UNIVERSITY OF DHAKA

Syllabus of the Department of

Genetic Engineering & Biotechnology

for

B.S.(Honours)Course

for the

Session: 2011-2012 & onward

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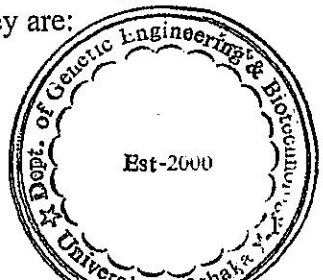
Bachelor of Science (Honors) 4 Year Integrated Course

Genetic engineering is the applied field of molecular biology, which is the very basis of all living species. Molecular biology deals with the molecular basis of biological or genetic specificity. It has three components: Biochemistry, Genetics, and Cell Biology. Broadly, genetic engineering means the manipulation of genes under controlled laboratory conditions. Gene cloning, which includes the isolation and characterization of single gene and reintroduction and expression of these genes into cells of same or different species, is the main focus of genetic engineering.

Biotechnology is the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services. Here, biological agents include microbial, animal or plant cells and enzymes that are used to synthesize, degrade or transform materials. The scientific and engineering principles are mainly: Biochemistry, Microbiology, Genetics, and Biochemical & Chemical Engineering. The most recently developed skill in present-day biotechnology is genetic engineering.

Genetic Engineering and Biotechnology has four broad areas of application. They are:
Agricultural Biotechnology
Medical Biotechnology
Industrial Biotechnology



Environmental Biotechnology

In light of the above, syllabus for **a four-year B.S. course in the Department of Genetic Engineering and Biotechnology** has been approved. Total number of credit is 132 spread over 4 years.

1. Each theory course will be of 25 marks per credit and will comprise 15 lecture hours per credit.
2. Each lecture hour will be of 50 minutes duration.
3. Each practical will be of 25 marks per credit and will comprise of around 45 hours of laboratory work per credit.
4. Courses, namely Chemistry for Biologists I & II, Mathematics for Biologists, FCL English Language, Physics for Biologists, Computing and Information Technology, and Biostatistics and Epidemiology, have been included as extra-departmental courses.
5. Examination rules and procedures are explained in the Letter grading system booklet.
6. The division of 132 credits year-wise is as follows:

Year	Theory	Practical	Viva-voce	Extra-departmental	Total Credit
First Year	14	4	2	10	**30**
Second Year	14	4	2	10	**30**
Third Year	24	4	2	4	**34**
Fourth Year	30	6	2	0	**38**
Grand Total	82	18	8	24	**132**

Course for 1st Year B.S. in Genetic Engineering and Biotechnology

Summary:

	Course code	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 and Biotechnology	4
*	GEB-106	Mathematics for Biologists	2
*	GEB-107	FCL English Language	4
	GEB-108	Laboratory Experiments	4
	GEB-109	Viva-voce	2
		Total	**30**

*** Extra-departmental courses**

GEB 101: Basic Biology (2 Credits)

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.
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 and their importance; brief organismal biology of Amoeba, Hydra, Corals, Tape worm, Ascaris, Earth worm, Snails, Starfish and Mouse.

5. Ecology and Environmental Biology

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

6. Biodiversity and Conservation Biology

Concepts of biodiversity and conservation.
Biodiversity in Bangladesh (flora and 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 learning resources will be suggested by the course instructor(s).

GEB-102: Chemistry for Biologists I (4 Credits)

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°, ΔG°□, 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.* *N.P* 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 learning resources will be suggested by the course instructor(s).

GEB 103: Basic Biochemistry (4 Credits)

1. Concept of Life and Living Processes

The identifying characteristics of living things.

2. The Cell–A brief Introduction

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
Amino acids: 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, a-helices, B-sheets, 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 / RAN / 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 lead a protein to be excreted from a cell: Secretion of Proteins.

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 learning resources will be suggested by the course instructor(s).

GEB 104: Basic Microbiology (4 Credits)

1. Historical Development of Microbiology

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 a 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.

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, 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

Etiology classification and spread of infections dieases, Pidemiology

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 learning resources will be suggested by the course instructor(s).

