B.Sc. (Hons.) Biotechnology

Detailed Syllabus

Programme Code: BTEB
Duration: 3 Years

EFFECTIVE FROM SESSION: 2019-2020

Department of Life Sciences & Biotechnology
Faculty of Science
CHHATRAPATI SHIVAJI MAHARAJ UNIVERSITY PANVEL, NAVI MUMBAI

About the Programme

The B.Sc. Biotechnology program is a three-year degree. In the first two years, students will tackle core subjects to ensure that they receive a solid grounding in fundamentals. Students will then specialize in the final year, making their choice from a wide range of options and research projects. Our biotechnology program contains topics covering all aspects of the applied biochemistry and the biotechnology industry, such as intellectual property and patents, commercializing technology etc.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS):

The programme educational objectives of the B. Sc. (Hons.) Biotechnology programme are:

PEO1	To prepare students for successful career in industry and research institutes.
PEO2	To develop the ability amongst the students to apply modern bioengineering techniques in industry and research.
PEO3	To enable students to work in a team with multidisciplinary approach.
PEO4	To provide students with fundamental strength in analysing, designing and solving industry related problems.
PEO5	To promote and inculcate ethics and code of professional practice among students.

PROGRAMME OUTCOMES (PO):

After completion of the B. Sc. (Hons.) Biotechnology programme students will be able to:

PO1	Exhibit effective oral and written communication skills.
PO2	Demonstrate critical reading, thinking and problem solving skills
PO3	Demonstrate quantitative reasoning skills in calculus and statistics.
PO4	Utilize scientific methods to explore natural phenomena.
PO5	Demonstrate a solid foundation in Chemistry and Organic Chemistry.
PO6	Demonstrate basic laboratory skills necessary for Biotechnology research.
PO7	Demonstrate a base of knowledge in Biology, Molecular Biology and Microbiology to qualify for upper divisional study.
PO8	Possess the requisite knowledge, skills and abilities to successfully transfer to a baccalaureate degree program in Biotechnology related degree area with junior status.

SEMESTER I

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	BCHB1010	Biochemistry & Metabolism	4	0	0	30	70	100	4
DSC	BINB1020	Biomolecules and Cell Biology	4	0	0	30	70	100	4
GE	**	General Elective - I	4	0/1	4/0	30	70	100	4
AECC	ENGG1000	English Communication	2	0	0	15	35	50	2
DSC	BCHB1011	Biochemistry & Metabolism**Lab**	0	0	4	15	35	50	2
DSC	BSCB1001	Biomolecules and Cell Biology Lab	0	0	4	15	35	50	2
GE	**	General Elective-I lab	0	1/0	0/4	15	35	50	2
		Total	**14**	**0**	**12**	**150**	**350**	**500**	**20**

Ability Enhancement Compulsory Courses (AECC)

Semester	Offering Department	Course Code	Course Name	(L-T-P)	Credits
I	English	ENGG1000	English Communication	2-0-0	2

BCHB1010	BIOCHEMISTRY & METABOLISM	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems. .
2. To develop skills to determine amino acid and nucleotide sequences of proteins and DNA respectively

3. To Understand the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.

UNIT 1: Chemical constituents of Life I: **(12 Lectures)**

1.1. Amino acids: Structure & Function. Structure and properties of Amino acids

1.2. Proteins**:** Types of proteins and their classification, Forces stabilizing protein structure and shape. Different Level of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins.

1.3.Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoprotein's and their biological functions

UNIT 2: Chemical constituents of Life II **12 lectures**

2.1. Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol.

2.2. Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids,

2.3. Nucleosides & Nucleotides, purines & pyrimidines,. Biologically important nucleotides,

2.4. Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA

UNIT 3 : Bioenergenetics **(12 lectures)**

3.1. Laws of thermodynamics,

3.2. concept of free energy, endergonic and exergonic reactions, coupled reactions,

3.3. Redox reactions.

3.4. ATP: structure, its role as a energy currency molecule.

UNIT 4: Enzymes **(12 lectures)**

4.1. Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group;

4.2. Classification of enzymes

4.3. Features of active site, substrate specificity,

4.4. Mechanism of action (activation energy, lock and key hypothesis, induced - fit theroy), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

UNIT 5: Carbohydrates Metabolism **12 lectures**

5.1. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions.

5.2. Pentose phosphate pathway and its significance,

5.3. Gluconeogenesis Glycogenolysis and glycogen synthesis.

5.4. TCA cycle, Electron Transport Chain, Oxidative phosphorylation

Text /Reference Books:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman
2. and Co.

3. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of
4. Plants.American Society of Plant Biologists.
5. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH
6. Freeman and Company, New York, USA.
7. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
8. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Develop an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes.
2. Gain proficiency in basic laboratory techniques in both chemistry and biology, and be able to apply the scientific method to the processes of experimentation and hypothesis testing

BCHB1011	**BIOCHEMISTRY & METABOLISM LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Quantitative estimation of RNA by orcinol reagent.
2. Quantitative estimation of DNA by DPA method.
3. Principles of Colorimetry**: (i)** Verification of Beer's law, **(ii)** To study relation between absorbance and % transmission.
4. Preparation of buffers.
5. Isolation of casein from milk.
6. Separation of sugars/amino acids by paper chromatography.
7. Qualitative tests for Carbohydrates, lipids and proteins
8. Determination of acid number of fats.

BINB1020	**BIOMOLECULES AND CELL BIOLOGY**	**4L:0T:0P**	**4 Credits**

Course objectives:

The objectives of this course are

1. To understand the structure of cell and various cellular events. .
2. To learn about cell theory and techniques for fractionation of sub cellular organelles.
3. To understand the composition of cytoskeleton and extracellular matrix.
4. To acquire knowledge of cell cycle, cell division and cell death mechanisms

UNIT 1: Biomolecules **(12 lectures)**

1.1. Carbohydrates: Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides.

1.2. Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

1.3. Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quarternary; Protein denaturation and biological roles of proteins.

1.4. Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

UNIT 2: The cell (12 lectures)

2.1. Cell as a unit of structure and function;

2.2. Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

3. Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

UNIT 3: Cell organelles (12 lectures)

3.1. Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.

3.2. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.

3.3. Chloroplast, mitochondria and peroxisomes: Structural organization;Function; Semiautonomous nature of mitochondria and chloroplast.

3.4. Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids;

3.5. Golgi Apparatus and lysosomes– organization, protein glycosylation, protein sorting and export from Golgi Apparatus.

UNIT 4: Cell cycle and cell death (12 lectures)

4.1.Phases of eukaryotic cell cycle- mitosis and meiosis;

4.2. Regulation of cell cycle- checkpoints, role of protein kinesis.

4.3. Apoptosis

UNIT 5: Tools of cell biology (12 lectures)

5.1. Light Microscope- phase contrast and dark field

5.2. Chromatography

5.3. Cell culture

5.4. Cell fractionation- centrifugation

Text /Reference Books:

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Fundamental understanding of Bio-molecules: Building blocks of living system
2. Understanding of structure and function of cell: Prokaryotic and Eukaryotic cells system.
3. Understanding the Basic of cellular transport system and cellular inheritance.
4. Understanding of the function of various subcellular organelles
5. They will be acquainted to various microscopic techniques to visualize subcellular organelles

BINB1021	**BIOMOLECULES AND CELL BIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Study of microscope
2. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
3. Study of cell and its organelles with the help of electron micrographs.
4. Study the phenomenon of plasmolysis and deplasmolysis.
5. Study the effect of organic solvent and temperature on membrane permeability.
6. Study different stages of mitosis and meiosis.
7. Study of structure of prokaryotic and eukaryotic cell.

