes
- Economic importance of actinomycetes in industrial and natural processes

8. Infectious diseases: host-microbe interactions

- Classification of infectious diseases;
- Spread of infections; portals of entry and exits; adherence, penetration and damage of the host
- Non-specific and specific defenses of the host
- Microbial drug resistance

9. Introductory applied microbiology

- Fermentation technology in food, beverage, chemical and pharmaceutical industries;
- Food spoilage and food preservation;
- Microbial wastewater treatment,
- Generation of biogas and biofuel,
- Bioremediation;
- Commercial products from primary- and secondary metabolites;
- Microbial pest control,
- Microbial nitrogen fixation;
- Roles of microbes in biogeochemical cycles.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Demonstrate comparative characteristics of microbial organisms
- Understand general microbial principles and techniques
- Recognize pathogenicity, virulence, and epidemiology
- Familiarize disease transmission and control, body defences and immunity.
- Explain microbial control by physical and chemical methods
- Collect, handle and culture of microorganisms.
- Know about common bacterial, fungal, and viral diseases

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Historical development	4
Microscope and observing microorganisms	4
Bacteria	7
Microbial growth and control	8
Virus	7
Algae and Fungi	5
Actinomycetes	5

Infectious diseases: host-microbe interactions	10
Introductory applied microbiology	10
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:

- Tortora, G. J., Funke, B. R., Case, C. L. (2019). Microbiology: an introduction (13th edition or a later edition, Pearson)
- Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., Stahl, D. A. (2019). *Brock Biology of Microorganisms* (15th edition or a later edition, Pearson)
- Pelczar, M. J. Jr., Chan, E. C. S., Krieg, N. R. (2004). *Microbiology* (5th edition or a later edition, Tata McGraw Hill)
- Wilson, B. A., Winkler, M., Ho, B. T. (2019). *Bacterial Pathogenesis: A Molecular Approach* (4th edition or a later edition, ASM Press)
- Denyer, S. P., Hodges, N., Gorman, S. P., Gilmore, B. F. (2011). *Hugo and Russell's Pharmaceutical Microbiology* (8th edition or a later edition, Wiley-Blackwell)
- Pommerville JC. Alcamos' Fundamentals of Microbiology. Jones and Bartlett (9th edition, 2010 or a later edition)

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 105	Human Physiology	4 Credit

Introduction to the Course:

This course covers the physiology of humans, with emphasis on the major organs and the processes they govern, including heart function and circulation, muscle function and movement and the kidney and osmo-regulation, brain and nervous system etc. It is a broad science which aims to understand the mechanisms of living, from the molecular basis of cell function to the integrated behaviour of the whole

body. Without an understanding of basic physiology, progress made in other areas – such as in life science is very limited because every biological advance must ultimately be related to the behaviour of the whole organism.

Specific objectives:
The study of this course will

- Enable students to learn the scientific concepts relating to a broad range of topics in physiology.
- Enable to become familiar with the basic concerning the mechanisms and functioning of human activities.
- Enable students to know about body composition, organs and systems.
- Help to gain confidence in applying this knowledge, in a quantitative manner where appropriate, to actual experiments.

GEB 105 (Human Physiology) Course Content

1. **Tissues and Organs:**
   - Basic structural features of human body
   - Types and Functions of tissues (Epithelial, connective, muscular and neuronal tissues)
   - The ultrastructure of muscle, molecular mechanism of muscle contraction
   - The organs and organ systems
   - Control systems and maintenance of homeostasis, Transport processes
2. **Digestive System**
   - General Anatomy
   - The digestive processes and functions
   - Digestive enzymes: composition, function and regulation of salivary, gastric, pancreatic, bile and intestinal juices
   - Digestion and absorption of protein, fat and carbohydrates
   - Balance diet, Importance of vitamins, minerals and trace elements
3. **Gastro-intestinal (GI) system and Liver**
   - An overview of GI system (mouth, pharynx, oesophagus, stomach, pancreas, small and large intestine), Gross anatomy, microscopic anatomy and functions of the liver
4. **Cardiovascular and the circulatory system**
   - Anatomy of heart, Systemic, pulmonary and coronary circulation
   - Cardiac muscle and the conduction system
   - The cardiac cycle, Electrical and contractile activity of the heart and electrocardiogram (ECG)
   - Circulatory system: Physiological classification of blood vessels
   - Cardiac output, Blood pressure, Regulation of blood pressure
5. **Respiratory System**
   - Introduction to cardiopulmonary anatomy and physiology
   - Mechanism of respiration, Pulmonary and alveolar ventilation
   - Diffusion and Transport of O_2 and CO_2
   - Regulation of Respiration, Lungs defence mechanisms

6. **Brain and Nervous system**

- Overview of brain and nervous system
- The neural circuits, Organization of cerebral cortex, brain stem, cerebellum and spinal cord
- Structure and function of central nervous system (CNS) and peripheral nervous system (PNS)
- Structure of neuron, Origin and propagation of nerve impulse
- Synapse and myoneural junction, Neurotransmitter
- Special senses (Vision, Audition, Taste and Smell)
- Higher brain functions (Brain waves and sleep, Cognition, Memory, Emotion, Sensation, Motor
- control, Speech and language)

7. **Renal System**

- Micro-architecture and function of kidney
- Nephron, Glomerular filtration, Mechanism of urine formation
- Role of kidney in the regulation of water, salt, blood pressure and acid base balance
- Renal insufficiency and haemodialysis

8. **Blood**

- Composition and function of blood, plasma and serum
- Erythrocyte (RBC), and Haemoglobin (Formation, structure, and function), ESR
- Erythrocyte disorders
- Leukocytes (WBC) (types, structure, properties and function), Abnormalities of leukocyte count
- Blood coagulation (Coagulation factors, Mechanism of blood coagulation)
- Blood group (ABO and Rh blood group system), Blood transfusion and cross matching test
- Erythroblastosis fetalis

9. **Endocrine System**

- Endocrine glands, Hormones and other signalling molecules, Mechanisms of hormonal action
- Hormones of endocrine glands (Hypothalamus, Pituitary gland, Thyroid gland, Parathyroid gland, Pancreas, Adrenal gland, Testes, Ovary and Placenta) and their functions.
- Consequence of endocrine malfunction

10. **Reproductive System**

- Overview of human reproductive physiology, puberty
- The male reproductive system (Spermatogenesis and regulation of Spermatogenesis)
- The female reproductive system (Ovulation, menstruation, menstrual cycle and its regulation)
- Pregnancy, Lactation, Male and female sterility, Birth control methods

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Understand the details of how the different cells, tissues, organs and systems of the body are integrated.
- Describe the physiology of body organs.
- Understand the physiology and function of digestive system, renal system, endocrine system, gastrointestinal system
- Describe the structure and functions of the blood & blood vessel.

- Understand how the nervous system controls the body parts.
- Understand the exchange and transportation of gases.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Tissues:	4
Digestive Systems:	4
Gastro-Intestinal (GI) System and Liver:	4
Cardiovascular and the Circulatory System:	6
Respiratory System:	7
Brain and Nervous System:	7
Renal System:	7
Blood:	7
Endocrine System:	6
Reproductive System:	8
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings*:*

- Barrett KE, Barman SM, Boitano S, Brooks H. *Ganong's Review of Medical Physiology (*24th Edition or a later edition*).* New York, McGraw-Hill (2012).

- Sylvia SM, Boyd RN. *Understanding Human Anatomy & Physiology (*5th Edition or a later edition*).* New York, McGraw-Hill (2010).
- Saladin KS. *Anatomy & Physiology: A Unity of Form and Function (*6th Edition or a later edition*).* Boston, McGraw Hill (2012).
- Guyton C and Hall JE. *Textbook of Medical Physiology (*12th Edition or a later edition*).* Philadelphia, WB Saunders (2010).
- Marieb EN, Wilhelm PB, Mallat JB. *Human Anatomy and Physiology (*10th Edition or a later edition*).* New York, Benjamin Cummings (2011).
- Jenkins G, Kemnitz C, Tortora GJ. *Anatomy and Physiology: From Science to Life (*3rd Edition or a later edition*).* New York, John Wiley (2012).

Additional reading materials may be suggested by the respective course instructor(s).

GEB 106	Chemistry for Biologists-1	4 Credit

Introduction to the Course:

This is an extra-departmental course. This course will focus on the basic concepts of chemistry with applications in biology. The course is designed with an attempt to teach the students about the fact that life is a result of a set of chemical reactions which follow the laws of physics and chemistry. The logical sequence of the course contents will help the students to develop the basic principles of chemistry. These principles can be applied to the biomolecules that make up cells and to the biochemical reactions that derive energy allowing biological systems to function.

Specific objectives:

The study of this course will:

- Enable students to recognize the basic concepts of inorganic, organic and physical chemistry
- Equip students with an understanding of the fundamental principles of chemistry applied to biological systems.
- Provide opportunities to learn about the applications of the laws of chemistry in biological processes.

GEB 106 (Chemistry for Biologists-1) Course Content

1. **Physical Chemistry**
   - **Basic Concepts:**
     - Energy and Matter: Energy, Matter, Phases and Classification of Matter, Physical and Chemical Properties of Matter
     - Measurements: Uncertainty, Accuracy, and Precision, Treatment of Measurement Results
     - Stoichiometry of Formulas and Chemical Equations
     - Major Classes of Chemical Reactions
   - **Structure and Bonding:**
     - Components of Matter: Atoms, Molecules, Elements, Compounds, and Mixtures
     - Atoms: Evolution of Atomic Theory, Dalton's Atomic Theory, Nuclear Atomic Model, Atomic Structure, Quantum-Mechanical Model of the Atom, Atomic Orbitals, Characteristics of Many-Electron Atoms, Atomic Spectra
     - Elements: Periodic Table, Electron Configuration and Chemical Periodicity, Quantum-Mechanical Model and the Periodic Table, Atomic Structure and Chemical Reactivity

- Compounds: Chemical Bonding, Ionic, Covalent and Metallic bonding, Theories of Covalent Bonding, Bond Energy and Chemical Change, Types of Chemical Formulas, Depicting Molecules and Ions with Lewis Structures, Valence-Shell Electron-Pair Repulsion (VSEPR) Theory
- Intermolecular Forces: Liquids, Solids, and Phase Changes, Physical States and Phase Changes, Phase Diagrams, Types of Intermolecular Forces, Properties of the Liquid State, Uniqueness of Water, Structure, Properties, and Bonding of Solid State
- Mixtures: Classification and Separation, Solutions and Colloids, Types of Solutions, Structure and Properties of Colloids

- **Thermodynamics:**
  - Thermochemistry: Energy Flow and Chemical Change, Forms of Energy and Their Interconversion
  - First Law of Thermodynamics: Conservation of Energy, Enthalpy, Heats of Reaction and Chemical Change, Stoichiometry of Thermochemical Equations, Hess's Law of Heat Summation, Standard Heats of Reaction
  - Second Law of Thermodynamics: Entropy, Free Energy, and the Direction of Chemical Reactions, Effect of Temperature on Reaction Spontaneity
  - Statistical Thermodynamics: Concepts and Applications
- **Chemical Equilibrium**
  - Basic Concepts: Equilibrium State, Equilibrium Constant, Reaction Quotient, Relation Between Kc and Kp, Reaction Direction, Reaction Conditions and the Equilibrium State, Le Chatelier's Principle
  - Acid-Base Equilibria: Acids and Bases in Water, Autoionization of Water and the pH Scale, Proton Transfer and the Brønsted-Lowry Acid-Base Definition, Leveling Effect, Lewis Acid-Base Definition, Acid-Base Strength, Weak Acid-Base Equilibria, Equilibria of Acid-Base Buffer Systems

2. **Inorganic Chemistry**
   - **Periodic Patterns in the Main-Group Elements:** Hydrogen, Alkali Metals, Alkaline Earth Metals, Boron Family, Carbon Family, Nitrogen Family, Oxygen Family, Halogens, Noble Gases
   - **Transition Elements and Their Coordination Compounds:** Properties of the Transition elements, Inner Transition Elements, Coordination Compounds, Complex Ions, Coordination Numbers, Geometries, and Ligands, Alfred Werner and Coordination Theory, Application of Valence Bond Theory to Complex Ions, Crystal Field Theory
3. **Organic Chemistry**
   - **Basic Concepts:**
     - Atomic Properties of Carbon: Structural Complexity, Chemical Diversity Allotropes of Carbon
     - Hydrocarbons: Structures and Classes of Hydrocarbons, Nomenclature of Organic Compounds, Conformation, Isomerism, Aromaticity
     - Stereochemistry: Basic Principles of Stereochemistry, Cis-Trans Isomers, Chirality, Dexter and Laevus (D And L) Designation, R and S designation
   - **Properties and Reactivity of Common Functional Groups**
     - Types of Organic Reactions: Oxidation-Reduction, Substitution Reactions, Addition Reactions, Elimination Reactions
     - Reactions of Functional Groups: Functional Groups with Only Single Bonds, Functional Groups with Double Bonds, Functional Groups with Single and Double Bonds, Functional Groups with Triple Bonds
     - Preparations and Reactions of Specific Functional Groups: Alkane, Alky Halide, Alkene, Alkyne, Alcohol, Ether, Cyclic Aliphatic Compounds, Benzene

- Radical Reactions

4. **Analytical Chemistry**
   - **Calorimetry:** Laboratory Measurement of Heats of Reaction
   - **Acid-Base Titration Curves:** Strong Acid-Strong Base Titration Curves, Weak Acid-Strong Base Titration Curves, Weak Base-Strong Acid Titration Curves, Titration Curves for Polyprotic Acids
   - **Ionic Equilibria in Chemical Analysis:** Selective Precipitation, Identifying Ions in Complex Mixtures
5. **Biological Chemistry**
   - **Chemical Equilibrium in Biology**: Design and Control of Metabolic Pathways
   - **Thermodynamics in Biology**: Coupling of Reactions to Drive a Nonspontaneous Change, Universal Role Of ATP, Dissipative Structures in Biological Systems
   - **Molecular Self-Assembly in Biology:** Concept of Self-Assembly, Self-Assembly of Lipids into Membranes, Liposomes, Protein Folding, Membrane Proteins, Cytoskeleton and Viruses.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Understand the importance of subdivisions of the periodic table: periods, groups, metals and nonmetals and to understand the various aspects of interactions among the elements forming chemical and biological molecules.
- Recognize the interrelationship of the structure of matter and its physical and chemical properties.
- Describe the concept of thermodynamics, reaction kinetics and other associated terms and their applications in biology.
- Understand the role of acid-base reactions, buffer systems and pH in biochemical systems.
- Explain the importance of carbon compounds along their with classification and the properties of the major groups of saturated and unsaturated organic compounds with the importance of unsaturation in biomolecules.
- Identify the role of functional groups in various chemical reactions and their effect on the physical and chemical properties of organic compounds and understanding the importance of polarity in biomolecules.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Physical Chemistry	27
Inorganic Chemistry	4
Organic Chemistry	23
Analytical Chemistry	3
Biological Chemistry	3
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:

1) Sackheim GI. (2008). *Introduction to Chemistry for Biology Students* (9th edition or a later edition). Benjamin Cummings.

2) Fisher J, Arnold J. (2012). *Instant Notes in Chemistry for Biologists* (3rd edition or a later edition). Garland Science.

3) Ebbing D, Gammon SD. (2011). *General Chemistry* (9th edition or a later edition). Brooks Cole

4) Kask U. (1993). *General Chemistry*. McGraw Hill

5) Solomons TWG, Fryhle CB. (2016). *Organic Chemistry* (12th Edition or a later edition). John Wiley.

6) Morrison RT, Boyd RN. (2011). *Organic Chemistry* (7th Edition or a later edition). Prentice Hall.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 107	Mathematics for Biologists	2 Credit

Introduction to the Course:

This course is designed to build students' strengths to increase overall mathematical understanding and skill. This course will focus on several topics to develop conceptual understanding and mathematical relevance; linear relationships; exponents and polynomials; rational expressions and equations; exponential and logarithmic functions; and geometry and trigonometry. Emphasize is given on conceptual understanding and problem solving rather than theory.

Specific objectives:

The study of this course will

- Provide students an intense foundational introduction to the fundamental concepts in Mathematics.
- Train students thoroughly in methods of analysis, algebra, functions, geometry, calculus, and differential equations.

- Develop the skills pertinent to the practice of mathematics, including the students' abilities to formulate problems, to think creatively, and to synthesize information.
- Enable students to use current mathematical concepts and data analysis techniques for problem solving.

GEB 107 (Mathematics for Biologists) Course Content

1. Functions and Their Graphs

- Functions, Graph of a Function, Properties of Functions, Library of Functions, Piecewise- defined Functions
- Graphing Techniques: Transformations, Mathematical Models: Building Functions, Composite Functions, One-to-One Functions, Inverse Functions, Exponential Functions, Logarithmic Functions
- Properties of Logarithms, Logarithmic and Exponential Equations
- Mathematical models to Biology, HIV density and exponential decay, population growth, elimination of a drug from the body, the biomechanics of human movement

2. Linear and Quadratic/ Polynomial Functions

- Properties of Linear Functions and Linear Models, Building Linear Models from Data
- Quadratic Functions and Their Properties, Build Quadratic Models from Verbal Descriptions and from Data, Inequalities Involving Quadratic Functions
- Polynomial functions
- Coding function of DNA.

3. Sequences and Series

- Sequences, Arithmetic Sequences, Geometric Sequences
- Mathematical Induction, Binomial Theorem
- Drug resistance in Malaria, Steady state drug levels, Accumulation of toxins in the body, geometric series in drug levels models to biology

4. Matrix Models

- Matrices and determinants, Systems of linear equations, Eigenvalues and Eigenvectors
- Emergence of geometric order in proliferating cells, models to biology

5. Coordinate Geometry

- The coordinate plane, Test for symmetry and their applications, Equations of lines and Circles and their graphs, Polar coordinates, Applications and Extensions of both rectangular and polar coordinates
- Translations of axes, Equation of a curve in a translated system, Graphing a translated conic,
- Rotation of axes, analysing an equation using a rotation (identify and sketch), Identifying conics without rotation (use discriminant)
- Definitions of parabolas, ellipses and hyperbolas and their standard equation, Solving applied problems involving parabolas, ellipses and hyperbolas

- 3-D coordinate system and applications to human biomechanics, Species, Vaccine design and vaccination.

6. Calculus

- Differential: Limits, Continuity, Derivatives and rate of change, Derivatives as a function, Basic formulas, Product and quotient rules, Chain rule, Exponential growth and decay, Implicit differentiation, Derivatives of logarithmic functions
- Applications of differentiations (Controlling red blood cell, Loss during surgery, Antibiotic effectiveness, the surge function, Drug concentration, Applications to biology, Planes and birds: Minimizing energy, Shape of a Can etc.), Maximum and minimum values
- Integrals: The definite integral, Fundamental theorem of calculus, Substitution rules, Integration by parts, Trigonometric substitutions, Partial fractions, Improper integrals
- Applications of integrals (Area, Cerebral blood flow, Disease progression and immunity, Survival and renewal, Blood flow, Cardiac output, Integrating relative growth, Population growth rates etc.)

7. Modelling with Differential Equations

- Mathematical Modelling: Setting Up a Differential Equation (Marine harvesting, Pollution in lake, Quality of a drug in the body, Logistic model), Solutions of Differential Equations (Another look at a Marine harvesting, Formula for the solutions, Initial and boundary conditions, General and particular solutions), Exponential Growth and Decay
- Applications and Modelling (The quantify drug in the body, Solving $dy/dt = k (y-A)$, Equilibrium solutions, Modelling the Interaction of Two Populations (A predator-Prey model, Phase line, Slope field and Equilibrium points, other forms), Modelling the Spread of a Disease (Flu in a boarding school, S-I-R model, Phase plane, Threshold value).

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Understand the concept of functions and will be able to perform operations with functions algebraically, graphically, and analytically.
- Learn basic properties of polynominal and rational functions and will apply these properties to develop graphs of these functions.
- Learn basic properties of exponential and logarithmic functions and will solve exponential and logarithmic equations.
- Understand trigonometric functions in terms of both the right triangle definition and the circular definition.
- Recognize the relationship between a function and an algorithm
- Understand concept and definition of a limit and know notation used for limits.
- Use their overall mathematical knowledge to analyze and solve problems

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Algebra	5

Sequences and Series	5
Functions	5
Co-ordinate Geometry	5
Calculus	5
Differential Equations	5
Total	**30**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Practice problem solving
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested readings:

- Anton H, Rorres C. *Elementary Linear Algebra with Application.* John Willey (2008 or a alter edition)
- Simmons GI. *Calculus with Analytic Geometry.* McGraw Hill (1996 or a later edition).
- Swokowski EW. *Calculus with Analytic Geometry.* Brooks Cole (2nd edition 1979 or a later edition).
- Ross SL. *Differential Equations.* Willey (3rd edition 1984 or a later edition).
- Bernard S, Child JM. *Higher Algebra* (originally published 1939).
- http://zpmbvb.typepad.com/blog/2011/11/higher-algebra-e-book-downloads.html

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 108 Physics for Biologists 2 Credit

Introduction to the Course:

Almost any scientific problem can be approached using the ideas and methods of physics. This course introduces the use of physical methods in the study of biological systems. Biophysics makes use of physical concepts and techniques to address problems in biology. Physics has been very successful at illuminating fundamental aspects of biological problems at the molecular level. This course will focus to expose students to modern topics in biophysics. This course will cover a broad spectrum of topics including aspects of biotechnology, bioengineering, nanotechnology, biomedical physics etc.

Specific objectives:

The study of this course will

- Enable students to describe the basic principles behind all physics
- Enable to learn the use of biological examples of physical principles
- Help to understand the theoretical basis and practical use of laws and physical phenomena and biophysical regularities in medical diagnostics, prophylaxis and therapy.