GEB 105: Fundamentals of Genetic Engineering and Biotechnology (4 Credits)

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 and 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 and safety of genetically engineered products.
Gel electrophoresis, Southern hybridization, Polymerase chain reaction (PCR)

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 learning resources will be suggested by the course instructor(s).

GEB 106: Mathematics for Biologists (2 Credits)

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 learning resources will be suggested by the course instructor(s).

GEB 107: FCL English Language (4 Credits)

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 and 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 learning resources will be suggested by the course instructor(s).

GEB 108: Laboratory Experiments (4 Credits)

GEB 109: Viva-voce (2 Credits)

Course for 2nd Year B.S. in Genetic Engineering and Biotechnology

Summary:

Course code	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
	Total	**30**

*** Extra-departmental courses**

GEB 201: Chemistry for Biologists II (4 Credits)

Organic Chemistry

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 and learning resources will be suggested by the course instructor(s).

GEB 202: Enzymes and Enzyme Kinetics (4 Credits)

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 and learning resources will be suggested by the course instructor(s).

GEB 203: Protein Structure and Function (2 Credits)

Peptides and Proteins
Biologically active peptides
General functions of proteins
Protein classification

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

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

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 and learning resources will be suggested by the course instructor(s).

GEB 204: Bioenergetics and Metabolism (4 Credits)

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 and 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 and learning resources will be suggested by the course instructor(s).

GEB 205: Human Physiology (4 Credits)

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 (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 and 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 and learning resources will be suggested by the course instructor(s).

GEB 206: Physics for Biologists (3 Credits)

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 Biophysics: 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 and learning resources will be suggested by the course instructor(s).

GEB 207: Computing and Information Technology (3 Credits)

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 System**
   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

   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 and learning resources will be suggested by the course instructor(s).

GEB 208: Laboratory Experiments (4 Credits)

GEB 209: Viva-voce (2 Credits)

Course for 3rd Year B.S. in Genetic Engineering and Biotechnology

Summary:

Course code	Course title	Credits
GEB-301	Plant Physiology	4
GEB-302	Basics of Molecular Biology	4
GEB-303	Basic Immunology	2
GEB-304	Microbial Genetics	2
GEB-305	Developmental Biology	2
GEB-306	Virology	2
GEB-307	Molecular Biology of Diseases	4
GEB-308	Methods in Biotechnology	2
GEB-309	Fermentation Technology and Bio-processing	2
*GEB-310	Biostatistics and Epidemiology	4
GEB-311	Laboratory Experiments	4
GEB-312	Viva-Voce	2
	Total	**34**

*Extra departmental courses

GEB 301: Plant Physiology (4 Credits)

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; photophos-phorylation; 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 (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, N/P **Keith Roderts & Peter Walter**.2007. Publisher-Garland Science.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 302: Basics of Molecular Biology (4 Credits)

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 (7th edition) by James D. Watson, Tania A. Baker, Stephen p. Bell, Alexander Gann, Michael Levine & Richard Losick. 2013. Publisher-Benjamin Cummings.

Molecular Biology of the Cell (5th edition) by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roderts & Peter Walter.2007. Publisher-Garland Science.

Molecular Cell Biology (6th edition) by Harvey Lodish, Arnold Berk, Chris A. Kaiser & Monty Kreger. 2007. Publisher- W. H. Freeman.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 303: Basic Immunology (2 Credits)

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(MALT).

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:

1. Immunology (8th edition) by Male, Brostoff, Rith & Roitt, 2012. Publisher- Elsevier.

2. Basic Immunology (8th edition) by Abul K. Abbas & Andrew H. Lichtman. 2010. Publisher-Saunders.

3. Roitt Essential Immunology (12th edition) by Peter J. Delves, Seamus J. Martin, dennis R. Burton & Ivan M. Roitt. 2011. Publisher- Wiley & Blackwell.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 304: Microbial Genetics (2 Credits)

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:

1. Principles of Genetics by Snustes, D, P. Simmons, M. J. and Jenkins & J. B. Jacaranda. 1997. Publisher-Wiley

2. Molecular Genetics of Bacteria (4th edition) by Larry . Snyder, Joseph E. Peters, Tina M. Henkin & Wendy Champness. 2013. Publisher-ASM Press.