SEMESTER II

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	BTEB2010	Introduction to Biotechnology	4	0	0	30	70	100	4
DSC	BTEB2020	Animal and Plant Physiology	4	0	0	30	70	100	4
GE	**	General Elective - II	4	0/1	4/0	30	70	100	4
AECC	EVSG2000	Environmental Science	2	0	0	15	35	50	2
DSC	BTEB2011	Introduction to Biotechnology Lab	0	0	4	15	35	50	2
DSC	BTEB2021	Animal and Plant Physiology Lab	0	0	4	15	35	50	2
GE	**	General Elective-II Lab	0	1/0	0/4	15	35	50	2
		Total	**14**	**0**	**12**	**150**	**350**	**500**	**20**

Ability Enhancement Compulsory Courses (AECC)

Semester	Offering Department	Course Code	Course Name	(L-T-P)	Credits
II	Basic Sciences	EVSG2000	Environmental Studies	2-0-0	2

BTEB2010	INTRODUCTION TO BIOTECHNOLOGY	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To study the different types of marine microorganisms, marine ecosystem
2. To study the use of marine organisms in production of drugs, enzymes, functional foods, nutraceuticals and cosmetics
3. To acquaint students with various fields of Biotechnology and their applications
4. To impart the knowledge of Healthcare and Food-Agri Biotechnology

Unit 1: History & Introduction to Biotechnology 12L

What is Biotechnology? Definition of Biotechnology, Traditional and Modern Biotechnology, Branches of Biotechnology-Plant, Animal Biotechnology, Marine Biotechnology, Agriculture, Healthcare,
Industrial Biotechnology, Pharmaceutical Biotechnology, Environmental Biotechnology. Biotechnology Research in India. Biotechnology Institutions I n India (Public and Private Sector)

Unit 2: Healthcare Biotechnology 12 L

Introduction, Disease prevention (Vaccines),types of vaccines,Disease Diagnosis, Detection of genetic diseases, Disease treatment, Drug designing, Drug delivery and targeting, Gene therapy

Unit 3: Food Biotechnology 12L

Biotechnological applications in enhancement of Food Quality Microbial role in food products Yeast, Bacterial and other Microorganisms based process and products Unit Operation in Food Processing, Food Deterioration and its Control.

Unit 4: Agriculture biotechnology 12L

GM Food, GM Papaya, GM Tomato, Fungal and Insect Resistant Plants Bt Crops, BT Cotton and BT brinjal, Golden Rice

Unit 5: Marine Biotechnology

Introduction to Marine Biotechnology, Bioprospecting, Methods for Microbial Bioprospecting in Marine Environments , Biotechnological Potential of Marine Microbes **,** Bioactive compounds from other Marine Organisms:fungi, Microalgae, Seaweeds, Actinomycetes, sponges

Text /Reference Books:

1) Biotechnology: Environmental Processes- Rehm and Reed- Wiley
2) Molecular Biotechnology- Glick and Pasterman ASM Press

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Obtain clarity on the functioning of marine ecosystem
2. Elucidate on the use of marine organisms and their applications in industry
3. Define biotechnology and its growth over time

4. Enlist and explain its major applications and areas under research
5. Link major allied sciences to this field
6. Focus on major application areas of healthcare, food, beverage and drug industry
7. Enlist and distinguish its past and existing commercial products from major biotech industries

BTEB2010	INTRODUCTION TO BIOTECHNOLOGY LAB	0L:0T:4P	4 Credits

LIST OF EXPERIMENTS:

1. Detection of food adulterants.
2. **Study of marine organisms**

BTEB2020	PLANT AND ANIMAL PHYSIOLOGY	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To acquaint students with Physiological Processes in Plants and Animals
2. To impart the knowledge of Physiology and Ecology

Detailed Syllabus:

Unit 1: Carbon and nitrogen metabolism in plants (12 Lectures)

1.1 Photosynthesis- Photosynthesis pigments,

1.2 concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point

1.3 Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

1.4 Nitrogen cycle

Unit 2: Plant Growth and development (12 Lectures)

2.1. Growth and development: Definitions, phases of growth, growth curve

2.2. Growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene)

2.3. Concept of photoperiodism and vernalization

Unit 3 :Animal Physiology I (12 lectures)

3.1.Physiology of Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids.

3.2.Mechanism of Respiration: Exchange of gases, Transport of O_2 and CO_2, Oxygen dissociation curve, Chloride shift.

3.3.Phsiology of excretion: urine formation and osmoregulation, ornithine cycle

Unit 4: Animal Physiology II (12 Lectures)

4.1. Composition of blood, Plasma proteins & their role, blood cells, Haematopoisis, Mechanism of coagulation of blood.

4.2. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

4.3. Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic

conduction, saltatory conduction, Neurotransmitters
4.4. Endocrine system-Mechanism of action of hormones (insulin and steroids)
Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

Unit 5: Mineral nutrition in plants and animals (12 Lectures)

5.1. Plant Nutrients- micro and macro nutrients and their role.
5.2. Mineral toxicity and Hydroponics
5.3. Vitamins and Minerals in animals

Text /Reference Books:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John Wiley & sons,Inc.
3. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
4. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
5. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
6. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
7. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
8. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4th edition, W.H.
9. Freeman and Company, New York, USA.
10. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
11. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand basic life processes of plants and animals
2. Understand important chemical reactions and pathways involved in major processes of plants and animals
3. Have knowledge about hormones and other chemical/ non chemical factors that affect the plant and animal growth characteristics
4. Have knowledge about the basic anatomy of organs and their systems along with their linkage to one another

BTEB2021	**PLANT AND ANIMAL PHYSIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC

5. Determination of Haemoglobin
6. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
7. Demonstration of plasmolysis by *Tradescantia* leaf peel.
8. Demonstration of opening & closing of stomata
9. Demonstration of guttation on leaf tips of grass and garden nasturtium.
10. Separation of photosynthetic pigments by paper chromatography.
11. Demonstration of aerobic respiration.
12. Preparation of root nodules from a leguminous plant

SEMESTER III

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	MCRB3020	General Microbiology	4	0	0	30	70	100	4
DSC	BTEB3020	Immunology	4	0	0	30	70	100	4
DSC	BTEB3030	Enzymology	4	0	0	30	70	100	4
GE		General Elective - II	4	0/1	4/0	30	70	100	4
SEC	BTEB3210	Skill enhancement course 1	2	0	0	15	35	50	2
DSC	MCRB3021	General Microbiology	0	0	4	15	35	50	2
DSC	BTEB3021	Immunology	0	0	4	15	35	50	2
DSC	BTEB3031	Enzymology	0	0	4	15	35	50	2
GE		General Elective – II	0	0	4	15	35	50	2
		Total	**16**	**0**	**22**	**185**	**455**	**650**	**26**

MCRB3020	**GENERAL MICROBIOLOGY**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To become aware with the contributions of Louis Pasteur, Edward Jenner and Robert Koch in microbiology and immunology.
2. To get acquainted with the discovery of antibiotics and their targets, drug/antibiotic resistance, preventive and therapeutic approaches of infectious diseases, hospital acquired infections.

3. To Understand the importance of microorganisms as model systems in genetics and biochemistry.
4. To know the contribution of gut microbiome in human health.
5. To understand the concepts of fight against major killer diseases – tuberculosis, HIV and malaria.

Unit 1: Introduction to Microbiology(12 lectures)

1.1. History , application and Status of Microbiology in India.
1.2. Classification of Micro-organisms.
1.3. General features.
1.4. Microbial taxonomy- Bergey manual.

Unit 2: Structure and Diversity of Microorganisms. (12 lectures)

2.1. bacteriology- morphology and structure of Archaebacteria.
2.2. Structure and function of cell organelles of bacteria.
2.3. Structure of viruses.

Unit 3: Staining methods(12 lectures)

1.1. Stains and Dyes
1.2. Simple staining
1.3. Differential staining
1.4. Special staining

Unit 4: Microbial growth(12 lectures)

4.1. Growth curve-mathematical expression of growth.
4.2. Factors affecting microbial growth.
4.3. Batch, continuous, synchronous and diauxic growth
4.4. Quantification of growth.