GEB 108 (Physics for Biologists) Course Content

1. **Fluid Mechanics:**
    - Nature of fluids and types
    - Dimension and units
    - Force and kinematics
    - Friction and drag, Poiseuille's equation, Viscosity, Strokes formula
    - Laminar and turbulent flow
    - Blood velocity and turbulence
2. **Electricity and Magnetism:**
    - The nature of electric charge, Coulomb force
    - Electrical potential, electric field, electric dipole, Ohm's law; Kirchhoff's law
    - Capacitors and dielectrics, RC circuits, capacitor charging, discharging and its application in biology
    - EMF, electromagnetic oscillations, electromagnetic spectrum (radio, micro-waves, infra-red, optical, ultraviolet, X-rays, alpha, beta and gamma rays) including elementary facts about their properties, uses and propagation
    - Magnetic field, nuclear magnetic resonance (NMR)
3. **Biophysical Phenomena of Light:**
    - Polarimeter
    - Photochemistry and transmitter of vision, Interaction of Light with Cells and Tissues
    - Light attenuation in vision
    - The eye as an optical instrument, illumination of retina; formation of image
    - Effects of long continued exposure of light
    - Biological light (bioluminescence)
    - Laser beam in diagnosis and therapy.
4. **Basic Electronics and Biosensors:**
    - Solid state electronics devices and their applications
    - Diode, transistors and amplifiers
    - Biosensors: miniaturization, microsystems- sensing using optical techniques, ion-selective and enzyme-sensitive electrodes and their monitoring, commercial biosensors (glucose monitoring and DNA analysis)
5. **Nucleonics and Nuclear Medicine:**
    - Radioactivity and its detection
    - Radioactive decay
    - Isotopes
    - Biological effects of radiation, radiation hazard
    - Positron emission tomography
    - X-ray imaging
    - Magnetic resonance imaging

6. Biochemical Instruments:

- Phase contrast microscope, florescence microscope, laser confocal microscope
- Scanning electron microscope, Transmission electron microscope

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Apply fundamental physical principles and concepts to biological phenomena.
- Recognize the nature of biophysics, from molecular to cellular and organism levels.
- Appraise recent advances in biophysics.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Fluid Mechanics:	5
Electricity and Magnetism:	4
Biophysical Phenomena of Light:	4
Basic Electronics and Biosensors:	4
Nucleonics and Nuclear Medicine:	4
Biochemical Instruments:	4
Acoustics:	5
Total	**30**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings*:*

1. Halliday D, Resnick R, Walker J. *Fundamentals of Physics (*9th Edition or a later edition*).* New York John Wiley (2010).
2. Beiser A. *Concepts of Modern Physics (*6th Edition or a later edition*).* McGraw-Hill (2003).
3. Franklin K, Muir P, Scott T, Wilcocks L, Yates P. *Introduction to Biological Physics for the Health and Life Sciences (*1st Edition or a later edition*),* John Wiley and Sons Ltd (2010).
4. Mathur DS, *Elements of Properties of Matter (*7th Edition or a later edition*)* S. Chand & Co.(2007)
5. Davidovits P. *Physics in Biology and Medicine* (3rd Edition or a later edition). New York, Academic Press (2007).
6. Boylestad RL, Nashelsky L, *Electronic Devices and Circuit Theory (*11th Edition or a later edition*),* Pearson (2013).
7. Malhotra BD and Pandey CM, *Biosensors: Fundamentals and Applications (*1st Edition or a later edition*),* Smithers Rapra Technology Ltd (2017)
8. Roy RN. *A Text Book of Biophysics*. New Central Book Agency Ltd. India (2009).

Additional reading materials may be suggested by the respective course instructor(s).

GEB 109	Laboratory Experiments	4 Credit

Introduction to the Course:

This course is designed to let the students perform experiments in Labs with an aim to make them understand the core concepts, theories and topics that are delivered in their class lectures. Experience in Lab work not only helps to eliminate doubts but also generates an interest in the subject. This course allows the students to know about the Lab safety guidelines and to develop practical skills maintaining good laboratory practices. In the Lab classes, students are instructed to follow a number of established protocols in order to attain a predicted result. The main purpose of each experimental class is to carry out experimental techniques properly to obtain data that should match with the predicted results. The experimental observations/results are then used to re-examine the theoretical concepts for better understanding. The Laboratory Experiment course thus considers Lab work as an integral part of the Biotechnology Curriculum in undergraduate level.

Specific objectives:

Performing Lab experiments under this course will

- Provide the students an opportunity to apply and investigate theoretical and conceptual knowledge.
- Help to learn a range of experimental techniques and approaches related to basic biochemistry/molecular biology/microbiology.
- Help to develop skills in handling the apparatus/instruments and taking readings on them.
- Enable students to record experimental data, analyse them and present their finding.
- Create opportunity of practising a wide range of skills such as problem solving, team working, instrument sharing, and protocol following.
- Allow students to learn about risks involved in laboratory experiments and to work more safely following bio-safety measures.

GEB 109 (Laboratory Experiments) Course Content

1. Introduction to laboratory, laboratory facilities and safety.
2. *Introduction of laboratory instruments and its operation.*
3. Preparation of buffers and other solution.
4. Preparation of normal solution of Na_2CO_3 and determination of the strength of HCl solution by titration method
5. Estimation of ascorbic acid content by Bessel's titrimetric method.
6. Estimation of acetic acid content of the supplied vinegar solution.
7. Standardization of Potassium Permanganate solution against Sodium Oxalate as primary standard
8. Determination of protein concentration by BIURET and Lowry method
9. Laboratory measurement of heat of reactions
10. Preparation of microbiological culture media
11. Inoculation and culturing of bacteria and fungi
12. Obtaining a pure culture; short- and long-term preservation of culture.
13. Determination of protease activity of bacteria, a qualitative test
14. Motility, Indole and Urease (MIU) Test
15. Gram staining and morphological study of bacteria.
16. Antimicrobial susceptibility testing of bacteria by agar diffusion method.
17. Growth of bacterial population: growth curve
18. DNA extraction from a biological sample.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Know the responsibilities and duties in the laboratory.
- Follow the proper bio-safety guidelines and understand the importance of personal protective equipment during the laboratory experiment.
- Follow a protocol independently, practice Good Lab Procedures and perform accurately all experimental procedures.
- Carry out a wide range of biochemical/microbiological procedures and techniques.
- Analyze experimental results, interpret them and make conclusions.
- Demonstrate competent approach in the classroom and workplace, including accountability, ethics, time management, etiquette and appropriate dress.
- Utilize technical skills acquired through lab experience and apply these skills in formulating solutions to life science questions.

Instructional Strategies:

- Interactive class Lectures on principle, procedure and application of each experiment
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Hands-on Laboratory training
- Encourage group discussions

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment

- Practical note-book assessment
- Final Examination: Assessment of written test
- Viva voce

Suggested Readings:

- Protocols, reading materials and other learning resources will be provided by the course teachers.
- Additional reading materials and internet learning resources will be suggested by the course teachers.

GEB 110	Viva voce	2 Credit

Introduction to the Course:

After completion of all theory course examinations of First Year, students will face a viva voce (oral examination) conducted by the respective examination committee approved by the University. The viva voce is an important mode of assessment, providing an opportunity for the students to demonstrate their knowledge, approach and understandings with the examiners.

Specific objectives:

Oral examination will

- Help to develop students' confidence in answering questions asked by the examiners.
- Prepare students to be ready for answering any related questions covering the whole courses offered in the academic year.
- Provide an opportunity for students to test their communication skills.
- Offer scopes for those who are less confident in the written exams to demonstrate their learning orally
- Create opportunity to practise for job interviews

GEB 110 (Viva voce) Course Content

All courses offered in First Year.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Know how to present (posture, eye contact, resonance etc.) him or herself in front of a viva-board.
- Know how to answer a question in a very logical way.
- Improve capacity of oral delivery.
- Reduce fear to face a viva board.
- Enhance confidence to face job interviews.

Assessment:

After a student finishes his/her viva-voce, the members of the examination committee will discuss about the student's performance and provide a mark getting consensus from all members.

2nd Year Curriculum
for
Bachelor of Science (Honours)

Session 2022-2023 onwards

Department of
Genetic Engineering and Biotechnology
University of Dhaka

Second Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB 201	Principles of Genetics	2
GEB 202	Basic Molecular Biology	4
GEB 203	Enzymes and Enzyme Kinetics	4
GEB 204	Protein Structure and Function	2
GEB 205	Bioenergetics and Metabolism	4
GEB 206	Virology	2
GEB 207*	Chemistry for Biologists-2	4
GEB 208*	Computing and Programming for Biologists	4
GEB 209	Laboratory Experiments	6
GEB 210	Viva voce	2
	Total	**34**

*Extra-departmental courses

Course Profile: Second Year

GEB 201 **Principles of Genetics** **2 Credit**

Introduction to the Course:
Knowledge of genetics is essential for a deeper understanding of the various branches of the biological sciences. This basic course explains the principles of heredity and variation of inherited characteristics in eukaryotic organisms as well as the biochemical structures that influence those traits. Genetic studies are important in biology and biotechnology to elucidate the basic properties of a population, to solve forensics problems, to identify and breed economically important traits, and to develop analytical and synthetic skills required for quantitative and evolutionary genetics. Another important component of the course is the historical perspective and ethical considerations. Given that the concept of a gene has changed over the time, principles of genetics are still applicable for the conceptualization of modern molecular genetics. This course provides an overview of genetics starting from the work of Mendel to the current understanding of various phenomena of heredity.

Specific objectives:
The study of this course will

- Demonstrate an understanding of the scientific principles of inheritance.
- Develop appropriate skills, techniques, and technologies to collect and analyze genetic data.
- Provide an understanding of contemporary genetics-related research being performed and how to access, summarize and communicate the contents of research papers.
- Present and utilize scientific data in different areas of genetics including clinical genetics.

GEB 201 (Principles of Genetics) Course Content

1. Mendelism and chromosomal theory of inheritance:

- Genes and chromosome in inheritance;
- Mendel's principles of inheritance; Applications and analysis of Mendel's principles;
- Mendelian principles in human genetics: autosomal and sex-linked dominance and recessiveness;
- Pedigree and pedigree analysis; Mendelian error.

2. Extension of Mendelian genetics:

- Incomplete dominance; Codominance;
- Lethality and embryonic lethality;
- Pleiotropy; Epistasis;
- Complementation and supplementation;
- Cytoplasmic inheritance.

3. Molecular basis of genetic dominance:

- Loss of function; Gain of function;
- Dominant negative effect; Hypomorphs; Neomorphs;
- Heterozygosity and haploinsufficiency; Reversion; Mosaicism; X-inactivation; Penetrance; Expressivity.

4. Population Genetics:

- Introduction;
- Protein polymorphism and DNA polymorphisms;

- Genetic equilibrium and Hardy-Weinberg principles;
- Allele frequency; Allelic heterozygosity and haplotype diversity;
- Effects of mutation, migration, selection, and mating patterns in allele frequency.

5. **Quantitative and evolutionary genetics**:
- Genes and quantitative traits; Difference between quantitative and Mendelian trait;
- Basis and determination of norm-of-reaction;
- Familiality and heritability; Quantitation of heritability; Use of heritability in artificial selection and quantitative linkage analysis;
- Founder effect and selection;
- Heritability of variation with and between populations;
- Gene inactivation and origin of a new gene.

6. Clinical genetics:
- Risk assessment of genetic diseases; importance of genetic counseling;
- Introduction to genetic testing;
- Ethical and social considerations.

Learning Outcomes:
Upon successful completion of this course the student should be able to:
- Explain the basic principles of how genetic material is inherited in essence of fundamentals of Mendelian and molecular genetics.
- Relate population genetics to evolution.
- Articulate the importance of genetics to societal, medical, and personal issues.
- Infer relationships, make predictions and solving problems based on an analysis of evidence or scientific information.
- Evaluate and discuss contemporary social and ethical issues related to biology.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Mendelism and chromosomal theory of inheritance	5
Extension of Mendelian genetics	6
Molecular basis of genetic dominance	4
Population Genetics	6
Quantitative and evolutionary genetics	6
Clinical genetics	3
Total	**30**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Brooker RJ. Genetics: Analysis and Principles. McGraw-Hill Education. 7th Edition. 2021.
- Hartl DL and Cochrane B. Essential Genetics and Genomics. Jones and Bartlett Publishers. 7th Edition. 2020.
- Sunstad P and Simmons MJ. Principles of Genetics. Wiley. 7th Edition. 2015.
- Griffith AJF, Doebley J, Peichel C, Wassarman DA. Introduction to Genetic Analysis. WH Freman. 12th Edition. 2020.
- Read A and Donnai D. New Clinical Genetics. Scion Publishing Ltd. 4th Edition. 2020.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 202	Basic Molecular Biology	4 Credit

Introduction to the Course:

This course focuses onthe structure and function of biologically important molecules- DNA, RNA and proteins and the molecular events that govern cell function while exploring the relevant aspects of genetics and cell biology. Students will be introduced to the properties of biomolecules, hereditary aspects, their function and implications.

Specific objectives:

The study of this course will

- Enable students to recognize the basic concepts of modern molecular biology, discuss the mechanisms by which biomolecules perform and control replication, transcription, and translation.
- Equip students with an understanding the principles and laws of inheritance at the cell and individual level.
- Provide opportunities to learn about dynamic implications of biomolecules in different diseases.
- Provide fundamental knowledge to the students to different scientific articles and reports related to molecular biology.

GEB 202 (Basic Molecular Biology) Course Content

1. Organization of the genome:

- The complexity of the eukaryotic genome;
- Nucleosome to chromatin, formation of euchromatin and heterochromatin – the importance of histone modifications;
- Chromosome, functional elements of a eukaryotic chromosome;
- Organization of genes and other non-coding DNA in a genome;
- Transposable elements.

2. DNA replication:

- Fundamental rules of replication,
- DNA polymerases;
- Details of replication in prokaryotic and eukaryotic systems;
- Replication accuracy,
- Alternative ways of replication
- End Replication Problem
- Regulation of DNA replication.

3. Transcription:

- Types of RNA
- Prokaryotic and eukaryotic RNA polymerases;
- Promoter, transcriptional factors;
- Mechanisms of transcription in prokaryotes and eukaryotes;
- Regulation of transcription,
- Reverse transcription;
- RNA processing; RNA editing;

4. Translation:

- Structure and functional sites of a ribosome;
- Genetic code, Wobble hypothesis;
- Amino acid-tRNA interaction;
- Protein synthesis: initiation, elongation and termination;
- Post-translational modification
- Protein sorting and transportation
- Protein targeting, the SRP mediated pathway, targeting to mitochondrion and chloroplast, nucleocytoplasmic transport
- Protein turnover: the ubiquitin system and protein turnover, the proteasome, lysosomal degradation.

5. Regulation of Gene Expression:

- Constitutive and regulated gene expression; induction and repression;
- Positive and negative regulation; enhancer and repressor;
- Transcription attenuation, repressor destruction, regulation by small RNAs, genetic recombination
- Post-transcriptional gene silencing, RNAinterference, miRNA, siRNA.

6. DNA repair and recombination:

- Types of mutations; variation and evolution;

- DNA damage, exogenous and endogenous DNA damaging agents; DNA damage response (DDR)
- DNA damage repair pathways – base excision repair, nucleotide excision repair, mismatch repair, inter-strand crosslink repair, translesion synthesis, single-stranded break repair, non-homologous end joining, microhomology-mediated end joining, homology-directed repair, etc.
- Association of DDR pathway genes with human diseases

7. Organelle genome:

- Genomes of mitochondria and plastid, and their interaction with the nuclear genome;
- Origin and evolution of organelle genome
- Replication of organelle genome;
- Pattern of inheritance;
- Diseases associated with organelle genome.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Familiarize the basic concepts of the structure and function of biomolecules
- Discuss the aspects of Mendelian principles of inheritance and solve different problems associated with it
- Understand the detailed organization and complexity of the genome and their relevance
- Acquire knowledge about DNA replication, transcription, translation
- Explain the relevance of SNPs and the mechanism of DNA repair and recombination.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Organization of the genome:	7
DNA replication:	10
Transcription:	10
Translation:	10
Regulation of Gene Expression	9
DNA repair and recombination:	10
Organelle genome:	4
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions

- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:
- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:
- 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.
- Molecular Biology of the Cell (7th edition) by Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, John Wilson & Tim Hunt.2022. Publisher-W. W. Norton & Company.
- Molecular Cell Biology (9th edition) by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Kelsy Martin, Michael Yaffe& Angelica Amon. 2021. Publisher-W. H. Freeman.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 203	**Enzymes and Enzyme Kinetics**	**4 Credit**

Introduction to the Course:
This course demonstrates the theory and knowledge relevant to the enzymology discipline including fundamental aspects of enzymes, catalysis and enzyme kinetics. Techniques employed in enzymes purification and characterizations are also emphasized in this course. This course will introduce the theory as well as applications of enzyme technology in food, medicine, industries and other aspects of biotechnology. As a whole, this course will implant in-depth knowledge on the current and possible future trends of enzyme technologies.

Specific objectives:
The study of this course will
- Emphasizing a deeper insight into the fundamentals of enzymes: its structure, functions, catalysis and the mechanisms of action.
- Describing kinetics of enzyme catalyzed reactions, its inhibitory and regulatory mechanism.
- Explaining the intricate mechanism of immobilized enzymes, metabolic enzymes and their regulations.
- Exposure of numerous applications of enzyme and their future implications.

GEB 203 (Enzymes and Enzyme Kinetics) Course Content

1. **Introduction:**
   - A brief history
   - Enzymes as biological catalysts
   - Classification and nomenclature of enzymes
   - Cofactors and prosthetic groups
   - Units of enzyme activity (IU, Katal)
   - Specific activity of enzymes, catalytic power
   - Enzyme assay methods

2. **Enzyme Catalysis:**
   - Role of enzymes in reducing activation energy
   - Factors affecting the rate of enzymatic reactions (substrate concentration, enzyme concentration, pH and temperature)
   - Factors affecting catalytic efficiency of enzymes (proximity, orientation-distortion or strain)
   - Enzyme catalysis mechanism: Covalent catalysis, general acid-base catalysis, metal ion catalysis
   - Substrate recognition, lock and key model, induced fit model

3. **Specificity of Enzymes:**
   - Absolute, broad and intermediate specificity, Stereospecificity
   - Active site: common features and determination

4. **Enzyme Kinetics:**
   - thermodynamic aspects of reactions: reaction coordinates, activated complexes and transition states
   - Steady state kinetics and pre-steady state kinetics
   - Enzyme-substrate complex formation and experimental evidences
   - Mono-substrate enzyme kinetics
   - Michaelis-Menten equation and its linear transformations: Lineweaver-Burk plot, Eadie-Hofstee plot, Hanes-Wolf plot, Cornish-Bowden plot and their limitations
   - Km, Vmax and Kcat/Km: definition, determination, significance
   - Bisubstrate enzyme kinetics: Single and double displacement reactions, random & ordered mechanism

5. **Enzyme Inhibition:**
   - Reversible inhibition: competitive, noncompetitive and uncompetitive kinetics
   - Irreversible inhibition
   - Specific examples of enzyme inhibitors as drugs and others

6. **Enzyme Regulation:**
   - General mechanism of enzyme regulation
   - Reversible and irreversible covalent modification of enzymes
   - Protein-ligand binding
   - Cooperativity phenomenon, Hill and Scatchard plots
   - Allosteric enzymes, sigmoidal kinetics and their physiological significance, symmetric and sequential modes of allosteric enzyme actions and their significance
   - Feedback inhibition and feed-forward stimulation
   - Enzyme repression, induction and degradation

- Control of enzymatic activity by products and substrates
- Monocyclic and multicyclic cascade systems

7. **Mechanism of Enzyme Action:**
   - Detailed mechanisms of Chymotrypsin, Lysozyme, RibonucleaseA, Carboxypeptidase

8. **Non-Protein Enzymes:**
   - Abzymes, Ribozymes and DNA enzymes

9. **Applications of Enzymes:**
   - Normal and diagnostic value of enzymes
   - Clinical and diagnostic importance of enzymes and isoenzymes: lactate dehydrogenase (LDH), creatine kinase (CK), transaminases, phosphatases, amylase and cholinesterase
   - Applications of enzymes in research
   - Industrial applications of enzymes
   - Biosensors
   - Immobilized enzymes

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Familiarize the basic concepts of enzymes & their properties; nomenclature and catalysis.
- Analyse structure/function relationships in biocatalysed reactions.
- Acquainted with the quantitative nature of enzyme kinetics
- Predict possible catalytic mechanisms of given reaction types
- Understand the mechanism of action of enzymes & their regulations.
- Acquire detail understanding of various applications of enzymes that can benefit human life.
- Develop ideas about the current and future trends of enzyme technology that can be applied for the commercialization purpose of biotechnological products.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Introduction:	5
Enzyme Catalysis:	5
Specificity of Enzymes:	5
Kinetics of Simple and Complex Reactions:	10
Enzyme Kinetics:	10
Enzyme Inhibition:	5
Enzyme regulation:	8

Mechanism of Enzyme Action:	5
Non-Protein Enzymes:	2
Applications of Enzymes:	5
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Palmer T, Bonner PL. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry (2nd Ed.)* Cambridge, Woodhead Publishing, Limited (2007).
- Polaina J, MacCabe P. *Industrial Enzymes: Structure, Function and Applications*. New York, Springer (2010).
- *Methods in Enzymology* (Book Series), selected volumes. New York, Academic Press (1955-2012).
- Lehninger A, Nelson DL, Cox MM. *LehningerPrinciples of Biochemistry (8th Ed.).* New York,W H Freeman (2021).
- Fersht A. *Enzyme Structure and Mechanisms(2nd Ed.).* New York, W. H.Freeman & Company (1985).
- Wiseman A. *Handbook of Enzyme Biotechnology (2nd Ed.).* New York, Ellis Horwood Publishers (1985).
- Berg JM, Tymoczko JL and Stryer L. *Biochemistry (10th Ed.)*. W H Freeman & Company, New York (2023).
- Voet D, Voet JG. *Biochemistry (4th Ed.).* John Wiley and Sons, Inc, New York (2010).
- Mckee T, Mckee JR.*Biochemistry the Molecular basis of life (6th Ed.).* Oxford University Press (2015).

Additional reading materials may be suggested by the respective course instructor(s).

GEB 204	Protein Structure and Function	2 Credit

Introduction to the Course:
This is a fundamental course covering structure and functions of proteins. Students will be introduced to the various types of functions of protein and their structural organization, concept of protein folding and its importance. This course will describe different techniques to work with protein.

Specific objectives:
The study of this course will

- Describe the major categories of proteins and their general functions.
- Define primary, secondary, tertiary and quaternary structure in proteins and identify the types of interactions important in each case.
- Describe the structural nature and corresponding functions of proteins in cells.
- Explain different techniques for separation and purification of proteins
- Explain how protein activity is (a) regulated, and (b) affected by binding with its ligand (hemoglobin as an example).
- Describe the co-operative protein- ligand binding of a multi subunit protein.

GEB 204 (Protein Structure and Function) Course Content

1. **Peptides and Proteins:**
   - Biologically active peptides
   - General functions of proteins
   - Protein classification

2. **Protein Composition and Structure:**
   - An overview of protein structure and conformation
   - Peptide bonds to form polypeptide chains
   - Primary structure, secondary structure (α-helix, β-sheet, turn and loop)
   - Tertiary structure and quaternary structure
   - Structural function of fibrous proteins
   - Structural features of α-keratin, collagen and silk fibroin
   - Structure of globular proteins: myoglobin
   - Molecular chaperone
   - Methods for determining threedimensional structure of proteins
   - Protein denaturation and folding, protein misfolding
   - Protein families, Definition of protein families
   - Motifs that characterize protein families
   - Prion diseases
   - Protein interactions: Protein-ligand, protein-DNA and protein-protein interactions. Thermodynamics in interactions.

