Curriculum

Bachelor of Science (Honours)

Session 2019-2020 onward

Department of

Genetic Engineering and Biotechnology

University of Dhaka

Preface

Updation and revision of the Curriculum at regular intervals is one of the most important criteria of Institutional Quality Assurance Cell (IQAC) of the University of Dhaka and a prime need for the undergraduate educational systems.

Biotechnology broadly refers to intentional manipulation of living organisms or their products to serve human needs. This technology is capable of revolutionizing the way we manufacture products and analyzing the relationships among all living systems. Despite being relatively a new branch of science, the processes used in biotechnology today have their basis in nature long before. These processes, empowered with modern technologies, are now used to transfer genetic materials from one organism into another to obtain beneficial traits. Biotechnology possesses a great potential to affect a number of areas/fields including agriculture, health care, energy production, and the environment.

The curriculum of BS (Honours) of the Department of Genetic Engineering and Biotechnology has been developed with an aim to impart fundamental knowledge of the subject needed at the level of undergraduate studies.

Members of Self Assessment Committee and
Members of Academic Committee
Department of Genetic Engineering and Biotechnology,
University of Dhaka

1. Introduction to the Department

Genetic Engineering and Biotechnology (GEB) is an applied science subject. The technology used in genetic engineering is generally aimed at harnessing the natural biological capabilities of microbial, plant and animal cells for the benefit of human. This technology, more specifically termed "Biotechnology", couples scientific and engineering principles with commercial considerations to develop and improve products and processes made from living systems. In Bangladesh, University of Dhaka has taken the lead to establish a department "Genetic Engineering and Biotechnology" aiming at generating skilled manpower with wide theoretical and practical knowledge.

2. Introduction to the Program

2.1 Title of the program:

Bachelor of Science (B.S. Honours) in Genetic Engineering and Biotechnology

2.2 Duration of the Program:

i. The duration of B.S. (Honors) Program under the Faculty of Biological Sciences will be of 4 (four) academic years divided into 4 (four) sessions, so that there will be one session in each academic year.

ii. The duration of each session will be a maximum of 42 working weeks, which will be distributed as follows:

Classes:	30 weeks
Preparation Time for Course Final Examination, 1st, 2nd & 3rd years:	4 weeks
Preparation Time for Course Final Examination, 4th year:	6 weeks
Course Final Examination (Theory + Practical):	8 weeks
Total:	42/44 weeks

iii. Results of annual examination should be published within 6 weeks from the date of holding the last examination.

iv. Practical examinations of departmental and/or extra-departmental courses may be taken before the final examination.

2.3 Eligibility for admission:

Students will be admitted to the undergraduate curricula in the department under the Faculty of Biological Sciences as per the existing rules of the university

2.4 General objective of the Program:

Biotechnology is a multi-disciplinary science that engages knowledge in life sciences and technological applications to improve human lives and the environment. This program is designed to enable the students to acquire sound knowledge related to the subject. The students will be introduced to the principles and applications of various areas of biotechnology. They will gain an understanding of molecular biology and related technologies, animal and plant biotechnology, microbial and medical biotechnology, and environmental biotechnology. The acquired knowledge will help the students to develop critical thinking and analytical reasoning skills in the context of modern biotechnology to contribute effectively in academics and related research fields.

3. Structure of Curriculum

3.1 Credit-wise distribution of Core courses, Practical courses and Extra-departmental course in 4 year B.S. Program:

Study Year	Credit distribution				Total Credit
	Core Theory	Practical	Viva-voce	Extra-departmental	
1st Year	14	4	2	10	30
2nd Year	14	4	2	10	30
3rd Year	24	4	2	4	34
4th year	30	6	2	0	38
Grand Total	82	18	8	24	132

For theoretical Courses, a minimum of 15 class hours per session will constitute1 (one) credit hour. Therefore, a minimum of 60, 45 and 30 contact hours per session should be allocated for 4, 3 and 2 credit courses, respectively.

4. Assessment system:

4.1 Number of In-course and Course Final Examination:

i. The total performance of a student in a given course (core or extra-departmental) will be assessed on the basis of a scheme of continuous assessment and course final examinations.

ii. For theory courses the continuous assessment will be made through a set of in-course examinations and class attendance.

iii. Continuous assessment of Practical (laboratory/field) courses will be made through observation of the student at work, *viva-voce*, assignments and evaluation of practical reports.

iv. An extra-departmental course will include practical classes based on the course materials. In such cases, the assessment on the practical part will be done only by a final examination.

v. The scheme of continuous assessment that a teacher proposes to follow for a course will be announced by the teacher on the first day of classes.

vi. The distribution of marks for a theoretical and practical courses will be as follows:

Class attendance:	5%
In-course assessment:	35%
Course final examination:	60%

vii. Basis for awarding marks for class attendance will be as follows:

Attendance	Marks
95% and above	5
90% to less than 95%	4
85% to less than 90%	3
80% to less than 85%	2
75% to less than 80%	1
Less than 75%	0

viii. In-course Assessment (Theory courses):

i. In-course tests of minimum one hour duration shall be conducted and evaluated by the course teacher. There will be at least 2 (two) written tests for 4/3-credit courses and at least 1 (one) written test for 2-credit courses. Maximum written tests for 4-, 3-, and 2-credit courses shall not exceed 4, 3, and 2, respectively.

ii. The course teacher will show the assessed in-course scripts to the students before the final examination.

iii. Make-up test: Make-up test will be arranged for a student who fails to appear in in-course tests. An absence in any in-course test will be counted as zero for calculating the average in in-course test for that course. However, a student can apply to the chairman of the department for make-up test. The chairman will only place the application before the Academic Committee if the particular student has undergone an accident or his/her parents have expired or s/he has gone through a surgical procedure or any other such situation, which the Academic Committee feels can be considered.

ix. The Course Final Examination (Theory Courses):

i. The course final examination will be conducted centrally by the Controller of Examinations as per existing system.

ii. The course final examinations will be of 3 hours duration for 4-credit courses, 2½ hours for 3-credit courses and 2 hours for 2- credit courses.

iii. For evaluation of the course final examination there will be two examiners: one internal (will be the course teacher/teachers) and the other external (will preferably be within the department provided that he/she was not a course teacher for the course paper to be examined).

iv. Under double-examiner system, in case of difference of more than 20% of marks between the two examiners in a particular, a 3rd examiner will be needed to evaluate the script. In this type of cases, the average mark of the nearest two examiners will be the final obtained mark of that course.

x. Course Final Examination (Practical courses):

The final examination on practical works will be conducted by the course teachers to be appointed as examiners along with the external examiner of the examination committee.

4.2 Assessment of Seminar/Project Courses:

Examination of seminar/project courses will be carried out by the respective examination committee and two nominee of the respective academic committee. The distribution of marks and pattern of examination for seminar/project courses will be determined by the academic committee of the department. The Academic Committee may or may not include the external member of the Examination Committee for the assessment of Practical/Seminar/Project courses.

4.3 *Viva-voce*/Oral examination: *Viva-voce*/Oral examination will be conducted by the respective Departmental Examination Committee approved by the University.

4.4 Types of Question:

i. For in-course: Questions for in-course tests should preferably be of the objective type; however, some short questions could be included. Questions will be set by the course teacher and no moderation of questions is required.

ii. For Final Examination: Questions for course final examinations should be a combination of short and descriptive type. However, there will be no objective type questions. Questions should be designed to test the conceptual knowledge and understanding of the basic concepts of the subject. There will be two question setters: one internal and the other external. The questions will be moderated by the respective examination committee. Total marks obtained for all the examination will be converted to the grade.

4.5 The Grading System:

Marks obtained for each course will be converted to grades. A basic four point (4.00) grading scale will be followed. The following letter grades and corresponding grade-points will be used to determine the student's grade point average (GPA).

Marks Obtained	Corresponding Letter Grade	Grade Point
80% or above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00

Note: The fractional total marks for a course will be rounded up to next higher mark.

4.6 Grading description:

The explanations of letter grades are described as follows:

A: Exceptional performance; all course objectives achieved; objectives met in a consistently outstanding manner.

B: Very good performance; significantly more than the majority (at least two thirds) of the course objectives achieved; objectives met in a consistently thorough manner.

C: Satisfactory performance; at least majority of the course objectives achieved; objectives met satisfactorily.

D: Minimally acceptable performance; less than the majority but more than the minimum required course objectives achieved; objectives achieved at a minimally acceptable level.

F: Unacceptable performance; minimum required course objectives not met; objectives not met at a minimally acceptable level; no credit earned.

4.7 Earned Credits:

A course in which a student has obtained 'D' or a higher grade will be counted as credits earned by him/her. Any course in which a student has obtained 'F' grade (Failed in the course) will not be counted towards his/her earned credits.

4.8 Calculation of GPA and CGPA:

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses passed/completed by a student in an academic year. The Grade Point Average (GPA) is computed in the following manner:

$$\text{GPA} = \frac{\Sigma\,(\text{Grade points} \times \text{Credits})}{\Sigma\,(\text{Credits Attempted})}$$

The Cumulative Grade point Average (CGPA) for 2nd year, 3rd year and 4th year results is computed by dividing the total accumulated grade points earned up to date by total credit points attempted. For student who earned 132 credits, after successful completion of his/her 4 year graduate program, the final CGPA will be calculated using all the credits attempted.

4.9 Class Attendance:

i. A student must attend **at least 75%** of the total classes held in an academic year to be eligible for appearing in the final examination of that year without paying any penalty.
ii. A student attending **at least 60%** classes but less than 75% classes will be allowed to appear for the examination after paying non-collegiate fees fixed by the university.
iii. A student attending **less than 60%** classes will not be allowed to appear for final examination for that year/session.

4.10 Requirements for Graduation:

i. To graduate with a Bachelor's degree, a minimum total of 132 credits with no F grade in any course must be earned by a student within 4-6 academic years after his/her first admission in the graduation program. He/she must also have earned the minimum required CGPA 2.5 on a 4.00 scale.
ii. A student who has fulfilled all the academic requirements for Bachelor's degree will have to file with the Controller of Examinations, an application for Graduation. Provisional degree will be awarded on completion of credit and CGPA requirements. Such provisional degree will be confirmed by the Academic Council.

5. Structure of Course:

First Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB-101	Basic Biology	2
GEB-102*	Chemistry for Biologists I	4
GEB-103	Basic Biochemistry	4
GEB-104	Basic Microbiology	4
GEB-105	Fundamentals of Genetic Engineering & Biotechnology	4
GEB-106*	Mathematics for Biologists	2
GEB-107*	FCL English Language	4
GEB-108	Laboratory Experiments	4
GEB-109	Viva-Voce	2
*Extra-departmental courses	Total	30

Second Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB 201*	Chemistry for Biologists II	4
GEB 202	Enzymes and Enzyme Kinetics	4
GEB 203	Protein Structure and Function	2
GEB 204	Bioenergetics and Metabolism	4
GEB 205	Human Physiology	4
GEB 206*	Physics for Biologists	3
GEB 207*	Computing and Information Technology	3
GEB 208	Laboratory Experiments	4
GEB 209	Viva-Voce	2
*Extra-departmental courses	Total	30

Third Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB-301	Plant Physiology	4.0
GEB-302	Basics of Molecular Biology	4.0

GEB-303	Basic Immunology	2.0
GEB-304	Microbial Genetics	2.0
GEB-305	Developmental Biology	2.0
GEB-306	Virology	2.0
GEB-307	Molecular Biology of Diseases	4.0
GEB-308	Methods in Biotechnology	2.0
GEB-309	Fermentation Technology and Bio-processing	2.0
GEB-310*	Biostatistics and Epidemiology	4.0
GEB-311	Laboratory Experiments	4.0
GEB-312	Viva-Voce	2.0
*Extra-departmental courses		Total 34

Fourth Year: Course No., Title and Credit

Course No.	Course Title	Credits
GEB - 401	Advanced Molecular Biology	4.0
GEB - 402	Cell Signaling	2.0
GEB - 403	Immunology	2.0
GEB - 404	Molecular Diagnostics	2.0
GEB – 405	Forensic DNA Technology	2.0
GEB - 406	Genomics, Proteomics, and Bioinformatics	2.0
GEB - 407	Microbial Biotechnology	4.0
GEB - 408	Plant Biotechnology	3.0
GEB - 409	Animal Biotechnology	3.0
GEB - 410	Environmental Biotechnology	4.0
GEB - 411	Laboratory Experiments	6.0
GEB - 412	Project	2.0
GEB - 413	Viva-Voce	2.0
		Total 38

Credit Hour:
For theoretical Courses, a minimum of 15 class hours per session will constitute 1 (one) credit hour.

Course Profile: First Year

GEB-101	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 organism, 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-101 (Basic Biology) Course Content

1. Origin of Life

- Early history of the universe, origin of the Earth, formation of the continents and the oceans.
- Definition and key characteristics of life, theories on the origin of life.
- Pre-biological formation of precursor and macromolecules.
- Theories on the origin of cells; fossils of ancient microorganisms.
- The three types of cells, species concept, classification of living things and domains of life.
- Historical geology and the scale of biological time.

2. Organic Evolution

- Theories of evolution and the supporting evidences.
- Evolution of sex, species and speciation.
- Genetic Equilibrium and microevolution.
- Macroevolution and its processes.
- Natural selection and its different formats.

3. Protists and Plants, and their Diversity

- Basic structure, characteristics and economic importance of major groups of algae, fungi, lichens and bryophytes.
- The origin of the terrestrial plants.
- Pteridophytes, gymnosperms and angiosperms, and their importance.

4. Animals and their Diversity

- Major animal phylae: characteristics & their importance; brief organismal biology of Amoeba, Hydra, Corals, Tape Worm, Ascaris, Earth worm, Snails, Starfish and Mouse.

6. Ecology and Environmental Biology

- Principles of general ecology.
- Elements of organismal, population, community and ecosystem ecology.
- Human impact on the environment.

7. Biodiversity and Conservation Biology

- Concepts of biodiversity and conservation.
- Biodiversity in Bangladesh (flora & fauna).
- Extinct and threatened species of Bangladesh.
- Conservation efforts in Bangladesh.

Suggested readings:

- Raven P, Johnson G, Singer S, Losos J. *Biology.* McGraw-Hill (8th Edition 2008 or a later edition).
- Urry LA, Cain ML, Wasserman SA, Minorsky PV, Jackson RB. *Campbell Biology*. Benjamin Cummings (10th Edition 2010 or a later edition).
- Starr C, Taggart R, Evers C, Starr L. *Biology-The unity and Diversity of Life*, Brooks Cole (12th Edition 2008 or a later edition).
- Attenborough D. *Life on Earth: A Natural History.* Little Brown & Co. (1983).
- *Conservation in Bangladesh: Protected Areas of Bangladesh, World Heritage Sites in Bangladesh, Zoos in Bangladesh, Sundarbans.* Google Books (2010).