Unit 5: Microbial Nutrition and metabolism. (12 lectures)

5.1. Nutritional classification of Microorganisms.
5.2. Concept of anabolism and catabolism process.
5.3. Nitrogen fixation- types and mechanism.
5.4. Microbial diseases in plants and animals.

Text /Reference Books:

1. Microbiology:Pelczar M J
2. Microbiology:Presscott L M,Harley J P and Klein D A
3. Textbook of Micrbiology-Ananthanarayan
4. General microbiology - Powar & Daginawala

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Usage of scientific terminologies to describe & express fundamental concepts in Microbiology.
2. Able to apply basic principles to understand host-microbe relationship in different Infectious diseases.

3. Able to connect and integrate the knowledge obtained for applications related to Microbes, their tools and database.
4. Able to connect and integrate the knowledge of microbiology and immunology from the perspective of a bioinformatician with special emphasis on microbe-immune interface

MCRB3011	**GENERAL MICROBIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Monochrome Staining, Differential Staining, Gram Staining, and Acid Fast Staining and Romonowsky Staining
2. Special Staining Technique for Cell Wall, Capsule and Endospores and Fungal Staining, Lipid granules, metachromatic, flagella, spirochetes
3. Motility test
4. Sterilization of Laboratory Glassware and Media using Autoclave
5. Preparation of Media- Nutrient broth and Agar, MacConkey Agar, Sabourauds Agar
6. Isolation of Organisms , Macroscopic and microscopic studies: T-streak, Polygon method, Colony characteristics of microorganisms
7. Enumeration of microorganisms: Serial Dilution, Pour Plate, Spread Plate Method, Nephlometry, Haemocytometry, Breeds count
8. Growth Curve of E.coli
9. Effect of pH and temperature on growth of organisms

BTEB3020	**IMMUNOLOGY**	**4L:0T:0P**	**4 CREDITS**

1. Course learning objectives:

The objectives of this course are

1. To Understand of the overview of immune system including cells, organs and receptors.
2. To learn structure and functions of different classes of immunoglobulins, the genetic basis of antibody diversity and the importance of humoral, cell-mediated and innate immune responses in combating pathogens.
3. To understand mechanisms involved in different types of hypersensitivity, and the importance of conventional vs.recombinant vaccines.
4. To get acquainted with the importance of antigen-antibody interaction in disease diagnosis.
5. To understand the principles of tolerance, autoimmunity and the role of immunity in protection against pathogens.

Unit 1 Introduction to Immunology (12 lectures)

Immune Response - An overview, components of mammalian immune system Molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T-lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte

differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

Unit 2 Immunoglobulin regulation (12 lectures)

Regulation of immunoglobulin gene expression – clonal selection theory, Allotypes & idiotypes, allelic exclusion immunologic memory, Heavy chain gene transcription, genetic basis of antibody diversity, Hypotheses (germ line & somatic mutation), antibody diversity.

Unit 3. MHC(12 lectures)

Major Histocompatibility complexes – class I & class II MHC antigens, Antigen processing.

Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS.

Unit 4. Immunotechniques (12 lectures)

Antigen antibody interaction techniques- Precipitation Reactions: Immunoprecipitation, Immunoelectrophoresis, CIEP, Rocket Electrophoresis and 2-D Immunoelectrophoresis Agglutination Reactions: Passive, Reverse Passive, Agglutination Inhibition. Coomb's Test; Complement Fixation Tests. Synthesis of Monoclonal antibodies & Applications.

Unit 5 DNA Vaccines (12 lectures)

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents,Passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA

Text /Reference Books:

1. Kuby immunology, Judy Owen, Jenni Punt, Sharon Stranford., 7th edition (2012), Freeman and Co., NY
2. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
3. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
4. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
5. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
6. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
7. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publications.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Students will be able to understand and apply basic microbiological techniques and correlate them with their fundamental concepts in the subject.
2. Students will be able to understand and apply basic immunological techniques and correlate them with their fundamental concepts in the subject.

BTEB3021	IMMUNOLOGY LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Passive Agglutination- RA Factor Test.
8. ELISA (Kit based).
9. Dot ELISA
10. Single radial immunodiffusion
11. Ouchterlony double immunodiffusion

BTEB3030	ENZYMOLOGY	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To understand the kinetics and mechanisms of action of enzymes
2. To become familiar with the basic methods of studying enzymes,
3. To appreciate how individual reactions are controlled and integrated into the metabolic pathways of the cell.
4. To find appropriate employment in different development, scientific-research laboratories, or to continue their further studies in biochemistry or related disciplines

1. Detailed Syllabus:

Unit 1 Introduction to enzymes (12 lectures)

1.1 Nature of enzymes - protein and non-protein (ribozyme). Cofactor and prosthetic group, apoenzyme, holoenzyme. IUBMB classification of enzymes.

1.2.Factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory, catalysis, reaction rates and thermodynamics of reaction.

1.3. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis,

Koshland's induced fit hypothesis.

Unit 2 Enzyme kinetics (12 lectures)

2.1. Relationship between initial velocity and substrate concentration, steady state kinetics, equilibrium constant - monosubstrate reactions.

2.2. Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofstee and Hanes plot.

2.3. Km and Vmax, Kcat and turnover number.

2.4.Effect of pH, temperature and metal ions on the activity of enzyme.

Unit 3 Bisubstrate reactions and Mechanism of action of enzymes (12 lectures)

3.1.Types of bi bi reactions (sequential – ordered and random, ping pong reactions).

3.2.Differentiating bi substrate mechanisms (diagnostic plots, isotope exchange).

3.3.General features - proximity and orientation, strain and distortion, acid base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues.

Unit 4 Regulation of enzyme activity (12 lectures)

4.1.Control of activities of single enzymes (end product inhibition) and metabolic pathways, feedback inhibition (aspartate transcarbomoylase), reversible covalent modification phosphorylation (glycogen phosphorylase).

4.2.Proteolytic cleavage- zymogen**.** Multienzyme complex as regulatory enzymes. Occurrence and isolation, phylogenetic distribution and properties (pyruvate dehydrogenase, fatty acyl synthase) Isoenzymes - properties and physiological significance (lactate dehydrogenase).

Unit 5 Applications of enzymes (12 lectures)

5.1. Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases),

5.2. Enzyme immunoassay (HRPO) and enzyme therapy (Streptokinase).

5.3. Immobilized enzymes.

Text /Reference Books:

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13: 978-1-4641-0962-1 / ISBN:10:1-4292- 3414-8.
2. Biochemistry (2011) 4th ed., Donald, V. and Judith G.V., John Wiley & Sons Asia Pvt. Ltd. (New Jersey), ISBN:978-1180-25024.
3. Fundamentals of Enzymology (1999) 3rd ed., Nicholas C.P. and Lewis S., Oxford University Press Inc. (New York), ISBN:0 19 850229 X.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Explain relationship between the structure and function of enzymes
2. Explain how enzymes are able to increase speed of an biochemical reaction in sense of thermodynamics, kinetics and molecular interactions
3. Use catalytic strategies in interpreting mechanisms of enzymatic action
4. Interpret t and explain significant mechanisms of regulation of enzymatic action and specifies importance of enzymes in regulation of metabolism

5. Apply appropriate methods for determination of catalytic parameters and activity of enzymes and resolve problems considering kinetics and thermodynamics of enzymatic reactions
6. Analyze options for applying enzymes and their inhibitors in medicine and various industries;

BTEB3031	**ENZYMOLOGY LAB**	**0L:0T:4P**	**1 Credits**

SUGGESTIVE LIST OF EXPERIMENTS:

1. Partial purification of acid phosphatase from germinating mung bean.
2. Assay of enzyme activity and specific activity, e.g. acid phosphatase.
3. Effect of pH on enzyme activity
4. Determination of Km and Vmax using Lineweaver-Burk graph.
5. Enzyme inhibition - calculation of Ki for competitive inhibition.
6. Continuous assay of lactate dehydrogenase.
7. Coupled assay of glucose-6-phosphate dehydrogenase.