3. **Protein Purification and Amino Acid Sequence Determination:**
   - Purification according to size, charge and binding affinity
   - Salting in, salting out, and dialysis of proteins
   - Chromatography: gel-filtration, Ion-exchange, Affinity chromatography, HPLC

- Gel electrophoresis, isoelectric focusing, 2D electrophoresis
- Protein quantification and detection
- Amino acid sequence determination by Edman degradation and other methods

4. Membrane Proteins and Transport

- Membrane proteins
- Membrane dynamics
- Solute Transport across the membranes
- Membrane transporters, channels and pumps

5. Protein Function:

- Protein-ligand binding
- Oxygen-binding proteins (myoglobin and hemoglobin)
- Oxygen transport by hemoglobin; structural change on oxygen binding; cooperative binding of oxygen
- Hill Equation and Hill Plot; models of cooperative binding
- The Bohr Effect
- Regulation of oxygen binding by 2,3-BPG; physiological consequences of 2,3-BPG binding to hemoglobin
- Sickle-cell anemia and hemoglobin

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Describe how proteins are constructed.
- Describe the interactions that hold proteins together.
- List and discuss four levels of a protein's structure, and tell how protein folding diseases relate to structure.
- Describe how a protein is stabilized thermodynamically.
- Relate chemical and physical properties of proteins to their function.
- Learn key concepts in protein function such as affinity and specificity, allosteric regulation.
- Describe how protein structures can be determined.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Peptides and Proteins:	3
Protein Composition and Structure:	7
Protein Purification and Amino Acid Sequence Determination:	5
Membrane Proteins and Transport	5
Protein Function:	10
Total	**30**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Lehninger A, Nelson DL, Cox MM. *LehningerPrinciples of Biochemistry (8th Ed.).* New York,W H Freeman (2021).
- Berg JM, Tymoczko JL and Stryer L. *Biochemistry (10th Ed.)*. W H Freeman & Company, New York (2023).
- Molecular Cell Biology (9th edition) by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Kelsy Martin, Michael Yaffe& Angelica Amon. 2021. Publisher- W. H. Freeman.
- Molecular Biology of the Cell (7th edition) by Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roderts, Peter Walter, John Wilson & Tim Hunt. 2022. Publisher- W. W. Norton & Company.
- Petsko GA, Ringe D. Protein Structure and Function, New Science Press (2008).
- David Whitford . Proteins structure and Function, John Wiley ans sons Ltd.(2005)

Additional reading materials may be suggested by the respective course instructor(s).

GEB 205	Bioenergetics and Metabolism	4 Credit

Introduction to the Course:

This course will provide a basic understanding of the fundamentals of biological metabolism. Students will be introduced to the fundamentals of membrane structure and dynamics, bioenergetics and the metabolism of dietary and endogenous carbohydrates, lipids, nucleotides and amino acids. This course will further describe the regulation of metabolic pathways and various types of metabolic errors that arise from the genetic defects.

Specific objectives:

The study of this course will

- Enable students to understand and learn the basic concepts of membrane biology and membrane transporters.

- Provide in-depth knowledge of metabolism and metabolic defects.
- Provide the basic information of metabolic pathway regulation.

GEB 205 (Bioenergetics and Metabolism) Course Content

1. **Bioenergetics:**
   - The second law of thermodynamics
   - The concept of free energy, entropy and enthalpy
   - The exergonic and endergonic reactions, high and low energy bonds and chemical compounds
   - Activation energy, enzyme catalysis
   - (Phosphoryl) group transfer in driving endothermic reactions
   - Biological oxidation and reduction reactions
   - Oxidation of the carbon fuels including sugars, amino acids and fatty acids
   - Roles of NAD, NADP and FADH, the electron transport system and ATP synthesis

2. **Regulation of metabolic processes**
   - Principles of regulation of metabolic pathways
   - Analysis of metabolic control
   - Hormonal regulation of metabolism
   - Tissue-specific metabolism

3. **Carbohydrate Metabolism:**
   - Glycolysis- the energy conversion pathway
   - Coordinated regulation of glycolysis and gluconeogenesis
   - Pentose Phosphate Pathway and NADPH generation
   - Coordinated regulation of glycogen synthesis and breakdown
   - Glycogen breakdown- the interplay of several enzymes: Phosphorylase, Epinephrine and Glucagon
   - The citric acid cycle- the reactions, its regulations and its role as a source of biosynthetic precursors
   - Anaplerotic reactions
   - Oxidative phosphorylation and its regulation: proton gradient powers the ATP synthesis
   - Glyoxylate cycle
   - Role of glucose-6-phosphate dehydrogenase in protecting against reactive oxygen species

4. **Fatty Acid Metabolism & Cholesterol Biosynthesis:**
   - Digestion, mobilization and transport of lipids
   - Fatty acid biosynthesis
   - Oxidation of fatty acids
   - The role of ketone bodies
   - Cholesterol biosynthesis

5. **Amino Acid metabolism:**
   - Transamination, deamination and decarboxylation of amino acid
   - Carbon atoms of degraded amino acids as major metabolic intermediates

- Urea cycle
- Inborn errors of amino acid metabolism

6. Nucleotide Biosynthesis and Metabolism

- Biosynthesis of the purine and pyrimidine nucleotides
- Formation of the deoxyribonucleotides
- Biosynthesis of NAD+, FAD, and CoA
- Catabolism and salvage of the purines and pyrimidines

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Familiarize with the fundamental concepts of biological metabolism.
- Understand the basic ideas of bioenergetics.
- Understand the basic composition of membrane structure and molecular basis of membrane asymmetry and fluidity.
- Appreciate the molecular basis of membrane dynamics, asymmetry and fluidity.
- Distinguish the different types of membrane transporter and their molecular basis.
- Familiarize with the core metabolic pathway.
- Understand the basic mechanisms of pathway regulation.
- Understand the relation between biochemical defects and metabolic disorders.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Bioenergetics	7
Principles of Metabolic Regulation	8
Carbohydrate Metabolism	15
Fatty Acid Metabolism & Cholesterol Biosynthesis	10
Amino Acid metabolism	10
Nucleotide Biosynthesis and Metabolism	10
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes

- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:
- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:
- Nelson DL. *LehningerPrinciples of Biochemistry (8th Ed.).* New York,WH Freeman (2021).
- Gatto G, Berg J M, Stryer L. and Tymoczko J L. *Biochemistry (9th Ed.)*. W H Freeman & Company, New York (2019).
- Lodish H, Berk E, Kaiser J et al. *Molecular Cell Biology (9th Ed.),* New York, WH Freeman (2021).
- Alerts B. *Molecular Biology of the Cell (7th Ed.),* New York, W. W.Norton & Company (2022).
- Pratt CW, Cornely K. *Essential Biochemistry (5th Ed.).* Wiley (2021).

Additional reading materials may be suggested by the respective course instructor(s).

GEB 206	Virology	2 Credit

Introduction to the Course:
This course will give a brief introduction to the basic principles of virology. The course will give an overview of viral structure, their replication strategies and mechanism for the development of viral infectious diseases. Topics will include taxonomy, viral pathogenicity, enumeration and cultivation strategies, viral replication strategies, transmission of viruses and, diagnosis, prevention and treatment of viral diseases.
Specific objectives:
The study of this course will
- Provide in-depth knowledge on viral taxonomy, cultivation, purification and enumeration strategies.
- Enable students with an understanding of the concepts of viral structure, viral replication strategies and mechanism of pathogenesis.
- Enable students to learn about the diagnosis, prevention and treatment strategies of viral diseases.

GEB 206 (Virology) Course Content

1. **Introduction to virus:**
   - Structure, classification and importance

2. **Cultivation, purification and enumeration of viruses:**
   - Cultivation of plant and animal viruses, and bacteriophages;
   - One step growth curve; estimation of yields;
   - Methods of virus purification;
   - Plaque assay;
   - Generation of transformed cell foci.

3. **Replication cycle:**
   - Entry of enveloped and non-enveloped virus;
   - Replication and expression of viral genome- dsDNA, ssDNA, dsRNA, +ssRNA; -ssRNA;
   - Bacteriophages- lytic and lysogenic cycle and its regulation;
   - Late events of viral infection- capsid assemble and virion release;
   - Non-specific introduction of viral genome into the cells.

4. **Pathogenesis of viral infection:**
   - Typical modes of virus spread;
   - Initial stages of infection; incubation period and spread;
   - Multiplication and occurrence of disease;
   - The immune response;
   - Virus transmission;
   - The fate of the host;
   - Pathogenesis of hepatitis, HIV, EBV and influenza virus infections.

5. **Prevention and treatment of viral infection:**
   - Vaccination strategy;
   - Chemotherapy for viral diseases;
   - Interferons: induction and action.

6. **Prions and viroids:**
   - General properties; hypothesis about prion generation;
   - Disease caused by prions and viroids.

7. **Viruses – promise and problems:**
   - Emergence of viral diseases - sources and causes;
   - Viruses as therapeutic agents;
   - Viruses for gene delivery.

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Describe methods used for laboratory diagnosis of viral infections.
- Explain viral replication strategies, including the process of entry, mechanismof genome replication, virion assembly and egress from the cell.
- Define the process of virus latency and the process andactivation of viral genomes during reactivation.
- Describe principles of viral pathogenesis.
- Explain vaccine strategies and mechanism of antiviral drugs.
- Explain the promises and problems with the use of viral vectors as therapeutics.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	No. of classes/unit
Introduction to virus	03
Cultivation, purification and enumeration of viruses	04
Replication cycle	06
Pathogenesis of viral infection	04
Prevention and treatment of viral infection	04
Prions and viroids	04
Viruses-promise and problems	05
Total	**30**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Basic Virology (3rd edition) by Edward K. Wagner and Martinez J. Hewlett. 2008. Publisher-Blackwell Science Ltd. USA.
- Fundamentals of Molecular Virology by Nicholas H. Acheson. 2nd edition, 2011. Publisher-John Wiley & Sons Ltd. UK.
- Principles of Molecular Virology (6th edition) by Alan J. Cann. 2015. Publisher- Elsevier Academic press. UK.
- Introduction to Modern Virology (7th edition, 2016) by Nigel Dimmock, Andrew Easton and Keith Leppard. Publisher- John Wiley & Blackwell.

Additional reading materials and internet learning resources will be suggested by the course instructors.

GEB 207	Chemistry for Biologists II	4 Credit

Introduction to the Course:

This course will discuss the reactions and properties of functional groups, their identification and occurrence in biomolecules. The physical chemistry part will discuss the control of chemical and biological reactivity in the light of thermodynamics, reaction kinetics, reaction order, stochiometry, redox potential, catalyst and photochemistry. Elucidation of reaction mechanisms of simple and complex biological reactions, especially enzyme-mediated reactions, is also included in this section. The spectroscopy part will discuss the identification, analysis and quantification of organic and related biomolecules. The organic chemistry part will discuss the properties and reactions of carboxylic acids and associated compounds, namely esters, carbonic anhydrides, amides, nitriles, phenols and sulfur compounds. Organic compounds of special interest like azo dyes, alkaloids, and antibiotics will be discussed in broader details. Natural and synthetic polymers, their usefulness in our daily lives and reaction processes involving their production will also be studied.

Specific objectives:

- Provide students with the knowledge of reaction kinetics, reaction mechanisms, photochemistry and electrochemistry and their implications in biology.
- Enable students to deduce structures, identify and quantify chemical compounds based on their spectroscopic properties.
- Introduce students to the chemistry of carbonyl carbon compounds, alkaloids, sulfadrugs and antibiotics.

GEB 207 (Chemistry for Biologists II) Course Content

1. **Physical Chemistry:**
   - **Reaction Kinetics:** Basic Concepts: Gas Laws and Their Experimental Foundations, Applications of the Ideal Gas Law, Ideal Gas Law and Reaction Stoichiometry, Kinetic-Molecular Theory, Deviations from Ideal Behaviour; Kinetics: Rates and Mechanisms of Chemical Reactions, Factors that Influence Reaction Rate, Steady State Approximation, Rate Law, Integrated Rate Laws, Effect of Temperature and Concentration on Reaction Rate, Reaction Mechanisms, Catalysis
   - **Electrochemistry:** Basic Concepts: Redox Reactions and Electrochemical Cells, Free Energy and Electrical Work, Electrochemical Processes in Batteries; Voltaic Cell: Using Spontaneous Reactions to Generate Electrical Energy, Cell Potential; Electrolytic Cell: Using Electrical Energy to Drive Nonspontaneous Reactions, Corrosion
   - **Photochemistry:** Basic Concepts: Photophysical and Photochemical process, Difference between Thermal and Photochemical Reactions, Law of Absorption; Interaction Between Radiation and Matter: Excitation and Emission, Laws of Photochemistry, Quantum Yield; Photochemical Processes: Energy Dissipation and Transition, Frank-Condon principle, Jablonski Diagram, Photosensitization, Quenching, Fluorescence and Phosphorescence
   - **Nuclear Reactions:** Radioactive Decay and Nuclear Stability, Kinetics of Radioactive Decay, Nuclear Transmutation, Fission and Fusion

2. **Inorganic Chemistry:**
   - **Metallurgy and Chemical Manufacturing:** Extracting a Metal from Its Ore, Isolation and Uses of the Elements

- **Polymers:** Definition, Classification, Mode of Polymerization, Applications
- **Cheminformatics**

3. Organic Chemistry

- Properties and Reactivity of Common Functional Groups: Preparations and Reactions of Specific Functional Groups: Aldehyde, Ketone, Carboxylic Acid, Amine, Phenol, Aryl Halide, Heterocyclic Aromatic Compounds, Conjugated Unsaturated Compounds
- Alkaloids: Classification, Extraction, General Mode of Action, Chemistry of Quinine, Papaverine, Morphine
- Antibiotics: Classification, General Mode of Action, Chemistry of Penicillin, Chloramphenicol

4. Analytical Chemistry

- **Measuring Reaction Rates**
- **Spectroscopy and Spectrometry:** Basic Concepts: Interaction of Matter with Energy, General Features of Spectroscopy; Rotational and Vibrational Spectroscopy: Infrared (IR) Spectroscopy; Absorption Spectroscopy: UV-Vis Spectroscopy; Magnetic Resonance Spectroscopy: Nuclear magnetic resonance (NMR) spectroscopy, Shielding, Chemical Shifts,Coupling Patterns, ^{13}C and ^{1}H NMR Spectra; Mass Spectrometry (MS): Formation of Ions in MS, Fragmentation, Isotopes in MS, GC/MS Analysis

Learning Outcomes:

Upon successful completion of this course the student should be able to:

- Understand the basis of chemical reactions involving carbonyl compounds, amines, nitriles and phenols.
- Describe the classification, mechanism of action, retrosynthetic analysis of major groups of alkaloids and antibiotics.
- Describe the classification and synthesis of biologically and industrially important polymers.
- Understand reaction mechanisms based on their kinetics and stoichiometry.
- Describe the basic concepts of electrochemistry.
- Describe the fundamentals of photochemistry.
- Apply the basic principles of spectroscopy to identify and quantify different chemical as well as biological compounds.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Physical Chemistry	20
Inorganic Chemistry	5
Organic Chemistry	25
Analytical Chemistry	10

Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Atkins P, de Paula J. (2018). *Physical Chemistry* (11th Ed.).Oxford University Press.
- Roussel MR. (2012). *A Life Scientist's Guide to Physical Chemistry*. Cambridge University Press.
- Van Holde KE, Johnson C, Ho PS. (2006). *Principles of Physical Biochemistry* (2nd Ed.). Prentice Hall.
- Fisher J, Arnold J. (2012).*Instant Notes in Chemistry for Biologists* (2nd Ed.).Taylor& Francis.
- Atkins RC, Carey FA. (2001). *Organic Chemistry: A Brief Course* (3rd Ed.). McGraw Hill. (or a later edition)
- Solomons TWG, Fryhle CB. (2016). *Organic Chemistry* (12th Ed.). John Wiley. (or a later edition)
- Morrison RT, Boyd RN. (2011). *Organic Chemistry* (7th Ed.). Prentice Hall. (or a later edition)
- Finar, I.L. (2012). *Organic Chemistry* (Vol II, 5th Ed).Pearson. (or a later edition)

Additional reading materials may be suggested by the respective course instructor(s).

GEB 208 Computing and Programming for Biologists 4 Credit

Introduction to the Course:

In this course students will learn all of the fundamental aspects of computer programming that are necessary for conducting biological research. By the end of the course one will be able to use these tools to import data, perform analysis on that data, and export the results as graphs, text files, or whatever else you might need.

This course is also designed to provide a detailed understanding of computer architecture, system software and important issues related to IT. The content of this course help to develop a technical foundation for understanding current technologies and how they work to solve a problem. Topics include principles of systems architecture, operating systems, application software, storage and systems

management as well as current developments in various aspects of computing and information technology.

Specific objectives:
The study of this course will -

- Enable students to describe the evolution, history, and development of electronic computers, microprocessors, and microcomputers.
- Enable to learn the fundamentals of computer hardware and software as well as recent trends in computer technology.
- Enable to describe and explain information processing.
- Enable to describe and explain basic computer components and functions, operating systems, database management systems and traditional applications, networks, and the Internet.
- Write simple computer programs in Python
- Automate data analysis
- Apply these tools to address biological questions
- Learn and understand programming concepts that will help with using other languages

GEB 208 (Computing and Programming for Biologists) Course Content

1. **Introduction:**
    - Brief history of computer
    - Basic organization, type
    - Overview of hardware and bios
    - Number system

2. **Operating Systems:**
    - Introduction to OSs (Windows, Linux/Unix)
    - Tools/software installation in Linux environment

3. **Shell/Bash scripting: Shell script writing for data processing**
    - Basic Linux commands, command line arguments, sed, grep, awk
    - Introduction to text editors: vim,gedit
    - Linux commands for batch file processing, data management and basic calculations (sum, subtract, multiplication, division, mean etc.).
    - Introductory regular expression
    - Introduction to Bash scripting, Bash Structure, Variables, User Input, Comments, Arguments, Arrays, Conditional Expressions, Loops, Functions, Debugging and testing.

4. **Computer Networks and Internet Systems:**
    - Basic concepts of networks, hubs, switches, gateways, and routers
    - Network security: basic concepts of public key and private key cryptography, digital signature, firewalls

5. **Databases:**
    - Introduction to flat files, DBMS and RDBMS, ER model
    - Database design (integrity constraints, normal forms)

- Query languages (SQL): Design, create, enter data into, and query databases, automated report generation.

6. **Basic Algorithms**
    - Sequence alignment
    - Basic Shotgun Sequencing Strategy
    - Hidden markov model (HMM)
    - Bayesian interpretation

7. Python Programming:
    - Introduction to python, installation.
    - Installation of python IDE/text editor (PyCharm), Jupyter Notebook, module installation, python interpreter.
    - Python Function, Variables, Data structure, loops, string, lists, tuples, dictionaries, sets.
    - Python file handling: Python in Data science (reading writing files, python matrix)
    - Python regular expression
    - Genomic/Proteomic data analysis/problem solve using python code.
    - Graph/plot in python

Learning Outcomes:
Upon successful completion of this course the student should be able to:
- Learn to effective use of computing and information technology frameworks to develop communication and technology solutions to a variety of problems.
- Learn how to analyze and create systems to accomplish tasks.
- Bioinformatic data analysis, writing program.

Unit-wise title, subtitle and number of classes per unit:

Unit-wise Title and Sub-title	**No. of classes/unit**
Introduction:	5
Operating Systems:	5
Shell/Bash scripting	15
Computer Networks and Internet Systems:	5
Basic Algorithms	5
Databases:	10
Python Programming:	15
Total	**60**

Instructional Strategies:

- Lecture with traditional method
- Lecture with power point/videos/models/pictures
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Arrange review classes
- Encourage group discussions
- Assignments for exploring creativity and knowledge in a topic

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Final Examination: Assessment of written test

Suggested Readings:

- Larry L. Peterson, Bruce S. Davie, *Computer Networks: A Systems Approach (5th Ed.).* New York, Morgan Kauffman Elsavier (2011).
- Kurose, James F., Ross, Keith W *Computer Networking: A Top-down Approach (7th Ed.).* New York,Addison-Wesley (2017).
- Comer D, Stevens D. *Internetworking with TCP-IP, vol. 1 (6th Ed.)* New York, Prentice Hall (2013).
- Douglas E. Comer, David L. Stevens. *Internetworking with TCP-IP, vol. 2 (3th Ed.)* New York, Pearson (1998).
- W. Richard Stevens, Bill Fenner, Andrew M. Rudoff, *Unix Network Programming: The Sockets Networking Api (1)* Subsequent Edition.New York, Addison-Wesley Professional (2003).
- Abraham Silberschatz, Henry Korth, S. Sudarshan, *Database System Concepts (6th Ed)*. New York, McGraw-Hill (2010).
- G.Michael Schneider, Judith Gersting, *An Invitation to Computer Science (8th Ed.).* Cengage Learning Course Technology (2018).
- Presented by: Victor Gedris, An Introduction to the Linux Command Shell for Beginners. In Co-Operation With: The Ottawa Canada Linux Users Group and ExitCertified (2003).
- William E. Shotts, Jr.The Linux Command Line: A Complete Introduction(1st Ed.), No Starch Press, Incorporated (2012).
- Mike G Mikkey. BASH Programming−Introduction HOW−TO. Independently published, (2019).
- Bobby Iliev.Introduction to Bash scripting for developers (**2021).**
- Vivek G Gite, Linux Shell Scripting Tutorial Ver. 1.0 (1998).
- Sebastian Bassi,Python for Bioinformatics (Chapman & Hall/CRC Computational Biology Series) (2nd Ed.) Chapman and Hall/CRC (2017).
- Guido van Rossum and the Python development team, Python Tutorial, Release 3.7.0. Python Software Foundation (2018).
- Ken Youens-Clark, Mastering Python for Bioinformatics: How to Write Flexible, Documented, Tested Python Code for Research Computing (1st Ed.). O'Reilly Media (2021).
- Mitchell L. Model, Bioinformatics Programming Using Python: Practical Programming for Biological Data (1st Ed.). O'Reilly Media (2010).
- Alex Douglas, Deon Roos, Francesca Mancini, Ana Couto & David Lusseau. (2022) An Introduction to R.

Additional reading materials may be suggested by the respective course instructor(s).

GEB 209	Laboratory Experiments	6 Credit

Introduction to the Course:

This course is designed to let the students perform experiments in Labs with an aim to make them understand the core concepts, theories and topics that are delivered in their class lectures. Students will be introduced with the different wings of biological, chemical, and molecular biological techniques, the principles of these techniques, the experimental procedure, and interpreting the outcome of these experiments. The main purpose of each experimental class is to carry out experimental techniques properly to obtain data that should match with the predicted results. The experimental observations/results are then used to re-examine the theoretical concepts for better understanding.