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

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**
Origin of Life	4
Organic Evolution	4
Protists and Plants, and their Diversity	6
Animals and their Diversity	6
Ecology and Environmental Biology	5
Biodiversity and Conservation Biology	5
Total	**30**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-102	Chemistry for Biologists I	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-102 (Chemistry for Biologists I) Course Content

1. Structure, Bonding, and Self-Assembly of Biological Structures

- Atoms: Electron configuration of atoms, Pauli's principle, Hund's rule. Covalent bonding in simple molecules - principally made up of C, O, H, N, S, P - using electron-sharing arguments (Lewis structures), Single and multiple bonds and bond order.
- Molecular Geometry: Geometry of covalently bonded molecules based on valence shell electron pair repulsion (VSEPR). Orbital overlap and hybridisation models for bonding (Valence Bond Theory). Sigma and pi bonds, rationalised use of diagrams for orbital overlap.
- Atomic and Molecular Orbitals: Basic Molecular Orbital Theory as an alternative representation of bonding in molecules. Electronegativity, and its relation to bond polarity, and ionic vs. covalent bonding.
- Non-covalent interactions: The role of non-covalent interactions between molecules in determining the properties of condensed-phase and biological materials. The interaction

between charges, dipoles, and induced dipoles in varying combinations. Significance of hydrogen bonds in biology. How molecular liquids behave as solvents, in particular their differing polarity.

- The solvent properties of water and its importance in biology: The property of water as the universal solvent, in particular the dissociation and hydration of ionic species in water, hydrogen bonding within bulk water, between water and solute molecules and within and between other molecules, the origin of hydrophobic interactions which cause the aggregation of non-polar moieties in water, salvation of non-polar molecules.
- Molecular self-assembly: The concept of self-assembly, self-assembly of lipids into membranes, liposomes, protein folding, membrane proteins, cytoskeleton and viruses.

2. Chemical Equilibrium and Thermodynamics

- Definition of energy, kinds of energy, units of energy.
- Energy consumption and power output, efficiency of different systems.
- The First Law of Thermodynamics- Conservation of energy, mechanisms of energy transfer.
- The Second Law of Thermodynamics- Spontaneous reactions vs. irreversible change- free energy as a criterion.
- The idea of ΔG, ΔG°, $\Delta G^{\circ\prime}$, low energy and high energy compounds-as a result of low energy and high energy bonds respectively, ATP as fundamental biological energy unit.
- Low and high energy compounds, ATP as fundamental biological energy unit.
- Simple introduction to Boltzmann's ideas on entropy as a measure of statistical thermodynamics.
- Excursion into energy flows, dissipative structures and protein folding.

3. Concentrations of H^+, pH and Equilibria

- Acids, bases and salts, strong and weak acids, multiple ionisations,
- Buffers, buffering capacity, titration curves and pH indicators.
- Elements of electrochemistry, types of electrochemical cells, Galvanic cells.
- Standard potentials and free energy.
- Chemical potential and extent of reaction.
- Equilibria in redox reactions, Nernst equation and its application.
- Membrane potentials.
- Reference electrodes and applications in biology, how to measure the pH.

4. Carbon, the Basis for Life on Earth

- Properties of the carbon, allotropes of carbon, nanochemistry, carbon nanotubes (CNTs), buckminister fullerenes.
- Nomenclature of organic compounds and conformation, chemistry of alkanes (common aliphatic hydrocarbons- petroleum and related products), free radical reactions of alkanes, alkenes, dienes, alkynes, aliphatic alcohols, aldehydes, ketones, carboxylic acids and their derivatives.
- Basic principles of stereochemistry, *cis-trans* isomers, plane polarized light, chirality, dexter and laevus (D and L) designation and absolute configuration.
- Aromaticity, antiaromatic and nonaromatic compounds, reaction of benzene.

5. The Bricks of Biological Architecture-Functional Groups and Reactivity

- Preparations and transformations of functional groups of relevance to biological applications, e.g. oxidation and reduction, substitution reactions, addition reactions, elimination reactions and formation of ethers, acetals and aldols.

6. The Inorganic Chemistry of Life

- The Periodic Table and the elements of life.
- Metal ions - hard and soft - polarizability and polarizing power in relation to the stability of compounds.
- Ligands and how they bind to metals-Werner's theory.
- Factors affecting binding strength - the stability constant.
- Metal binding sites – selectivity.
- The role of metal ions in biological systems - examples drawn from iron chemistry, ferredoxin hydrogenases, and haem proteins.

Suggested readings:

- Sackheim GI. *Introduction to Chemistry for Biology Students.* Benjamin Cummings (8th edition 2004 or a later edition).
- Fisher J, Arnold J. *Instant Notes in Chemistry for Biologists.* Garland Science, (2nd edition 2004 or a later edition).
- Royal Society of Chemistry. *Chemistry for Biologists.*
- http://www.rsc.org/Education/Teachers/Resources/cfb/index.htm
- Ebbing D, Gammon SD. *General Chemistry.* Brooks Cole ((9th Edition) 2009 or a later edition).
- Kask U. *General Chemistry*. McGraw Hill (1993);
- *Solomons TWG, Fryhle CB. Organic Chemistry.* Willey ((10th Edition 2007 or a later edition).
- Morrison RT, Boyd RN. *Organic chemistry*. Alyn and Beacon (6th edition 2001 or a later edition).

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

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 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
Structure, Bonding, and Self-Assembly of Biological Structures	5
Chemical Equilibrium and Thermodynamics	15
Concentrations of H^+, pH and Equilibria	10
Carbon, the Basis for Life on Earth	15
The Bricks of Biological Architecture-Functional Groups and Reactivity	10
The Inorganic Chemistry of Life	5
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

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.
- 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. Concept of Life and Living Processes

- The identifying characteristics of living things.

2. The Cell–Structure and Organization

- Visualizing cell, prokaryotes and eukaryotes: plants and animal.
- Cell wall, cell membranes and organelles
- Transport of small molecules across the membranes
- Cell division: Mitosis and Meiosis
- Mitochondria, peroxisomes and glyoxysomes
- Golgi bodies: the sorting and distributing center of cell
- ER translocation, ER-Golgi modifications, quality control
- Nucleus, genetic material, chromosomes; packaging of DNA
- Mitochondria and respiration
- Chloroplasts and photosynthesis

3. Biomolecules of life

- Introduction to biomolecules and their functions
- Macromolecules: polysaccharides, fats, proteins and nucleic acids; their structures
- Carbohydrates: occurrence, structure, classification and biological importance
- Glycoconjugates: proteoglycan, glycoproteins and glycolipids
- Storage and structural lipids, lipids as signals, cofactors and pigments
- Watson and Crick model of DNA, B and Z model of DNA structure, other secondary forms of DNA and RNA

4. Amino Acids and Proteins

- Nomenclature, Properties, Stereochemistry, Ionization of weak acids and bases, pK, ionization at given pH
- Aminoacids: nomenclature and classfications, Zwitterionic structure; Titration curve for amino acids, Isoelectric point (pI)
- Peptide bonds: features of the naturally occurring peptide bonds
- Protein structure: Primary structure, Secondary structure: α-helix, β-sheets, Tertiary structure, Quaternary structure
- Summary of covalent and non covalent forces that maintain appropriate structures

- Introduction to the determination of amino acid composition of a protein

5. Central Dogma of Biological Systems

- DNA ⟶ RNA ⟶ protein
- DNA "self-replicating" genetic material
- Transcription of DNA to RNA
- Translation of RNA to protein
- ATP for each step in cycle
- Sequence dependence between DNA and protein
- DNA mutation yields different proteins
- Signals that led a protein to be excreted from a cell

Suggested readings:

- Nelson DL, McKee MM. *Lehninger's Principles of Biochemistry.* W H Freeman ((5th edition 2010 or a later edition).
- Karp G. *Cell and Molecular Biology: Concepts and Experiments.* Willey (6th edition 2009 or a later edition).
- Mckee T, Mckee JR. *Biochemistry the Molecular Basis of Life.* Oxford ((4th Edition 2002 or a later edition).
- Berg J, Tymoczko JL, Stryer L. *Biochemistry.* WH Freeman (5th edition 2010 or a later edition).
- Voet D, Voet JG. *Biochemistry*. Wiley and Sons (4th edition 2010 or a later edition).

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

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, membrane transportation and Cell division
- Acquire detail understanding of energy-yielding cellular processes - Respiration and photosynthesis.
- 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
- Be acquainted to basic cellular genetic information pathways: DNA replication, transcription and translation
- Develop ideas about genetic diseases as a consequence of mutations in DNA sequence

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

Unit-wise Title and Sub-title	No. of classes/unit
Concept of Life and Living Processes	3
The Cell–Structure and Organization	12
Biomolecules of life	20
Amino Acids and Proteins	10
Central Dogma of Biological Systems	15
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

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 causing 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 of Microbiology as a Field of Instruction

- Early usages of microbes, the theory spontaneous generation and its role in the development of microbiology.
- The First Golden age (contributions of Pasteur, Koch, Lister, Fleming and Waksman and others) of microbiology.
- The Second Golden age (advent of molecular biology and recombinant DNA technology), and recent developments in microbiology.

2. Observing Microorganisms

- Structure of light, fluorescence, confocal and electron microscopes, image magnification and resolution.
- Sample preparation for microscopic observations.
- Principle of staining, simple staining, differential staining (Gram staining and acid-fast staining), special staining (capsule, flagella and endospore staining).

3. Introduction to Bacteriology

- Structure and anatomy of bacterial cell.
- Bacterial cell clustering, endospores and other bacterial structures.
- Methods for identification of common pathogenic bacteria.
- Classification of bacteria, basis of bacterial classification, common groups of eubacteria and their economic importance

4. Microbial Growth and Control

- Bacterial cell division, growth phases and growth curve.
- Methods of estimation and enumeration of bacteria.
- Factors affecting bacterial growth, liquid and semi-solid culture media, use of culture media in identification of bacteria
- Establishment and maintenance of pure culture, preservation of isolated bacterial strains.
- Disinfection and sterilization, physical and chemical methods of controlling microbial growth.

5. Elements of Virology

- Structural features and general characteristics virus particles.
- Isolation, cultivation and identification of viruses.
- Multiplication of viruses, one step growth curve, steps of virus replication cycle.
- Bacteriophages; lytic and lysogenic cycles.
- Classification of animal viruses, common human viral pathogens.
- Bacteriophages, lytic and lysogenic cycles and their clinical significance.
- Subviral agents and their economic importance.

6. Algae and Fungi

- Characteristics of algae and fungi

- Sexual and asexual reproduction of fungi
- Fungal diseases
- Algal and fungal toxins, other economic importance of algae and fungi

7. Actinomycetes

- Characteristics of Actinomycetes, modes reproduction of actinomyceted.
- Importance in industry and natural processes
- Common human mycoses and actinomycosis and their treatments.
- Economic importance of actinomyceties in industry and natural processes

8. Infectious Diseases: Host-Microbe Interactions

- Clonization versus infection, normal microbiota and opportunistic microorganisms
- Etiologym classification and spread of infections dieases, epidemiology of infectious diseases
- Microbial mechanisms of pathogenicity, roles of microbes and host immune system in disease progression
- Innate and adaptive host defenses

9. Control of Microbial Pathogens

- Antimicrobial drugs, mechanisms of microbial drug resistance; drug sensitivity testing, drug toxicity, drug interactions and process of developing antimicrobial drugs.
- Classification of antibiotics based on structure and mode of actions; natural, semisynthetic and synthetic antibiotics.
- Common antifungal and anti-viral drugs and their modes of action.

10. Introductory Applied Microbiology

- Fermentation technology in food, beverage and chemical industries, food spoilage and food preservation.
- Microbial waste water treatment, generation of biogas and biofuel, bioremediation of polluted water and soil.
- Commercial products from primary- and secondary metabolites, expression and isolation of recombinant proteins from microbes.
- Microbial paste control, microbial nitrogen fixation, photosynthetic bacteria and roles of microbes in biogeochemical cycles.

Suggested readings:

- Madigan MT, Martinko JM, Stahl D, Clark DP. *Brock Biology of Microorganisms.* Benjamin Cumming (13th edition 2010 or a later edition).
- Tortora GJ, Funke BR, Case CL. *Microbiology: An Introduction.* Addison Wesley Longman (10th edition 2004 or a later edition).
- **Pelczar and Reid**, *Microbiology* (5th Edition, McGrow Hill)
- Pommerville JC. *Alcamos's Fundamentals of Microbiology.* Jones and Bartlett (9th edition 2010 or a later edition).
- Kuddus R. *Microbiology for Health Professions.* Linus ((1st edition 2010 or a later edition).

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

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 of Microbiology as a Field of Instruction	4
Observing Microorganisms	3
Introduction to Bacteriology	7
Microbial Growth and Control	8
Elements of Virology	8
Algae and Fungi	5
Actinomycetes	5
Infectious Diseases: Host-Microbe Interactions	6
Control of Microbial Pathogens	6
Introductory Applied Microbiology	8
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-105 Fundamentals of Genetic Engineering and Biotechnology 4 Credit

Introduction to the Course:

This is a fundamental course covering various aspects and scopes 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 to animals, plants and microbial organisms. 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.
- Provide opportunities to learn about ethical and social implications of biotechnology.

GEB-105 (Fundamentals of Genetic Engineering and Biotechnology) Course Content

1. Biotechnology

- Definitions; traditional and modern biotechnology, multidisciplinary nature of biotechnology.
- Applications of genetic engineering and biotechnology.
- Scope of biotechnology in developing countries.
- Careers in biotechnology.

2. Potential Areas of Biotechnology

- Agricultural biotechnology:
  - Applications; scope and opportunities of agricultural biotechnology in Bangladesh.
  - Genetic manipulation in plants; seed quality improvement, nitrogen fixation and bio-fertilizers.
  - Genetically Modified (GM) crops: implications & concerns.
  - Biocontrol of plant pathogens, insects, pests and weeds.
- Medical biotechnology:
  - Medical products and applications of biotechnology.
  - Commercial production of hormones, vaccines etc.
  - Gene therapy.
  - Disease diagnosis.
  - Monoclonal antibodies and their applications.
  - Forensic applications: DNA fingerprinting.
- Environmental Biotechnology:
  - Applications of biotechnology in the environment.
  - Pollution control; recalcitrant molecules and xenobiotics, use of specialized microorganisms to detoxify chemicals.
  - Bioremediation of water, soil; waste disposal.
  - Livestock and fish biotechnology:
  - Improving dairy and meat animals.
  - Improvement of culturable fish species.
  - Feed improvement.

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; 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; scope and applications.
- Gene cloning—concept and basic steps.
- Restriction endonucleases, ligases and other enzymes useful 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 & safety of genetically engineered products.

Suggested readings:

- Thieman WJ, Palladino MJ. *Introduction to Biotechnology.* Pearson (3rd edition 2012 or a later edition).
- Ratledge C, Kristiansen B. *Basic Biotechnology*. Cambridge Univ. Press (1st edition 2001 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.