SEMESTER IV

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	BTEB4030	Molecular biology	4	0	0	30	70	100	4
DSC	BTEB4020	Bioprocess technology	4	0	0	30	70	100	4
DSC	BTEB4010	Pharmagenomics	4	0	0	30	70	100	4
GE		General Elective - II	4	0/1	4/0	30	70	100	4
SEC	BTEB4210	Skill enhancement course 2	2	0	0	15	35	50	2
DSC	BTEB4031	Molecular biology Lab	0	0	4	15	35	50	2
DSC	BTEB4021	Bioprocess technology lab	0	0	4	15	35	50	2
DSC	BTEB4011	Pharmagenomics Lab	0	0	4	15	35	50	2
GE		General Elective – II	0	0	4	15	35	50	2
		Total	**16**	**0**	**22**	**185**	**455**	**650**	**26**

BTEB4030	**MOLECULAR BIOLOGY**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To acquaint students with DNA Replication, Repair and Genetic Engineering.
2. Impart the knowledge of molecular Biology Techniques.

Detailed Syllabus:

Unit 1 Hereditary material- DNA (12 lectures)

1.1 DNA as the vehicle of inheritance- Experimental evidence -Griffith, McLeod, McCarty and Avery, HerscheyChase experiments.

1.2.Definition of Gene, organization of genes and non-coding

1.3.DNA in prokaryotes and Eukaryotes - unique, moderately repetitive and highly repetitive DNA sequence, Satellite DNA.

1.4. Cot value.

Unit 2 DNA replication in prokaryotes (12 lectures)

2.1. DNA Replication in Prokaryotes - Semi-conservative DNA replication,

2.2. DNA Polymerases and its role, E.coli Chromosome Replication,

2.3.Bidirectional Replication of Circular DNA molecules.

2.4. Rolling Circle Replication, DNA

Unit 3 DNA replication (12 lectures)

3.1. Replication in Eukaryotes

3.2. DNA Recombination –Holliday Model for Recombination

3.3. Transformation

Unit 4 Mutations(12 lectures

4.1. Definition and Types of Mutations.

4.2. Mutagenesis and Mutagens.(Examples of Physical, Chemical and Biological Mutagens)

4.3. Types of Point Mutations,

1.1. DNA REPAIR Photoreversal, Base Excision Repair, Nucleotide Excision Repair, Mismatch Repair, SOS Repair and Recombination Repair**.**

Unit 5 Genetic and Chromosomal variation (12 lectures)

5.1. Genetic variation and chromosomal basis of inheritance Types: Discontinuous and continuous

5.2. Molecular basis of allelic variation.

5.3. Historical development of chromosomal theory, nature of chromosome, chromosomal behaviour 5.4. Inheritance in eukaryotes

Text /Reference Books:

1. Upadhya- Molecular Biology- Himalaya pub.
2. Watson – Molecular biology of gene- Pearson pub.
3. David Freifelder- Microbial Genetics – Narosa Pub.
4. David Freifelder– Molecular Biology – Narosa pub.
5. Gardner – Principals of Genetics – Wiley international pub.
6. Albert Bruce- Molecular biology of the cell- garland science.
7. Loddish - Molecular cell biology – W-H. freeman
8. Lewin – Genes X- Oxford
9. Fundamentals of Cell and Molecular biology-Baig, Telang and Ingle-Amruta

Genome- T.A. Brown- John Wiley

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand basic molecular biology terms and definitions
2. Understand the molecular model of DNA and its replication in various ways
3. Define mutations and predict their outcomes
4. Enlist various possibilities and probable reasons which may lead to mutations
5. Explain certain medical conditions related to one's genetics
6. Elucidate the concept of heredity and passing of information from generation to other

BTEB4031	**MOLECULAR BIOLOGY LAB**	**0L:0T:4P**	**2 CREDITS**

LIST OF EXPERIMENTS:

1. Isolation and purification of DNA from plant sources (genomic)
2. Agarose Gel Electrophoresis of the genomic DNA
3. Quantitative analysis of DNA by DPA
4. Quantitative analysis of RNA by Orcinol method
5. Study of DNA repair mechanism by photo reactivation

Determination of Tm value of DNA

BTEB4020	**BIOPROCESS TECHNOLOGY**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

- To Learn various bioprocess related terms and principles
- To Learn about microbial growth kinetics in various mode of fermentation
- To Learn about the principles and application of Mass transfer and Sterilization
- To Develop an understanding of important concepts and design aspects of bioreactors
- To Learn about the functioning of various bioreactors
- To Learn about the principle of scaling up and scaling down of bioprocesses

Unit 1 Fermentor design (12 lectures)

Design of a fermentor**:** - Basic Design; Parts of a Typical Industrial Fermentor. Types of fermenter- Stirred Tank Fermentor, Air lift, Pneumatic, Bubble column, Tower fermentor, Process Parameters : *pH*, Temperature, Aeration, Agitation, Foam, Pressure, Inlet and exit gas analysis, Dissolved oxygen. Carbon dioxide electrodes, microbial biomass, Safety valves.

Unit 2 Industrial Fermentation (12 lectures)

Production of industrial cPropionic acid, butyric acid, 2-3 butanediol,hemicals, biochemicals and chemotherapeutic products. gluconic acid, itaconicacid, Biofuels: Biogas, Ethanol, butanol, hydrogen, biodiesel, microbial electricity, starch conversion processes; Microbial polysaccharides; Microbial insecticides; microbial flavours and fragrances, newer antibiotics, anti cancer agents, amino acids.

Unit 3 Microbial metabolites(12 lectures)

Microbial products of pharmacological interest, steriod fermentations and transformations.

Over production of microbial metabolite, Secondary metabolism – its significance and products. Metabolic engineering of secondary metabolism for highest productivity. Enzyme and cell immobilization techniques in industrial processing, enzymes in organic synthesis, proteolytic enzymes, hydrolytic enzymes, glucose isomerase, enzymes in food technology/organic synthesis.

Unit 4 Purification of protein (12 lectures)

Purification & characterization of proteins, Upstream and downstream processing, solids and liquid handling. Distribution of microbial cells, centrifugation, filtration of fermentation broth, ultra centrifugation, liquid extraction, ion-exchange recovery of biological products. Experimental model for design of fermentation systems, Anaerobic fermentations.

Text /Reference Books:

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology.
3. 2nd edition. Panima Publishing Co. New Delhi.
4. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
5. 4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.
6. Salisbury, Whitaker and Hall. Principles of fermentation Technology,

Course Outcomes:

At the end of this course students will demonstrate the ability to:

- Able to use correct biological terms to describe & analyze phenomena/ problems in bioprocesses
- Able to apply engineering principles to address issues in various bioprocesses
- Able to analyze bacterial growth kinetics (homogeneous reaction) in batch /continuous/ Fed-batch reactor and sterilization
- Able to understand and to solve problems related to bioprocess phenomena including mixing, Mass transfer and sterilization
- To develop a strong foundation about bioreactor designs and their applications
- Able to understand the basis of bioprocess scale up and the related basic design calculations

BTEB4021	**BIOPROCESS TECHNOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Comparative analysis of design of a batch and continuous fermenter.
2. Calculation of Mathematical derivation of growth kinetics.
3. Solvent extraction & analysis of a metabolite from a bacterial culture.
4. Perform an enzyme assay demonstrating its hydrolytic activity (protease/peptidase/glucosidase etc.)