Specific objectives:

Performing Lab experiments under this course will

- Provide the students an opportunity to apply and investigate theoretical and conceptual knowledge.
- Help to learn a range of experimental techniques and approaches related to biochemistry, physiology and bioinformatics.
- Provide opportunities to the students so that they learn why, when, and how to perform a laboratory experiments as well as how to discuss and conclude experimental findings.
- Facilitate the students to improve observational skills.
- Enable students to record experimental data, analyze/interpret them and present their finding in written format.
- Create opportunity of practising a wide range of skills such as problem solving, team working, instrument sharing, and protocol following.
- Allow students to learn about risks involved in laboratory experiments and to work more safely following bio-safety measures.

GEB 209 (Laboratory Experiments) Course Content

Wet-lab Experiments

General Practices

1. Introduction to basic biosafety practices
2. Preparation of disinfectants
3. Sterilization by chemical agents, autoclaving and hot air oven.

Chemistry

4. Determination of equilibrium constant of a chemical reaction.
5. Determination of dissociation constant (Ka) of a weak acid.
6. Preparation of buffers and estimation of buffer capacity.
7. Entropy driven chemical reactions
8. Orders and rates of chemical reactions
9. Determination of total antioxidant capacity.
10. Determination of total reducing power.

Enzymes and Enzyme Kinetics

11. Determination of Km and Vmax of enzyme
12. Effect of catalase concentration on reaction rate.
13. Catalase activity test of bacteria.
14. Succinic dehydrogenase activity and effects of inhibitors.
15. Isolation of alkaline protease

Biochemistry and Metabolism

16. Isolation of casein by precipitation at its isoelectric point.
17. Purification of protein by dialysis
18. Salting out of protein using ammonium sulfate precipitation
19. Estimation of glucose content of blood serum by Nelson- Somogyi method.
20. Tissue glycogen extraction and determination.
21. The quantitative determination of glucose concentration in serum by enzymatic colorimetric method (GOD/POD/PAP).
22. Determination of the creatinine content of urine.

Physiology

23. Human blood group testing.
24. Preparation of blood film and differential count of WBC
25. Determination of total WBC count
26. Determination of total RBC count
27. Estimation of hemoglobin
28. Estimation of ESR by Westergren method

Molecular Biology

29. Isolation of genomic DNA from bacteria.
30. Estimation of DNA concentration and purity

Bioinformatics Experiments

1. Introduction to bioinformatics, goal and scope
    - Introduction to Bioinformatics and Bioinformatics Lab
    - Installation of required software/tools
    - Various Bioinformatic File format and Text editing tools
2. Exploring Nucleic Acid Databases and Data mining
    - Introduction to Nucleic acid database (NCBI)
    - Retrieving sequence from NCBI (GenBank, nucleotide, gene, polymorphism)
    - Specialized Genome databases: Virus, Bacteria, Plant
    - Exploring EnsEMBLBiomart portal: Retrieve BED file of genomic locations; Retrieve FASTA sequence of a gene/promoter; Obtain Gene Ontology functions; Retrieve whole genome sequence
3. Proteomics: Biochemical Properties and Structure predictions of Proteins
    - Download protein sequence from NCBI and Uniprot

- Predicting the main physico-chemical properties of a protein
- Digesting a protein in a computer
- Primary Structure Analysis of protein
- Looking for transmembrane segments
- Finding Known Domains in Protein
- Prediction of Motif in Protein
- Predicting the secondary structure of a protein sequence

4. Sanger Sequence data analysis: Quality Assurance and Information Mining from DNA Sequence Data
    - Basics of Sanger sequencing and understanding Chromatogram
    - Open, Edit and Ensure sequence quality (chromatogram)
5. DNA Amplification and Cloning
    - Restriction Digestion and Computing restriction map (pGLO and PUC19)
    - Designing a PCR primer

Learning Outcomes:
Upon successful completion of this course the student should be able to:

- Know the responsibilities and duties in the laboratory.
- Follow a protocol independently, practice Good Lab Procedures and perform accurately all experimental procedures.
- Perform some basic laboratory and bioinformatic experiments independently.
- Analyze experimental results, interpret them, make conclusions and discuss the finding thoroughly in written format.
- Utilize technical skills acquired through lab experience and apply these skills in formulating solutions to life science questions.

Instructional Strategies:

- Interactive class Lectures on principle, procedure and application of each experiment
- Obtain immediate feedback by asking questions
- Answer queries, if any
- Practice problem solving
- Hands on Laboratory training
- Encourage group discussions

Assessment:

- Class participation: Attendance
- Continuous assessment: In-course examination, assignment
- Practical note-book assessment
- Final Examination: Assessment of written test
- Viva voce

Suggested Readings:
Protocols, reading materials and other learning resources will be provided by the course teachers.

GEB 210	Viva voce	2 Credit

Introduction to the Course:
After completion of all theory course examinations of Second Year, students will face a viva voce (oral examination) conducted by the respective examination committee approved by the University. The viva voce is an important mode of assessment, providing an opportunity for the students to demonstrate their knowledge, approach and understandings with the examiners.

Specific objectives:
Oral examination will

- Help to develop students' confidence in answering questions asked by the examiners.
- Prepare students to be ready for answering any related questions covering the whole courses offered in the academic year.
- Provide an opportunity for students to test their communication skills.
- Offer scopes for those who are less confident in the written exams to demonstrate their learning orally
- Create an opportunity to practice for job interviews

GEB 210 (Viva voce) Course Content

All courses offered in Second Year.

Learning Outcomes:
Upon successful completion of this course the student should be able to:

- Know how to present (posture, eye contact, resonance etc.) him or herself in front of a viva-board.
- Know how to answer a question in a very logical way.
- Improve capacity of oral delivery.
- Reduce fear to face a viva board.
- Enhance confidence to face job interviews.

Assessment:
After a student finishes his/her viva-voce, the members of the examination committee will discuss about the student's performance and provide a mark getting consensus from all members.

3rd Year Curriculum
for
Bachelor of Science (Honor's)

Session 2023-2024 onwards

Department of
Genetic Engineering and Biotechnology
University of Dhaka

Course Profile: Third Year

Course Code	Course Title	Credits
GEB 301	Microbial Genetics	2
GEB 302	Developmental Biology	2
GEB 303	Basic Immunology	2
GEB 304	Plant Physiology	4
GEB 305	Molecular Biology of Diseases	4
GEB 306	Methods in Biotechnology	3
GEB 307	Fermentation Technology and Bioprocessing	3
GEB 308	Environmental Biotechnology, Biosafety and Biosecurity	4
GEB 309*	Biostatistics and Epidemiology	4
GEB 310	Laboratory Experiments	6
GEB 311	Viva voce	2
Total	**36**	

*Extra-departmental courses

GEB 301	Microbial Genetics	2 Credit

Introduction

The science of microbial genetics represents a subject area which includes microbiology and genetics and plays a pivotal role in the development of modern genetics and rDNA technology. It deals with the genetics of microorganisms, such as bacteria, virus, archaea, fungi and protozoa. Because of rapid growth rate and short generation time, microbes are ideally suited for basic biochemical and genetics research and made huge contribution to the birth of modern genetic engineering & biotechnology. Microbial genetics encompasses the study of the genotype and phenotypes of various microbial species, regulation of gene expression, phylogenetics and evolutionary studies.

Course objectives

The study of this course will

1. Allow students to understand the fundamental differences of prokaryotic and eukaryotic genetic mechanism;
2. Help students to understand the recent progress in mechanism of gene regulation in prokaryotes;
3. Broaden the horizon of knowledge related to prokaryotic molecular biology;
4. Provide opportunities to learn basic concepts to be implemented in rDNA technology.
5. Help students to improve their capacity for critical thinking through a detailed analysis and evaluation of scientific concepts;
6. Enable students to gain an appreciation for past scientific achievements and how they have helped pave the way for present-day scientific discoveries of exceptional merit.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to Microbial Genetics	Differences between eukaryotic and prokaryotic genetics; Physical organization of bacterial genomes; Molecular biology of bacterial cell division; Genetic variation of bacteria; Mutation; mechanisms of mutation; isolation and identification of mutants	5
2. Transfer of Genetic Elements	Molecular mechanism of transformation; Conjugation of conjugative and non-conjugative plasmids; Generalized and specialized transduction; Consequences of recombination; site-specific and non-homologous recombination; Mosaic genes and chromosome plasticity	5
3. Movable Genetic Elements	Plasmids: structure, properties, functions and stability; Plasmid replication and its regulation; Transposons, mechanisms of transposition; Phase variation	5
4. Regulation of Gene Expression	Transcriptional control - promoter, terminator, attenuator, anti-terminator, etc; Translational control - ribosome binding, stringent response, regulatory RNA, etc; Two-component regulatory pathway,	6

Unit	Course Content	No. of Lectures
	global regulatory systems; Operon model of gene expression, inducible and repressible operons	
5. Genetics of bacteriophage	Structure and classification of bacteriophages; Genetics and molecular biology of λ (lambda) phage, lytic and lysogenic cycle, restriction and modification, and bacterial resistance to phage attack.	3
6. CRISPR Technology	CRISPR-Cas system; anti-CRISPR; CRISPR technology and its applications	3
7. Genetics of Yeast	Yeast as a model organism - advantages, life cycle; Yeast-*E. coli* shuttle vector - YEp, YIp, YCp; Mating type switching in yeast - transformation and recombination; Yeast artificial chromosome; Yeast two-hybrid system	3

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize with the basic concepts of microbial genetics.
2. Understand molecular mechanism of prokaryotic life cycle, horizontal gene transfer and regulations of gene expression.
3. Develop analytical skills to evaluate the information from a wide variety of sources to understand the key concepts of molecular biology.
4. Read, interpret and discuss ground-breaking recent knowledge on genetics.
5. Foster intellectual curiosity in microbial genetics and related fields that goes beyond the course.
6. Introduce with microbial and eukaryotic systems to be used in modern biotechnology.
7. Provide opportunities to learn basic concepts to be implemented in rDNA technology.

Suggested Readings

1. Principles of Genetics by Snustes, D, P. Simmons, M. J. and Jenkins & J. B. Jacaranda. 7th edition (October 26, 2015). Publisher-Wiley
2. Molecular Genetics of Bacteria by Larry. Snyder, Joseph E. Peters, Tina M. Henkin& Wendy Champness 4th edition (January 7, 2013). Publisher-ASM Press.
3. Molecular Genetics of Bacteria by Jeremy W. Dale, Simon F. Park. 5th edition (May 17, 2010). Publisher-Wiley.

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes

7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 302	Developmental Biology	2 Credit

Introduction

The goal of this course is to introduce students to the molecular and cellular mechanisms that underlie the early development of organisms in the broad field of developmental biology. This course will address how complex multicellular organisms with diverse forms and cell types arise from single cells. The field encompasses molecular biology, genetics, cell biology, ecology and evolution. From these viewpoints, students will explore developmental processes and mechanisms that are shared by many diverse organisms. This course will also consider some human implications of developmental biology including medically relevant disorders and ethical questions related to the field. The focus will be on the genes and proteins involved in controlling the behavior of cells in the processes of differentiation, morphogenesis and growth. Developmental mechanisms and processes will be studied in genetic model organisms such as the fruit fly (*D. melanogaster*) and the worm (*C. elegans*) as well as in vertebrates such as the frog (*X. laevis*), chicken and humans.

Course Objectives

The study of this course will

1. Provide the fundamental concepts of cellular, molecular and genetic aspects of developmental biology.
2. Furnish students with insightful knowledge of underlying principles of developmental strategies from fertilized egg to adult animals especially discussed in model organisms and to understand significance of gene regulatory proteins and signaling molecules in embryonic stages from studying genetic mutants.
3. Emphasize dynamic behavior and biological functions of cellular cytoskeletal systems along with regulation of their dynamic structures
4. Implant foundation for analyzing development, post embryonic development and genetic defects to apply in stem cell research and tissue engineering.

Course Content

Unit	Course Content	No. of Lectures
1. Development of multi-cellular organisms	Universal mechanisms of animal development; basic anatomical features of animal; Fertilization, internal and external fertilization; Early development and gastrulation, axis and cell fate specification, genes controlling developmental processes; positional values,	5

Unit	Course Content	No. of Lectures
	inductive interaction and morphogenic effects- growth and division, cell death, sex determination; Organogenesis; Regeneration- repair of lost or damaged tissue; Environmental factors influencing development; Developmental plasticity	
2. Cytoskeleton	Assembly and dynamic structure of actin filaments, microtubules and intermediate filaments; Effects of drugs on filament polymerization; Regulation of cytoskeletal filaments; Molecular motor proteins- structural features and function of myosins, kinesins and dyenins	10
3. Development of Model organisms	*Caenorhabditis elegans*: Cell fates; asymmetric division of egg; pattern formation; developmental signal and changes in cell; apoptotic cell death; *Drosophila melanogaster*: Overview of Drosophila development; syncytium development; genes involved in early patterning- role of egg-polarity genes, dorsoventral signaling genes, Embryo patterning and segmentation, mutations and segmentation genes, homeotic selector genes and patterning of anteroposterior axis, organogenesis and patterning of appendages; *Xenopus laevis*: Overview of Xenopus development; asymmetries of Xenopus egg, blastula formation and gastrulation; convergent extension; neural tube formation, Neurogenesis, Axial patterning, Limb development, Regeneration, Sex Determination; Neural development in higher animals: Neurulation in chick and human embryos.	15

Learning Outcomes

Students who successfully complete the course will be able to:

1. Interpret, clarify and order the main stages of development common to most multicellular organisms.
2. Describe the main structural changes that occur during development.
3. Categorize the cellular behaviors that lead to morphological change during development.
4. Outline the hierarchy of gene activation that occurs in early *Drosophila* development.
5. Understand how gene activation plays a role in differentiation and development.
6. Describe the distinctive characteristics of the Hox genes and clarify how they act as principal regulators of development in multicellular organisms.
7. Illustrate the main signaling pathways that play vital roles in development.
8. Realize how errors in development lead to congenital defects and spontaneous abortion.
9. Understand the influence of external environment in the developmental process.

Suggested Readings

1. Developmental Biology by Scott F. Gilbert. 11th edition (May 31, 2016) Publisher-Sinauer Associates Inc.

2. Principles of Development by Lewis Wolpert, Cheryll Tickle. 6th edition (June 4, 2019). Publisher- Oxford University Press, USA.
3. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter. 7th edition (July 1, 2022). Publisher- W. W. Norton & Company

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 303 Basic Immunology 2 Credit

Introduction

This is an introductory course of immunology. This course will provide an in-depth overview of the basics of immunology. Students will be introduced to the basic concepts/principles of immune system and its roles in body defense mechanism.

Course Objectives

The study of this course will

1. Familiarize students with basic concepts/principles in immunology
2. Introduce students about innate and adaptive immune responses, and the cells and organs involved in those responses
3. Familiarize the students with the different types of immunglobulins and their functions
4. Introduce students about antigen-antibody interaction and antigen presentation

Course Content

Unit	Course Content	No. of Lectures
1. Introduction	Properties and overview of the immune system; Historical perspective	2
2. Innate and adaptive immunity	Innate immunity; external barriers against infection; Features of innate and adaptive immunity; Components of innate/adaptive	5

Unit	Course Content	No. of Lectures
	immune system, connections between innate and adaptive immunity; Humoral and cell-mediated immunity; Clonal selection of B and T lymphocytes	
3. Cells and organs of the immune system	Hematopoiesis; Cells of innate immunity—structure and functions of monocytes/macrophages, neutrophils, basophils, eosinophils, NK cells, mast cells, platelets and dendritic cells; Cells of adaptive immunity—structure and functions of T and B lymphocytes; Organs of the immune system: primary lymphoid organs—thymus, bone marrow, lymphatic system; secondary lymphoid organs—lymph nodes, spleen, mucosa-associated lymphoid tissue	5
4. Antigens and antibodies	Immunogenicity vs antigenicity; properties of antigen/immunogen; Conformation of antigen-antibody binding; antibody affinity and avidity; Structure and function of antibodies; antibody diversity generation	5
5. T cell receptors and MHC molecules	Structural features of TCR; comparison between TCR and Immunoglobulin; Structural features of class I and class II MHC molecules; genomic organization of MHC; MHC polymorphism	4
6. Antigen presentation	Processing and presentation of antigen by class I and class II MHC.	3
7. The complement system	Functions and components; Activation and regulation of complement pathways—classical, alternative and lectin pathways; Membrane attack complex; Biological effects of complement	4
8. Immunological Techniques	Examples and applications of different immunological techniques	2

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize the basic concept of immune system.
2. Understand the principle of adaptive and innate immune system and their differences.
3. Understand the roles of different immune cells/organs.
4. Understand the structure/functions of antibodies and their interactions with antigens.
5. Explain antigen recognition by T and B cells.
6. Acquainted with activation/function/regulation of complement system.

Suggested Readings

1. Immunology by David Male, Jonathan Brostoff, David Roth & Ivan Roitt, 8th edition, 2012. Publisher- Elsevier.
2. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman and Shiv Pillai 10th Edition - February 19, 2021 Publisher-Elsevier.

3. Roitt's Essential Immunology by Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt. 13th edition January 2017. Publisher- Wiley & Blackwell.
4. Kuby Immunology by Judith A Owen, Jenni Punt, Sharon A Stranford, Patricia P Jones. 8th edition 2019. Publisher-WH Freeman and Company.

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 304	Plant Physiology	4 Credit

Introduction

This course is designed to make the students understand the basics of plant physiology and to explain important metabolic processes that occur in plants. It will focus on the physiology and basic architecture of a plant body as well as the molecular biology and biochemistry of plants. In doing so, it will discuss the basic body plan of plants, elaborate the phenomena of growth and development of plants, illustrate the concept of plant-water relations and how transport of water and nutrients take place in plants. From the metabolism standpoint, students will get a deeper idea of several metabolic processes including photosynthesis, respiration, nitrogen fixation, lipid metabolism etc. This course will also give an idea of various plant hormones, acclimation of plants to environmental stress as well as various plant secondary metabolites.

Course Objectives

The study of this course will

1. Introduce students with the basics of plant body plan and physiology.
2. Provide comprehensive understanding on plant growth and development and elaborate water and nutrients transport in plants.
3. Enable students to obtain detailed knowledge on several plant metabolic processes including photosynthesis, lipid metabolism, and nitrogen fixation, to name a few.
4. Enable to have an overall idea about various plant hormones and plant secondary metabolites as well as their functions and commercial applications.
5. Enable to understand plants' response to stress and also senescence in plants.

Course Content

Unit	Course Content	No. of Lectures
1. Plant Cell	Structural and functional features; Plant specific organelles	3
2. Plant growth and development	Concept of growth and development; Seed dormancy, germination, and seedling establishment; Cotyledon, endosperm, and seed coat development; Growth in Response to directional stimuli, Phototropism, Photomorphogenesis; Vascular tissue differentiation; Different types of root growth and differentiation; Flowering and control of flower development, Vernalization; Hormonal and genetic regulation of plant growth and development from seed germination to flowering; *Arabidopsis* as a model plant	13
3. Photosynthesis	Photosynthetic apparatus and light-harvesting complexes, Electron transport pathways in chloroplast membranes, ATP synthesis, Photophosphorylation; Leaf morphology for different light-independent phase reactions; CO_2 fixation: C_3, C_4, CAM plants; Regulation of the Calvin cycle	6
4. Respiration	Aerobic and anaerobic respiration; Oxidative phosphorylation and mitochondrial electron transport complex I, II, III and IV; Regulation of respiration	6
5. Plant-water relations	Types of water movements in plant cells: diffusion, osmosis; Water potential of cells and contributing factors; Positive pressure, negative pressure, root pressure; Cavitation, Permeability; Xylem and Phloem loading, Mechanisms of water absorption; Transpiration, Stomatal complex	5
6. Solute Transport	Active and passive transport system; Transport of nutrients across the primary root, transport in roots via plasmodesmata; Genetic regulation of transport systems	5
7. Nitrogen fixation and nutrient assimilation	Rhizosphere, Plant-mycorrhiza association; Nitrogen fixation by symbiotic and non-symbiotic nitrogen-fixing bacteria, *nif* genes; Uptake and assimilation of nitrate and ammonium; Nitrogen, iron, sulfur, and phosphate metabolisms	7
8. Plant Lipids	Fatty acid biosynthesis and regulation; Beta-oxidation pathway and its regulation; Membrane lipids, Cell wall lipids, storage lipids	6
9. Phytohormones	Types of hormones and functions; Phytohormone signaling pathways	3
10. Acclimation and adaptation	Biotic and abiotic stresses of plants; Hypersensitive response and relevance with diseases; Induction of apoptosis and roles of various genes	4

Unit	Course Content	No. of Lectures
11. Plant secondary metabolites and their importance	Introduction and examples; Applications	2

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Grasp the idea of basic organization of a plant cell and basic architecture of a plant body.
2. Differentiate between plant growth and development; define morphogenesis and differentiation;
3. Gain comprehensive knowledge about plant development starting from seed to shoot formation and finally the advancement from vegetative to flowering stages.
4. Define and elaborate the key concepts and ideas of plant water and nutrient transport through xylem and phloem.
5. Relate the roles, applications and commercial uses of different hormones and secondary metabolites.
6. Gain comprehensive knowledge on a variety of plant metabolic processes such as photosynthesis, respiration, lipid metabolism, nitrogen fixation, and plants adaptation to stress.

Suggested Readings

1. Plant Physiology and Development by Taiz, Lincoln and Zeiger, Eduardo. 6th edition (October 15, 2014) Publisher-Sinauer Associates Inc.
2. Biochemistry and Molecular Biology of Plants by Buchanan B, Gruissem W, Jones R. 2nd edition (August 31, 2015) Publisher-Wiley.
3. Plant Physiology by Lincoln Taiz and Eduardo Zeiger. 5th edition (June 11, 2010). Publisher-Sinauer Associates Inc.
4. Introductory to Plant Physiology by William G. Hopkins, Norman P. A. Huner. 4th edition (December 10, 2008). Publisher-John Wiley & Sons Ltd. UK.
5. Plant Biochemistry & Molecular Biology by Hans-Walter Heldt. 1st edition (January 1, 1997). Publisher-Oxford University Press, USA.
6. Introduction to Plant Biochemistry by Goodwin, T. W. and Mercer, E. I. 2nd edition (January 15, 1990). Publisher-Pergamon Press, Australia.
7. Plant Biochemistry and Molecular Biology by peter J. Lea & Richard C. Leegood. 1st edition (January 1, 1993). Pulisher-John Wiley & Sons Ltd.UK.
8. Plant Physiology by Hans Mohr, Peter Schopfer, January 23, 1995. Publisher-Springer.
9. Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts& Peter Walter. 7th edition (July 1, 2022). Publisher- W. W. Norton & Company.