Learning Outcomes

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

- Familiarize the basic concepts of biotechnology.
- Be 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 pint/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

GEB-106 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-106 (Mathematics for Biologists) Course Content

1. Algebra

- Quadratic functions, graphical presentation of quadratic functions and quadratic equations.
- Simultaneous equations and linear and quadratic inequalities.
- Algebraic manipulation of polynomials.
- Matrices and determinants.
- Systems of linear equations.
- Eigenvalues and Eigenvectors.

2. Sequences and Series

- Sequences, arithmetic series, geometric series and sum to infinity of a convergent geometric series.
- Binomial expansion and binomial series.
- Remainder theorem.

3. Functions

- Function and its composition, inverse functions, graphical representation of function and inverse functions.
- The modulus function.
- Trigonometric, exponential and logarithm functions.
- The Exponential growth and decay.

4. Co-ordinate Geometry

- Equation of straight lines, conditions for two straight lines to be parallel or perpendicular to each other.
- Co-ordinate geometry of the circle.
- Cartesian and parametric equations of curves and inter-conversion of the two forms.
- Equations for ellipse, parabola, hyperbola, sphere and cone.

5. Calculus

- Limit, continuity and differentiability of functions.
- Partial derivatives, maxima and minima.
- Methods of integration, integration by parts; definite integrals and application for finding areas.
- Test for convergence.
- Fourier series.

6. Differential Equations

- Linear and nonlinear first order ordinary differential equations (ODE).
- Higher order ODEs with constant coefficients.
- Solution of simple ODEs.
- Cauchy's and Euler's equations.

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.

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 pint/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

GEB-107	FCL English Language	4 Credit

Introduction to the Course:

This course is designed to improve students' overall English competency across the four skills—speaking, reading, listening and writing. Students will get a general introduction to English linguistics, including grammar, syntax (the structure of sentences), and semantics (the study of word and sentence meaning). Students will also be introduced to a range of interpretive practices, and the course is designed to increase their skills in critical analysis, writing and reasoning.

Specific objectives:

The study of this course will:

- Enable students to utilize the skills of listening and speaking for the purposes of providing and obtaining information, expressing personal logics and opinions, and persuading others to adopt a course of action
- Demonstrate the ability to listen actively to speakers within the classroom setting.
- Familiarize to comprehend messages and short conversations when listening to peers and instructors
- Enable the students to utilize the skills of reading to comprehend course materials written in English.
- Enable the students to utilize the skills of writing for the purposes of expressing their ideas and logic in written report format.

GEB-107 (FCL English Language) Course Content

1. Reading

- Reading will involve activities and discussions that will lead to effective writing.
- Strategies of reading: Predicting, skimming, scanning, inference, and analysis.
- Selected texts: Diverse general texts reflecting common interests and special texts related to biotechnology.

2. Grammar: Modern English Usages

- Articles: definite and indefinite and one, a little, a few, this, that.
- Prepositions, types and different uses: place, time, addition, exception, replacement, example, condition, cause, means and time limit.
- Prepositions used with adjectives and participles, verbs and prepositions, gerunds and prepositions, prepositions and adverbs.
- Relative pronouns and clauses.
- Verbs: classes of verbs, auxiliary verbs (be, have, do, may, can, might, should, need etc.).
- Agreement of the verb with the subject.
- Tense: the present tense, the past and perfect tense and the future tense
- The conditionals: the conditional tenses, and conditional sentence type 1, 2 and 3.
- The Gerund: forms and uses.
- Active and passive voice.
- Clauses of reason, result concession, comparison and time.

3. Writing

- The writing process: Brainstorming, outlining, drafting, editing and proofreading
- Paragraph development: Paragraph structure, transitional devices and connectives, types of paragraphs including descriptive and narrative, process analysis, cause and effect, argumentative paragraphs.
- Essay writing: Essay structure, thesis statement, introduction and conclusion, and different essay types.
- Writing formal letters.
- Report writing including academic reports, newspaper reports and laboratory reports.
- Writing research papers: Planning a research paper, method of conducting research, taking notes, organizing extracted information, drafting, documenting, revising and editing.
- Style of writing research papers including APA style, Chicago manual of style, Turabian Style, CGOS Style, CBE style and MLA style.
- Combining sentences, summary and paraphrase writing.

4. Ethical Issues of Writing

- Defining and avoiding plagiarism.
- How to quote sources and copyright materials.

5. Speaking: This segment will include, but will not be limited to, the following functions:

- Introducing self and others.
- Expressing likes & dislikes, personal experiences, past habits, requests and offers, apologies and excuses, inviting, comparison and contrast.
- Describing people, places, things; narrating action and events, saying numbers and time.
- Giving and following instructions, asking for and giving directions.
- Reporting, complaining and suggesting.
- Role-plays in various authentic situations.
- Rhetoric, (Cicero's) five cannons of rhetoric and public speaking.
- Participating in debates, making extempore speeches.
- Seminar presentations & interviews.
- Phonetics: International Phonetic Alphabet (IPA) symbols, using a dictionary for pronunciation, phonetic transcriptions, intonation and stress.

6. Listening

- Listening comprehensions focusing on varying elements of vocabulary and structures will be practiced.
- Students will be taught how to be an active listener to obtain information and understand the key ideas.
- Class practice will include listening to tapes according to students' needs.

Suggested readings:

- Ramage JD, Bean JC, Johnson J. *Allyn & Beacon Guide to Writing.* Longman (5th edition 2008 or a later edition).
- Beaumont D, Granger C. *The Heinemann ELT English Grammar.* Macmillan (1995 or a alter edition).
- Thomson AJ, Martinet AV. *A Practical English Grammar.* Oxford (4th edition 1986 or a later edition).
- Wegmann BA, Knezevic MP. *Mosaic One: A Reading Skills Book.* McGraw Hill ((3rd edition 1985 or a later edition).
- Smithies M. *Advanced English Comprehension Texts for Science Students.* Collier- Macmillan (1973 or a alter edition).
- Imhoof ML, Hudson H. *From Paragraph to Essay: Developing Composition Writing.* Longman (1975 or a alter edition).

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

Learning Outcomes

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

- Use proper grammar and grammatical patterns with competence and confidence.
- Apply listening and speaking skills effectively while exploring communication in English.
- Apply reading skills to improve their comprehension and reading speed.
- Use their writing ability to compose written works more effectively.

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Reading	5
Grammar: Modern English Usages	15
Writing	10
Ethical Issues of Writing	10
Speaking: This segment will include different topics	10
Listening	10
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-108	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.
- Facilitate the students to improve observational skills.
- Help to develop skills in handling the apparatus/instruments and taking readings on them.
- 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-108 (Laboratory Experiments) Course Content

- Preparation of 0.1N solution of Na_2CO_3 and determination of the strength of HCl solution by titration method
- Estimation of ascorbic acid content by Bessel's titrimetric method
- Estimation of acetic acid content of the supplied vinegar solution
- Standardization of Potassium Permanganate solution against Sodium Oxalate as primary standard
- Determination of protein concentration by BIURET method
- Protein estimation by Lowry method
- Preparation of Microbiological Culture Media
- Inoculation and culturing of bacteria
- Isolation of bacteria from soil sample
- Protease Activity of Bacteria, a qualitative Test
- Motility, Indole and Urease (MIU) Test
- Gram staining and morphological study of Bacteria
- Antimicrobial Susceptibility Test of Bacteria by Agar Diffusion
- Growth of bacterial population: growth curve
- DNA extraction from biological sample

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.

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.
- Calculate and prepare common biotechnology laboratory reagents/solutions/samples.
- 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

GEB-109	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 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-109 (Viva voce) Course Content

All theory courses (GEB-101 to GEB-107) 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.
- Capacity of oral delivery will be improved.
- Fear to face a viva board will reduce.
- Will 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.

Course Profile: Second Year

GEB-201 **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, stoichiometry, redox potential, catalyst and photochemistry. Elucidation of reaction mechanisms of simple and complex biological reactions, specially 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:
The study of this course will:

- 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-201 (Chemistry for Biologists II) Course Content

Organic Chemistry

1. **Chemistry of:**
    - Carboxylic acids
    - Amines
    - Diazonium salts
    - Azo dyes
    - Sulfadrugs
    - Phenols

2. **Alkaloids and Antibiotics:**
    - Alkaloids and their classification
    - Extraction of important alkaloids and their biological roles
    - Chemistry of quinine, papavarine, morphine
    - Classification and general mode of action of antibiotics and chemistry of penicillin, chloramphenicol

3. Polymers:

- Definition and classification- natural and synthetic polymers
- Mode of polymerization- addition and condensation.

Physical Chemistry:

4. Kinetics and reaction mechanisms:

- Nature and scope of chemical kinetics
- Rate laws
- Rate of reaction: definition; factors influencing rate of reaction- temperature, concentration, pH, pressure, nature of the reactant and catalysts
- The Arrhenius equation
- Collision theory and transition state theory
- Catalysts and catalysis
- Concept of reaction order: first, second and pseudo-order reactions; determination of reaction order
- The relationship between reaction order and stoichiometry
- Molecularity of reactions
- Kinetics and reaction mechanism
- Concepts of elementary processes
- The steady state approximation

5. Electrochemical Cells:

- Standard electrode potential
- Electromotive force of a cell
- Nernst equation
- Redox potential and biology

6. Quantum Theory and Photochemistry:

- Light energy and its interaction with matter
- Excitation and emission
- The Frank-Condon principle
- Nature of chromophores: d-d transitions, ($n \rightarrow \pi$) and ($\pi \rightarrow \pi^*$) transition
- Fluorescence and Phosphorescence

7. Spectroscopy and Quantification:

- The nature of light and how it interacts with molecules
- Vibrations of molecules (basic theory)
- Infrared (IR) spectroscopy of organic molecules and functional groups
- UV-visible spectroscopy and electronic structure, Beer-Lambert-Bouguer law
- Nuclear magnetic resonance (NMR) spectroscopy (basic concepts); ^{13}C spectra (shielding and chemical shifts); high-resolution ^{1}H NMR spectra (coupling patterns); interpreting NMR spectra of organic molecule
- Mass spectrometry (MS) and its use in the determination of structure of organic molecules

Suggested Readings*:*

- Atkins P, de Paula J. *Physical Chemistry (9th Ed.).* New York, WH Freeman (2009).
- Roussel MR. *A Life Scientist's Guide to Physical Chemistry*. London, Cambridge University Press (2012).
- Solomons TWG, Fryhle CB. *Organic Chemistry (9th Ed.).* New York, John Wiley (2007).
- Morrison RT, Boyd RN. *Organic Chemistry (6th Ed.).* Prentice Hall (1992).
- Van Holde KE, Johnson C, Ho PS. *Principles of Physical Biochemistry (2nd Ed.).* New York, Prentice Hall (2005).
- Fisher J, Arnold J. *Instant Notes in Chemistry for Biologists (2nd Ed.).* New York, Taylor & Francis (2012).
- Atkins RC, Carey FA. *Organic Chemistry: A Short Course (3rd Ed.).* New York, McGraw Hill (2001).

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

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**
Organic Chemistry Chemistry of Carboxylic acids, Amines, Diazonium salts, Azo dyes, Sulfadrugs, Phenols	15
Organic Chemistry Alkaloids and Antibiotics:	10
Organic Chemistry Polymers:	2
Physical Chemistry: Kinetics and reaction mechanisms:	10
Physical Chemistry: Electrochemical Cells:	6
Physical Chemistry: Quantum Theory and Photochemistry:	7
Physical Chemistry: Spectroscopy and Quantification:	10
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-202	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 introduced 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:

- Emphasize a deeper insight into the fundamentals of enzymes: its structure, functions, catalysis and the mechanisms of action.
- Describe kinetics of enzyme catalyzed reactions, its inhibitory and regulatory mechanism.
- Explain the intricate mechanism of immobilized enzymes, metabolic enzymes and their regulations.
- Provide exposure to numerous applications of enzyme and their future implications.

GEB-202 (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
    - 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, temperature and the rate of mixing)
    - Factors affecting catalytic efficiency of enzymes (such as proximity, orientation-distortion or strain)
    - Covalent catalysis and general acid-base catalysis

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

4. **Kinetics of Simple and Complex Reactions:**
    - Thermodynamic aspects of reactions: reaction coordinates, activated complexes and transition states

5. **Enzyme Kinetics:**
    - Introduction to kinetics: 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
    - K_m, V_{max} and $K_{cat/Km}$: definition, determination, significance
    - Bisubstrate enzyme kinetics: Single and double displacement reactions, random & ordered mechanism

6. **Enzyme Inhibition:**
    - Reversible inhibition: competitive, noncompetitive and uncompetitive kinetics
    - Irreversible inhibition, specific examples

7. **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 for action of allosteric enzymes and their significance
    - Feed Back inhibition and Feed Forward stimulation
    - Enzyme repression, induction and degradation
    - Control of enzymatic activity by products and substrates
    - Monocyclic and multicyclic cascade systems

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

9. Non-Protein Enzymes:

- Abzymes, Ribozymes and DNA enzymes

10. Industrial and Diagnostic Application of Enzymes:

- Isoenzymes: characteristics and importance
- Enzymes and isoenzymes in diagnosis (lactate dehydrogenase (LDH), creatine kinase (CK), transaminases, phosphatases, amylase and cholinesterase)
- Serum enzymes in health and diseases
- Normal and diagnostic value of enzymes
- Industrial applications of proteins and enzymes
- Biosensors and immobilized enzymes

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. *Lehninger Principles of Biochemistry (5th Ed.).* New York, W H Freeman (2008).
- Fersht A. *Enzyme Structure and Mechanisms*. New York, WH Freeman, W. H. & Company (1998).
- Wiseman A. *Handbook of Enzyme Biotechnology (2nd Ed.).* New York, Ellis Horwood Publishers (1985).
- Berg JM, Tymoczko JL and Stryer L. *Biochemistry (7th Ed.).* W H Freeman & Company, New York (2010).
- 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 (5th Ed.).* Oxford University Press (2011).

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

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.
- Be acquainted with the quantitative nature of enzyme kinetics
- Predict possible catalytic mechnisms 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
Industrial and Diagnostic Application of Enzymes:	5
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-203 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-203 (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 three dimensional structure of proteins
    - Protein denaturation and folding, protein misfolding
    - Prion diseases

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. **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

Suggested Readings*:*

- Lehninger A, Nelson DL, Cox MM. *Lehninger Principles of Biochemistry (5th Ed.). New York,* W H Freeman (2008).
- Berg JM, Tymoczko JL and Stryer L. *Biochemistry (7th Ed.)*. W H Freeman & Company, New York (2010).
- Lodish H, Berk E, Kaiser J et al. Molecular Cell Biology (7th Ed.), New York, WH Freeman (2012).
- Alerts B, Johnson A, Lewis J et al. Molecular Biology of the Cell (5th Ed.), New York, WH Freeman (2007)..
- Petsko GA, Ringe D. *Protein Structure and Function,* New Science Press (2008).