BTEB4010	**PHARMAGENOMICS**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To understand different antimicrobial agents
2. To learn the general principles of pharmacology
3. To understand the concept of toxicology
4. To study the mechanism of drug absorption and distribution
5. To understand basic and regulatory toxicology

Detailed Syllabus:

Unit I- Chemotherapeutic agents

Discovery and Design of antimicrobial, Classification of Antibacterial agents, Selective toxicity, MIC, MLC, Inhibition of cell wall synthesis (Mode of action for): Beta lactam antibiotics: Penicillin, Cephalosporins; Glycopeptides: Vancomycin; Polypeptides: Bacitracin Injury to plasma membrane: Polymyxin, Inhibition of protein synthesis: Aminoglycosides, Tetracyclines, Chloramphenicol, Macrolides Erythromycin, Inhibition of nucleic acid synthesis: Quinolones, Rifampicin, Metronidazole, Antimetabolites: Sulphonamides, Trimethoprim Drug resistance: Mechanism origin, transmission, Use and misuse of antimicrobial agents, Antifungal drugs, Antiviral drugs.

Unit 2 General principles of pharmacology

Mechanism of drug action , drug receptors and biological responses second-messenger systems, the chemistry of drug–receptor binding, dose–response relationship: therapeutic index, ED, LD, Potency and Intrinsic Activity, Drug antagonism

Unit 3 Drug Absorption and distribution

Absorption of drugs from the alimentary tract, factors affecting rate of gastrointestinal absorption, absorption of drugs from lungs and skin , absorption of drugs after parenteral administration factors influencing drug distribution , binding of drugs to plasma proteins, Physiological barriers to drug distribution

Unit 4 Basic and regulatory toxicology

Background Definitions Causation: degrees of certainty Classification, Causes Allergy in response to drugs, Effects of prolonged administration: chronic organ toxicity , Adverse effects on reproduction Poisons: Deliberate and accidental self-poisoning, Principles of treatment Poison-specific measures General measures , Specific poisonings: cyanide, methanol, ethylene glycol, hydrocarbons, volatile solvents, heavy metals, herbicides and pesticides,

biological substances (overdose of medicinal drugs is dealt with under individual agents**)**, Incapacitating agents: drugs used for torture, Nonmedical use of drugs

Text /Reference Books:

1. Textbook of Medical Physiology Guyton, A.C and Hall 11th edition J.E Saunders
2. Modern Pharmacology with clinical Applications Craig,C.R, Stitzel,R.E 5th edition
3. Clinical Pharmacology Bennet,PN,Brown,M.J, Sharma,P 11th edition Elsevier
4. Biochemistry Metzler, D.E Elsevier
5. Microbiology by Prescott Harley and Klein 5th edition Mc Graw Hill
6. Medical Microbiology Jawetz,E., Brooks,G.E, Melnick,J.L., Butel,J.S Adelberg E. A 18th edition

7. Medical Microbiology by Patrick Murray 5th edition
8. Foundations In Microbiology by Talaro and Talaro Third edition W.C Brown
9. Understanding Viruses by Teri Shors
10. Mim's Medical Microbiology 5th edition
11. Casarett & Doull's Toxicology- The Basic Science Of Poisons

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Elucidate the concepts of pharmacology
2. Comment on causes of allergic reactions with response to drug or poison
3. Obtain clarity about mechanism of absorption of drugs from different tissues
4. State the mechanism of action of different antimicrobials

BTEB4011	PHARMAGENOMICS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Antibiotic sensitivity test using agar cup method
2. Antibiotic sensitivity test using paper disc method
3. Antibiotic sensitivity test using ditch method.
4. Synergistic action of two drugs
5. LD 50, ED 50 evaluation using suitable models

SEMESTER V

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	BTEB5010	Principles of genetics	4	0	0	30	70	100	4
DSC	BTEB5030	Recombinant technology	4	0	0	30	70	100	4
DSE	BTEB5020	Discipline Specific Elective 1	4	0/1	4/0	30	70	100	4

DSE	BTEB5310	Discipline Specific Elective 2	2	0	0	15	35	50	2
DSC	BTEB5011	Principles of genetics Lab	0	0	4	15	35	50	2
DSC	BTEB5031	Recombinant technology Lab	0	0	4	15	35	50	2
DSE	BTEB5021	Discipline Specific Elective 1 Lab	0	0	4	15	35	50	2
DSE	BTEB5311	Discipline Specific Elective 2 Lab	0	0	4	15	35	50	2
		Total	**16**	**0**	**20**	**180**	**420**	**600**	**24**

BTEB5010	**GENETICS**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To acquaint students with concepts in Genetics
2. To impart skills in Techniques in Genetic Analysis and Population Genetics

Detailed Syllabus

Unit 1: Mendels Law (12 lectures)

1.1.Mendel‘s Laws of HeredityMonohybrid Cross: Principleof Dominance and Segregation. Dihybrid Cross: Principle ofIndependent Assortment.

1.2 Application of Mendel‘s Principles Punnett Square.

1.3. Mendel‘s Principle in HumanGenetics. Incomplete Dominance and Co-dominance. Multiple Alleles.Allelic series.Variations among the effect of the Mutation.Genotype and Phenotype.

1.1.Environmental effect on the expression of the Human Genes. Gene Interaction.Epistasis.

Unit 2: Genetic analysis (12 lectures)

2.1. Genetic analysis in Bacteria- Prototrophs, Auxotrophs.

2.2. Bacteriophages: Lytic and Lysogenic Development of Phage. Mechanism of Genetic Exchange in Bacteria:

2.3. Conjugation; Transformation; Transduction; (Generalized Transduction, Specialized Transduction)

2.4. Bacterial Transposable Elements

Unit 3: Prokaryotic and Eukaryotic transcription (12 lectures)

3.1. Transcription Process in Prokaryotes :RNA Synthesis; Promoters and Enhancers;

3.2. Initiation of Transcription at Promoters; Elongation and Termination of an RNA Chain.

3.3. Transcription in Eukaryotes Transcription of Protein Coding Genes by RNA Polymerase.

Unit 4: Genetic code (12 lectures)

4.1. Nature of Genetic Code.

4.2. Wobble Hypothesis.

4.3.Translation: Process of Protein Synthesis (Initiation, Elongation, Translocation, Termination)

Unit 5: Regulation in prokaryotes and eukaryotes (12 lectures)
5.1. Gene regulation In prokaryotes: In Bacteria: *Lac* operon of *E.coli, trp* Operon of *E.coli.*
5.2. In Eukaryotes: Operons in Eukaryotes; Control of Transcriptional Initiation
5.3. Jumping genes in maize

Text /Reference Books:

1. General Principles of Microbiology- Stanier
2. Fundamental Principles of Bacteriology - A. J. Salle McGraw Hill
3. Genetics, (2006) Strickberger MW - (Prentice Hall, India)
4. Human Genetics- A. M. Winchester – MacMillan Press
5. iGenetics- Peter Russell -Pearson Education
6. Microbial Genetics- Freifelder –Narosa Publishing House

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Define and explain the three laws of Heredity
2. Explain the patterns of breeding and cross breeding
3. Explain the concept of alleles, their dominant and recessive nature
4. Explain unusual patterns of inheritance and deviations from the normal laws

BTEB5011	**GENETICS LAB**	**0L:0T:2P**	**4 Credits**

LIST OF EXPERIMENTS:

1. Isolation, Quantitative Analysis and AGE of Genomic DNA from Bacteria and Yeast.
2. Mutations by UV rays
3. Mutations by chemical agents such as; base analogue, intercalating agents or Alkylating agents.
4. Bacterial transformation
5. Bacterial conjugation
6. Bacterial transduction
7. Karyotyping with the help of photographs

BTEB5030	**RECOMBINANT TECHNOLOGY**	**4L:0T:0P**	**4 Credits**

1. Course learning objectives:
The objectives of this course are

1. To chose a career in molecular biology and genetic engineering
2. To Exploit the basic understanding of the subject to create something that can help society
3. To Equip oneself with skills to grow in the biotech sector
4. To Work in biotechnology industries in Research and Development/Production/ Quality Assurance
5. To Carry out basic research in understanding many more molecular mechanisms inside a cell

2. Detailed Syllabus

Unit I: Basic Concepts and Tools of Gene cloning

What is gene cloning and why do we need to clone a gene?; Introduction to recombinant DNA technology: Introduction to vehicles of gene cloning, Handling of DNA, RNA, cDNA and Restriction enzymes, Laboratory requirements, Safety measures and regulations for rDNA work, Choice and selection of the tools and techniques; Purification of DNA from bacterial, plant and animal cells; Manipulation of purified DNA; Introduction of DNA into living cells; Different methods of horizontal gene transfer: Transformation, Conjugation and Transduction.