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions

8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 305 Molecular Biology of Diseases 4 Credit

Introduction

This course encompasses all molecular aspects of diseases processes by integrating knowledge from genetic pathology, immunology, microbiology, parasitology, and virology and illustrates those using specific examples. Students will have detailed knowledge on various diseases (e.g. diabetes, liver diseases, cancer etc)-their cause and classification along with a detailed understanding of their pathobiology and implications in our body at the molecular level.

Course Objectives

The study of this course will

1. Enable students to recognize the basic concepts of disease mechanisms
2. Equip students with an understanding of recent advances in diagnosis and treatment of diseases at the molecular level
3. Provide opportunities to identify the contributing risk factors and the changing profile of different disease incidences worldwide

Course Content

Unit	Course Content	No. of Lectures
1. Introduction	Manifestations and molecular basis of diseases	4
2. Cancer	Definition and diversity; Hallmarks of cancers; Genetic and epigenetic changes in tumor cells; Oncogene and tumor suppressor genes, Activation of proto-oncogene into oncogenes; Chemical carcinogens, Methods of testing chemical carcinogens; Oncogenic viruses and their roles in tumor formation; Hematological malignancies - leukemia, lymphoma and myeloma; Diagnosis of cancers; Cancer treatment: Chemotherapy- antimetabolites, alkylating agents, plant alkaloids, antibiotics and miscellaneous compounds; Immunotherapy; Current trends in cancer therapy	10
3. Cardiovascular disease	Atherosclerosis- molecular mechanism of atheromatous plaque formation; Involvement of LDL and foam cells in heart diseases; Ischemic heart disease; Myocardial infarction (MI) and biochemical markers for MI diagnosis; Heart failure; Disorders of lipoprotein metabolism; Molecular markers of cardiovascular diseases	5

Unit	Course Content	No. of Lectures
4. Diabetes mellitus	Type I, type II and other major clinical classes of Diabetes Mellitus (DM); Genetic basis of type I and type II DM; MODY (maturity onset diabetes mellitus in young), Diabetes insipidus, Gestational DM; Insulin gene and biosynthesis of insulin, Mechanism of insulin action; Complications associated with DM; Diagnosis and treatment of DM	8
5. Liver disease	Microarchitecture of liver; Hyperbilirubinemia; Dubin-Jhonson syndrome, Criglar-Najaar syndrome; Viral hepatitis- types of hepatitis virus and their genomic organization; Fatty liver diseases, Liver cirrhosis; Acute hepatocellular carcinoma, Chronic hepatocellular carcinoma; Liver function tests	7
6. AIDS	Definition and historical perspective; Characteristic features and genomic organization of HIV; HIV mode of transmission HIV and the immune system; Pathogenesis of AIDS: asymptomatic carrier, PGL, ARC, full blown AIDS; Diagnosis of AIDS; Anti-HIV drugs, Vaccine possibilities and recent successes in treatment	5
7. Gastrointestinal diseases	Diarrheal disease caused by *Vibrio cholerae* - acute and chronic diarrhea; pathogenesis and epidemiology; virulence factors; regulation of virulence genes; mode of action of cholera toxin; treatment-antibiotics and vaccine possibilities; prevention; Dysentery caused by *Shigella* - virulence factors; adhesion, invasion, intracellular release and killing of mucosal cells; shiga toxin; Reiter's syndrome - an autoimmune response; organization and regulation of virulence genes; treatment and prevention; *E. coli* gastrointestinal infection: serotypes and verotypes; Virulence factors of ETEC, EAggEC, EPEC, EHEC and EIEC; *Salmonella* infection: diseases caused by species and serotypes of *Salmonella*; virulence factors and their regulation; treatment and prevention; Rota-virus infection	5
8. Brain diseases	Molecular basis of Alzheimer's, Parkinson's and Huntington's disease; Treatment and management of Alzheimer's, Parkinson's and Huntington's disease	5
9. Metabolic disorders	Molecular basis of Phenylketonuria, Alkaptonuria, Maple syrup urine disease, Nieman-pick disease, Glycogen storage diseases and Gout.	5
10. Chromosomal abnormalities	Variations in the number and structure of chromosomes- euploids, aneuploids and polyploids; Deletion, duplication, aberrations, translocation and other structural rearrangements in chromosomes; Chromosomal abnormalities- Down's syndrome, Cystic fibrosis,	6

Unit	Course Content	No. of Lectures
	Fragile-X syndrome, Meta females; etc; Detection of chromosomal abnormalities – karyotyping, FISH; amniocentesis (chorionic villi sampling, alpha fetoprotein sampling); Genetic counselling	

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the molecular mechanism and genetic basis of cancer, protooncogene activation, various agents responsible for the development of cancer and cancer chemotherapy.
2. Familiarize the basic concepts of genetic and epigenetic features of different diseases such as, cardiovascular disease, diabetes mellitus and liver disease.
3. Would be able to know the genomic organization of AIDS virus, mode of transmission, different stages in the developments of full-blown AIDS, antiviral therapies and vaccine possibilities against HIV.
4. Generate a good knowledge on the cell-cell communication, how the signal transduction events underlie various pathological processes.
5. Understand the molecular processes that lead to the development of metabolic disorders, different brain diseases.
6. Explain the cause and complications of structural and numerical chromosomal abnormalities.
7. Demonstrate how detailed knowledge on disease mechanism can drive the development of potential therapeutic strategies.

Suggested Readings

1. Human Molecular Biology: An Introduction to the Molecular Basic of Health and by Richard J. Epstein. 1st edition (November 18, 2002). Publisher-Cambridge University Press.
2. Textbook of Biochemistry with Clinical Correlations by Thomas M. Develin. 7th edition (January 19, 2010). Publisher- John Wiley & Sons Ltd. UK.
3. Harper's Illustrated Biochemistry by Peter Kennelly, Owen McGuinness, Kathleen M. Botham, Victor W. Rodwell, P. Anthony Weil. McGraw Hill / Medical, 32nd edition (2022).
4. Molecular Biology of Health and Disease by Undurti N. Das. Publisher-Springer 1st edition (April 2, 2011)
5. Molecular Pathology: The Molecular Basis of Human Disease by William B. Coleman (Editor), Gregory J. Tsongalis(Editor). Publisher-Academic Press, 2nd edition (November 21, 2017).

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 306 Methods in Biotechnology 3 Credit

Introduction

This course introduces the students to the principles of advance methods and techniques used in molecular biology and biotechnology laboratories. The methods covered in this course have diverse uses including in research; isolation, detection and purification of bio-molecules; and disease diagnosis. A major focus of this course is on the potential applications of different methods and techniques.

Course Objectives

The study of this course will

1. Enable students to understand and learn the principles and applications of basic molecular biology and biotechnology techniques such as: isolation and purification of proteins and nucleic acids, polymerase chain reaction (PCR) and related techniques, gel electrophoresis, hybridization-based techniques, etc.
2. Enable students to understand and learn the principles and applications of advanced molecular biology and biotechnology techniques such as: next generation sequencing, flow cytometry, immunofluorescence imaging, ChIP on chip, LC-MS/MS, etc.
3. Enable students to design experiments to answer complex biological questions using molecular biotechnology techniques.

Course Content

Unit	Course Content	No. of Lectures
1. Isolation of DNA, RNA and proteins	Isolation, detection and quantification of DNA, RNA and protein from bacteria, virus, plant and animal cells	4
2. Gel electrophoresis	Basic principles and uses of agarose and polyacrylamide gel electrophoresis; Pulsed field gel electrophoresis; Capillary gel electrophoresis; Temperature and denaturing gradient gel electrophoresis; 2D gel electrophoresis	3
3. Polymerase chain reaction and related techniques	Standard polymerase chain reaction (PCR) and real-time PCR; Primer design; Variants of conventional PCR - Multiplex PCR, LAMP PCR, Allele specific PCR, ARMS PCR, etc.; RFLP; AFLP; RAPD	5
4. Hybridization-based techniques	Southern, Western and Northern blotting; Micro-array; Probe synthesis; FISH	5

Unit	Course Content	No. of Lectures
5. Recombinant DNA technology	Restriction digestion of DNA/plasmid, ligation and transformation; Recombinant protein expression, extraction and purification.	3
6. DNA sequencing and related techniques	DNA sequencing by Sanger's dideoxy method; 2nd and 3rd generation DNA sequencing techniques; Whole genome sequencing; ChIP-seq, RNA-seq, methyl-seq; Exome-seq SAGE; DNA barcoding; Metagenomics	5
7. Detection of macromolecular interactions	DNA-protein and RNA-protein interaction studies (EMSA, REMSA, ChIP, ChIP on chip, DNAase foot-printing, in vitro transcription); Y2H and B2H systems	5
8. Gene Knockout and Knock-in methods	Recombination based knockouts; CRISPR-Cas9 and other methods; RNAi	3
9. Chromatography techniques	Hydrophobic column chromatography; Ion-exchange chromatography; Affinity chromatography; HPLC; LC-MS/MS	3
10. Flow cytometry	Introduction, principle and applications	3
11. Immunofluorescence microscopy	Immunohistochemistry and immunocytochemistry; Wide-field, confocal, two and multi-photon microscopy; Immunogold microscopy	3
12. Immunoassays	RIA; ELISA, ELISPOT; Gel immunodiffusion assay; Neutralization assay; Coombs tests, etc.	3

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the principles and applications of basic and advanced molecular biotechnology techniques.
2. Design experiments to answer complex biological questions using molecular biotechnology techniques.

Suggested Readings

1. Principles and techniques of biochemistry and molecular biology by K. Wilson and J. Walker 7th edition (April 12, 2010). Publisher- Cambridge University Press.
2. PCR Protocols, Vol. 226 by JMS Bartlett JMS and D. Stirling. 2nd ed. 2003 edition (August 1, 2003) Publisher- Humana press.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Bernard R. Glick and Cheryl L. Patten 6th edition (March 15, 2022). Publisher- ASM publications.
4. Laboratory Protocols: CIMMYT Applied Molecular Genetics Laboratory by CIMMYT 3rd edition 2005. Publisher- Mexico, D.F.

5. Molecular diagnostics: fundamentals, methods, and clinical applications by L. Buckingham and M. Flaws. 1st edition 2007. Publisher- Davis Company.
6. Biotechnology and Genomics by Gupta P. K. 2005. Publisher-Rastogi Publications.
7. Molecular Biotechnology: Principles and Applications of Recombinant DNA by B. R. Glick and J. J. Pasternak. 6th edition (March 15, 2022). Publisher- ASM Press.
8. Microbial Biotechnology: Fundamentals of Applied Microbiology by A. N. Glazer and H. Nikaido. 2nd edition (October 1, 2007). Publisher- Cambridge University Press.
9. Recombinant DNA: Genes and Genomes- A Short Course by J.D. Watson, R.M. Myers, A.A. Caudy, J.A. Witkowski 3rd edition (January 5, 2007). Publisher- W. H. Freeman.
10. Introduction to Biotechnology by W. J. Thieman and M.J. Palladino. 4th edition (July 6, 2018). Publisher- Pearson.
11. Basic Biotechnology by C. Ratledge and B. Kristiansen 3rd edition (June 19, 2006). Publisher- Cambridge Univ. Press.

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 307 Fermentation Technology and Bioprocessing 3 Credit

Introduction

This course aims to provide students with fundamental concepts of fermentation technology. Students will be introduced to the basic knowledge of fermenter design, fermentation modeling, fermentation kinetics, and upstream, downstream and process control knowledge of fermentation technology. Furthermore, this course will describe an in-depth knowledge on media preparation, sterilization and inoculum preparation for the fermentation processes.

Course Objectives

The study of this course will

1. Enable students to recognize the basic concepts of fermentation technology.
2. Provide in-depth knowledge of fermentation kinetics and growth equation.
3. Enable students with an understanding of the importance of sterilization, media preparation and mixing and aeration in cell growth.

4. Provide an opportunity to learn about the application of bioprocess technology.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to fermentation processes	Biochemical and industrial definitions, Types of fermentation processes; Brief history of the development of fermentation industry; General concepts of fermentation process: Submerged fermentation, Solid-state fermentation, Basic components of a fermentation process	5
2. Inoculum	Criteria used for inoculum preparation; Development of inoculum for bacterial, yeast and fungal processes; Culture preservation	3
3. Fermentation media	Essential criteria of media, Medium formulation, Types of medium; Carbon sources, Nitrogen sources, Water, Minerals, Chelators, Growth factors, Buffers, Precursors and Metabolic regulators; Oxygen requirements; Foaming: problems created by foaming, patterns of foaming, solution to foaming, properties of antifoams	4
4. Sterilization processes	Physical sterilization methods; Heat sterilization of media: Batch heat sterilization, Kinetics of batch heat sterilization, Continuous heat sterilization; Filter sterilization: Mechanisms of filtration, Filtration efficiency, Classification of filters, Filter sterilization of media and air, HEPA filters; Sterilization of fermenter, feeds and liquid wastes	6
5. Bioreactors	Design of a typical stirred-tank bioreactor: Basic design, Temperature control, Aeration and agitation, Impeller, Baffles, Sparger; Airlift bioreactors, Bubble column bioreactors and other types of liquid state bioreactors; Solid-state bioreactors: Classification, Basic features, Selection criteria	5
6. Growth kinetics	Feeding strategies for liquid state fermenters; Batch fermentation, Growth kinetics during batch fermentation; Continuous fermentation, Growth kinetics during continuous fermentation; Fed-batch fermentation; Perfusion culture	6
7. Operating conditions and control	Classification of process sensors; Measurement and control of process variables: temperature, mass flow, pressure, rotation rate, foam, weight, biomass, dissolved oxygen, inlet and exit gas, pH, redox, dissolved carbon dioxide; Control systems: Components of control loop, Feedback control loop, Manual and automatic control systems, Classification of automatic control systems	4
8. Fermentation Scale-up	Concepts of scale-up, Factors affecting fermentation scale-up; Fermentation scale-down	3
9. Downstream processing	Cell separation; Cell disruption; Product isolation and purification; Product polishing; Effluent treatment	5
10. Bioprocessing	Applications of bioprocessing in biopharmaceuticals; food and feed; biofuels; biochemicals	4

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize with the fundamental concepts of fermentation technology.

2. Understand the basic design of bioreactor.
3. Understand and use the rate equation for predicting cell growth kinetics.
4. Describe the various modes of bioreactor operation, the advantages and disadvantages of each, and some specialised reactors.
5. Understand the importance of sterilization, media preparation and inoculum development during fermentation processes.
6. Compare and contrast different methods of downstream processing of fermentation processes.
7. Explain the challenges associated with scale-up of processes from lab to pilot to production.

Suggested Readings

1. Principles of Fermentation Technology by Stanbury P F, Whitaker A, Hall SJ. Publisher-Elsevier 3rd edition 2017.
2. Essentials in fermentation technology by Berenjian A. Publisher-Springer; 1st ed. 2019 edition (July 25, 2019).
3. Principles and Applications of Fermentation Technology by Kuila A, Sharma V, Publisher-Wiley-Scrivener; 1st edition (July 30, 2018)
4. Practical Fermentation Technology by Brian McNeil, Linda Harvey Publisher-John Wiley & Sons 1st edition (March 17, 2008).
5. Bioprocessing for Biomolecules Production by Molina G, Gupta VK, Singh B. N, Gathergood N., Wiley- 1st edition January 2020.
6. Bioprocessing Technology for Production of Biopharmaceuticals and Bioproducts by Komives C, Zhou W, editors. Publisher- John Wiley & Sons, Incorporated; 1st edition (December 27, 2018.

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 308	Environmental Biotechnology, Biosafety and Biosecurity	4 Credit

Introduction

This course includes different aspects of environmental and biological challenges and addresses how microbiology can be applied to address these challenges through the integration of biology and environmental science with consideration to important legal, regulatory and social issues.

Course Objectives

The study of this course will

1. Underline an interdisciplinary perspective to deal with environmental pollution.
2. enable students to have detailed knowledge on GMOs and their current trend
3. allow students to discuss different topics in association with the ethical issues and bio-safety regulations
4. enable students to explain issues related to GM foods, food security and safety assessment
5. equip students with an understanding of the utilization of microbial processes in waste and water treatment, and bioremediation

Course Content

Unit	Course Content	No. of Lectures
1. Environmental Issues	Global climate changes and its impact; Pollution of air, water and soil - causes, effects, prevention and mitigation; Pollution by heavy metals; sources, metal solubility, bioavailability and speciation; toxic effects of metals on microbial cells; mechanisms of microbial metal resistance and detoxification; Pollution by recalcitrant xenobiotic compounds and microplastics; Transfer of harmful compounds through the ecosystems; bioaccumulation and biomagnification	10
2. Applied Environmental Biotechnology	Bioremediation: biodegradation of xenobiotic compounds, in-situ and ex-situ approaches to bioremediation, phytoremediation; Applications of genetically engineered organisms in bioremediation; Microbial treatment of solid wastes and effluents; Biosensors for environmental monitoring; Indicator microorganisms, microbial source tracking; Biogas, biofuel, bioplastic, biofertilizer, biopesticides; Biomining and bioleaching; Conservation of biodiversity	15
3. GMOs and Environment	GMOs and their applications, commercially important GMOs; Effects of GMOs on human health, agriculture and environment; Social and ethical concerns about GMOs; Safety assessment of GM foods; Food safety and security	10
4. Biosafety and Biosecurity	Definitions and comparison of biosafety and biosecurity; Biological risk analysis: biorisk, biorisk spectrum, components of risk analysis, risk assessment and risk management, general principles of risk analysis, WHO biorisk management framework for life sciences research; Risk group classification of biological agents: necessity and criteria of risk group classification, risk group classification of pathogenic microorganisms, risk group databases, risk group classification of genetically modified agents, classification of biological agents affecting animals and plants; Biosafety levels; practices, equipment and facilities required for various biosafety levels; containment levels for research with plants, animals and arthropods; Primary containment: good microbiological practices; personal protective equipment; biosafety cabinets, types of biosafety cabinets, selection of biosafety cabinet types, comparison of biosafety cabinets with laminar flow cabinets and fume hoods; Biohazard communication:	20

Unit	Course Content	No. of Lectures
	definition and examples of biohazard, criteria and applicability of biohazard sign, other hazard symbols, pathogen safety data sheet, materials safety data sheet, chemical hazard rating diamond; Packing and shipping of biological materials; Disposal of biohazardous wastes; Bioterrorism: definition, categories of bioterrorism agents, historical events of bioterrorism; Biosecurity, standard biosecurity measures; Biosafety regulations in Bangladesh	
5. Environmental Regulations and Ethics	Convention on Biological Diversity, Cartagena Protocol, Nagoya Protocol, Kyoto Protocol, Paris Agreement, Glasgow Climate Pact; Environmental policies and legislations in Bangladesh; Ethical issues in environment	5

Learning Outcomes

1. Upon successful completion of this course the student should be able to:
2. Describe existing and emerging technologies that are important in the area of environmental biotechnology.
3. Understand the principles and techniques underpinning the application of biosciences to the environment.
4. Describe global climate change pattern and their causes.
5. Address biotechnological solutions to address environmental issues including pollution, renewable energy and water treatment.
6. Analyze case-studies representative of key areas of environmental biotechnology.
7. Implement a range of practical approaches relevant to environmental microbiology and biotechnology.
8. Acknowledge the ethical implications of biotechnology.

Suggested Readings

1. Basic Concepts in Environmental Biotechnology by Sharma N, Sodhi AS, Batra N, editors. Publisher-CRC Press; 1st edition (September 9, 2021).
2. Advances in Environmental Biotechnology by Kumar R, Sharma AK, Ahluwalia S. S., editors. Publisher- Springer, 1st edition (April 19, 2017).
3. Principles and Applications of Environmental Biotechnology for a Sustainable Future by Ram Lakhan Singh (Editor), Publisher-Springer, 1st edition 2017.
4. Textbook of Environmental Biotechnology by Pramod Kuma, Vipin Kumar, Pravin Kumar SachanPublisher-Woodhead Publishing India; 1st edition (June 30, 2018).
5. Environmental Microbiologyby Ian L. Pepper, Charles P. Gerba, Terry J. Gentry, Raina M. Maier (Editor).Publisher-Academic Press, 2nd edition (October 3, 2008).
6. Biological Safety: Principles and Practices by Karen B. Byers, Dawn P. Wooley (Editor), Publisher-ASM Press, 5th edition (February 22, 2017).
7. Biosafety Resource Book by Food and Agriculture Organization of the United Nations (Author), Publisher-FAO; Box edition (December 30, 2011).

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 309 Biostatistics and Epidemiology 4 Credit

Introduction

This is a basic course covers the fundamentals of statistics, biostatistics and epidemiology. Basic knowledge of statistics is essential to analyze and interpret basic, clinical, and genotyping data. Understanding of probability, different statistical tests, data representation methods, sampling methods are important to design experiments and to deduce experimental findings.