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

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:	8
Protein Purification and Amino Acid Sequence Determination:	7
Protein Function:	12
Total	**30**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-204	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-204 (Bioenergetics and Metabolism) Course Content

1. **Biological Membranes and Transport:**
    - The composition and architecture of membranes
    - Membrane lipids and proteins
    - Membrane dynamics
    - Solute Transport across the membranes
    - Various types of membrane transporters, channels and pumps
    - Membrane integrated ATPases involved in ion pumping across the membrane

2. **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

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

Suggested Readings*:*

- Lodish H, Berk E, Kaiser J et al. *Molecular Cell Biology (7th Ed.),* New York, WH Freeman (2012).
- Alerts B, Johnson A, Lewis J et al. *Molecular Biology of the Cell (5th Ed.),* New York, WH Freeman (2007).
- Berg J M, Tymoczko J L and Stryer L. *Biochemistry (7th Ed.)*. W H Freeman & Company, New York (2010).
- Voet D, Voet J, Pratt C. *Fundamentals of Biochemistry (4th Ed.).* New York, John Wiley (2012).
- Lehninger A, Nelson DL, Cox MM. *Lehninger Principles of Biochemistry (5th Ed.).* New York, WH Freeman (2008).
- Pratt CW, Cornely K. *Essential Biochemistry (3rd Ed.).* Wiley, John & Sons (2013).

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

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**
Biological Membranes and Transport:	13
Bioenergetics:	06
Carbohydrate Metabolism:	15
Fatty Acid Metabolism & Cholesterol Biosynthesis:	09
Amino Acid metabolism:	09
Nucleotide Biosynthesis and Metabolism	08
Total	**60**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-205 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
- 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-205 (Human Physiology) Course Content

1. **Tissues:**
    - Types and functions of tissues (epithelial, connective, muscular and neuronal tissues)
    - The ultra structure of muscle, molecular mechanism of muscle contraction
    - The organs and the organ systems- lymph, lymphatic vessels and the primary, secondary and tertiary lymphatic tissues (bone marrow, thymus, lymph nodes, spleen, tonsils, and the Payer's patches)
    - Control systems and maintenance of homeostasis

2. **Digestive Systems:**
    - General anatomy
    - The digestive processes and functions
    - Digestive enzymes: composition, function and regulation of salivary, gastric, pancreatic, bile and intestinal juices
    - Chemical digestion and absorption of carbohydrates, lipids, proteins and nucleic acids
    - Balanced diet; importance of vitamins, minerals and trace elements

3. **Gastro-Intestinal (GI) System and Liver:**
    - An overview of the GI system
    - Mouth, pharynx, esophagus, 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 blood circuits
    - Cardiac muscle and the conduction system
    - The cardiac cycle (origin, conduction and regulation of heart beat)
    - Electrical and contractile activity of the heart and electrocardiogram
    - Circulatory system (general anatomy of blood vessels, arteries veins and capillaries)
    - Blood pressure, capillary pressure, regulation of blood pressure

5. **Respiratory System:**
    - Introduction to cardiopulmonary anatomy and physiology
    - Mechanism and control of breathing (inspiration and expiration), control of respiration

- Transport of oxygen and carbon dioxide; oxygen dissociation curve of hemoglobin and myoglobin
- The Bohr effect; chloride shift
- The effects of hydrogen ions
- Respiratory system defense mechanisms

6. Brain and Nervous System:

- Overview of the brain,
- The hindbrain, midbrain and forebrain
- 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 the neurons
- Nature of nerve impulse- its origin and propagation
- Membrane potential and action potential
- Synapse and myoneural junction
- Different types of neurotransmitters
- The neural circuits
- Structure and function of sensory organs concerned with vision, sound perception, taste, smell and touch
- 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
- Renal functions and glomerular filtration
- Urine formation and its properties
- Role of the kidney in the regulation of water, salt and acid base balance
- The relationship between kidney function and blood pressure
- Renal insufficiency and hemodialysis

8. Blood:

- Composition and function of blood, plasma and serum
- Erythrocytes and hemoglobin: formation, structure and function
- Structure and properties of different types of leukocytes, abnormalities of leukocyte count,
- Blood group (A, B, O and Rh) antigens, blood transfusion and cross-matching tests
- Blood coagulation,
- Erythrocyte disorders, erythroblastosis fetalis,
- Significance of erythrocyte sedimentation rate (ESR)

9. Endocrine System:

- Hormones and other signaling molecules
- Anatomy of the endocrine organs (hypothalamus, pituitary, thyroid, parathyroid, adrenal, pancreas, testes, ovary, pancreatic islets and other endocrine elements)
- Local chemical mediators; prostaglandins
- Consequence of endocrine malfunction

10. Reproductive System:

- Human reproduction and development
- The male reproductive system: spermatogenesis and regulation of spermatogenesis
- The female reproductive system: oogenesis and its regulation, puberty, menstruation, menstrual cycle and its regulation,
- Male and female sterility and infertility
- Birth control strategies, pregnancy & lactation

Suggested Readings*:*

- Barrett KE, Barman SM, Boitano S, Brooks H. *Ganong's Review of Medical Physiology (24th Ed.).* New York, McGraw-Hill (2012).
- Sylvia SM, Boyd RN. *Understanding Human Anatomy & Physiology (5th Ed.).* New York, McGraw-Hill (2010).
- Saladin KS. *Anatomy & Physiology: A Unity of Form and Function (6th Ed.).* Boston, McGraw Hill (2012).
- Guyton C and Hall JE. *Textbook of Medical Physiology (12th Ed.).* Philadelphia, WB Saunders (2010).
- Marieb EN, Wilhelm PB, Mallat JB. *Human Anatomy and Physiology (10th Ed.).* New York, Benjamin Cummings (2011).
- Jenkins G, Kemnitz C, Tortora GJ. *Anatomy and Physiology: From Science to Life (3rd Ed.).* New York, John Wiley (2012).

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

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.
- Explain the structures of different body organs.
- 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 pint/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

GEB-206	Physics for Biologists	3 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-206 (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
- Diffusion constant and Einstein Formulas
- Laminar, turbulent and pulsatile 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; Kirchiff'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, photometer
- Photochemistry and transmitter of vision
- Light attenuation in vision
- The eye as an optical instrument, illumination of retina; formation of image
- Effects of long continued exposure of light
- Light application in therapy
- Biological light (bioluminescence)

4. Basic Electronics and Biosensors:

- Solid state electronics devices and their applications
- Diode, transistors and amplifiers
- Oscillators, Integrated circuits
- Electrical signal detection in biological systems: silicon, glass and metal electrodes
- Bioelectronics device production: microelectronic fabrication methods as adapted to bioelectronics, hard and soft lithography
- Biosensors: miniaturization, microsystems- sensing using optical techniques, field effect transistors, ion-selective and enzyme-sensitive electrodes and their monitoring, commercial biosensors (glucose monitoring and DNA analysis)

5. Nuclonics and Nuclear Medicine:

- Radioactivity and its detection
- Radioactive decay
- Isotopes
- Biological effects of radiation, radiation hazard
- Organ scan (liver, bone, brain etc.)
- Positron emission tomography
- X-ray
- Magnetic resonance imaging
- Radioiodine for diagnosis of disorder (thyroid disorder)
- Laser beam in diagnosis and therapy
- Nuclear medicine in therapy

6. Biochemical Instruments:

- Compound light microscope: phase contrast microscope, florescence microscope, UV-microscope, laser confocal microscope
- Electron microscope
- Ultramicroscope and micromanipulator

7. Acoustics:

- Vibration
- Sound, ultrasound, infra-sounds and their application
- Hearing aids

Suggested Readings*:*

- Halliday D, Resnick R, Walker J. *Fundamentals of Physics (9th Ed.).* New York John Wiley (2010).
- Serway RA, Faughn JS. *College Physics (8th Ed.*). New York, Brooks Cole (2008).
- Raicu V, Popescu A. *Integrated Molecular and Cellular Biophysics*. New York, Springer (2010).
- Davidovits P. *Physics in Biology and Medicine (3rd Ed.)*. New York, Academic Press (2007).
- Batchelor GK. *An Introduction to Fluid Dynamics.* London, Cambridge University Press (2000).
- Bar-Meir G. *Basics of Fluid Mechanics.* Orange Grove Texts Plus (2009).
- Serdyuk IN, Zaccai NR and Zaccai J. *Methods in Molecular Biophys*ics: *Structure, Dynamics, Function.* London, Cambridge University Press *(*2007).
- 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).

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:	7
Biophysical Phenomena of Light:	7
Basic Electronics and Biosensors:	7
Nuclonics and Nuclear Medicine:	7
Biochemical Instruments:	7
Acoustics:	5
Total	**45**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-207	Computing and Information Technology	3 Credit

Introduction to the Course:

Computing and Information Technology course is 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.

GEB-207 (Computing and Information Technology) Course Content

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

2. **Operating Systems:**
    - Introduction to OSs (Windows, Linux, Mac OSx, Unix)
    - Tools/software installation in Linux environment
    - Basic Linux commands, command line arguments

- 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

3. 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,
- Application layer protocols (icmp, dns, smtp, pop, ftp, http)

4. Databases and XML:

- Introduction to flat files, DBMS and RDBMS, ER model
- Database design (integrity constraints, normal forms)
- Query languages (SQL)

5. Programming basics:

- Introduction of C and C++ with fundamental object-oriented concepts

6. Basic Perl:

- Introduction to Perl and basic terminologies
- Working with scalars, decisions, loops, lists, arrays, hashes, string operations, subroutines, control flow (if, else, elseif)
- File handling, files and directories, and basic calculation using Perl script: read data from single and multiple files, manipulation, format conversion, sorting, concatenating; file parsing; pattern matching and regular expression
- Mutation and randomization: Perl skills to acquire randomly select an index into an array and a position in a string

Suggested Readings*:*

- Peterson LL, Davie BS. *Computer Networks: A Systems Approach (5th Ed.).* New York, Morgan Kauffman Elsavier (2011).
- Kurose JF, Ross KW. *Computer Networking: A Top-down Approach (5th Ed.).* New York, Addison-Wesley (2009).
- Comer D, Stevens D. *Internetworking with TCP-IP, vol. 1 and 2 (5th Ed.)* New York, Prentice Hall (2005).
- Stevens WR, Fenner B, Rudoff AM. (2003). *UNIX Network Programming, Vol. I: The Sockets Networking API*. New York, Prentice Hall (2003).
- Silberschatz A, Korth HF, Sudarshan S. *Database System Concepts*. New York, McGraw-Hill (2002).
- Schneider MG, Gersting J. *An Invitation to Computer Science (5th Ed.).* Independence (KY), Cengage Learning Course Technology (2009).

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

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.

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

Unit-wise Title and Sub-title	No. of classes/unit
Introduction:	4
Operating Systems:	10
Computer Networks and Internet Systems:	8
Databases and XML:	8
Programming basics:	8
Basic Perl:	7
Total	**45**

Instructional Strategies

- Lecture with traditional method
- Lecture with power pint/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

GEB-208 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. 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-208 (Laboratory Experiments) Course Content

1. Practical Laboratory Experiments

1. Determination of ABO and Rh blood type of the blood sample
2. Estimation of Glucose content of Blood serum by Nelson Somogyi method
3. Tissue glycogen extraction and determination
4. Determination of the creatinine content in urine sample
5. Succinicd and the use of inhibitors
6. Effect of catalase concentration on reaction rate
7. Isolation of casein protein at its isoelectric point by precipitation method
8. Isolation of streptococcus from saliva
9. Isolation and detection of genomic DNA from bacteria
10. Determination of antibiotic potency test
11. Determination of total antioxidant capacity
12. Determination of total reducing power

2. Bioinformatics Practical:

1. Determination of secondary and tertiary protein structure of proteins
2. Determination of 3-D structure of proteins
3. BLAST (BLASTn, BLASTp)

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.

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

GEB-209	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 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-209 (Viva voce) Course Content

All theory courses (GEB-201 to GEB-207) 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.
- Student will know how to answer a question in a very logical way.
- Capacity of oral delivery will be improved.
- Fear to face a viva board will reduce.
- Will 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.

Course Profile: Third Year

GEB-301 Plant Physiology 4 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-301 (Plant Physiology) Course Content

1. Features of plant cell: Structural organization of a typical plant cell; functions of different components.

2. Plant growth: Concept of growth and development; cell differentiation and morphogenesis in plants; transition to flowering from vegetative to reproductive stages; structure and development of flowers; seed dormancy and germination; cotyledon, endosperm and seed coat development; genetic regulation of vernalization; lateral and adventitious root development; root hair development; hormonal regulation in root development.

3. Photosynthesis: Photosynthetic apparatus and light harvesting complexes; light absorption, emission and energy transfer; electron transfer; photophosphorylation; CO_2 fixation; C_3, C_4, CAM plants; leaf morphology for different dark phase reactions; environment and its impact on photosynthesis.

4. Respiration: Aerobic and anaerobic respiration; oxidative phosphorylation and electron transport; complex I, II, III and IV (in plant system).

5. Plant water relations: Types of water movements in plant cells; properties of solutions; inhibition; permeability; water potential to plant cell; mechanisms of water absorption.

6. Transport phenomena: Active and passive transport system; transport of nutrients across the primary root, genetic regulation of transport systems in response to nutrient availability and growth conditions.

7. Nitrogen fixation and nutrient assimilation: Plant mycorrhiza association; mechanisms of nitrogen fixation; symbiotic and non-symbiotic nitrogen fixing bacteria and their fixation activity; uptake and assimilation of nitrate; assimilation of ammonia; the *nif* gene; nitrogen, iron, potassium, sulfur, phosphate and calcium metabolisms.

8. Lipid metabolism: Fatty acid biosynthesis; membrane lipid biosynthesis; lipid desaturation; triacylglycerols; cell wall lipid; ceramides.

9. Plant hormone: Types of hormones; **auxins:** the master growth hormone, distribution in plants,roles, auxin binding proteins, signal transduction, auxin-responsive genes/promoters, model of gene regulation, commercial uses; **gibberellins:** foolish seedling disease, functions of GAs, location, signal transduction of Gas, commercial uses; **cytokinins:** mechanisms of action, application; **ethylene:** location and functions, mechanisms of action, application; **abscisic acid:** a stress hormone, location and functions, mechanisms of action, application.

10. Acclimation to environmental stress and adaptation to environment/ Programmed cell death: Hypersensitive response; relevance with diseases; induction and role of various apoptotic genes involved in cell death.