Unit II: Cloning Vectors and Identification of a clone

Vehicles: Plasmids, Bacteriophages and viruses, Phagemids and Cosmids; Bacterial Artificial Chromosomes; Vectors for yeast and other fungi: 2µ plasmid, YEPs, YIPs, YRPs, and YACs;

To obtain a clone of a specific gene: Direct selection, Selection using hybridization from Genomic DNA library, cDNA library; Probe designing and labeling; Identification of clones using alternative methods

Unit III: Studying gene location and structure

Gene location: Hybridization techniques – Southern blotting; In situ hybridization, FISH, OFAGE.

Studying gene structure; DNA sequencing: Sanger's method of chain termination and Maxam Gilbert's method of chemical degradation; Automated sequencing; Polymerase Chain Reaction and its types; Chemical synthesis of oligonucleotides.

Unit IV: Gene Expression and Regulation

Transcript analysis; Studying gene expression; Regulation of gene expression; Studying translated product of the gene; Studying protein – protein interactions; Expression vectors; Promoters used in expression vectors; Cassettes and gene fusions; Problems associated with production of recombinant protein in E.*coli;* Production of recombinant protein by eukaryotic cells like yeast and fungi; Study of protein functions by *in vitro* mutagenesis

Text /Reference Books:

1) Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York).
2) Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK)
3) Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Tawyman, R. M., Blackwell publishing (Oxford)
4) Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC)

3. Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the basic tools required in recombinant DNA technology
2. Explore the methods used to study gene location and structure
3. Know the various techniques used to study the gene expression and regulation
4. Understand the techniques used in analyzing transcripts and proteins
5. Understand problems associated with production of recombinant molecules
6. Explore the use of recombinant DNA technology in betterment of the society

7. Appreciate experiments carried out by scientists to enable understand various molecular mechanisms

BTEB5031	RECOMBINANT TECHNOLOGY LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1) Genomic DNA isolation from bacteria
2) Plasmid DNA isolation
3) Assessment of quality and quantity of DNA
4) Agarose gel electrophoresis to visualize DNA
5) Restriction digestion
6) DNA ligation
7) DNA transformation

SEMESTER VI

Course Code	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	BTEB6010	Bioanalytical Tools	4	0	0	30	70	100	4
DSC	BINB6020	Genomics and Proteomics	4	0	0	30	70	100	4
DSE	BTEB6320	Discipline Specific Elective 3	4	0/1	4/0	30	70	100	4
DSE	BTEB6310	Discipline Specific Elective 4	2	0	0		35	50	2
DSC	BTEB6011	Bioanalytical Tools Lab	0	0	4	15	35	50	2
DSC	BINB6021	Genomics and Proteomics Lab	0	0	4	15	35	50	2
DSE	BTEB6321	Discipline Specific Elective 3 lab	0	0	4	15	35	50	2
DSE	BTEB6331	Discipline Specific Elective 4 Lab	0	0	4	15	35	50	2
		Total	**16**	**0**	**20**	**180**	**420**	**600**	**24**

BTEB6010	BIOANALYTICAL TOOLS	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

- To develop the skills to understand the theory and practice of bio analytical techniques.
- To provide scientific understanding of analytical techniques and detail interpretation of results.

UNIT I Microscopy

Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

UNIT II Centrifugation (15 Lectures)

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared), centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT III Chromatography (15 Lectures)

Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV Electrophoresis (20 Lectures)

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno- electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

Text /Reference Books:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

3. Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Apprehend the functioning, maintenance and safety aspects of the basic apparatus used in a Biotechnology lab.
2. Assimilate the principles and applications of centrifuge, electrophoresis and chromatography in research and related experiments.

3. Employ the knowledge for the separation of proteins/peptides by selecting appropriate separation techniques.
4. Characterize certain functionalities of biomolecules by using spectroscopic techniques.

BTEB6011	BIOANALYTICAL TOOLS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.
7. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.

BINB6020	GENOMICS AND PROTEOMICS	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. The course is intended to provide thorough understanding of the genomics i.e. modern technologies in whole genome sequencing, genome mining, comparative genomics, global gene function technologies, protein structure & function technologies at the genome level, etc.
2. The course will explore that how technological innovations fostered by the Human Genome Project, will lead to significant advances in our understanding of diseases that have a genetic basis and, more importantly, how health care will be delivered from this point forward

2. Detailed Syllabus

Unit 1: Genomics (12 lectures)

1.1. Introduction to Genomics

1.2. DNA sequencing methods – manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing,

1.3. Genome Sequencing: Shotgun & Hierarchical (clone contig) methods,

1.4. Computer tools for sequencing projects: Genome sequence assembly software.

Unit 2: Genome data(12 lectures)

2.1.Managing and Distributing Genome Data: Web based servers

2.2. Softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome.

2.3. Selected Model Organisms' Genomes and Databases.

Unit 3: protein structure (12 lectures)

3.1.Introduction to protein structure,

3.2. Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions.

3.3. Determination of sizes (Sedimentation analysis, gel filteration, SDS-PAGE); Native PAGE,

3.4.Determination of covalent structures – Edman degradation.

Unit 4: Proteomics (12 lectures)

4.1. Introduction to Proteomics, Analysis of proteomes.

4.2. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE.

4.3. Mass spectrometry based methods for protein identification.

4.4. De novo sequencing using mass spectrometric data.

Unit 5. Molecular Markers (12 lectures)

5.1. Dominant and codominant markers,

5.2. Homoplasy concept, Identical by state Vs Identical by descent markers,

5.3. Hybridization based marker system – RFLP, PCR based marker systems – RAPD, AFLP, CAPS, SCAR, SSRs,

5.4.Microarray based SNP detection techniques, Applications of DNA markers

Text /Reference Books:

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
7. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
8. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Students will have a thorough understanding of various genomic technologies such as whole genome mapping & sequencing, genome annotation, global gene cloning and gene expression technologies, comparative genomics, introduction to pharmacogenomics
2. The students will know the vast amount of genome information in publically available databases and how to access and best utilize for practical purposes.
3. Able to analyze the gene expression data sets to derive the biologically meaning information Assessment
4. Able to apply the knowledge of function genomics in public health

BINB6021	**GENOMICS AND PROTEOMICS LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database 5. Softwares for Protein localization.
5. Hydropathy plots
6. Native PAGE
7. SDS-PAGE

LIST OF GENERAL ELECTIVE SUBJECTS

List of Generic Electives Available for students of B.Sc. (Hons.) Biotechnology

Semester	Offering Department	Course Code (T+P)	Course Name	(L-T-P)	Credits
I	Botany	MCRB1010+ MCRB1011	Microbiology and Phycology	4-0-4	6
II	Botany	BOTB2010+ BOTB2011	Diversity of Archaegoniates&Plant Anatomy	4-0-4	6
III	Botany	BOTB3020+ BOTB2021	Economic botany	4-0-4	6
IV	Botany	BOTB4020+ BOTB4021	Phytogeography	4-0-4	6
II	Bioinformatics	BINB2010+BINB2011	Introduction to Bioinformatics	4-0-4	6
III	Bioinformatics	BINB3010+ BINB3011	Concepts in Bioinformatics	4-0-4	6
IV	Bioinformatics	BINB4010+BINB4011	Computer aided drug design.	4-0-4	6
II	Biochemistry	BCHB2020+ BCHB2021	Enzymes	4-0-4	6
III	Biochemistry	BCHB3020+ BCHB3021	Membrane Biology and Bioenergetics	4-0-4	6