Course Objectives

The study of this course will

1. Enable students to understand basic statistical principles and its application/scope in biosciences.
2. Enable students to have basic concepts of probability, random variation and commonly used statistical probability distributions.
3. Familiarize the students with the principles and uses of linear and logistic regression models.
4. Create an opportunity to identify key sources of data for epidemiologic purposes and to draw appropriate inferences from epidemiologic data.
5. Enable students to interpret results of statistical analyses found in clinical and public health studies.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to biostatistics	Definition, application and scope of biostatistics; Basic statistical principles and terminologies- population, sample, parameter, statistic, variable, measurement scales etc.	2
2. Frequency distribution	Constructing frequency distributions for qualitative and quantitative data; Relative frequencies and percentages,	5

Unit	Course Content	No. of Lectures
	cumulative frequencies; Usefulness of frequency distribution with numerical examples	
3. Graphical representation of data	Histogram; Bar-diagram; Pie chart; Line-graph; Ogive	5
4. Descriptive statistics	**Central tendency-** Concept, objectives of measure of central tendency and different measures e.g., arithmetic mean, geometric mean, harmonic mean, median and mode; properties of different measures and their uses; **Dispersion-** concept, objectives of measures of dispersion, absolute and relative measures of dispersion e.g., range, variance, standard deviation, co-efficient of variation etc., properties of different measures of dispersion and their uses; **Position-** Concept, different measures of positions - quartiles and percentiles; interquartile range and box-whisker plot.	5
5. Sampling techniques	Concept; sampling frame; sampling design; Simple random sampling; Stratified random sampling.	4
6. Probability and probability distribution	Definition and properties of probability; Marginal and conditional probabilities; Different rules of probability - multiplication and addition rules, independence etc; Definition of random variable and probability distribution; binomial distribution, Poisson distribution and normal distribution; Concept and different measures of skewness and kurtosis	6
7. Test of hypothesis	Concept of statistical inference and statistical hypothesis testing; Definition of null and alternative hypothesis; Type 1 and type 2 errors; Level of significance; Confidence intervals; Test of mean- test of hypothesis about a single mean, test of hypothesis for the difference between two means; Paired t-test; Tests for proportions; General test of independence; Analysis of variance (ANOVA) test- one-way and two-way classifications; P-value of a test; Adjusted p-value, FDR q-value	8
8. Correlation and regression	**Correlation analysis-** concept, definition and properties of correlation coefficient, different methods of studying correlation coefficient, interpretation and uses of correlation coefficient; **Linearregression analysis-** concept and definition of dependent and independent variables and regression, least square method to estimate the parameters of simple linear regression model and its assumptions, linear regression with qualitative explanatory variables, multiple linear regression, interpretation and	7

Unit	Course Content	No. of Lectures
	application of linear regression analysis; **Regression with binary dependent variable-** logistic regression and odds ratio and their interpretation and usefulness; Clustering, Principle component analysis.	
9. Epidemiology	Definition and scope of epidemiology; Types of epidemiologic research- experimental (laboratory, clinical trial, community intervention), quasi experimental (clinical/laboratory, program/policy), observational studies; Design options in observational studies methods; Types of observational study designs (cohort, case-control, cross-sectional studies)	7
10. Quantification of disease events	Basic measures of disease frequency, incidence and prevalence; Mortality measures- age, period and cohort effects; Measures of association- ratio measures and difference measures (relative risk, odds ratio, risk difference, etc.)	5
11. Use of software in biostatistics	Hands on training on R/SPSS/SAS.	6

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the importance and applications of statistics in biosciences and epidemiological studies
2. Comfortable with statistical methods for calculating summary estimates, measures of variability, and confidence intervals.
3. Aware of and able to manipulate probabilities and the Normal and Binomial distributions.
4. Calculate and define the significance of probability values, odds ratio, and risk difference, statistical scores etc.
5. Able to carry out and interpret a variety of tests of significance, including two-group comparisons using t-tests, chi-square tests, one-way/two-way ANOVA and others.
6. Familiar with basic principles and uses of linear and logistic regression models for biological/clinical research.
7. Carry out data analyses using statistical software such as SPSS.
8. Describe and apply a variety of epidemiologic concepts and methods in population-based clinical studies.

Suggested Readings

1. Basic Biostatistics for Geneticists and Epidemiologists: A Practical Approach by Robert C. Elston, William D. Johnson. Publisher-John Wiley & Sons, Ltd.1st edition (December 3, 2008).
2. Fundamentals of Biostatistics by Bernard Rosner. Publisher-Cengage Learning, 8th edition (August 3, 2015)
3. Statistics for Biologist by R.C. Campbell. Publisher-Cambridge University Press, 3rd edition (July 28, 1989).

4. Epidemiology and Biostatistics: An Introduction to Clinical Research by Bryan Kestenbaum (Author)
5. Publisher-Springer 2nd edition 2019
6. Text Book of Biostatistics by A.K. Sharma (Author). Publisher-DISCOVERY PUBLISHING HOUSE (January 1, 2022).

Additional reading materials will be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 310	Laboratory Experiments	6 Credit

Introduction

This course is designed to let the students perform experiments in Labs with an aim to make them understand the core concepts, theories and topics that are delivered in their class lectures. Students will be provided hands-on training on different methods and techniques of molecular biology and biotechnology. Emphasis will be given on handling and working with DNA/RNA in micro-liter volumes, DNA/RNA extraction basis and methodology, EK genomic DNA isolation, gel electrophoresis, restriction digestion analysis, expression of reporter genes in bacteria, and so on. The students will also be familiarized and get hands-on Bioinformatics training on working/analyzing DNA/RNA sequences, and exploring functions of DNA sequences from genes to genomes. As a whole, this course will provide an in-depth training on the manipulation of DNA sequences and prepare students to implement their knowledge in Biotechnology.

Course Objectives

This course will enable the students to:

1. Apply and investigate theoretical and conceptual knowledge.
2. Isolate, detect, and quantify DNA from both animal and plant sources.
3. Perform PCR (Polymerase chain reaction), restriction digestion, and RNA extraction.
4. Carry out basic microbiological and tissue culture experiments.
5. Observe gene expression in bacteria.
6. Enable students to understand the use of bioinformatics in DNA sequence analysis.
7. Gain knowledge about biological databases, data format and extraction, the resources, tools/software.

8. Perform DNA/RNA sequence analysis.
9. Learn the basic and advanced bioinformatics tools to deal with DNA/RNA sequence data and explore from genes to genome.
10. Emphasize on learning about the central aspects of the flow of information from DNA, and RNA to protein and apply them in genetic engineering.
11. Enable students to record experimental data, analyze/interpret them and present their findings in written format.

Wet-Lab experiments. The titles of the experiments are as follows:

Unit	Course Content
1.	Handling and measuring small volumes: Micro pipetting.
2.	Solution preparation for analytical measurement.
3.	Isolation and detection of genomic DNA from animal tissue.
4.	Quantification of DNA using Nanodrop.
5.	Genomic DNA isolation from plant materials by CTAB method.
6.	Restriction digestion analysis of plasmid DNA.
7.	Amplification of DNA by polymerase chain Reaction (PCR).
8.	DNA Restriction Fragment Length Polymorphism (RFLP) analysis.
9.	Excision and extraction of DNA fragments from agarose gel.
10.	Isolation and quantification of RNA from animal tissue.
11.	Expression of GFP protein of pGLO plasmid in *E. coli*.
12.	Isolation of chloroplast from plant leaves.
13.	Induction of callus from sunflower seeds.
14.	Analyzing sporulation of Yeast.
15.	Identification of human streptococcal pathogens.
16.	Isolation of bacteriophages from sewage water sample.
17.	Observation of a typical fermenter and its operation.

Dry- Lab. experiments (*in silico* bioinformatics)

Unit	Content
1. Activity 1	**Exploring National Center for Biotechnology Information (NCBI)**. The gateway, biological databases, Entrez, the search engine & its resources. Introducing various databases like PubMed, PubMed Central, Refseq, Gene, Protein, Structure, Genome, OMIM, MapViewer, and tools like BLAST- hands-on training on data extraction, structuring, storing, saving, and analysis.
2. Activity 2	**Working with DNA sequences I (Nucleotide database, data extraction & sequence alignment).** Exploring primary and secondary databases of nucleotide sequences their organization & data type. GenBank entry, Flat file format, FASTA format. Basis of sequence alignment: local & global alignment. DNA sequence analysis using: DotPlot, Nucleotide BLAST (BLASTn), Global align.
3. Activity 3	**Working with DNA sequences II (Data analysis for recombinant DNA technology).** Analyzing DNA composition, codon frequency, finding repeats, Finding open reading frames, protein-coding regions, locating genes, finding exon-intron boundaries,

Unit	Content
	computing restriction mapping, designing PCR primers, removing vector sequences, VecScreen, primer BLAST, UniProt.
4. Activity 4	**Working with whole genomes.**Complete whole viral genomes, bacterial genomes, bacterial genomics at TIGR, Human genome, Mitochondrial DNA, Mito-MAP, Genome Browser, Ensemble and UCSC genome browsers, reading into genes and genomes, analyzing sequence with genome scan, assembling sequence fragments to contigs, assembling your sequences with CAP3.
5. Activity 5	**Human genome polymorphisms and biomarkers**. Single nucleotide polymorphism (SNPs) databases exploration: dbSNP, Ensemble variation, global human genome variation analysis, finding disease genes with SNPs, population genetics: 1000 genome phase 3.
6. Activity 6	**Exploring cancer genomics.** Gene finder & gene info, SNPs associated with cancers, ATM signaling pathway, gene ontology, chromosome maps, FISH maps, analyzing RNA sequence, RNA folding, and secondary structure prediction, RNAi view.

Field trip/industry visit/study tour

Unit	Content
Activity 1	**Field trip/industry visit/study tour.** Get first hand information or experience from industry research organization / field trip through direct observation/participation in events relevant to courses.

Learning Outcomes

Upon successful completion of this course, the student should be able to:

1. Handle and work with small volumes of samples with confidence.
2. Familiarize the basic concepts of molecular biotechnology techniques for analyzing DNA and RNA.
3. Perform qualitative and quantitative analysis of DNA/RNA using gel electrophoresis, micro-volume spectrophotometer NanoDrop.
4. Understand the basis of PCR reactions and perform amplification reactions using thermocycler.
5. Able to extract DNA from gel.
6. Able to do bacterial transformation and gene expression.
7. Acquainted with the technique of microbial culture and characterization.
8. Understand about homology, local and global sequence alignments.
9. Find the best local alignments between your two sequences.
10. Perform BLAST and interpret results.
11. Design PCR primer using bioinformatics tool.
12. Familiarize with the basic techniques of DNA sequence data analysis like ORF, restriction mapping, and vector contamination detection.
13. Understand the organization of whole genome databases, data extraction and interpretation.
14. Acquire detail understanding of MapViewer, Ensemble & UCSC genome browser.
15. Develop ideas about cancer genomics, genes, and SNPs associated with cancer.

Suggested readings

1. Protocols, reading materials, and other learning resources will be provided by the course teachers.

2. Additional reading materials will be suggested by the course teachers.

Instructional Strategies

1. Interactive class Lectures on the principle, procedure and application of each experiment.
2. Obtain immediate feedback by asking questions.
3. Answer queries, if any.
4. Practice problem solving.
5. Hands-on Laboratory training.
6. Encourage group discussions.

Assessment

1. Class participation: Attendance.
2. Continuous assessment: In-course examination, assignment.
3. Practical note-book assessment.
4. Final Examination: Assessment of written test.
5. Viva voce

GEB 311	Viva voce	2 Credit

Introduction

After completion of all theory course examinations of Third Year, students will face a viva voce (oral examination) conducted by the respective examination committee approved by the University. The viva voce is an important mode of assessment, providing an opportunity for the students to demonstrate their knowledge, approach and understandings with the examiners.

Course Objectives

Oral examination will

1. Help to develop students' confidence in answering questions asked by the examiners.
2. Prepare students to be ready for answering any related questions covering the whole courses offered in the academic year.
3. Provide opportunity for students to test their communication skills.
4. Offer scopes for those who are less confident in the written exams to demonstrate their learning orally
5. Create opportunity to practice for job interviews

Course Content

All courses offered in Third Year.

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Know how to present (posture, eye contact, resonance etc.) him or herself in front of a viva-board.
2. Know how to answer a question in a very logical way.
3. Improve capacity of oral delivery.
4. Reduce fear to face a viva board.
5. Enhance confidence to face job interviews.

Assessment

After a student finishes his/her viva-voce, the members of the examination committee will discuss about the student's performance and provide a mark getting consensus from all members.

4th Year Curriculum
for
Bachelor of Science (Honor's)

Session 2024-2025 onwards

Department of
Genetic Engineering and Biotechnology
University of Dhaka

Course Profile: Fourth Year

Course Code	Course Title	Credits
GEB 401	Advanced Molecular Biology	4
GEB 402	Cell Signaling	2
GEB 403	Immunology	2
GEB 404	Molecular Diagnostics and Pharmacogenomics	2
GEB 405	Forensic DNA Technology	2
GEB 406	Genomics, Proteomics and Bioinformatics	3
GEB 407	Microbial Biotechnology	3
GEB 408	Plant Biotechnology	3
GEB 409	Animal Biotechnology	3
GEB 410	Marine Biotechnology	2
GEB 411	Research Methodology	2
GEB 412	Laboratory Experiments	6
GEB 413	Project	2
GEB 414	Viva voce	2
	Total	**38**

GEB 401 Advanced Molecular Biology 4 Credits

Introduction

Molecular Biology is an extensive and diverse field of sciences which deals with the molecular basis of biological activities among biomolecules in the diverse systems of a cell, which includes the interactions of DNA, RNA and proteins as well as the regulation of these interactions. Molecular biology is involved in determining how intricate biological systems work; from the coding potential of DNA to RNA to protein as well as RNA-mediated regulations through to the regulated activity of proteins and large protein complexes. Molecular biology plays a pivotal role in sustained biotechnological development. With this background, this course will focus on recent advancement in Molecular Biology field to promote student understanding of the biological systems and the art of scientific communication.

Course Objectives

The study of this course will

1. Allow students to understand the most recent advancement in molecular biology
2. Help students to understand the recent progress in mechanism of gene regulation in eukaryotes
3. Enable students to improve their capacity for critical thinking through a detailed analysis and evaluation of scientific concepts in advanced molecular biological research

4. Broaden the horizon of knowledge related to molecular biology
5. Help students to gain an appreciation for past scientific achievements and how they have helped pave the way for present-day scientific discoveries of exceptional merit
6. Provide opportunities to learn basic concepts to be implemented in rDNA technology
7. Help students to improve their capacity for critical thinking through a detailed analysis and evaluation of scientific concepts and experimental designs in advanced molecular biological research.

Course Content

Unit	Course Content	No. of Lectures
8. Organization of eukaryotic genome	Evolution of complex genome; Content of the genome; Interrupted gene; Gene and gene number; Gene mapping; Gene amplification, Clusters and Repeats; Repetitive DNA and its relevance to plants and animals, Inverted and tandem repeats; Evolution of globin genes; Polytene and Lampbrush chromosome; Regulation of chromatin structure; Insulator and anti-insulator	8
9. Molecular biology of the telomere and telomerase	Structure, function and biogenesis; TERT structure and mechanism of replication by TERT, Regulation of TERT activity; Telomere-independent functions of TERT; Significance of TERT in diseases	5
10. The dynamic genome	Mobile genetic elements in eukaryotes (jumping genes) – relevance to plants and studies in maize; Targeting the mobile genetic elements of disease	5
11. Regulation of eukaryotic gene expression	Elements of transcriptional unit; Promoters, enhancers and repressors: structure, conserveness and specificity; Catalytic introns;Activating transcription complex: Mediators of transcription; Structural features of transcription factors; Co-activators & co-repressors; Locus control region; Nuclear receptors and response elements; Models of transcription complex assembly;Regulation of gene expression in heterologous system; Heterologous transgene expression in animals; Tissue-specific promoters; Examples of specific gene expression regulation (histone, globin, heatshocks, leghaemoglobin and storage proteins etc.)	7
12. Structural and regulatory RNA	Structure and complexity of RNAs; structures of rRNA and tRNA; Regulation of rRNA & tRNA expression; Processing of rRNA and tRNA; Riboswitching; RNA editing; Non-coding RNAs (Antisense RNA; RNAi; miRNA; sRNA; siRNA; lncRNA; tmRNA; eRNA; piwiRNA; snRNA etc.); Regulatory RNA; Catalytic RNA and ribozyme	8
13. Protein localization and dynamics	Protein translocation; Translocon; Membrane localization; Sec system; Homeostasis of cellular proteins; Proteasome, ClpP protease; Protein splicing; Molecular chaperones and protein folding; Unfolded protein response; Transport of molecules between nucleus and cytosol; Nuclear pore complex; Nuclear localization signal; Nuclear import and export model; Transport across ER, Golgi, Mitochondria and chloroplast; Signal peptide and signal recognition particle	10
14. Epigenetics	Concepts of epigenetics; Mechanisms of DNA methylation, methyl CpG recognition and demethylation, mechanisms of various histone modification; Chromatin reader and domain; Structural properties of HMTs and HDMs; Histone modification patterns of active and	12

Unit	Course Content	No. of Lectures
	silenced gene; Chromatin remodeling through chromatin regulatory factors (CRFs); Polycomb silencing mechanisms and the management of genomic program; Epigenetic regulation of cancers; Histone onco-modification; Epigenetic drugs for cancer treatment; Reversibility of epigenetic modification patterns	
15. Genomic imprinting	Concept; Mechanism of imprinting: DNA methylation, chromatin modification, chromosomal position effect; chromatin insulators	5

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize with the advanced concepts of molecular biology.
2. Understand the critical principles of cellular systems, which include genomic imprinting and epigenetics, telomere biogenesis and telomeric sciences, role of nuclear receptor and co-receptor in transcriptional activation, RNA mediated regulation of gene expression, protein folding and dynamics.
3. Develop analytical skills to evaluate the information from a wide variety of sources to understand the key concepts of molecular biology.
4. Read, interpret and discuss ground-breaking recent knowledge on molecular biology.
5. Foster intellectual curiosity in molecular biology and related fields that goes beyond the course.
6. Introduce with microbial and eukaryotic systems to be used in modern biotechnology.
7. Understand different type of modification in DNA and histone with their epigenetic affect in gene expression.
8. Able to think the association of the different mechanisms which control the epigenetic outcome individually and in combination.
9. Explain different types of diseases associated with epigenetics.

Suggested Readings

1. Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Genes XII. 2017. Jones and Bartlett Learning.
2. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, John Wilson, Tim Hunt. Molecular Biology of the Cell. 7th edition. 2022. W. W. Norton & Company.
3. D. Peter Snustad and Michael J. Simmons. Principles of Genetics. 7th Edition. 2015. Wiley.
4. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Kelsey C. Martin, Michael Yaffe, Angelika Amon. Molecular Cell Biology. 9th edition. 2021. W. H. Freeman.
5. Trygve O Tollefsbol. Handbook of Epigenetics. 3rd edition. 2022. Academic Press.
6. Manel Esteller. Epigenetics in Biology and Medicine. 1st edition. 2008. CRC Press.
7. Woodward, T., James, G. The Mysterious Epigenome: What Lies Beyond DNA. 1st edition. 2011. Kregel Publications.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures

3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 402 Cell Signaling 2 Credits

Introduction

This course will provide a full overview of the cellar signal transduction mechanism. Students will be introduced to signaling molecules/receptors and the general principles of cell signaling. Various signaling pathways involving G-protein coupled receptors; enzyme coupled receptors; signaling in plants/microorganisms and regulation of signaling pathways will be discussed.

Course Objectives

The study of this course will

- Familiarize students with basic concepts/principles cell signaling
- Introduce students about signaling molecules and their corresponding receptors for transduction of signals
- Familiarize the students with various signaling pathways and their regulations.

Course Content

Unit	Course Content	No. of Lectures
1. General principles of cell signaling	Extracellular signal molecules and their receptors; Action of signaling molecules; Cellular response by different cell types; Signaling by nitric oxide (NO), Nuclear receptor, Ion channel-linked, G-protein-linked and enzyme-linked receptors; Signal relay by cell surface receptors; Intracellular signaling proteins as molecular switches, Role of scaffold proteins; Modular binding domain and signaling protein interaction, Desensitization to signal molecules	5
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, cAMP-dependent protein kinase A (PKA)-mediated signaling; Inositol phospholipids signaling pathway, Ca^{2+} as intracellular messenger; Ca^{2+}/calmodulin-dependent protein kinase signaling; Regulation of ion channels by G-proteins; Sensory transduction in vision, olfaction and gestation; Amplification of extracellular signals, Desensitization of G-protein-coupled receptors	5

Unit	Course Content	No. of Lectures
3. Signaling through enzyme-coupled receptors	Classification of enzyme-coupled receptors; Receptor tyrosine kinases (RTKs), Docking sites for proteins; Activation and regulation of Ras, Activation of MAP kinase signaling module;EGF-signaling leading to Ras activation; Insulin receptor-mediated signaling, PI 3-kinase/protein kinase B signaling pathway; Cytokine receptors and the JAK-STAT pathway; Receptor Ser/Thr kinases and TGF-ß signaling pathway	5
4. Signaling in microorganisms and plants	Two component signaling pathway of bacterial chemotaxis; Detection of ethylene by plants through two-component system and MAPK cascade	5
5. Signaling pathways depending on proteolysis	Activation of Notch receptor by cleavage; Frizzled receptors and Wnt signaling; Hedgehog signaling in *Drosophila*; NF-kB dependant signaling pathway; Cleavage of signaling proteins by matrix metalloproteinases; Cleavage of amyloid precursor and Alzheimer's disease	5
6. Regulation of cell cycle by protein kinases	Activation of cyclin-dependent protein kinases (CDKs) by cyclin; Regulation of CDKs; Controlled degradation of cyclin; Regulated synthesis of CDKs and cyclins	5

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize the basic concept/principles of cell signaling.
2. Understand how interaction between signaling molecules and receptors relay signals
3. Understand various forms of signaling that transmit signals to short and long distances
4. Familiarize with various signaling pathways for growth, differentiation, death
5. Familiarize with signaling pathways for vision, taste and odor
6. Familiarize with the regulation of cell cycle and signaling pathways

Suggested Readings

1. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, John Wilson, Tim Hunt. Molecular Biology of the Cell. 7th edition. 2022. W. W. Norton & Company.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, HiddePloegh, Kelsey C. Martin, Michael Yaffe, Angelika Amon. Molecular Cell Biology. 9th edition. 2021. W. H. Freeman.
3. David L Nelson and Michael M Cox. Lehninger Principles of Biochemistry. WH Freeman. 8th edition. 2021.
4. Gerhard Crauss. Biochemistry of Signal Transduction and Regulation. Wiley. 5th edition. 2014.
5. Lewis Cantley, Tony Hunter, Richard Sever and Jeremy Thorner. Signal Transduction: Principles, Pathways and Processes. CSH Press. 1st edition. 2014.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 403 Immunology 2 Credit

Introduction

This fundamental course will provide in-depth knowledge on advanced immunology. Students will be introduced to the concepts of defense against infectious agents, immune deficiency,immunological tolerance, autoimmunity and hypersensitivity. Furthermore, this course will provide knowledge on barriers of transplantation and the general immune responses against tumors.

Course objectives

The study of this course will

1. Provide in-depth knowledge on general immune response against infectious agents.
2. Enable students with an understanding of the concepts of immunological tolerance, autoimmunity, immunodeficiency and hypersensitivity.
3. Enable students to recognize the basic concepts of transplantation and rejections.