11. **Plant secondary metabolites and their importance**

Suggested Reading:

- Plant Physiology (5th edition) by Lincoln Taiz and Eduardo Zeiger. 2010. Publisher-Sinauer Associates Inc.
- Introductory to Plant Physiology (4th edition) by William G. Hopkins, Norman P. A. Huner. 2008. Publisher-John Wiley & Sons Ltd. UK.
- Plant Biochemistry & Molecular Biology (1st edition) by Hans-Walter Heldt. 1997. Publisher-Oxford University Press, USA.
- Introduction to Plant Biochemistry (2nd edition) by Goodwin and Mercer. 1990. Publisher-Pergamon Press, Australia.
- Plant Biochemistry and Molecular Biology by peter J. Lea & Richard C. Leegood. 1993. Pulisher-John Wiley & Sons Ltd.UK.
- Plant Physiology by Mohr and Schopfer. 1995. Publisher-Springer.
- Molecular Biology of the Cell (5th edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roderts & Peter Walter.2007. Publisher-Garland Science.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Features of plant cell:	6
Plant growth:	8
Photosynthesis:	6
Respiration:	6
Plant water relations:	3
Transport phenomena:	6
Nitrogen fixation and nutrient assimilation:	8
Lipid metabolism:	6
Plant hormone:	5
Acclimation to environmental stress and adaptation to environment/ Programmed cell death:	4
Plant secondary metabolites and their importance	2
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

GEB-302	Basics of Molecular Biology	4 Credit

Introduction to the Course:

This course focuses on the 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-302 (Basics of Molecular Biology) Course Content

1. Introduction: Physical and chemical properties of nucleosides and nucleotides; DNA structure; RNA structure; Tm value; cot value; central dogma; heredity.

2. Organization of the genome: The complexity of eukaryotic genome; chromosome and chromatin; organization of histone octamer; genes and gene number; evolution of genes, chromosomal redundancy; repetitive DNA, SNPs and their relevance.

3. DNA replication: Modes of replication; DNA polymerases; regulation of DNA replication.

4. Transcription: Prokaryotic and eukaryotic RNA polymerases; transcriptional factors; mechanisms of transcription; reverse transcriptase; RNA processing; RNA editing; RNAi; miRNA.

5. Translation: Structure of ribosome; functional site of ribosome; genetic code, amino acid-tRNA interaction; Wobble hypothesis; protein synthesis: initiation, elongation and termination; protein folding and processing; protein degradation; protein sorting and transportation.

6. DNA repair and recombination: Variation and evolution; types and mechanism of mutation; DNA repair; homologous and non-homologous recombination; site-specific recombination and transposition rearrangement.

7. Organelle genome: Genomes of mitochondria and plastid- their interaction with nucleus; replication; repair; inheritance; diseases associated with organelle genome.

Suggested Reading:

- Molecular Biology of the Gene (7^{th} 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 (5^{th} edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roderts & Peter Walter.2007. Publisher-Garland Science.
- Molecular Cell Biology (6^{th} edition) by Harvey Lodish, Arnold Berk, Chris A. Kaiser & Monty Kreger. 2007. Publisher- W. H. Freeman.

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

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**
Introduction:	9
Organization of the genome:	7
DNA replication:	10
Transcription:	10
Translation:	10
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

GEB-303	Basic Immunology	2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-303 (Basic Immunology) Course Content

1. Introduction: Properties and overview of the immune system; historical perspective.

2. Innate and adaptive immunity: Innate immunity; external barriers against infection; features of innate and adaptive immunity; components of innate/adaptive immune system; humoral and cell-mediated immunity; clonal selection of B 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 immune system: primary lymphoid organs—thymus, bone marrow, lymphatic system; secondary lymphoid organs—lymph nodes, spleen, mucosa-associated lymphoid tissue.

4. Antigens and antibodies: Immugenicity vs antigenicity; properties of antigen/immunogen; conformation of antigen-antibody binding; antibody affinity and avidity; structure and function of antibodies; antibody diversity generation.

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.

6. **Antigen presentation:** Processing and presentation of antigen by class I and class II MHC.

7. **The complement system:** Functions, components, activation and regulation of complement system.

Suggested Reading:

- Immunology (8th edition) by David Male, Jonathan Brostoff, David Roth & Ivan Roitt, 2012. Publisher- Elsevier.
- Cellular and Molecular Immunology (8th edition) by Abul K. Abbas, Andrew H. Lichtman and Shiv Pillai 2015. Publisher-Elsevier.
- Roitt's Essential Immunology (12th edition) by Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt. 2011. Publisher- Wiley & Blackwell.
- Kuby Immunology (7th Edition) by Judith A Owen, Jenni Punt, Sharon A Stranford, Patricia P Jones. 2013. Publisher-WH Freeman and Company.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Introduction:	2
Innate and adaptive immunity:	5
Cells and organs of the immune system:	5
Antigens and antibodies:	5
T cell receptors and MHC molecules:	5
Antigen presentation:	3
The complement system:	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

GEB-304	Microbial Genetics	2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

- Allow students to understand the fundamental differences of prokaryotic and eukaryotic genetic mechanism;
- Help students to understand the recent progress in mechanism of gene regulation in prokaryotes;
- Broaden the horizon of knowledge related to prokaryotic molecular biology;
- Provide opportunities to learn basic concepts to be implemented in rDNA technology.
- Help students to improve their capacity for critical thinking through a detailed analysis and evaluation of scientific concepts;
- 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.

GEB-304 (Microbial Genetics) Course Content

1. Introduction: Differences between eukaryotic and prokaryotic Genetics; physical organization of bacterial genomes; genotype and phenotype; dominance and recessive characters, molecular biology of bacterial cell division and plasmid replication.

2. Gene transfer: Molecular mechanism of transformation, conjugation and transduction; consequences of recombination; gene mapping; mosaic genes and chromosome plasticity.

3. Movable genetic elements: Plasmids: structure, properties, functions and stability; transposons; mechanism of transposition; phase variation; CRISPR.

4. Regulation of gene expression: Induction and repression; operon model of gene expression; transcriptional control; promoter, terminator, attenuator and anti-terminator; two component regulatory pathway; global regulatory systems; translational control.

5. Genetics of bacteriophage: Bacteriophage structure; ssDNA bacteriophage; RNA containing phages; dsDNA phages; genetics and molecular biology of λ (lambda) phage; lytic and lysogenic cycle; restriction and modification; and bacterial resistance to phage attack.

6. Genetics of yeast: Yeast as a model organism; advantages, life cycle, mating type switching in yeast; transformation and recombination; yeast artificial chromosome; yeast two-hybrid systems.

Suggested Reading:

- Principles of Genetics by Snustes, D, P. Simmons, M. J. and Jenkins & J. B. Jacaranda. 1997. Publisher-Wiley
- Molecular Genetics of Bacteria (4th edition) by Larry. Snyder, Joseph E. Peters, Tina M. Henkin & Wendy Champness. 2013. Publisher-ASM Press.
- Molecular Genetics of Bacteria (5th edition) by Jeremy W. Dale, Simon F. Park. 2010. Publisher-Wiley.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	No. of classes/unit
Introduction:	5
Gene transfer:	5
Movable genetic elements:	5
Regulation of gene expression:	7
Genetics of bacteriophage:	4
Genetics of yeast:	4
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

GEB-305	Developmental Biology	2 Credit

Introduction to the Course:

Developmental Biology is one of the fundamental modern biological disciplines. This course provides an in-depth knowledge of the basic cellular, molecular, and genetic mechanisms by which a fertilized zygote transforms into an organism with fully differentiated and functioning tissues. In the context of model organisms, this course will impart elementary concepts on cell-cell communication, embryo patterning, cell differentiation and gene regulatory proteins underlying basic principles of developmental events. Detailed study of the dynamic structures and functions of cytoskeletal proteins including motor functions is also included. As a whole, this course has a profound contribution in building cellular and molecular concepts of developmental sequence of events in animal cells

Specific objectives:

The study of this course will

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

GEB-305 (Developmental Biology) Course Content

1. Development of multi-cellular organisms: Universal mechanisms of animal development; basic anatomical features of animal; genes controlling developmental processes; cell fate and determination, positional values, inductive interaction and morphogenic effects.

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.

3. Caenorhabditis elegans: Cell fates; asymmetric division of egg; pattern formation; developmental signal and changes in cell; apoptotic cell death.

4. Drosophila melanogaster: Synopsis of *Drosophila* development; syncytium development; genes involved in early patterning- role of egg-polarity genes, dorsoventral signaling genes, mutations and segmentation genes, homeotic selector genes and patterning of anteroposterior axis, organogenesis and patterning of appendages.

5. Xenopus laevis: Synopsis of *Xenopus* development; asymmetries of *Xenopus* egg, blastula formation and gastrulation; convergent extension; neural tube formation.

6. **Neural development in higher animals:** Neurulation in chick and human embryos.

Suggested Reading:

- Developmental Biology (10th edition) by Scott F. Gilbert. 2013. Publisher-Sinauer Associates Inc.
- Principles of Development (4th edition) by Lewis Wolpert, Cheryll Tickle. 2010. Publisher-Oxford University Press, USA.
- Molecular Biology of the Cell (6th edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter. 2015. Publisher-Garland Science.

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

Learning Outcomes:

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

- Acquire fundamental concepts on developmental biology- from one cell stage to adult animal.
- Have deep insight on underlying mechanisms of cell proliferation, differentiation, cell-cell interactions by morphogens and other signalling molecules during developmental stages
- Gain a detail understanding of synopsis of development including gastrulation in model organisms-*Drosophila, C. elegans* and *Xenopus*
- Understand genetic control of development-roles of maternal and zygotic genes in embryonic axes and pattern determination, cell signaling, organogenesis in respect of these model organisms
- Be familiar with the basic mechanism of neural tube formation and neurulation
- Obtain profound knowledge on the structure and biological functions of Cytoskeleton-Actin filaments, microtubules and intermediate filament and regulation of their dynamic structuresby accessory proteins along with motor proteins

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Development of multi-cellular organisms:	4
Cytoskeleton:	10
Caenorhabditis elegans:	2
Drosophila melanogaster:	8
Xenopus laevis:	3
Neural development in higher animals:	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

GEB-306	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-306 (Virology) Course Content

1. **Overview of virus structure and classification**

2. Cultivation, purification and enumeration of viruses: Cultivation of plant, animal and bacterial virus; one step growth curve; estimation of yields; methods for purification of viruses; quantitative measure of infectious centers: plaque assay; generation of transformed cell foci.

3. Replication cycle: Entry of enveloped and non-enveloped animal virus; plant virus and bacteriophage; replication and expression of viral genome- dsDNA, ssDNA, dsRNA, +ssRNA; -ssRNA; bacteriophages- lytic and lysogennic cycle and its regulation; late events of viral infection- capsid assemble and virion release; non-specific method of introducing viral genomes 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 spread to the next individual; fate of the host; pathogenesis of hepatitis, HIV, EBV and influenza virus.

5. Prevention and treatment of viral infection: Vaccination strategy; chemotherapy of viral diseases; interferon-its induction and action.

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

7. Viruses-promise and problems: Cloud of horizon-emerging disease; source and caused of emergent virus diseases; silver linings-virus as therapeutic agent; viruses for gene delivery.

Suggested Reading:

- Basic Virology (2nd edition) by Edward K. Wagner and Martinez. J. Hewlett. 2004 .Publisher-Blackwell Science Ltd.USA.
- Virology-Principles and Applications by John B. Carter and Venetia A. Saunders. 2009. Publisher-John Wiley & Sons Ltd. UK.
- Fundamentals of Molecular Virology by Nicholas H. Acheson. 2007. Publisher -John Wiley & Sons Ltd.UK.
- Principles of Molecular Virology (4th edition) by Alan J. Cann. 2005. Publisher-Elsevier Academic Press. UK.
- Introduction to Modern Virology (6th edition) by Nigel Dimmock, Andrew Easton and Keith Leppared. 2007. Publisher-John Wiley & Blackwell.

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

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, mechanism of genome replication, virion assembly and egress from the cell.
- Define the process of virus latency and the process and activation 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**
Overview of virus structure and classification	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

GEB-307	Molecular Biology of Diseases	4 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-307 (Molecular Biology of Diseases) Course Content

1. Cancer: Characteristics of tumor cells; genetic and epigenetic changes in tumor cells; oncogene and tumor suppressor genes; mechanisms of activation of proto-oncogene into oncogenes; chemical carcinogens; methods of testing chemical carcinogens; oncogenic viruses; mechanisms of oncogenic viruses in tumor formation; hematological malignancies- leukemia, lymphoma and myeloma; cancer chemotherapy- antimetabolites, alkylating agents, plant alkaloids, antibiotics and miscellencious compounds.

2. Cardiovascular disease: Atherosclerosis- molecular mechanism of atheromatus plaque formation-involvement of LDL and foam cells; ishchemic heart disease; myocardial infarction (MI) and biochemical markers for the diagnosis of MI; heart failure; disorders of lipoprotein metabolism.

3. Diabetes mellitus: Type I, type II and other major clinical classes; genetic basis of type I DM; HLA-DQ, HLA-DR and MHC pattern of inheritance in type II DM; MODY (maturity onset diabetes mellitus

in young); Diabetes insipidus; insulin gene; biosynthesis of insulin; mechanism of insulin action; complications of DM; diagnosis and treatment.

4. Liver disease: Microarchitecture of the liver; Hyperbilirubinemia; Dubin-Jhonson syndrome; Criglar-Najaar syndrome; viral hepatitis- types of hepatitis virus and their genomic organization; acute hepatocellular carcinoma; chronic hepato cellular carcinoma; cirrhosis of the liver; liver function tests.

5. AIDS: Definition; biology of HIV; genomic organization; origin – mode of transmission; HIV and the immune system; pathogenesis of AIDS: asymptomatic carrier, PGL, ARC, full blown AIDS; diagnostic test, anti-AIDS drugs; vaccine possibilities.

6. Gastrointestinal diseases: Diarrheal disease caused by *Vibrio cholera*- 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**.

7. Brain diseases: Molecular basis of Alzheimer's, Parkinson's and Huntington's disease.

8. Metabolic disorders: Molecular basis of Phenylketonuria, Alkaptonuria, Maple syrup urine disease, Nieman-pick disease, Glycogen storage diseases and Gout.

9. Chromosomal abnormalities: Variations in the number and structure of chromosomes- euploids, aneuploids and polyploids; deletion; duplication; aberrations; translocation and other structural rearrangements; chromosomal studies- karyotyping; amniocentesis (chorionic villi sampling, alpha fetoprotein sampling); chromosomal abnormalities- Down's syndrome, Cystic fibrosis, Fragile-X syndrome, Meta females; etc.

Suggested Reading:

- Human Molecular Biology: An Introduction to the Molecular Basic of Health and Disease (1st edition) by RJ Epstein. 2002. Publisher-Cambridge University Press.
- Textbook of Biochemistry with Clinical Correlations (7th edition) by Thomas M. Develin. 2010. Publisher- John Wiley & Sons Ltd. UK.
- Herper's Review of Biochemistry (24th edition) by Harold Anthony Harper, David W. Martin, peter A. Mayes, Victor W. Rodwell. Publisher-Lange Medical Publications.
- Molecular Biology of Health and Disease (1st edition) by Undurti N. Das. 2011. Publisher-Springer.
- Molecular Basis of Human Disease (1st edition) by William J. Tsongalis. 2009. Publisher-Academic Press.