IV	Biochemistry	BCHB4030+ BCHB4031	Hormone: Biochemistry and Function	4-0-4	6
I	Zoology	ZOOB1010+ ZOOB1011	Non-Chordates	4-0-4	6
II	Zoology	ZOOB2010+ ZOOB2011	Chordates	4-0-4	6
III	Zoology	ZOOB3010+ ZOOB3011	Animal Physiology: Controllong and coordinating system	4-0-4	6
IV	Zoology	BCHB4210+ BCHB4211	Biochemistry Of Metabolic Processes	4-0-4	6
II	Microbiology	MCRB2020+ MCRB2021	Bacteriology	4-0-4	6
III	Microbiology	MCRB3030+ MCRB3031	Medical Microbiology	4-0-4	6
IV	Microbiology	MCRB4020+ MCRB4021	Food and Dairy Microbiology	4-0-4	6
I	Chemistry	CHYB1010 + CHYB1011	Inorganic Chemistry	4-0-4	6
II	Chemistry	CHYB2010 + CHYB2011	Organic Chemistry	4-0-4	6
III	Chemistry	CHYB3010 + CHYB3011	Physical Chemistry	4-0-4	6
IV	Chemistry	CHYB4010 + CHYB4011	Basic Analytical Chemistry	4-0-4	6

----------BOTANY ----------

MCRB1010	**MICROBIOLOGY AND PHYCOLOGY**	**4L:0T:0P**	**4 Credits**

Course objectives:

The objectives of this course are

1. To gain knowledge of diversity, life forms, life cycles, morphology and importance of microorganisms (Bacteria and algae).

UNIT- 1: Microbial World (Origin and Evolution of Life, Microbial diversity (12Lectures)

1.1. Discovery of microorganisms, origin of life, spontaneous, biogenesis, Pasteur experiments, germ theory of disease.

1.2. Classification of microorganisms – R.H. Whittaker's five kingdom concept, Carl Woese's- Domain system.

1. 3. Brief account of special groups of bacteria- Archaebacteria, Mycoplasma, Chlamydia, Actinomycetes, Rickettsias and Cyanobacteria.

UNIT- 2 : VIRUSES (12 Lectures)

2.1. Viruses- Discovery, general account, structure& replication of –T4 Phage (Lytic, Lysogenic) and TMV, Viroids, Prions.

2.2. Plant diseasescaused by viruses– Symptoms, transmission and control measures (Brief account only).

2.3. Study of Tobacco Mosaic, Bhendi Vein clearing and Papaya leaf curl diseases.

UNIT 3: BACTERIA (12 Lectures)

3. 1. Bacteria: Discovery, General characteristics, cell structure andnutrition.

3.2. Reproduction- Asexual and bacterial recombination (Conjugation, Transformation, Transduction).

3.3. Economic importance of Bacteria.

UNIT –4: ALGAE (12Lectures)

4.1. General account - thallus organization and reproduction in Algae.

4.2. Fritsch classification of Algae (up to classes only) and economic importance.

4.3. Structure, reproduction and life history of Oedogonium, Ectocarpus and Polysiphonia.

UNIT 5: FUNGI (12 Lectures)

5.1. General characteristics and outline classification (Ainsworth).

5.2. Structure, reproduction and life history of Rhizopus (Zygomycota),Penicillium (Ascomycota), and Puccinia (Basidiomycota).

5.3. Lichens-Structure and reproduction; ecological and economic importance.

Text /Reference Books:

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Develop understanding on the concept of microbial nutrition
2. Classify viruses based on their characteristics and structures
3. Develop critical understanding of plant diseases and their remediation.
4. Examine the general characteristics of bacteria and their cell reproduction/ recombination
5. Increase the awareness and appreciation of human friendly viruses, bacteria, algae and their economic importance
6. Conduct experiments using skills appropriate to subdivisions

MCRB1011	**MICROBIOLOGY AND PHYCOLOGY LAB**	**0L:0T:4P**	**2Credits**

LIST OF EXPERIMENTS:

1. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawings/ Photographs of Lytic and Lysogenic Cycle.
2. Types of Bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root Nodule.
3. Gram staining.
4. Endospore staining with malachite green using the (endospores taken from soil bacteria).
5. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), Volvox, *Oedogonium,Coleochaete, Chara, Vaucheria, Ectocarpus, Fucus and Polysiphonia,Procholoron* through electron micrographs, temporary preparations and permanent slides.

BOTB2010	**DIVERSITY OF ARCHAEGONIATES &PLANT ANATOMY**	**4L:0T:0P**	**4Credits**

Course Objectives:

2. This course aims at making a familiarity with special groups of plants joined together by a common feature of sexual reproduction involving Archegonia.
3. To Create an understanding by observation and table study of representative members of phylogenetically important groups should be able to make students learn the process of evolution in a broad sense.

4. To Study of morphology, anatomy, reproduction and developmental changestherein through typological study should create a knowledge base in understanding plant diversity, economic values, taxonomy of lower group of plants

UNIT – 1: BRYOPHYTES (12Lectures)

1.1 Bryophytes: General characters, Classification (up to classes)

1.2. Structure, reproduction and Life history of Marchantia, and Funaria.

1.3. Evolution of Sporophyte in Bryophytes.

UNIT – 2: PTERIDOPHYTES (12Lectures)

2.1. Pteridophytes: General characters, classification (up to Classes)

2.2. Structure, reproduction and life history of Lycopodium, and Marsilea.

2.3. Heterospory and seed habit.

2.4. Evolution of stele in Pteridophytes.

UNIT – 3: GYMNOSPERMS (12Lectures)

3.1. Gymnosperms: General characters, classification (up to classes)

3.2. Morphology, anatomy, reproduction and life history of Pinus and Gnetum

3.3. Economic importance with reference to wood, essential oils and drugs

UNIT –4: Tissues and Tissue systems (12Lectures)

4.1.Meristems - Root and Shoot apical meristems and their histological organization.

4.2.Tissues – Meristematic and permanent tissues (simple, complex, secretory)

4.3.Tissue systems–Epidermal, ground and vascular.

UNIT – 5. Secondary growth (12Lectures)

5.1. Anomalous secondary growth in Achyranthes, Boerhaavia and Dracaena.

5.2. Study of local timbers of economic importance-Teak, Rosewood, Red sanders and Arjun (Tella maddi).

Course Learning Outcomes:

1. Demonstrate an understanding of archegoniatae, Bryophytes, Pteridophytes and Gymnosperms
2. Develop critical understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms
3. Understanding of plant evolution and their transition to land habitat.
4. Demonstrate proficiency in the experimental techniques and methods of appropriate analysis of Bryophytes, Pteridophytes, Gymnosperm

Text /Reference Books

1. Agrios, G.N. (1997) Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
4. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies,

Macmillan Publishers India Ltd.
Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.

BOTB2011	**DIVERSITY OF ARCHAEGONIATES &PLANT ANATOMY LAB**	**0L:0T:2P**	**4 Credits**

LIST OF EXPERIMENTS

1. Introduction to the world of fungi (Unicellular, coenocytic/septate mycelium, ascocarps & basidiocarps).
2. *Rhizopus*: study of asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Aspergillus* and *Penicillium*: study of asexual stage from temporary mounts. Study of Sexual stage from permanent slides/photographs.
4. *Peziza*: sectioning through ascocarp.
5. *Alternaria:* Specimens/photographs and temporary mounts.
6. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.
7. *Agaricus*: Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*, fairy rings and bioluminescent mushrooms to be shown.
8. Study of phaneroplasmodium from actual specimens and /or photograph. Study of *Stemonitis* sporangia.
9. *Albugo:* Study of symptoms of plants infected with *Albugo*; asexual phase study through section/ temporary mounts and sexual structures through permanent slides.
10. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates. Study of thallus and reproductive structures (soredia and apothecium) through permanent slides. Mycorrhizae: ectomycorrhiza and endomycorrhiza (Photographs)
11. Phytopathology: Herbarium specimens of bacterial diseases; Citrus Canker; Angular leaf spot of cotton, Viral diseases: TMV, Vein clearing, Fungal diseases: Early blight of potato, Black stem rust of wheat and White rust of crucifers.