Course Content

Unit	Course Content	No. of Lectures
1. Defense Against Infectious Agents	Immunity to viruses; Immunity to bacteria and fungi; Immunity to protozoa and worms	5
2. Immunodeficiency	Primary immunodeficiency: B and T cell deficiency; Severe combined immunodeficiency (SCID); Deficiencies of complement proteins; Secondary immunodeficiency; Immunodeficiency caused by drugs, mutation, and immune response; AIDS; Vaccination	4

Unit	Course Content	No. of Lectures
3. Immunological Tolerance	Features and mechanisms of immunological tolerance; Experimental induction of tolerance; T and B-cell tolerance; Artificially induced tolerance;Application of tolerance	4
4. Autoimmunity and Autoimmune diseases	Association of autoimmunity with diseases; Genetic factors, pathogenesis, etiology, diagnosis and treatment	5
5. Transplantation and rejection	Barriers of transplantation; Host vs graft response; Graft vs host reactions; Hyperacute and chronic rejections; Role of T-cell in rejection; Genetic predisposition to graft rejection; Prevention of rejection; Xenogenic transplantation and bone marrow transplantation	4
6. Immunity to tumors	General features of tumor immunity; Tumor antigens, their characterization and detection; Immune response to tumors; Evasion of immune responses by tumors; Immunodiagnostics and immunotherapy for tumors	3
7. Hypersensitivity reactions	Coombs and Gell classification of four types of hypersensitivity reactions; Type I: IgE-mediated hypersensitivity; IgE cross-linkage and biochemical events in mast cell degranulation; Role of T-cell in immune response to inhalant allergens; Genetics of allergic diseases; Factors influencing the symptoms of allergic disease; Asthma and bronchial reactions to inhalant antigens; Type II: Causes; Mechanism of cell damage; Reaction against blood cells and platelets; Reaction against tissue antigens; Hemolytic diseases of newborn; Type III: Causes and mechanisms; Experimental models of immune-complex disease; Removal of immune complexes; Deposition and detection of immune-complexes; Type IV: Overview of DTH; Types of DTH: Contact hypersensitivity, tuberculin-type hypersensitivity, granulomatous hypersensitivity; Cellular reaction in type IV hypersensitivity; Diseases manifesting delayed hypersensitivity	5

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the general immune responses against bacteria, virus, fungi and parasites.
2. Explain the basic principles and mechanism of immunological tolerance.
3. Understand the reason behind primary and secondary immunodeficiency and its associated diseases.
4. Familiarize with the fundamental concepts of transplantation and rejections.
5. Explain the concepts of autoimmunity and autoimmune diseases.
6. Acknowledge the role of immunity to tumors.

Suggested Readings

1. Immunology by David Male, Jonathan Brostoff, David B Roth and Ivan Roitt. Saunders. 8th edition. 2012.
2. Roitt's Essential Immunology by, Seamus J Martin, Dennis R Burton, Ivan M Roitt and Peter J Delves. Wiley-Blackwell. 13th edition. 2017.
3. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H Lichtman and Shiv Pillai. Elsevier. 10th edition. 2021.
4. Kuby Immunology by Jenni Punt, Sharon Stranford, Patricia Jones, Judy Owen. W. H. Freeman. 8th edition. 2018.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment:

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 404	Molecular Diagnostics	2 Credit

Introduction

This course is a comprehensive introduction to the basic principles of the rapidly growing field of molecular diagnostics emphasizing molecular test methods and their applications in the laboratories. The whole course represents an in-depth knowledge of molecular diagnostics which will render the students a strong foundation for future exploration.

Course Objectives

The study of this course will:

1. Emphasize a deeper insight into the fundamental methods of molecular diagnostics.
2. Equip the students about the preparation of clinical specimens and test methodologies used for molecular diagnostic testing.
3. *Describe the techniques used in diagnostics laboratories and the underlying advantages and limitations of each technique.*
4. Underline numerous applications of molecular diagnostic techniques and their future implications.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to molecular diagnostics	History and evolution of molecular diagnostics as it transformed the medicine; Types of samples (blood, buccal cells, sputum, amniotic fluid, CVS etc); Collecting and handling samples; Sample storage strategies; Characterization of samples	2
2. Molecular diagnostic techniques	Hybridization based techniques; PCR; Variations of PCR (e.g., ARMS PCR, Allele specific PCR etc) and their applications in molecular diagnosis; Combination techniques; PCR-Electrophoresis, PCR-Hybridization, PCR-Hybridization (PCR-SSP, PCR-SSOP), PCR-RFLP, PCR-Capillary Electrophoresis, PCR-sequencing; Primer extension method; Melting curve analysis; Karyotyping technology: strengths and limitations of karyotyping; Fluorescent *in situ* hybridization (FISH) analysis/interpretation; Chromogenic *in situ* hybridization (CISH); Sequencing techniques: Sanger sequencing and NGS; Germline vs somatic variation analysis	2
3. DNA-based molecular diagnostics and their applications	Principles of DNA extraction and quantification; Detection of viral pathogens (HBV, HPV etc); quantitation of viral copy number; Genotyping of viral strains (HBV); Bacterial pathogen (MTB, Shigella, Salmonella, E. coli etc); Diagnosis of genetic diseases; α and β thalassemia, Fragile X Syndrome, Cystic fibrosis; Transplantation genetics; HLA-A, B, DR typing, Molecular cytogenetics; Detection of chromosomal abnormalities (trisomy 13, 18, 21 and sex chromosome abnormalities); DNA microarrays	2
4. RNA-based molecular diagnostics and their applications	Isolation of RNA from clinical samples; Necessary precautions while working with RNA; qRT PCR: Preparation of cDNA; Sample preparation and study design; Interpretation of qRT PCR results; Detection of viral pathogens (HCV, HIV influenza virus); Genotyping of viral strains (HCV); Detection of the expression of oncogenes (Her2/neu, BRCA1/BRCA2, N-myc); Quantitative expression of fusion transcripts (BCR-ABL, PML-RARA, TEL-AML); RNA sequencing application in molecular diagnosis	10
5. Liquid biopsy techniques and application	Circulating tumor cells and cell-free/circulatingtumorDNA/RNAas substrates for molecular diagnostics; Clinical utility of ctDNA testing; Logistics and laboratory techniques for testing cell-free DNA/RNA; Molecular barcoding/unique molecular indices	10
6. Molecular diagnosis and precision medicine	Concepts and principle of personalized medicine; Current status of personalized medicine in NCDs; CYP genes and drug metabolism; Warfarin sensitivity (CYP2C9, VKORC1 genotyping); Beta blocker metabolism (CYP2D6 genotyping)	2

Unit	Course Content	No. of Lectures
7. Issues related to molecular diagnostics	Ethical, legal and social issues; Informed consent; Confidentiality and discrimination; Genetic counselling; Pre-implantation genetic screening/diagnosis	2

Learning Outcomes

Upon successful completion of this course, the students should be able to:

1. Demonstrate a strong background in molecular diagnostics.
2. Identify the challenges to diagnose the life-threatening diseases and create strategies to minimize those by molecular approach.
3. Identify the role and importance of molecular diagnostic techniques such as Real-time PCR, Hybridization and Next Generation sequencing technologies.
4. Explain high-tech approaches of contemporary molecular diagnostic methods.
5. Acknowledge the ethical aspects and legal implications of molecular diagnostic procedures.

Suggested Readings

1. Molecular Diagnostics: For the clinical laboratorian. William B Coleman & Gregory J Tsongalis. 2nd Edition. Humana Press, 2005.
2. Molecular Diagnostics. George P. Patrinos, Wilhelm J. Ansorge and B. Danielson. 3rdedition. Academic Press. 2016.
3. Molecular Diagnostics: Fundamentals, methods and clinical applications. Lela Buckingham. 3rd Edition. F.A. Davis Company. 2019.
4. Human Molecular Genetics. Strachan & Read. 5th Edition. Garland Science. 2018.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 405 Forensic DNA Technology 2 Credit

Introduction

The course focuses on introducing students to modern human DNA typing, laboratory practices, ethics and applications DNA technology in criminal justice system. It will cover a brief history of forensic DNA typing, basic genetic principles of the variability among individuals, DNA extraction and typing methods

from crime scene and reference samples, applications of DNA profiling, interpretation of the DNA profiling results and DNA database issues.

Course Objectives

The study of this course will

1. Enable students to know the history of DNA typing methods
2. Introduce students the polymorphism concept that makes DNA unique to all individuals
3. Make students familiar with handling of biological specimens required for DNA analysis
4. Learn DNA extraction from various biological specimens
5. Understand various DNA profiling techniques such as, autosomal, X-chromosome, Y-chromosome and mtDNA
6. Learn how to apply these methods in personal identification, parentage testing, kinship analysis and disaster victim identification

Course Content

Unit	Course Content	No. of Lectures
1. Overview and History of Forensic DNA Typing	Brief overview of forensic science; Pre-DNA era; Early forensic markers; Blood typing; Serum protein typing; Serum enzyme typing; Discovery of DNA fingerprinting; First use of DNA to solve an immigration dispute; First use of DNA in solving a crime	2
2. Basic genetic principles	DNA Polymorphism; Minisatellite sequences or Variable Number of Tandem Repeats (VNTRs); Microsatellite sequences or Short Tandem Repeats (STRs); Biology and nomenclature of STR markers; Single Nucleotide Polymorphism (SNPs); Mitochondrial DNA variations; Y-Chromosome variations; X-Chromosome STRs; Insertion-Deletion polymorphisms (InDels); Amelogenin: the sex typing marker	4
3. Biological specimen handling	Collection preservation and transportation of blood, semen, saliva, tissue, bone & teeth samples; Presumptive tests for blood, semen and saliva	4
4. DNA extraction and quantitation from forensic samples	DNA extraction by organic method, Chelex method, FTA Card, Differential extraction, Spin columns, magnetic beads etc.; DNA Extraction from liquid blood, soft tissues, bone, teeth, buccal cells, semen, blood stains, semen stains etc.; DNA quantitation by spectrophotometry, fluorometry, slot-blot, real-time PCR etc.	4
5. DNA typing methods	DNA Profile: Definition (DNA fingerprinting/ DNA typing/ DNA testing); Restriction Fragment Length polymorphism (RFLP); Single locus and multi-locus DNA typing; Allele specific oligonucleotides (ASO); Analysis of minisatellites by PCR; Current DNA typing method; STR based DNA analysis; DNA detection methods: silver staining, fluorescent dyes; Capillary electrophoresis: principles and Instrument platform for capillary electrophoresis; NGS in forensics	4

Unit	Course Content	No. of Lectures
6. Applications of DNA Profiling	Identity test; Parentage test; Sibship analysis; Kinship analysis; Identification of disaster victims/missing persons; DNA testing in immigration and inheritance disputes	4
7. Non-human DNA Testing	Microbial DNA testing; Plant DNA testing; Animal DNA testing (animal trafficking)	2
8. Statistical issues	Calculation of allele frequency; Calculation of forensic efficiency parameters; Calculation of Random Probability of Match (PM); Calculation of Paternity Index (PI); Probability of paternity; Calculation of Sibling index and Likelihood ratio; PopAffiliator; Online calculator for individual affiliation to a major population group	3
9. DNA database	Allele frequency database; Convicted offender database; Crime-scene database; Missing person's database; Benefit of DNA database; International DNA databases: NDNA, CODIS, YHRD, EMPOP etc.	3

Learning Outcomes

Upon successful completion of the course students will be able to

1. Know the history of DNA typing, early forensic markers and current state of the technology
2. Understand the underlying principle of genetic variation among individuals based on different genetic markers.
3. Learn proper handling of biological specimens required for DNA analysis.
4. Enable them to carry out DNA extraction from different biological specimens.
5. Learn about different DNA typing methods using autosomal STR, X-chromosome, Y-chromosome and mitochondrial DNA markers.
6. Understand the applications of DNA profiling in personal identification, parentage testing, relationship testing and disaster victim identification.
7. Know statistical issues related to DNA analysis result interpretation.
8. The usefulness of creating a DNA database.

Suggested Readings

1. Forensic DNA typing: Biology, Technology and Genetics of STR Markers, JOHN M. BUTLER (2nd Edition). Elsevier Academic Press. 2005.
2. Advanced Topics in Forensic DNA typing: Interpretation, JOHN M. BUTLER Elsevier Academic Press. 2014.
3. Jaiprakash G. Shewale, Ray H. Liu. Forensic DNA Analysis: Current Practices and Emerging Technologies. 1st Edition. CRC Press. 2016.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any

5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 406	Genomics, Proteomics and Bioinformatics	3 Credit

Introduction

This course offers the students comprehensive information on recent advances in Genomics, Proteomics and Bioinformatics. Genomics, proteomics and bioinformatics are the cornerstones of the so-called 'Omics technologies that are routinely applied in medical research and throughout the drug-development process. In recent years genomic and proteomic technologies, combined with bioinformatics, and rapid progress in high throughput technologies, have made it possible to study gene regulation and protein function in high throughput. In contrast to studies of single genes or single proteins, genomic and proteomic methods simultaneously investigate large numbers of genes or proteins in one single experiment. This capstone subject will focus on the historical development of these technologies to provide a platform from which the key applications, techniques and recent advances in these fields can be appreciated.

Course Objectives

The study of this course will

1. Introduce the students with the background and advancements of Genomics and Bioinformatics.
2. Give the students in-depth understanding on the major tools and techniques in this field.
3. Make the students aware about the applications of computational and systems biology in discovery.
4. Innovation and critical analysis of the classic and latest works in this field and generate new ideas.

Course Content

Unit	Course Content	No. of Lectures
1. Overview of 'Omics' Sciences	Scopes, resources and applications	1
2. Biological databases	Terminologies, file formats; Biological databases classification, pitfalls of biological databases, exploring databases and datamining	2
3. Comparative Genomics	Fundamentals of sequence analysis; sequence alignment methods: local and global alignment concepts; dot matrix, dynamic programming methodology; Needleman-Wunsch and Smith-Waterman algorithm. Scoring/substitution matrices: PAM and BLOSUM. Statistics of alignment score. Heuristic methods for	6

Unit	Course Content	No. of Lectures
	data base searching - BLAST and FASTA. Multiple sequence alignment: applications, position-specific scoring matrices (PSSMs), profiles, and hidden Markov models (HMMs). Heuristic algorithms for alignment (progressive, iterative and block-based); Genome comparison and genome evolution: algorithm of large scale-genome alignment	
4. Evolutionary Genomics	Phylogenetic analysis, Model of nucleotide evolution; Jukes-Cantor; Molecular clock; Methods of building a phylogenetic tree: distance based (UPGMA, Neighbour-Joining) and character-based methods (Maximum Parsimony, Maximum Likelihood); Phylogenetic tree evaluation and comparison strategies**:** Bootstrapping, Jackknifing, Kishino-Hasegawa and Shimodaira-Hasegawa test	5
5. Structural Genomics and Proteomics	Protein motif and domain architecture, Sequence-structure mapping and protein folding, forces and interactions; Protein sequence predictions: *Ab initio*, homology based and threading; Protein identification and quantification: 2D gel electrophoresis, mass spectrometry/MALDI-TOF, other arrays, yeast 2-hybrid system, ICAT;Protein 3D structure prediction methods and structure validation algorithms; Protein-DNA recognition: Models and algorithms; Biomolecular dynamics (MD) simulation: Protein-Drug, Protein-protein, membrane protein	5
6. Functional Genomics	Gene expression quantification and functional analysis: basic concepts, applications of microarray; Experiment & probe design of DNA microarray; Image analysis; Normalization algorithms for single and dual channel data; Quality control measures; Batch affect and its removal; Differential expression; Microarray data visualization techniques and clustering algorithms; Enrichment/functional over-representation analysis	5
7. Basic Network Biology	Gene regulation, and function, conservation, detecting regulatory elements; Evolution of networks: Basic Graph theory; Terminologies and properties in network biology~~,~~ Network motif & modules; Topological and statistical features; Network construction visualization, analyses, integration, and analysis tools	4
8. Pharmacoinformatics	Molecular library management and virtual screening, computer assisted drug design and quantitative modelling of structure-activity relationships (QSAR and 3D-QSAR). Protein-protein/peptide docking, protein-drug docking. ADMET prediction, bioavailability prediction	4
9. Immunoinformatics	Introduction to Vaccine design and Reverse vaccinology; **Functional Analysis of Antigenic Proteins:** Primary protein structure prediction of antigenic protein, Prediction of	4

Unit	Course Content	No. of Lectures
	antigenicity of antigenic proteins, Prediction of allergic nature of antigenic proteins, Prediction of physiochemical properties of antigenic proteins; **Structural Analysis of Antigenic Proteins:** Prediction of the secondary structure of the antigenic protein, Prediction of domains and important sites in antigenic protein; **Epitope Prediction:** Continuous B-cell epitope prediction, Discontinuous B-cell epitope prediction, Prediction of immunogenic regions in antigenic protein, Prediction of glycoprotein antigen epitopes, Cytotoxic T cell epitope prediction, MHC class I and II prediction, T cell epitopes processing prediction, T cell epitopes Immunogenicity prediction; **Antigen and Antibody Modelling &Docking:** Automated antigen modelling, Alignment based antigen modelling, Antibody modelling, Antigen-Antibody Docking; **Antiviral peptide prediction; mRNA-based vaccine design; Chimeric vaccine design; Immune simulation**	
10. Genome editing	Basics, Applications; The principle to select target sequences to design gRNA sequences; Synthesize gRNA sequences; Detection of off targets	2
11. RNA informatics	RNA structure prediction (secondary, tertiary) methods; miRNA and other ncRNA databases; Prediction of miRNA and other non-coding RNA	2
12. Metagenomics	Metagenomics basic principles and theories; Metagenomic Protocols and Strategies; Strategies for Taxonomic and Functional Annotation of Metagenomes; Computational and Statistical Considerations in the Analysis of Metagenomic Data; 16S rRNA-Based Taxonomy Profiling in the Metagenomics Era; Analyzing High-Throughput Microbial Amplicon Sequence Data Using Multiple Markers; Measuring Microbiome Diversity and Similarity with Hill Numbers	5

Learning Outcomes:

Upon successful completion of this course the student should be able to:

1. Understand the development of Omics technologies, with emphasis on genomics and proteomics
2. Learn about genome sequencing, major differences between prokaryotic and eukaryotic genomes
3. Learn about basic proteomics and its applications.
4. Use bioinformatics search tools for mining data, pair-wise and multiple sequence alignments and predict protein structures.
5. Gain skills in applied bioinformatics, comparative, evolutionary, human genomics and functional genomics.

Suggested Readings

1. Discovering Genomics, Proteomics, & Bioinformatics. Campbell &Heyer. 2nd edition. 2007. Benjamin Cummings Publishing Co.
2. Bioinformatics - A practical Guide to the analysis of genes and proteins. Edited by Andreas D. Baxevanis, Gary D. Bader, David S. Wishart. 4th Edition. 2020. Wiley.
3. Essential Bioinformatics by JinXiong. 1st edition. 2006. Cambridge University Press.
4. Bioinformatics. Andrzej Polanski A. Marek Kimmel. 1st edition. 2007. Springer.
5. Structural Bioinformatics. Edited by Jenny Gu and Philip E Bourne. 2nd edition. 2009. Wiley-Blackwell.
6. Bioinformatics & Functional Genomics. Pevsner J. 3rd edition. 2015. Wiley-Blackwell.
7. Metagenomics Perspectives, Methods, and Applications. Editor: Muniyandi Nagarajan. 2nd Edition. 2023. Academic Press.
8. Immunoinformatics. Editor: Namrata Tomar. 3rd Edition. 2020. Springer

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 407	Microbial Biotechnology	3 Credit

Introduction

This course introduces students to microbial biotechnology, the use of microbes to generate useful products of various types or to degrade wastes (bioremediation) and protect environment. Students learn about fermentation products of microorganisms and their importance in food, health, agriculture and environment. Examples include the microbial production of enzymes, antibiotics, vaccines, small molecules, biochemicals, biomining, pesticides, and the development of microbial strains that are highly efficient at catabolizing natural organic compounds or synthetic chemical compounds. This module will take an in-depth look at how microbes and their metabolic pathways and products can be used in biotechnology.

Course Objectives

The study of this course will

1. Provide in-depth knowledge on current applications of microbes for the production of various useful commercial products.

2. Enable students critically evaluate the role of microorganisms in specific biotechnological processes.
3. Provide students with an understanding of the recent advances in rDNA technology and its applications to improve human life and the environment using microorganisms.
4. Demonstrate students an overview of how microbes are manipulated to solve practical problems through biotechnology.
5. Provide students with sound theoretical knowledge of the biological and biochemical processes used in biotechnology.
6. Create interactive learning forum to help students with the understanding of basic approaches to biotechnology research and development.

Course Content

Unit	Course Content	No. of Lectures
1. Microbial production of therapeutic agents	Biopharmaceuticals - Isolation and engineering of human interferon and human growth hormone; Optimizing gene expression, Enzymes: DNase I, alginate lyase, phenylalanine ammonia lyase; Therapeutics produced and delivered by intestinal bacteria; Monoclonal antibody as therapeutic agents; Production of antibodies in *E. coli*; Nucleic acids as therapeutic agents; Clinical trials and its phases	3
2. Synthesis of commercial products by recombinant microorganisms	Restriction endonucleases; Small biomolecules -Ascorbic acid, Indigo, Amino acids, Antibiotics; Biopolymers	4
3. Bioremediation and biomass utilization	Microbial degradation of xenobiotics; Commercial production of fructose and alcohol; Glycerol production; Silage fermentation; Utilization of cellulose	4
4. Plant growth-promoting bacteria	Effects of microorganisms on plant growth; Genetic engineering of nitrogenase gene cluster; Engineering oxygen level; Modulation of plant hormone by bacteria	3
5. Microbial insecticides	Biopesticides; Isolation, modification and diverse application of Bt toxin; Genetic modification to improve insecticidal properties of baculoviruses	4
6. Large scale production of enzymes and proteins from recombinant microorganisms	Enzymes used in fermentation process; sources of enzyme, selection of microorganisms; Genetic manipulation of microbes for protein and enzyme biosynthesis; Cultivation techniques and processes; Generalized scheme of large-scale fermentation process; basics of batch, fed batch and continuous culture; properties of stirred tank, bubble columns and airlift reactor; Cell harvesting and product recovery	5

Unit	Course Content	No. of Lectures
7. Vaccines	Development and production of subunit vaccines (Herpes simplex virus, Foot and mouth disease); Peptide vaccines; Genetic immunization; Attenuated vaccines (Cholera, *Salmonella)*; Vector vaccines; mRNA vaccine	6
8. Fermented food and beverage production	Production of beer, wine, distilled beverages and vinegar; Microbial food products; Role of microbes in dairy products (e.g. Cheese, yogurt, butter, buttermilk); Flavors; single cell protein; microbial biomass proteins; probiotics	6
9. Renewable Energy	Biomass as a source of energy, biomass conversion;Alcohol - the liquid fuel; gaseous fuels- biogas and hydrogen	4
10. Immobilized cells and enzymes	Methods of cell and enzyme immobilizations; Use of immobilized cell systems for the production of industrially important products	3
11. Microbial ore leaching	Leaching microorganism and their properties; Practical applications of bacterial leaching	3

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Demonstrate a familiarity with the wide diversity of microbes, and their potential for use in microbial biotechnology.
2. Demonstrate a knowledge of microbial gene and genome structure and function, and how these can be manipulated.
3. Demonstrate an understanding of the differences between classical genetic selection and recombinant or synthetic DNA technologies.
4. Demonstrate familiarity with methods to analyze and engineer genes for optimal expression
5. Demonstrate an understanding of the processes involved in small-scale and industrial scale bacterial fermentations.
6. Demonstrate an understanding of some of the legislative and ethical issues related to microbial biotechnology.
7. Explain the complex processes behind the development of genetically manipulated organisms
8. Demonstrate a clear understanding of how biochemical pathways relate to biotechnological applications.
9. Describe common methodologies used in biotechnological processes, and Identify and analyze the current trend in biotechnology.
10. Develop innovative strategies for discovering products of industrial importance.
11. Demonstrate and apply theoretical knowledge to production and application of microbial metabolites.