3. Molecular Genetics of Bacteria (5th edition) by Jeremy W. Dale, Simon F. Park. 2010. Publisher-Wiley.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 305: Developmental Biology (2 Credits)

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:

1. Development Biology (10th edition) by Scott F. Gilbert. 2013. Publisher-Sinauer Associates Inc.

2. Principles of Development (4th edition) by Lewis Wolpert, Cheryll Tickle. 2010. Publisher-Oxford University Press, USA.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 306: Virology (2 Credits)

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 learning resources will be suggested by the course instructor(s).

GEB 307: Molecular Biology of Diseases (4 Credits)

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.
Horper'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 learning resources will be suggested by the course instructor(s).

GEB 308: Methods in Biotechnology (2 Credits)

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:

Analytical Techniques in Biochemistry and Molecular Biology (1st edition) by Rajan Katoch. 2011 Publisher-Springer.
Protein Purification (1st edition) by Phillip L. R. Bonner. 2007. Publisher-Taylor and Press.
Spectroscopic Methods and Analysis: NMR, Mass Spectrometry and Metalloprotein Techniques (1st edition) by Christopher Jones, Barbara Mulloy and Adrian H.Thomas. 1993. Publisher-Springer.
Short Protocols in Molecular Biology, (5th edition, 2 Volume) by Frederick M. Ausubel, Roger Brent, Robert E. Kingston, David D. Moore, J. G. Seidman, John A. Smithand Kevin Struhl. 2002. Publisher- Wiley.

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 309: Fermentation Technology and Bioprocessing (2 Credits)

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 learning resources will be suggested by the course instructor(s).

GEB 310: Biostatistics and Epidemiology (4 Credits)

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. Epidemiology: Definition and scope of epidemiology; types of less 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 editin) 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.

Text Book of Biostatistics by A.K. Sharma. 2005 Publisher-Discovery Publishing House

Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 311: Laboratory Experiments (4 Credits)

GEB 312: Viva-voce (2 Credits)

Course for 4th Year B.S. in Genetic Engineering and Biotechnology

Summary:

Course code	Course title	Credits
GEB - 401	Advanced Molecular Biology	4
GEB - 402	Cell Signaling	2
GEB - 403	Immunology	2
GEB - 404	Molecular Diagnostics	2
GEB – 405	Forensic DNA Technology	2
GEB - 406	Genomics, Proteomics, and Bioinformatics	2
GEB - 407	Microbial Biotechnology	4
GEB - 408	Plant Biotechnology	3
GEB - 409	Animal Biotechnology	3
GEB - 410	Environmental Biotechnology	4
GEB - 411	Laboratory Experiments	6
GEB - 412	Project	2
GEB - 413	Viva-Voce	2
	Total	**38**

GEB 401: Advanced Molecular Biology (4 Credits)

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

Molecular Biology of the Telomere and Telomerase

Structure and functions of telomere and telomerase
Biogenesis of telomerase
Significance of telomerase in cancer and aging.

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.

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.

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.

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.

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.

Genomic Imprinting

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

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 learning resources will be suggested by the course instructor(s).

GEB 402: Cell Signaling (2 Credits)

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.

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.

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

Signaling in Microorganism and Plants

Two component signaling pathway of bacterial chemotaxis

Detection of ethylene by plants through two-component system and MAPK cascade.

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

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 learning resources will be suggested by the course instructor(s).

GEB 403: Immunology (2 Credits)

Defense Against Infectious Agents

Immunity to viruses, bacteria, fungi and parasitic infection.

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.

Immunological Tolerance

Features and mechanisms of immunological tolerance
Experimental induction of tolerance; T and B-cell tolerance; Artificially induced tolerance; Therapeutic application of tolerance.

Autoimmunity and Autoimmune Diseases

Association of autoimmunity with diseases
Genetic factors, pathogenesis, etiology, diagnosis and treatment.

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.

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.