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

Learning Outcomes:

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

- Understand the molecular mechanism and genetic basis of cancer, protooncogene activation, various agents responsible for the development of cancer and cancer chemotherapy.
- Familiarize the basic concepts of genetic and epigenetic features of different diseases such as, cardiovascular disease, diabetes mellitus and liver disease.
- 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.
- Generate a good knowledge on the cell-cell communication, how the signal transduction events underlie various pathological processes.
- Understand the molecular processes that lead to the development of metabolic disorders, different brain diseases.
- Explain the cause and complications of structural and numerical chromosomal abnormalities.
- Demonstrate how detailed knowledge on disease mechanism can drive the development of potential therapeutic strategies.

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Cancer:	10
Cardiovascular disease:	06
Diabetes mellitus:	08
Liver disease:	08
AIDS:	06
Gastrointestinal diseases: Diarrheal disease caused by *V. cholera*	05
Brain diseases:	05
Metabolic disorders:	05
Chromosomal abnormalities:	07
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

GEB-308	Methods in Biotechnology	2 Credit

Introduction to the Course:
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.

Specific objectives:
The study of this course will

- 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.
- 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.
- Enable students to design experiments to answer complex biological questions using molecular biotechnology techniques.

GEB-308 (Methods in Biotechnology) Course Content

- Isolation, detection and quantification of DNA, RNA and protein from bacteria, virus, plant and animal cells.
- Stand polymerase chain reaction (PCR) and real-time PCR; RFLP; AFLP; RAPD.
- Basic principles and uses of agarose and polyacrylamide gel electrophoresis.
- Hybridization; Southern, Western and Northern blotting; micro-array.
- Restriction digestion of DNA/plasmid, ligation and transformation; recombinant protein expression; protein extraction; protein purification.
- DNA sequencing; next generation DNA sequencing (whole genome, ChIP-seq, RNA-seq, methyl-seq; Exome-seq); RNA interference (RNAi).
- DNA-protein and RNA-protein interaction studies (EMSA, REMSA, ChIP, ChIP on chip, DNAase foot-printing, DNase protection, *in vitro* transcription); Y2H and B2H systems.
- Chromatography techniques: Hydrophobic column chromatography; ion-exchange chromatography; affinity chromatography; HPLC; GLC.
- Flow cytometry.
- Mutation analysis; recombination models; Rec system; conjugation, transduction, transfection and transformation.

Suggested Reading:

- Principles and techniques of biochemistry and molecular biology (7^{th} ed.) by K. Wilson and J. Walker. Publisher- Cambridge University Press.

- PCR protocols. Humana press (2nd ed., volume 226) by JMS Bartlett JMS and D. Stirling. Publisher- Humana press.
- Laboratory Protocols: CIMMYT Applied Molecular Genetics Laboratory (3rd ed.) by CIMMYT. Publisher- Mexico, D.F.
- Molecular diagnostics: fundamentals, methods, and clinical applications (1st ed.) by L. Buckingham and M. Flaws. Publisher- Davis Company.
- Biotechnology and Genomics by Gupta PK. 2005. Publisher-Rastogi Publications.
- Molecular Biotechnology: Principles and Applications of rDNA (4th ed.) by B.R. Glick and J.J. Pasternak. 2012. Publisher- ASM Press.
- Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2007. Publisher- Cambridge University Press.
- Recombinant DNA: Genes and Genomes- A Short Course (3rd ed.) by J.D. Watson, R.M. Myers, A.A. Caudy, J.A. Witkowski. Publisher- W. H. Freeman.
- Introduction to Biotechnology (3rd ed.) by W.J. Thieman and M.J. Palladino. Publisher- Pearson.
- Basic Biotechnology (1st ed.) by C. Ratledge and B. Kristiansen. Publisher- Cambridge Univ. Press.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Isolation, detection and quantification of DNA, RNA and protein	3
Stand polymerase chain reaction (PCR) and real-time PCR	3
Basic principles and uses of agarose and polyacrylamide gel electrophoresis	3
Hybridization	3
Restriction digestion of DNA/plasmid	3
DNA sequencing	3
DNA-protein and RNA-protein interaction studies	4
Chromatography techniques	3
Flow cytometry	3
Mutation analysis	2
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

GEB-309	Fermentation Technology and Bioprocessing	2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

- Enable students to recognize the basic concepts of fermentation technology.
- Provide in-depth knowledge of fermentation kinetics and growth equation.
- Enable students with an understanding of the importance of sterilization, media preparation and mixing and aeration in cell growth.
- Provide an opportunity to learn about the application of bioprocess technology.

GEB-309 (Fermentation Technology and Bioprocessing) Course Content

1. **Introduction to fermentation Processes:** History, general concept of fermentation processes.

2. **Sterilization of fermenters and media:** Design of batch continuous sterilization processes; sterilization of the media, fermenter; feed and air.

3. **Inoculum preparation and development:** Development of inoculum for bacterial, yeast and fungal processes; scale-up principles; methods of scale-up and their analysis.

4. **Fermentor/bioreactor:** Types, configuration, mixing and aeration; power requirements; impeller designs baffle; oxygen demand and supply.

5. Batch and plug flow culture: Open and close systems; batch, fed-batch, continuous culture and their control variations in actual practice; plug flow culture with and without feedback.

6. Fermentation modeling: Rate equations for cell growth, substrate utilization and product formation; transfer across phase boundaries.

7. Instrumentation and process control: Control systems- manual, automatic, and combinations of methods of control; methods of control of process variables as temperature, pH, flow measurement, pressure measurement, pressure control, safety valves, agitation-shaft power, rate of stirring foam sensing and control weight, measurement and control of dissolved oxygen; exit-gas analysis; redox and carbonidoxide electrodes.

8. Introduction to bioprocess technology: Importance and development of bioprocess technology; upstream and downstream processing.

9. Applications of bioprocess technology to various industries: Biopharmaceuticals; food, feed and fuel; biochemicals; biocomposts; mammalian cell culture; stem-cell bio-processing and tissue engineering.

Suggested Reading:

- Principles of Fermentation Technology (2nd edition) by P.F. Stanbury, A. Whitaker & S.J. Hall. 2003 publisher Elsevier Science.
- The Art of Fermentation: An in-Depth Exploration of Essential Concepts and Processes form Around the World by Sandor Ellix Datz. 2012. Publisher-Chelsea Green Publishing.
- Wild Fermentation: The Flavor, Nutrition, and Craft of Live-Culture foods by Snador Katz. 2003 Publisher-Chelsea Green Publishing Co.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Introduction to fermentation Processes:	02
Sterilization of fermenters and media:	03

Inoculum preparation and development:	04
Fermentor/bioreactor:	03
Batch and plug flow culture:	04
Fermentation modeling:	03
Instrumentation and process control:	04
Introduction to bioprocess technology:	03
Applications of bioprocess technology to various industries:	04
Applications of bioprocess technology to various industries:	02
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

GEB-310 Biostatistics and Epidemiology 4 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-310 (Biostatistics and Epidemiology) Course Content

1. Introduction to biostatistics: Definition, application and scope of statistics and biostatistics; basic statistical principles and terminologies- population, sample, parameter, statistic, variable, etc.

2. Frequency distribution: Frequency distribution; necessity of frequency distribution, principles of classification, numerical examples.

3. Graphical representation of data: Histogram; bar-diagram; pie chart; line-graph; Ogive.

4. Descriptive statistics: Central tendency- Concept, objectives of measure of central tendency and different measures as arithmetic mean, geometric mean, harmonic mean, median, quartiles, percentiles, deciles, mode; properties of different measures and their uses; **dispersion-** concept, objectives of measures of dispersion, different; **measures-** absolute measures, relative measures, range, quartiles deviation, standard deviation, variance, co-efficient of variation, properties of different measures of dispersion and their uses.

5. Sample regression and correlation: regression analysis- concept, definition and properties of regression co-efficient, least square method to estimate the parameters of simple linear regression model, uses of regression analysis; **correlation analysis-** concept, definition and properties of correlation co-efficient, different methods of studying correlation co-efficient, uses of correlation co-efficient.

6. Sampling techniques: Concept; sampling frame; sampling design; simple random sampling; stratified random sampling.

7. Probability and probability distribution: Definition of probability; different approaches of probability; conditional probability; definition of random variable; probability distribution, binomial distribution, Poisson distribution and normal distribution; concept and different measures of skewness and kurtosis.

8. Hypothesis testing: Concept; tests of hypotheses; statistical hypothesis; null hypothesis; alternative hypothesis; level of significance; type 1 error; type 2 error; mean test- test of hypothesis about single mean, test of hypothesis about quality of two means; proportion; confidence interval; paired t-test; general test of independent in one rxe contingency level; p-value; Z-score; non-parametric test; analysis of variance (ANOVA) test- one-way and two-way classifications.

9. Use of software in biostatistics: Hands on training on SPSS/SAS.

10. E**pidemiology:** 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; typology of observational study designs (cohort, case-control, cross-sectional studies).

11. 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 different measures (relative risk odds ratio; risk difference, etc.

Suggested Reading:

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

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

Learning Outcomes:

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

- Understand the importance and applications of statistics in biosciences and epidemiological studies
- Comfortable with statistical methods for calculating summary estimates, measures of variability, and confidence intervals.
- Aware of and able to manipulate probabilities and the Normal and Binomial distributions.
- Calculate and define the significance of probability values, odds ratio, and risk difference, statistical scores etc.
- 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.
- Familiar with basic principles and uses of linear and logistic regression models for biological/clinical research.
- Carry out data analyses using statistical software such as SPSS.
- Describe and apply a variety of epidemiologic concepts and methods in population-based clinical studies.

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Introduction to biostatistics:	2
Frequency distribution:	6
Graphical representation of data:	6
Descriptive statistics: Central tendency	7
Sample regression and correlation: regression analysis	8
Sampling techniques:	5
Probability and probability distribution:	4
Hypothesis testing:	6
Use of software in biostatistics:	5
Epidemiology:	7
Quantification of disease events:	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

GEB-311	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. 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-litre volumes, DNA/RNA extraction basis and methodology, EK genomic DNA isolation, gel electrophoresis, restriction digestion analysis, expression of reporter gene 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 manipulation of DNA sequences and prepare students to implement their knowledge in Biotechnology.

Specific objectives:

This course will enable the students to:

- Apply and investigate theoretical and conceptual knowledge.
- Isolate, detect and quantify DNA from both animal and plant sources.
- Perform PCR (Polymerase chain reaction), restriction digestion and RNA extraction.
- Carry out basic microbiological and tissue culture experiments.
- Observe gene expression in bacteria.
- Enable students to understand the use of bioinformatics in DNA sequence analysis.
- Gain knowledge about the biological databases, data format and extraction, the resources, tools/software.
- Perform DNA/RNA sequence analysis.
- Learn the basic and advanced bioinformatics tools to deal with DNA/RNA sequence data and explore from genes to genome.
- Emphasise on learning about the central aspects of the flow of information from DNA, RNA to protein and apply them in genetic engineering.
- Enable students to record experimental data, analyze/interpret them and present their finding in written format.

GEB-311 (Laboratory Experiments) Course Content

Wet-Lab experiments: The titles of the experiments are as follow:

- Handling and measuring small volumes: Micro pipetting
- Solution preparation for analytical measurement
- Observation of a typical fermenter and its operation
- Isolation and detection of genomic DNA from animal tissue
- Quantification of DNA using Nanodrop
- Amplification of DNA by polymerase chain Reaction (PCR)
- Restriction digestion analysis of plasmid DNA
- Excision and extraction of DNA fragment from agarose gel.
- Extraction of RNA from animal tissue
- Genomic DNA isolation from plant materials by CTAB method
- Extraction and quantification of stress hormone from hair sample
- Expression of GFP protein of pGLO plasmid in *E. coli*
- Identification of human streptococcal pathogens.
- Isolation of bacteriophages from sewage water sample.
- Induction of callus from sunflower seeds.
- Analyzing sporulation of Yeast.

Dry- Lab. Experiments: *In silico* bioinformatics.

- **Activity 1: Exploring National Center for Biotechnology Information (NCBI)**. The gateway, biological databases, Entrez, the search engine & its resourses. 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.
- **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.
- **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, computing restriction mapping, designing PCR primers, removing vector sequences, VecScreen, primer BLAST, UniProt.
- **Activity 4: Working with whole genomes:** complete whole viral genomes, bacterial genomes, bacterial genomics at TIGR, Human genome, Mitochondrial DNA, Mito-MAP, MapViewer, Ensemble and UCSC genome browsers, reading into genes and genomes, analyzing sequence with genome scan, finding disease genes with coding SNPs, assembling sequence fragments to contigs, assembling your sequences with CAP3.
- **Activity 5: Exploring the cancer genome anatomy project (CGAP).** Gene finder & gene info, SNPs associated with cancers, ATM signaling pathway, gene ontology, chromosome link, FISH maps, analyzing RNA sequence, RNA folding and secondary structure prediction, RNAi view.

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.

Learning Outcomes:

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

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

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

GEB-312	Viva voce	2 Credit

Introduction to the Course:
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.

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 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-312 (Viva voce) Course Content

All courses offered in Third 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.

Course Profile: Fourth Year

GEB-401	Advanced Molecular Biology	4 Credit

Introduction to the Course:
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.

Specific objectives:
The study of this course will

- Allow students to understand the most recent advancement in molecular biology;
- Help students to understand the recent progress in mechanism of gene regulation in eukaryotes;
- Enable students to improve their capacity for critical thinking through a detailed analysis and evaluation of scientific concepts in advanced molecular biological research;
- Broaden the horizon of knowledge related to molecular biology;
- 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.
- Provide opportunities to learn basic concepts to be implemented in rDNA technology;
- 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;

GEB-401 (Advanced Molecular Biology) Course Content

1. **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 Lamphbrush chromosome
   - Regulation of chromatin structure; Insulator and anti-insulator

2. **Molecular biology of the telomere and telomerase**
   - Structure and functions of telomere and telomerase
   - Biogenesis of telomerase
   - Significance of telomerase in cancer and aging.

3. **The dynamic genome**
   - Mobile genetic elements in eukaryotes (jumping genes) – relevance to plants and studies in maize; Transposons; Catalytic introns
   - Targeting the mobile genetic elements of disease.

4. **Regulation of eukaryotic gene expression**
   - Structure and complexity of RNAs
   - Activating transcription complex: enhancers and repressors; Locus control region. Nuclear receptors and response elements; enhancers and repressors
   - Co-Activators/Co-Repressors Locus control region. Nuclear receptors and response elements; Interrupted genes and RNA splicing

- Expression of specific genes: Genes for ribosomal RNA; Histone genes; Globin genes; Heat-shock genes; Leghaemoglobin genes; Genes for storage proteins of legumes and cereals; Repetitive DNA in control of gene expression.