Suggested Readings

1. Glick, B. Pasternak, J. Patten, C. Molecular Biotechnology Principles and Applications of Recombinant DNA. ASM Books. 6th edition. 2022.

2. Goutam Brahmachari. Biotechnology of Microbial Enzymes: Production, Biocatalysis, and Industrial Applications. 2nd Edition. Academic Press. 2023.
3. E. M. T. El-Mansi, Jens Nielsen, David Mousdale, Ross P. Carlson. Fermentation Microbiology and Biotechnology. 4th edition. CRC Press. 2018.
4. Nduka Okafor, Benedict C. Okeke. Modern Industrial Microbiology and Biotechnology. 2nd Edition. CRC Press. 2017.
5. Ramesh ChanderKuhad, Ajay Singh. Biotechnology for Environmental Management and Resource Recovery. Springer. 2013.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 408	Plant Biotechnology	3 Credit

Introduction

This course explores the use of biotechnology to genetically modify and hence study various metabolic pathways in plants. Emphasis will be given on the molecular mechanisms controlling plant gene expression under diverse environmental and developmental stimuli. Knowledge gained from this course will help to modify plant responses and properties for global food security and commercial gains in agriculture. Example-based learning approach will be employed to demonstrate the use of various omics technologies (such as genomics, proteomics and metabolomics) in plant biotechnology.

Course Objectives

The study of this course will

1. Explain the basic principles of plant biotechnology and their application to plant improvement
2. Enable students to learn recombinant DNA technology and genetic transformation techniques in plants
3. Describe experimental design and analysis of plant biotechnology experiments
4. Analyze issues and challenges encountered in the area of plant biotechnology

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to Plant Biotechnology	History; Principles and techniques of plant biotechnology; Current trends and applications	5
2. Plant Tissue Culture	Introduction; Media preparation; Sterile techniques and laboratory practices before starting plant tissue culture; Plant growth regulators in plant tissue culture and development; Types of tissue culture: callus culture, shoot and root culture, cell suspension culture, embryo culture, protoplast isolation and culture, anther and microspore culture, etc.; Embryo rescue, development of polyploidy; Micropropagation: Propagation from non-meristematic tissues-organogenesis and non-zygotic/somatic embryogenesis; Somaclonal variation; Germplasm storage and preservation	10
3. Transgenesis and Mutagenesis for Crop Improvement	Development of transgenics and mutants by recombinant DNA technology: vectors, gene cloning, transgene identification and its transient and stable expression, *in vitro* mutagenesis, transposons and gene tagging, CRISPR; *Agrobacterium* mediated transformation and *Agrobacterium*-independent transformation; Development of biotic and abiotic stress-tolerant crops with stress-tolerance mechanisms/pathways and examples; Improvement of yield: quantity, quality, nutritional profile of medicinal and crop plants	10
4. Plant molecular markers and their applications	Identification and application of molecular markers; Genotyping tools in plant breeding- from restriction fragment length polymorphisms to single nucleotide polymorphisms; Use of molecular markers in model crop species- rice, wheat, maize, jute etc.	5
5. Plant Breeding	Various breeding strategies, CMS line development, heterosis, hybrid vigor, inbred depression; Marker assisted selection (MAS) and marker assisted backcross with examples in rice, maize, wheat, soybean etc.; QTL mapping	9
6. Molecular Farming	Production of carbohydrates, lipids, proteins; Production of vaccines, secondary metabolites-vitamins, antibiotics, etc.	6

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the basics of plant tissue culture methods.
2. Describe the principle of in vitro whole plant regeneration.
3. Identify the commonly used molecular markers.
4. Compare the advantages and disadvantages among various breeding strategies.
5. Understand the key mechanism of *Agrobacterium*-mediated plant transformation.
6. Discuss the development strategies of popular GM crops.
7. Describe the role of plant biotechnology in developing plant-based pharmaceuticals.
8. Understand the fundamentals of germplasm preservation techniques.

Suggested Readings

1. Trigiano, R.N., Gray, D.J. (2016) Plant Tissue Culture, Development, and Biotechnology. (1st edition) CRC Press.
2. Karl-Hermann Neumann, Ashwani Kumar, Jafargholi Imani. Plant Cell and Tissue Culture - A Tool in Biotechnology. 2020. Basics and Application. SpringerLink.
3. Slater, A., Scott, N. and Fowler, M. (2008) Plant Biotechnology. The genetic manipulation of plants (2ndedition). Oxford University Press.
4. Acquaah, G. Principles of Plant Genetics and Breeding, 3rdEdition. (2020). Willey- Backwell
5. Chawla S. (2022). Introduction to plant biotechnology (3rdedition). CBS PUBLISHERS AND DISTRIBUTORS PVT LTD.
6. Christou P, Klee H. (2004). Handbook of Plant Biotechnology (1stedition). Wiley.
7. Altman A, Hasegawa P. (2011). Plant Biotechnology and Agriculture: Prospects for the 21stCentury (1stedition). Academic Press.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 409	Animal Biotechnology	3 Credit

Introduction

This course is offered to make students understand the major concepts in animal biotechnology. The course discusses about the applications and basics of the techniques like tissue culture, cloning, embryo -culture and -transfer etc. This course also makes students aware of the ethics of animal biotechnology for the rightful use of this revolutionary technology.

Course Objectives

The study of this course will

1. Make students understand various tools and techniques used in Biotechnology.
2. Enable to understand protocols of embryo culture, transfer and their limitations.
3. Enable to learn about the applications and advantages of cloning, especially of reproductive cloning.

4. Make students understand ethical aspects of animal biotechnology.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction	Scope and applications of animal biotechnology.	2
2. Animal cell and tissue culture	Basics of animal cell culture: culture media, culture of mammalian cells, tissues and organs; Primary culture; Secondary culture; Continuous cell lines; Somatic cell cloning and hybridization; Transfection and transformation of cells; Organoid and 3D cell culture, Organ culture and whole embryo culture; Application of animal cell culture in production of human and animal viral vaccines and pharmaceutical proteins; cell cultures as a source of valuable products; Cord blood banking	7
3. Reproduction and embryo transfer technology	Overview of reproductive physiology and reproductive technology; Steps in embryo transfer technology; Advantages and application of embryo transfer; Selection and management of donor and recipients; Artificial insemination, Insemination of donor; Collection, identification and evaluation of embryo; Cryopreservation of embryo; Transfer of embryo; Limitations of embryo transfer techniques	6
4. Ruminant fertilization	Uses of in vitro fertilization; Different fertilization mechanisms; Harvesting and maturation of oocytes; Collection and capacitation of sperm; Fertilization and development of embryos to a transferable stage	5
5. Genetic manipulation and Transgenic animal	Genetic manipulation in animals: Gene editing and modification technologies; strategies for the production of transgenic animals and their importance in biotechnology; Transgenic mice and their use; Production of transgenic mice: retroviral vector method, DNA microinjection method, engineered embryonic stem cell method; Genetic modification with cre-*loxP* recombination system	8
6. Animal Cloning	Concepts and historical background of animal cloning; Various cloning techniques and their advantages and disadvantages; Production of transgenic cattle, sheep, goat, birds, fish and other economically important animals; Cloning and conservation of endangered animals; Organ cloning	7
7. Animal diseases and their diagnosis	Common bacterial and viral diseases in animals and their symptoms; Molecular diagnostic techniques	5
8. Ethics in animal biotechnology	Ethical, legal and social issues of animal biotechnology; Animal welfare, sentiency and speciesism; Ethical issues and concern: Human subjects and animal model; Religious concerns; Risk of animal biotechnology	5

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the production and applications of various biotechnological produces and principles.
2. Learn about the protocols and techniques in reproductive cloning, such as embryo cloning and somatic cell nuclear transfer (SCNT).
3. Understand the commercial applications of animal biotechnology.
4. Understand the ethical questions surrounding animal biotechnology and how to address them.

Suggested Readings

1. Reproductive Technologies in Farm Animals by Ian Gordon. CABI publishing. 2nd edition. 2017.
2. Reproductive Technologies in Farm Animals: Artificial Insemination. Johann Casini. Murphy & Moore Publishing. 2022.
3. Animal Biotechnology by Srivastava and Singh.CBS Publishers & Distributors Pvt Ltd. 1st edition. 2018.
4. Animal Biotechnology and Ethics by Alan J. Holland & Andrew Johnson. Springer. 1st edition. 1997.
5. Animals as Biotechnology: ethics, sustainability and critical animal studies by Richard Twine. Routledge. 1st edition. 2010.
6. Glick, B. Pasternak, J. Patten, C. Molecular Biotechnology Principles and Applications of Recombinant DNA. ASM Books. 6th edition. 2022

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 410	Marine Biotechnology	2 Credit

Introduction

Marine biotechnology is the application of science and technology to living organisms from marine resources, as well as parts, products, and models thereof, to alter living or non-living materials for the production of knowledge, goods, and services. This course will give a brief introduction to marine environments and their living components, with an emphasis on their biodiversity. This course will focus on the prospects, challenges, and current applications of marine biotechnology for attaining economic and social prosperity.

Course objectives

The objectives of this course are to -

1. Introduce to marine environments and their living components.
2. Introduce to the value chain of marine biotechnology.
3. Understand the prospects, challenges, and current applications of marine biotechnology.
4. Learn about the techniques for marine bioprospecting.

Course Content

Unit	Course Content	No. of Lectures
1. Introduction to marine biotechnology	Marine biotechnology; Its current and potential contributions to social and economic growth; Generic value chain of marine biotechnology	3
2. Marine biodiversity and marine ecosystem	Marine biodiversity**;** factors that influence marine biodiversity; different ecosystems of the sea and the producers of marine ecosystem; Important concepts of the water environment including water chemistry; Components of seawater and transmission of energy; Marine area and resources of Bangladesh	4
3. Marine bioprospecting	Marine bioprospecting for sustainable development; Targeted and systematic bioprospecting approaches for components, and gene pools within marine environment; Global trends in marine biotechnology-based product development	5
4. Applications of marine biotechnology	Marine organisms as sources of energy; Marine bioactive compounds as food and feed supplements; marine biotechnology applications in functional foods; Marine natural products and enzymes in the pharmaceuticals, nutraceuticals and cosmeceuticals industries; Bio-processing using marine enzymes; industrial applications of marine carbohydrates; anti-photoaging and photoprotective compounds derived from marine organisms; biosurfactants from marine sources; marine algae biomass for removal of heavy metals; marine biotoxins; Transgenic marine organisms; Bioreactors for culturing marine organisms/cells	18

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Understand the major marine ecosystems, including the trophic levels of their inhabitants and how they have adapted to different environmental conditions.
2. Understand the value chain of marine biotechnology and its uniqueness.
3. Comprehend the prospects, challenges, and current applications of marine biotechnology.
4. Learn about the current approaches and techniques for marine bioprospecting.

Suggested Readings

1. Handbook of Marine Biotechnology, Editor: Kim, Se-Kwon, 2015, Springer.

2. Marine Biotechnology I, Editors: Le Gal, Yves, Ulber, Roland, 2005, Springer
3. Marine Biotechnology II, Yves Le Gal, Roland Ulber, 2010, Springer
4. Marine Bioprospecting and Natural Product Research, (2010) Author: Vanessa Sunkle, Lambert Academic Publishing
5. Chemistry of Marine Natural Products, Author: Paul J. Scheuer, 2012. Academic Press. New York.
6. Handbook of Marine Natural Products. Editors: Fattorusso, Ernesto, Gerwick, William H., Taglialatela-Scafati, Orazio (Eds.), 2012, Springer.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 411 Research Methodology 2 Credit

Introduction

This course will provide an overview of the various research methods used when addressing a research question, including quantitative methods for analyzing data, qualitative research, study design, literature review and how to write a scientific paper.

Course Objectives

The study of this course will

1. Familiarize students with basic concepts of research problem.
2. Help students to design scientific research
3. Make the students acquainted with various statistical methods for analyzing data

Course Content

Unit	Course Content	No. of Lectures
1. Fundamentals of research	Definition, background, characteristics, objectives, hypothesis, approaches, motivation, significance and ethics; Types of Research: Experimental research, Clinical trials, Surveys/Observational studies; Basic and applied research; Educational research, Descriptive research; Diagnostic research; Case study; Qualitative and	4

Unit	Course Content	No. of Lectures
	quantitative studies. Epidemiology, primary and secondary data, different levels of research, steps in conducting a research.	
2. Research problem and its Importance	Definition of a research problem, Selecting research problem, Problem formulation; Identifying variables and specifying research objectives; Characteristics and examples of good research topics; Reasons why research questions are crucial.	3
3. Review of Literature	Meaning of literature review, Necessity of literature review before formulating a research; Sources of documents for literature review; Types of literature review; Search and sorting strategy of articles, Process to carry out a literature review	3
4. Planning of Research	Importance of writing a research proposal, Features and Characteristics of a good research proposal; Guidelines and explanations of different parts of a research proposal; Preparations before conducting the research.	3
5. Research Design	Meaning, Need, Features and Types; Non-experimental research designs; Experimental research designs.	3
6. Sample design	Types and characteristic of sampling design; Statistical considerations and steps in sampling design; Probability and non-probability sampling; Characteristics of a good sample design, selecting a random sample, examples of good sampling.	3
7. Data collection	Meaning and importance of data; Sources and methods of collection of primary data; Secondary data and its rules for use; Observation data; Simulation; Tools for data collection (schedule, survey questionnaire, pilot study, study parameters, pre-tests, collection of final data).	3
8. Data processing and analysis	Data Analysis by various statistical methods including ANOVA (analysis of variance), Tukey HSD, Dunnett's *t*- test, Student *t*-test, Chi-square test; Analysis of Qualitative studies.	5
9. Writing of research reports	Explanation of different sections of thesis/dissertation and scientific articles (Title; Authors affiliation; Abstract; Keywords; Introduction; Background; Aim and objectives of the study; Materials and Methods; Results: tables, graphs, figures and statistical presentation; Discussion- In support or non-support of hypothesis, practical and theoretical implications; Conclusion; Acknowledgements; Citations and References writing styles); Writing a review article.	3

Learning outcomes:

Upon successful completion of this course the student should be able to:

1. Understand about the meaning, types, methods, criteria and significance of research.
2. Analyze research data using different statistical software.
3. Write a research proposal
4. Write a research report.

Suggested Readings

1. Research Methodology, C.R. Kothari, New age international publishers, second revised edition.
2. An Introduction to Research Methods, M. Nurul Islam, Mullick& Brothers, Third revised edition, 2015.
3. Research in Medical and Biological Sciences from Planning and Preparation to Grant Application and Publication. Edited by Laake P, Benestad HB and Olsen BR. Elsevier, 2015.
4. An Introduction to Scientific Research, E Bright Wilson Jr., Dover Publications, 1991.
5. Research Methodology in the Medical and Biological Sciences, PetterLaake, Elsevier, 2007.
6. Research Methodology: A step-by-step Guide for Beginners, Ranjit Kumar, Sage Publication Ltd., 2012.

Additional reading materials may be suggested by the course instructors.

Instructional Strategies

1. Lecture with traditional method
2. Lecture with power point/videos/models/pictures
3. Obtain immediate feedback by asking questions
4. Answer queries, if any
5. Practice problem solving
6. Arrange review classes
7. Encourage group discussions
8. Assignments for exploring creativity and knowledge in a topic

Assessment

1. Class participation: Attendance
2. Continuous assessment: In-course examination, assignment
3. Final Examination: Assessment of written test

GEB 412	Laboratory Experiments	6 Credit

Introduction

This course is designed to let the students perform experiments in Labs with an aim to make them understand the core concepts, theories and topics that are delivered in their class lectures. Students will be provided hands-on training on molecular biotechnology techniques for isolation, amplification and detection of DNA, RNA and protein. Emphasis will be given on working with the techniques such as polymerase chain reaction (PCR), reverse transcription, gel electrophoresis, Western blotting, bacterial transformation, gene cloning, fluorescence microscopy, etc. In addition, the students will be introduced to PCR based genotyping technique. This course will also provide hands-on training on basic and advanced bioinformatics tools to analyze biological information and data.

Course Objectives

The study of this course will

1. Enable the students to use basic and advanced molecular biotechnology techniques.
2. Facilitate the students to improve observational skills.
3. Help to develop skills in performing PCR, electrophoresis and blotting, transformation and cloning.
4. Enable the students to use basic and advanced bioinformatics tools to analyze biological information and data.
5. Enable students to record experimental data, analyze/interpret them and present their finding in written format.

Course Content

Experiments

Unit	Course Content
18.	Cell counting with a hemocytometer and distinguishing different blood cell types under a microscope.
19.	Extraction of human DNA from buccal cells using Chelex™ and determination of genotype at D1S80 VNTR locus.
20.	Isolation and detection of plasmid DNA from bacteria.
21.	Preparation of competent bacterial cells and transformation with pGLO plasmid.
22.	Isolation of DNA from bacteria and amplification of specific gene sequence.
23.	Isolation of RNA from bacteria and reverse transcription PCR of specific transcript.
24.	Isolation of protein from bacteria and detection of GFP following SDS-PAGE and transfer to membrane (Western blot).
25.	Detection of a differentially expressed protein in SDS-PAGE and determination of molecular weight of the differentially expressed protein.
26.	Immunufluorescence imaging to detect expression of protein in tissues.
27.	Detection of indicator microorganisms in various samples.
28.	Purification of GFP protein by column chromatography.
29.	*Agrobaterium tumefaciens*-mediated transformation of plants.

Bioinformatics

Unit	Course Content
1. Proteomics to Metabolomics: Structure Analysis	• Selecting a Target Protein and its Sequence Retrieval • Homology Analysis: PSI-BLAST, T-COFFEE • Phylogeny Analysis: COBALT, PHYML • Motif Finding: Interproscan, Glycosylation site, Signal peptide Cleavage Site • Epitope Prediction: Vaxijen, BEPIPRED, BCPREDS, IEDB

Unit	Course Content
	• 3-D Structure Prediction: I-TASSER • 3-D Structure Modeling: Homology based modeling (Modeller), 3D structure modeling of a small molecule (ligand), Protein-ligand interaction (PyRx) and comparison (PyMol)
2. Proteomics to Metabolomics: Function Analysis	• Gene Ontology and Function Prediction: GO, GO Slim, MapMan • PPI Network: BioGrid, IntAct, Cytoscape
3. Genomics to Metabolomics: PPI Network Building	• GEO Datasets: Retrieval, Processing • Gene Ontology and Function Prediction: GO Slim, MapMan
4. Primer Designing: Basics	• For regular PCR • For rDNA technology (restriction enzyme based)

Field trip/industry visit/study tour

Unit	Content
Activity 1	**Field trip/industry visit/study tour.** Get first hand information or experience from industry research organization / field trip through direct observation/participation in events relevant to courses.

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Familiarize the advanced molecular biotechnology techniques for analyzing DNA, RNA and proteins.
2. Perform qualitative and quantitative analysis of DNA, RNA and proteins using gel electrophoresis and blotting techniques.
3. Understand the basis of PCR reactions and perform amplification reactions using thermal cycler.
4. Carry out bacterial transformation and gene expression.
5. Prepare samples and observe under fluorescence microscopy, and to conclude observation.
6. Carry out protein purification techniques.

Suggested Readings

1. Protocols, reading materials and other learning resources will be provided by the course teachers.
2. Additional reading materials may be suggested by the course teachers.

Instructional Strategies

1. Interactive class Lectures on principle, procedure and application of each experiment
2. Obtain immediate feedback by asking questions
3. Answer queries, if any
4. Practice problem solving
5. Hands on Laboratory training
6. Encourage group discussions

Assessment

1. Class participation: attendance
2. Continuous assessment: In-course examination, assignment
3. Practical note-book assessment
4. Final Examination: Assessment of written test
5. Viva voce

GEB 413	Project	2 Credit

Introduction

The project course provides an important opportunity for the students to plan and carry out a detailed theme/idea-based or original scientific research related to biotechnology supervised by a respective teacher. To carry out the project work, the students have to discuss with his/her supervisor about the type of work they would perform. The project work should not exceed 1-3 months.

For allocating students to carry out project work, they will be asked to submit their choice of supervisor (at least 3) under whom he/she wants to perform the work. The academic committee of the department will assess their choices and will finally take a decision.

Course Objectives

Carrying out this course will

1. Provide undergraduate students a scope of research opportunities (idea-based or original) in biotechnology field.
2. Allow students to engage in deeper study of specific areas of interest
3. Enhance capability to contribute in research and development work.
4. Increase knowledge of interpreting and arguing the findings of a research work

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Acquire more in-depth knowledge in the field of study, including deeper insight into current research and future prospects.
2. Enhance their capability to plan and use appropriate methods to conduct research in a framework.
3. Increase capability to analyze and critically evaluate their findings.
4. Attain capability to clearly present orally and in written format, and discuss the conclusions as well as the knowledge and arguments that form the basis for their findings.

Instructional Strategies

The supervisor will:

1. Discuss the project plan with the student and suggest how to conduct it
2. Advise on the appropriate methods for carrying out the work.
3. Offer advice on sources of information for the work.
4. Discuss any issue regarding data collection
5. Advise on issues relating to writing up the project report

Assessment

1. Assessment of oral presentation of the project
2. Assessment of submitted project report

GEB 414	Viva voce	2 Credit

Introduction

After completion of all theory course examinations of Fourth Year, students will face a viva voce (oral examination) conducted by the respective examination committee approved by the University. The viva voce is an important mode of assessment, providing an opportunity for the students to demonstrate their knowledge, approach and understandings with the examiners.

Course Objectives

Oral examination will

1. Help to develop students' confidence in answering questions asked by the examiners.
2. Prepare students to be ready for answering any related questions covering the whole courses offered in the academic year.
3. Provide an opportunity for students to test their communication skills.
4. Offer scopes for those who are less confident in the written exams to demonstrate their learning orally.
5. Create an opportunity to practice for job interviews.

Course Content

All courses offered in Fourth Year.

Learning Outcomes

Upon successful completion of this course the student should be able to:

1. Know how to present (posture, eye contact, resonance etc.) him or herself in front of a viva-board.
2. Know how to answer a question in a very logical way.
3. Improve capacity of oral delivery.
4. Reduce fear to face a viva board.
5. Enhance confidence to face job interviews.

Assessment

After a student finishes his/her viva-voce, the members of the examination committee will discuss about the student's performance and provide a mark getting consensus from all members.