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 learning resources will be suggested by the course instructor(s).

GEB 404: Molecular Diagnostics (2 Credits)

Introduction to Molecular Diagnostics

Brief introduction to molecular diagnosis

History and evolution of molecular diagnostics as it transformed the medicine.

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.

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.

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).

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, less N-myc); Quantitative expression of fusion transcripts (BCR-ABL, PML-RARA, TEL-AML).

Future Molecular Diagnosis

Personalized medicine; Warfarin sensitivity (CYP2C9, VKORC1 genotyping)

Beta blocker metabolism (CYP2D6 genotyping)

NGS in clinical diagnosis.

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 learning resources will be suggested by the course instructor(s).

GEB 405: Forensic DNA Technology (2 Credits)

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.

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.

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

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.

Applications of DNA Profiling

Identity test; Parentage test; Sibship analysis; Kinship analysis

Identification of disaster victims/missing persons

Resolving immigration and inheritance disputes.

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

Pop Affiliator; Online calculator for individual affiliation to a major population group.

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 learning resources will be suggested by the course instructor(s).

GEB 406: Genomics, Proteomics and Bioinformatics (2 Credits)

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

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

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

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.

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 it's removal; Differential expression; Microarray data visualization techniques and clustering algorithms; Enrichment/functional over-representation analysis.

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. BnjaminCumnings 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 learning resources will be suggested by the course instructor(s).

GEB 407: Microbial Biotechnology (4 Credits)

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.

Synthesis of Commercial Products by Recombinant Microorganisms

Restriction endonucleases

Small biomolecules -Ascorbic acid, indigo, amino acids, Antibiotics, Biopolymers.

Bioremediation and Biomass Utilization

Microbial degradation of xenobiotics

Commercial production of fructose and alcohol; glycerol production

Silage fermentation; utilization of cellulose.

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.

Microbial Insecticides

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

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.

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.

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.

Renewable Energy

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

Immobilized Cells and Enzymes

Methods of cell and enzyme immobilizations
Advantages; use of immobilized cell systems for the production of industrially important chemicals.

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.
Bullock, 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 learning resources will be suggested by the course instructor(s).

GEB 408: Plant Biotechnology (3 Credits)

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.

Molecular Approaches of Plant Development

Molecular aspects of *in vitro* organogenesis and non-zygotic/somatic embryogenesis.

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.

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.

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.

GM Crops

Application, development and Current status;

Cotton, Brinjal, Maize, golden rice, soyabean and canolla etc.

Biotechnological Approaches for Improvement of Medicinal Plants

Current trends in forest tree biotechnology
In vitro regeneration and improvement in tropical fruit trees.

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 learning resources will be suggested by the course instructor(s).

GEB 409: Animal Biotechnology (3 Credits)

Introduction

Scope and applications of animal biotechnology.

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.

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.

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.

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

Cloning

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

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 learning resources will be suggested by the course instructor(s).

GEB 410: Environmental Biotechnology (4 Credits)

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.

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.

Risk of GMOs

Direct and indirect effects on human health, agriculture and environment

Social and ethical concern about GMOs

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.

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.

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.

Biosensors

Characteristics and components of biosensor

Application of biosensors for the detection of environmental pollutants.

Biotechnological Aspects of Waste Management

Industrial and domestic solid waste and effluents treatment

Safe disposal; Biogas production

Role of enzymes and microorganisms.

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 Bebjamin-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.
Biology and the Future of Man by Handler, P. Oxford University Press. 1st edition. 1970.

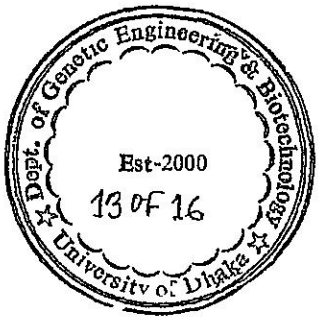
Additional reading materials and learning resources will be suggested by the course instructor(s).

GEB 411: Laboratory Experiments (6 Credits)

GEB 412: Project (2 Credits)

GEB 413: Viva-voce (2 Credits)

-The End-



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