5. Structural and regulatory RNA

- rRNA; tRNA; Biogenesis of rRNA & tRNA; RNA editing
- Regulatory RNA; Riboswitching; Catalytic RNA and ribozyme
- RNA splicing and processing; Introns; Antisense RNA
- RNA interference; miRNA; sRNA; siRNA; ncRNA; lnc RNA; tm RNA; eRNA; piwiRNA; snRNA etc.

6. 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; Signal peptide and signal recognition particle
- Transport across ER, Golgi, Mitochondria and chloroplast; Nuclear pore complex; Nuclear localization signal; Nuclear import and export model.

7. 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 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.

8. Genomic imprinting

- Concept; Mechanism of imprinting: DNA methylation, chromatin modification, chromosomal position effect; chromatin insulators.

9. Regulation of gene expression in heterologous system and in cell

- Heterologous transgene expression in animals
- Tissue-specific promoters; Selectable and screenable markers; Cloning vectors; DNA delivery; Fusion proteins.

Suggested readings:

- Jocelyn E. Krebs. Lewin's Genes XI. 2012. Jones and Bartlett Learning.
- Alberts, B. Bray, D. Lewis, J. Molecular Biology of the Cell. 5th edition. 2007. Garland Publishing, Inc. New York.
- Wolfe, S.L. Molecular and Cellular Biology. 1st edition. 1993. Wardsworth Publishing Company.
- Tollefsbol, T. Handbook of Epigenetics. 1st edition. 2010. Academic Press.
- Esteller, M. Epigenetics in Biology and Medicine. 1st edition. 2008. CRC Press.
- Woodward, T., James, G. The Mysterious Epigenome: What Lies Beyond DNA. 1st edition. 2011. Kregel Publications.

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

Learning Outcomes:

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

- Familiarize with the advanced concepts of molecular biology.
- 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.
- Develop analytical skills to evaluate the information from a wide variety of sources to understand the key concepts of molecular biology.
- Read, interpret and discuss ground-breaking recent knowledge on molecular biology.
- Foster intellectual curiosity in molecular biology and related fields that goes beyond the course.
- Introduce with microbial and eukaryotic systems to be used in modern biotechnology.
- Provide opportunities to learn basic concepts to be implemented in rDNA technology.
- Understand different type of modification in DNA and histone with their epigenetic affect in gene expression.
- Able to think the association of the different mechanisms which control the epigenetic outcome individually and in combination.
- Explain different types of diseases associated with epigenetics.

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Organization of eukaryotic genome	8
Molecular biology of the telomere and telomerase	5
The dynamic genome	4
Regulation of eukaryotic gene expression	7
Structural and regulatory RNA	8
Protein localization and dynamics	9
Epigenetics	12
Genomic imprinting	4
Regulation of gene expression in heterologous system and in cell	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

GEB-402	Cell Signaling	2 Credit

Introduction to the Course:

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.

Specific 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

GEB-402 (Cell Signaling) Course Content

1. General principles of cell signaling

- Extracellular signal molecule 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.

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-dependant protein kinase (PKA)-mediated signaling
- Inositol phospholipids signaling pathway, Ca^{2+} as a intracellular messenger
- Ca^{2+}/calmodulin-dependant 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.

3. Signaling through enzyme-coupled receptors

- Classification of enzyme-coupled receptors
- Receptor tyrosine kinases (RTKs), Docking sits for proteins

- Activation and regulation of Ras, Activation of MAP kinase signaling module
- 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

4. Signaling in microorganism and plants

- Two component signaling pathway of bacterial chemotaxis
- Detection of ethylene by plants through two-component system and MAPK cascade.

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

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

Suggested readings:

- Molecular Biology of the Cell by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Gerald Science. 5th edition. 2007.
- Molecular Cell Biology by Harvey Lodish, Arnold Berk, Cris A Kaiser, Monty Krieger, Matthew P Scott, Hidde Ploegh and Paul Matsudaira. WH Freeman and Company. 6th edition. 2007.
- Lehninger Principles of Biochemistry by David L Nelson and Michael M Cox. WH Freeman and Company. 5th edition. 2008.
- Biochemistry of Signal Transduction and Regulation by Gerhard Crauss. Wiley. 5th edition. 2014.
- Signal Transduction: Principles, Pathways and Processes edited by Lewis Cantley, Tony Hunter, Richard Sever and Jeremy Thorner. CSH Press. 1st edition. 2014.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	No. of classes/unit
General principles of cell signaling	5
Signaling through G-protein-coupled receptors	5
Signaling through enzyme-coupled receptors	5
Signaling in microorganism and plants	5
Signaling pathways depending on proteolysis	5
Regulation of cell cycle by protein kinases	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

GEB-403 Immunology 2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-403 (Immunology) Course Content

1. **Defence against infectious agents**
   - Immunity to viruses, bacteria, fungi and parasitic infection.

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.

3. **Immunological tolerance**
   - Features and mechanisms of immunological tolerance
   - Experimental induction of tolerance; T and B-cell tolerance; Artificially induced tolerance; Therapeutic application of tolerance.
4. **Autoimmunity and autoimmune diseases**
   - Association of autoimmunity with diseases
   - Genetic factors, pathogenesis, etiology, diagnosis and treatment.

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.

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.

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.

Suggested readings:

- Immunology by David Male, Jonathan Brostoff, David B Roth and Ivan Roitt. Mosby Elsevier. 7th edition. 2006.
- Roitt's Essential Immunology by Peter J Delves, Seamus J Martin, Dennis R Burton and Ivan M Toitt. Blackwell Publishing. 11th edition. 2006.
- Cellular and Molecular Immunology by Abul K. Abbas, Andrew H Lichtman and Shiv Pillai. Saunders Elsevier. 6th edition. 2009.
- Kuby Immunology by Judith A Owen, Jenny Punt, Sharon A Stranford and Patricia P Jones. WH Freeman and Company. 7th edition. 2013.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Defence against infectious agents	05
Immunodeficiency	04
Immunological tolerance	04
Autoimmunity and autoimmune diseases	04
Transplantation and rejection	04
Immunity to tumour	04
Hypersensitivity reactions	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

GEB-404	Molecular Diagnostics	2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will:

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

GEB-404 (Molecular Diagnostics) Course Content

1. **Introduction to molecular diagnostics**
   - Brief introduction to molecular diagnosis
   - History and evolution of molecular diagnostics as it transformed the medicine.

2. **Sample collection and preservation**
   - Types of sample (blood, buccal cells, sputum, amniotic fluid, CVS etc)
   - Collecting and handling samples; Sample storage strategies; Characterization of samples.

3. **Molecular diagnostic techniques**
   - Hybridization based techniques; PCR; Real-time PCR; Direct sequencing
   - Combination techniques; PCR-Electrophoresis, PCR-Hybridization, PCR-Hybridization (PCR-SSP, PCR-SSOP) , PCR-RFLP, PCR-Capillary Electrophoresis, PCR-sequencing
   - QF-PCR, Other techniques, Primer extension method;
   - Karyotyping; Fluorescent *in situ* hybridization (FISH); Chromogenic *in situ* hybridization (CISH); DNA microarrays.

4. **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; Tansplantation genetics; HLA-A, B, DR typing, Molecular cytogenetics; Detection of chromosomal abnormalities (tisomy 13, 18, 21 & sex chromosome abnormalities).

5. **RNA-based molecular diagnostics and their applications**
   - Necessary precautions while working with RNA; Isolation of RNA from clinical samples; Preparation of cDNA; Northern blotting and reverse-transcription PCR
   - 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).

6. **Future molecular diagnosis**
   - Personalized medicine; Warfarin sensitivity (CYP2C9, VKORC1 genotyping)
   - Beta blocker metabolism (CYP2D6 genotyping)
   - NGS in clinical diagnosis.

7. **Issues related to molecular diagnostics**
   - Ethical, legal and social issues
   - Informed consent; Confidentiality and discrimination; Genetic counselling; Pre-implantation genetic diagnosis.

Suggested readings:

- Molecular Diagnostics: For the clinical laboratorian. William B Coleman & Gregory J Tsongalis. 2nd Edition. Humana Press, 2012.
- Molecular Diagnostics. George P. Patrinos and Wilhelm J. Ansorge. 2nd edition. Academic Press. 2009.
- Molecular Diagnostics: Fundamentals, methods and clinical applications. Lela Buckingham. 2nd Edition. F.A. Davis Company. 2011.
- Human Molecular Genetics. Strachan & Read. 4th Edition. Garland Science. 2010.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	No. of classes/unit
Introduction to molecular diagnostics	02
Sample collection and preservation	02
Molecular diagnostic techniques	02
DNA-based molecular diagnostics and their applications	10
RNA-based molecular diagnostics and their applications	10
Future molecular diagnosis	02
Issues related to molecular diagnostics	02
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

GEB-405 Forensic DNA Technology 2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

- Enable students to know the history of DNA typing methods
- Introduce students the polymorphism concept that makes DNA unique to all individuals
- Make students familiar with handling of biological specimens required for DNA analysis
- Learn DNA extraction from various biological specimens
- Understand various DNA profiling techniques such as, autosomal, X-chromosome, Y-chromosome and mtDNA

- Learn how to apply these methods in personal identification, parentage testing, kinship analysis and disaster victim identification

GEB-405 (Forensic DNA Technology) Course Content

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. **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.

   - **Biological specimen**
   - Collection preservation and transportation of blood, semen, saliva, tissue, bone & teeth samples
   - Presumptive tests for blood, semen and saliva.

3. **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. **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 e.g 310/3100 Genetic analyzer
   - NGS in forensics.

5. **Applications of DNA Profiling**
   - Identity test; Parentage test; Sibship analysis; Kinship analysis
   - Identification of disaster victims/missing persons
   - Resolving immigration and inheritance disputes.

6. **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.

7. **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.

Suggested readings:

- Forensic DNA typing: Biology, Technology and Genetics of STR Markers, JOHN M. BUTLER (2nd Edition) Elsevier Academic Press.
- Advanced Topics in Forensic DNA typing: Interpretation, JOHN M. BUTLER Elsevier Academic Press
- *Additional reading materials and internet learning resources will be suggested by the course instructors.*

Learning Outcomes:

Upon successful completion of the course students will be able to

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

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

Unit-wise Title and Sub-title	No. of classes/unit
Overview and History of Forensic DNA Typing	2
Basic genetic principles	5
Biological specimen	4
DNA extraction and quantitation from forensic samples	4
DNA typing methods	5
Applications of DNA Profiling	4
Statistical issues	3
DNA database	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

GEB-406 Genomics, Proteomics, and Bioinformatics 2 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

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

GEB-406 (Genomics, Proteomics, and Bioinformatics) Course Content

1. Overview of 'Omics' Sciences: Scopes, resources and application

2. Comparative Genomics

- Fundamentals of sequence analysis; sequence alignment methods: local and global alignment concepts; dot matrix, dynamic programming methodology; Needlham-Wunsch and Smith-Waterman algorithm. Scoring/substitution matrices: PAM and BLOSUM. Statistics of alignment score. Heuristic methods for 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

3. Evolutionary Genomics

- Phylogenetic analysis, Model of nucleotide evolution; Jukes-Cqantor; 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

4. 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-DNA recognition: Models and algorithms.

5. 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.

6. **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.

Suggested readings:

- Discovering Genomics, Proteomics, & Bioinformatics. Campbell & Heyer. 2nd edition. 2007. Bnjamin Cumnings Publishing Co.
- Bioinformatics – databases and systems. Edited by Stanley I. Letovsky. 1st edition. 2013. Springer publications.
- Bioinformatics - A practical Guide to the analysis of genes and proteins. Edited by Andreas D. Baxevanis, B.F. Francis Ouellette. 3rd Edition. 2009. Wiley-Interscience.
- Essential Bioinformatics by Jin Xiong. 1st edition. 2006. Cambridge University Press.
- Bioinformatics. Andrzej Polanski A. Marek Kimmel. 1st edition. 2007. Springer.
- Structural Bioinformatics. Edited by Philip E Bourne. Helge Weissig. 1st edition. 2003. Wiley-Liss.
- Bioinformatics & Functional Genomics. Pevsner J. 2nd edition. 2009. Wiley-Blackwell.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Overview of 'Omics' Sciences	2
Comparative Genomics	7
Evolutionary Genomics	5
Structural Genomics and Proteomics	5
Functional Genomics	6
Basic Network 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

GEB-407	Microbial Biotechnology	4 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

- Provide in-depth knowledge on current applications of microbes for the production of various useful commercial products.
- Enable students critically evaluate the role of microorganisms in specific biotechnological processes.
- Provide students with an understanding of the recent advances in rDNA technology and its applications to improve human life and the environment using microorganisms.
- Demonstrate students an overview of how microbes are manipulated to solve practical problems through biotechnology.
- Provide students with sound theoretical knowledge of the biological and biochemical processes used in biotechnology.
- Create interactive learning forum to help students with the understanding of basic approaches to biotechnology research and development.

GEB-407 (Microbial Biotechnology) Course Content

1. **Microbial production of therapeutic agents**
   - Biopharmaceuticals – Isolation of interferon cDNAs; Engineering 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
- Strategies for testing genetic disorders; Clinical trials and its phases.

2. Synthesis of commercial products by recombinant microorganisms
- Restriction endonucleases
- Small biomolecules -Ascorbic acid, Indigo, amino acids, Antibiotics, Biopolymers.

3. Bioremediation and biomass utilization
- Microbial degradation of xenobiotics
- Commercial production of fructose and alcohol; glycerol production
- Silage fermentation; Utilization of cellulose.

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
- Phytoremediation; Ice nucleation and antifreeze proteins.

5. Microbial insecticides
- Advantages and disadvantages of biopesticides
- Isolation, modification and diverse application of Bt toxin
- Genetic modification to improve baculoviruses; Insecticidal properties.

6. Large scale production of proteins from recombinant microorganisms
- 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.

7. Vaccines
- Subunit vaccines – Herpes simplex virus, Foot and mouth disease
- Peptide vaccines; Genetic immunization; Attenuated vaccines – Cholera, *Salmonella*
- Vector vaccines – vaccines directed against viruses and bacteria.

8. Microbial 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, butter milk); Flavors
- Single cell protein; Microbial biomass proteins; Probiotics.

9. Renewable Energy

Biomass as a source of energy, Biomass conversion
Alcohol- the liquid fuel
Gaseous fuels- Biogas and Hydrogen.

10. **Immobilized cells and enzymes**
    - Methods of cell and enzyme immobilizations
    - Advantages; use of immobilized cell systems for the production of industrially important chemicals.

11. **Microbial ore leaching**
    - Leaching microorganism and their properties
    - Practical applications of bacterial leaching
    - Biochemical and chemical reactions in leaching
    - Extraction of copper by microbial leaching.

Suggested readings:

- Glick, B. Pasternak, J. Patten, C. Molecular Biotechnology Principles and Applications. ASM Press. 4th edition. 2009.
- Rehm, H. J., and G. Reed (Editors). Biotechnology. VCH Publication. All volumes. 1990.
- Primrose, SB. Modern Biotechnology. Blackwell Science Inc. 1st edition. 1987.
- Fogarty, W., Kelly, C. Microbial Enzymes and Biotechnology. Springer. 2nd edition. 1990.
- Bu'lock, J., Kristiansen, B. Basic Biotechnology. Saunders College Publishing. 1st edition. 1987.
- Gibson, D. Microbial degradation of organic compounds. CRC Press. 1st edition. 2002.
- Lizuka, H. Microbial conversion of steroid and alkaloids. Springer-Verlag. 1st edition. 1981.
- Laskin, A. Enzymes and immobilized cells in biotechnology. Butterworth-Heinemann. 1st edition. 1985.
- Davis, P. Single-cell protein. Academic Press Inc. 1st edition. 1975.
- Reed, G. Prescott & Dunn's Industrial Microbiology. CBS Publisher. 1st edition. 2004.
- Kumar, H.D. A Textbook on Biotechnology. Affiliated East-West Press. 2nd edition. 1991.

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

Learning Outcomes:

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

- Demonstrate a familiarity with the wide diversity of microbes, and their potential for use in microbial biotechnology.
- Demonstrate acknowledge of microbial gene and genome structure and function, and how these can be manipulated.
- Demonstrate an understanding of the differences between classical genetic selection and recombinant or synthetic DNA technologies.
- Demonstrate familiarity with methods to analyze and engineer genes for optimal expression
- Demonstrate an understanding of the processes involved in small-scale and industrial scale bacterial fermentations.
- Demonstrate an understanding of some of the legislative and ethical issues related to microbial biotechnology.
- Explain the complex processes behind the development of genetically manipulated organisms
- Demonstrate a clear understanding of how biochemical pathways relate to biotechnological applications.

- Describe common methodologies used in biotechnological processes, and Identify and analyze the current trend in biotechnology.
- Develop innovative strategies for discovering products of industrial importance.
- Demonstrate and apply theoretical knowledge to production and application of microbial metabolites.

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Microbial production of therapeutic agents	4
Synthesis of commercial products by recombinant microorganisms	6
Bioremediation and biomass utilization	5
Plant growth-promoting bacteria	4
Microbial insecticides	5
Large scale production of proteins from recombinant microorganisms	6
Vaccines	5
Microbial food and beverage production	6
Renewable Energy	2
Immobilized cells and enzymes	2
Microbial ore leaching	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

GEB-408 Plant Biotechnology 3 Credit

Introduction to the Course:

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.

Specific objectives:
The study of this course will

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

GEB-408 (Plant Biotechnology) Course Content

1. **Plant tissue culture**
   - Introduction; Media preparation; Sterile techniques and laboratory equipments
   - Plant growth regulators in plant tissue culture and development; Shoot and root culture
   - Plant protoplast culture, haploid culture, embryo rescue and development of polyploidy
   - Propagation from non-meristematic tissues-organogenesis and nonzygotic/somatic embryogenesis.

2. **Molecular approaches of plant development**
   - Molecular aspects of *in vitro* organogenesis and non-zygotic/somatic embryogenesis.

3. **Plant molecular markers and their applications**
   - Principles of identification and application of molecular markers
   - Genotyping tools in plant breeding- from restriction fragment length polymorphisms to single nucleotide polymorphisms
   - A model crop species- molecular markers in rice
   - From markers to cloned genes: map-based cloning; genomic analysis in crop breeding.

4. **Breeding strategies based on markers**
   - Marker-Assisted Selection for quantitative trait loci
   - Optimum design of marker-assisted backcross programs
   - Examples of marker assisted selection in rice, maize, wheat, soybean, etc.

5. **Plant genetic engineering**
   - *Agrobacterium* mediated transformation
   - Protoplast mediated transformation; Micro-projectile bombardment
   - Other DNA transfer methods: Ti and Ri plasmids
   - Role of GFP in plant genetic engineering
   - Genetic manipulation of herbicide resistance, pest resistance, disease resistance, stress tolerance, improved crop yield and productivity
   - Metabolic engineering for molecular farming.

6. **GM Crops**
   - Application, development and Current status**;** Cotton, Brinjal, Maize, golden rice, soyabean and canolla etc.

7. **Biotechnological approaches for improvement of medicinal plants**
   - Current trends in forest tree biotechnology
   - *In vitro* regeneration and improvement in tropical fruit trees.

8. **Germplasm preservation**
   - Importance of germplasm preservation
   - Preservation of seed propagated species; preservation of pollen; preservation of vegetatively propagated species- active collection and cryopreservation.

Suggested readings:

- Principles and practices in plant science by Walton P.D. Prentice Hall. 7th edition 2001.
- Biochemistry and Molecular Biology of Plants By Buchanan B, Gruissem W, Jones R. Wiley. 1st edition. 2002.
- Plant cell culture (advance in biochemical engineering/biotechnology) by Anderson LA. Springer. 1st edition. 1985.
- Introduction to plant biotechnology by Chawla S. CRC Press. 3rd edition. 2009.
- Handbook of Plant Biotechnology by Chistou P, Klee H. Wiley. 1st edition. 2004.
- Plant Biotechnology and Agriculture: Prospects for the 21st Century by Altman A, Hasegawa P. Academic Press. 1st edition. 2011.

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

Learning Outcomes:

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

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

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

Unit-wise Title and Sub-title	**No. of classes/unit**
Plant tissue culture	7
Molecular approaches of plant development	4
Plant molecular markers and their applications	4
Breeding strategies based on markers	4
Plant genetic engineering	8

GM Crops	10
Biotechnological approaches for improvement of medicinal plants	4
Germplasm preservation	4
Total	**45**

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

GEB-409 Animal Biotechnology 3 Credit

Introduction to the Course:

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.

Specific objectives:

The study of this course will

- Make students understand various tools and techniques used in Biotechnology.
- Enable to understand protocols of embryo culture, transfer and their limitations.
- Enable to learn about the applications and advantages of cloning, especially of reproductive cloning.
- Make students understand ethical aspects of animal biotechnology.

GEB-409 (Animal Biotechnology) Course Content

1. **Introduction**
   - Scope and applications of animal biotechnology.

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

- Organ culture and whole embryo culture
- Application of animal cell culture in production of human and animal viral vaccines and pharmaceutical proteins; Cord blood banking.

3. **Embryo transfer technology**
   - Advantages and application of embryo transfer
   - Steps in embryo transfer technology
   - Selection and management of donor and recipients
   - Insemination of donor; Collection, identification and evaluation of embryo
   - Cryopreservation of embryo; Transfer of embryo; Limitations of embryo transfer techniques.

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. **Transgenic animal**
   - Transgenic mice; Production of transgenic mice: retroviral vector method, DNA microinjection method, engineered embryonic stem cell method
   - Genetic modification with cre-*loxp* recombination system; Transgenic mice applications

6. **Cloning**
   - Cloning of sheep cattle and endangered animals
   - Organ cloning, Cloning livestock by nuclear transfer
   - Production of transgenic cattle, sheep goats, birds and fish.

7. **Ethics in animal biotechnology**
   - Animal welfare, sentiency and speciesism
   - Problems with nature and naturalness
   - Religious concerns; Risk of animal biotechnology
   - Ethical issues and concern; Human subjects, Animal model

Suggested Readings:

- Reproductive Technologies in Farm Animals by Ian Gordon. CABI publishing. 1st edition. 2005.
- Animal Biotechnology by Srivastava. Oxford & IBH Publishing Company Pvt. Limited. 1st edition. 2005.
- Animal Biotechnology and Ethics by Alan J. Holland & Andrew Johnson. Springer. 1st edition. 1997.
- Animals as Biotechnology: ethics, sustainability and critical animal studies by Richard Twine. Routledge. 1st edition. 2010.
- Molecular Biotechnology: Principles & Applications of Recombinant DNA by Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. ASM Press. 4th edition. 2009.

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

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

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

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

Unit-wise Title and Sub-title	No. of classes/unit
Introduction	2
Animal cell and tissue culture	7
Embryo transfer technology	7
Ruminant fertilization	7
Transgenic animal	8
Cloning	7
Ethics in animal biotechnology	7
Total	**45**

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

GEB-410 Environmental Biotechnology 4 Credit

Introduction to the Course:
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.

Specific objectives:

The study of this course will

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

GEB-410 (Environmental Biotechnology) Course Content

1. **Environmental biology and man**
   - Global climate changes and its impact on living beings
   - Greenhouse gases, increase of CO_2 and effect
   - Rise of temperature; Ozone hole; El Nino and oscillations in world's climate
   - Desertification, Global warming.

2. **GMOs**
   - GMOs currently in commercial production
   - Future trends in GMOs; Principles for the safety assessment of GM foods
   - Food security; The challenges to food security; Attaining food security.

3. **Risk of GMOs**
   - Direct and indirect effects on human health, agriculture and environment
   - Social and ethical concern about GMOs

4. **Biosafety regulations**
   - Biosafety act of Bangladesh; Risk assessment and risk management
   - Physico-chemical and biological containments-procedure and facilities (BSL I, II, III and IV)
   - GLP; GILSP; Frameworks for risk assessment; Biohazard communication.

5. **Environmental pollution**
   - Pollution of air, water, soil, and sound; Acid rain
   - Transfer of harmful compounds through ecosystems
   - Nuclear winter and its consequences
   - Metal pollution: source of metals, metal bioavailability in the environment, metal toxicity, mechanism of microbial metal resistance & detoxification, innovative microbial approaches to the remediation of metal contaminated aquatic system with special reference to arsenic, chromium, lead and mercury; Nitrate and Phosphorus pollution and their bioremediation.

6. **Recalcitrant molecules and its management**
   - Characteristics and sources of recalcitrant molecules in the environment
   - Persistence and biomagnification of xenobiotic compounds
   - Bioremediation of contaminated soil and water bodies.

7. **Biosensors**
   - Characteristics and components of biosensor
   - Application of biosensors for the detection of environmental pollutants.

8. **Biotechnological aspects of waste management**
   Industrial and domestic solid waste and effluents treatment
   Safe disposal; Biogas production
   Role of enzymes and microorganisms.

9. **Environmental laws**
   - Environmental legislation and regulation
   - Environmental ethics.

Suggested Readings:

- Environmental Biotechnology (Vol. 10) by Wang, L.K., Ivanov, V., Tay, J.-H., Hung. Humana Press. 2010.
- Advanced Environmental Biotechnology by S. K. Agarwal. APH Publishing. 1st edition. 2005.
- Environmental laws & regulations by University of California College. 2009.
- Textbook of Environmental Biotechnology by Mohapatra, P.K. International publishing House Pvt Ltd, India. 1st edition. 2006.
- Microbial Ecology: Fundamentals and Applications by Ronald M. Atlas & Richard Bartha. The Benjamin-Cummings publishing company. 4th edition. 1997.
- Biosafety Guidelines of Bangladesh. MOF, GOB, 2007.
- Advances in Biotechnological Processes by A. Mizrahi, A. L. van Wezel. Alan R. Liss Inc. 2011.
- Biotechnology for Waste Management and Site Restoration by Ronneau, C., Bitchaeva. Springer. 1st edition. 1997.
- Environmental Science, Botkin, Keller, 8th edition,2012

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

Learning Outcomes:

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

- Describe existing and emerging technologies that are important in the area of environmental biotechnology.
- Understand the principles and techniques underpinning the application of biosciences to the environment.
- Describe global climate change pattern and their causes.
- Address biotechnological solutions to address environmental issues including pollution, renewable energy and water treatment.
- Analyze case-studies representative of key areas of environmental biotechnology.
- Implement a range of practical approaches relevant to environmental microbiology and biotechnology.
- 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
Environmental biology and man	04
GMOs	14
Risk of GMOs	04
Biosafety regulations	06
Environmental pollution	10
Recalcitrant molecules and its management	08
Biosensors	05
Biotechnological aspects of waste management	05
Environmental laws	04
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

GEB-411 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 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.

Specific objectives:

The study of this course will

- Enable the students to use basic and advanced molecular biotechnology techniques.
- Facilitate the students to improve observational skills.
- Help to develop skills in performing PCR, electrophoresis and blotting, transformation and cloning.

- Enable the students to use basic and advanced bioinformatics tools to analyze biological information and data.
- Enable students to record experimental data, analyze/interpret them and present their finding in written format.

GEB-411 (Laboratory Experiments) Course Content

- Cell counting with a hemocytometer and distinguishing different blood cell types under a microscope.
- Extraction of human DNA from buccal cells using Chelex^{TM} and determination of genotype at D1S80 VNTR locus.
- Isolation and detection of plasmid DNA from bacteria.
- Preparation of bacterial competent cells and transformation with pGLO plasmid.
- Isolation of RNA from bacteria and reverse transcription PCR of specific transcript.
- Isolation of DNA from bacteria and amplification of specific gene sequence.
- Isolation of protein from bacteria and detection of GFP following SDS-PAGE.
- Isolation of protein from bacteria and detection of GFP following transfer to membrane (Western blot).
- Detection of a differentially expressed protein in SDS-PAGE and determination of molecular weight of the differentially expressed protein.
- Detection of GFP protein in bacteria under fluorescence microscope.
- Purification of GFP protein by column chromatography.
- *Agrobaterium tumefaciens*-mediated transformation of plants.
- Detection of indicator microorganisms in various samples.
- Database searching and uses.
- Determination of evolution and missing link.
- Conformational change of protein.
- Analysis of genomic variation (SNP, sequence repeats, etc)
- DNA microarray.
- Integrated genomic circuit and networking.

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.

Learning Outcomes:

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

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

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

GEB-412	Project	2 Credit

Introduction to the Course:

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.

Specific objectives:

Carrying out this course will

- Provide undergraduate students a scope of research opportunities (idea-based or original) in biotechnology field.
- Allow students to engage in deeper study of specific areas of interest
- Enhance capability to contribute in research and development work.
- 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:

- Acquire more in-depth knowledge in the field of study, including deeper insight into current research and future prospects.
- Enhance their capability to plan and use appropriate methods to conduct research in a framework.
- Increase capability to analyze and critically evaluate their findings.
- 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:

- Discuss the project plan with the student and suggest how to conduct it
- Advise on the appropriate methods for carrying out the work.
- Offer advice on sources of information for the work.

- Discuss any issue regarding data collection
- Advise on issues relating to writing up the project report

Assessment:

- Assessment of oral presentation of the project
- Assessment of submitted project report

GEB-413	Viva voce	2 Credit

Introduction to the Course:

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.

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 practise for job interviews.

GEB-413 (Viva voce) Course Content

All courses offered in Fourth 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.