BOTB3020	**ECONOMIC BOTANY**	**4L:0T:0P**	**4 Credits**

COURSE OBJECTIVES

1. To relate the principles of Economic Botany to other disciplines in biology.
2. To relate useful plants to the affairs of mankind.
3. To relate useful plants to the local and world economy.

Unit 1: Origin of Cultivated Plants (6 lectures)

Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of new crops/varieties, importance of germplasm diversity.

Unit 2: Cereals and Legumes (6 lectures)

Wheat and Rice (origin, morphology, processing & uses); Brief account of millets. Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man

and ecosystem.

Unit 3: Sources of sugars and starches (4 lectures)

Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Unit 4 : Spices and Beverages (6 lectures)

Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper Tea, Coffee (morphology, processing & uses)

Unit 5 : Sources of oils and fats (10 lectures)

General description, classification, extraction, their uses and health implications groundnut, coconut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

COURSE OUTCOME

1. Understand core concepts of Economic Botany and relate with environment, populations, communities, and ecosystems
2. Develop critical understanding on the evolution of concept of organization of apex new crops/varieties, importance of germplasm diversity, issues related to access and ownership
3. Develop a basic knowledge of taxonomic diversity and important families of useful plants
4. Increase the awareness and appreciation of plants & plant products encountered in everyday life
5. Appreciate the diversity of plants and the plant products in human use

Text/ Reference Books

1) Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2) Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers,
3) The Netherlands.
4) Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers**.**

BOTB3021	**ECONOMIC BOTANY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1) **Cereals**: Wheat (habit sketch, L. S/T.S. grain, starch grains, micro-chemical tests)Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2) **Legumes**: Soybean, Groundnut, (habit, fruit, seed structure, micro-chemical tests).
3) **Sources of sugars and starches**: Sugarcane (habit sketch; cane juice- micro-chemical tests),
4) Potato(habit sketch, tuber morphology, T.S. tuber to show localization of starch grains, w.m. starch grains, micro-chemical tests).
5) **Spices:** Black pepper, Fennel and Clove (habit and sections).
6) **Beverages**: Tea (plant specimen, tea leaves), Coffee (plant specimen, beans).

7) **Sources of oils and fats**: Coconut- T.S. nut, Mustard–plant specimen, seeds; tests for fats in crushed seeds.
8) **Essential oil-yielding plants**: Habit sketch of *Rosa*, *Vetiveria*, *Santalum* and *Eucalyptus* (specimens/photographs).

BOTB4010	PHYTOGEOGRAPHY	4L:0T:0P	4 Credits

COURSEOBJECTIVE

1. To give a fundamental understanding of the distribution of vascular plants and of the basic models which describe it.
2. To know about the floristic regions and plant formations of the Planet, in the light of previous continental and climatic evolution.
3. To learn floristic recording of specific habitats and the assessment of their naturality on the basis of chorological and life form spectra of the flora.

Unit I: Introduction, soil and water 15 lectures

Basic concepts; Levels of organization. Abiotic and biotic Components and their interrelationships and dynamism, homeostasis. Soil: Origin; Types and Formation; Composition; Physical, Chemical and Biological components; Soil profile. Types of soils in India. Water: States of water in the environment; Precipitation types (rain, fog, snow, hail, dew); Hydrological Cycle; Atmospheric moisture; Water in soil; Ground water table. Water
resources of India

Unit II: Ecological adaptations, Population ecology 15 lectures

Variations in adaptation of plants in relation to light, temperature, water, wind and fire. Biotic interactions: Competition: Inter- and intraspecific competition; Ammensalism, heterotrophy; mutualism, commensalism, parasitism; herbivory, carnivory, protocooperation, Population ecology: Characteristics and population growth, population regulation, life history strategies; *r* and *k* selection. Ecological Speciation.

Unit III: Plant Communities and Ecosystem 15 lectures

Community characteristics: analytical and synthetic; Concept of ecological amplitude; Habitat and niche; Ecotone and edge effect; Succession: processes, types; climax concept. Primary vs Secondary succession. Ecosystem: Structure; Processes; Trophic organization; Food chains and Food webs; Ecological pyramids. Ecosystems of India.

Unit IV: Functional Aspects of Ecosystem and Phytogeography 15 lectures

Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles of carbon, nitrogen and phosphorus. Phytogeography: Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phyto-geographical division of India; Local Vegetation.

Course outcomes

On completion of this course, the students will be able to:

1. Understand core concepts of biotic and abiotic
2. Classify the soils on the basis of physical, chemical and biological components
3. Analysis the phytogeography or phytogeographical division of India
4. Evaluate energy sources of ecological system
5. Assess the adaptation of plants in relation to light, temperature, water, wind and fire.
6. Conduct experiments using skills appropriate to subdivisions

Text/ Reference Books

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.

2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation. Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.

BOTB4011	**PHYTOGEOGRAPHY LAB**	**0L:0T:4P**	**2Credits**

LIST OF EXPERIMENTS:

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH of various soil and water samples (with pH meter, universal indicator/Lovibond comparator and/or pH paper strip)
3. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid field tests.
4. Determination of organic matter of different soil samples by Walkley & Black rapid
5. titration method.
6. Comparison of bulk density, porosity and rate of infiltration of water in soils of three habitats.
7. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
8. Study of morphological adaptations of hydrophytes and xerophytes (four each).
9. Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanche) Epiphytes, Predation (Insectivorous plants).
10. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
11. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

----------ZOOLOGY----------

ZOOB1010	**NON-CHORDATES : PROTISTS TO ECHINODERMATA**	**4L:0T:0P**	**4Credits**

Course Objectives:

1. To understand different levels of biological diversity through the systematic classification of invertebrate fauna
2. To understand the taxonomic position of protozoa to echinodermatas.
3. To understand the general characteristics of animals belonging to protozoa to echinodermatas.
4. To understand the body organization of phylum from protozoa to echinodermatas.
5. To understand the origin and evolutionary relationship of different phylum from protozoa to to echinodermata.

Unit 1: Protista, Parazoa and Metazoa 12 lectures

1.1.General characteristics and Classification up to classes
1.2.Study of *Euglena*, *Amoeba* and *Paramecium*
1.3.Life cycle and pathogenicity of *Plasmodium vivax* and *Entamoeba histolytica*
1.4. Locomotion and Reproduction in Protista

Unit 2: Porifera and Cnidaria 12 lectures

2.1.General characteristics and Classification up to classes
2.2. Canal system and spicules in sponges
2.3. General characteristics and Classification up to classes and Metagenesis in *Obelia*
2.4. Polymorphism in Cnidaria
2.5. Corals and coral reefs

Unit 3: Helmimthes, Platyhelminthes and Annelida 12 lectures
3.1.General characteristics and Classification up to classes
3.2. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*

Unit 4: Arthropoda 12 lectures
4.1. General characteristics and Classification up to classes
4.2. Type study of palamaneous
4.3. Type study of periplata
4.4. Insect and vectorsof human diseases.

Unit 5 Mollusca and Echinodermata 12 lectures
5.1. General characteristics and Classification up to classes
5.2. Mollusca –type study of prawn
5.3. Echinodermata – study of star fish.
5.4. Minor Phyla- Ectophora and rotifera

Course Learning Outcomes: The course will enable the students to learn the following:

1. Student should be able to describe unique characters of protozoa to echinodermata
2. Student should be able to recognize life functions of protozo to echinodermata
3. To recognise the ecological role of phylum protozoa to echinodermata
4. **T**o recognise the diversity from protozoa to echinodermata

Text /Reference Books:

1. Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson

ZOOB1011	**NON CHORDATES LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*
2. Examination of pond water collected from different places for diversity in protista
3. Study of *Sycon* (T.S. and L.S.), *Hyalonema, Euplectella, Spongilla*
4. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*
5. One specimen/slide of any ctenophore
6. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/micro-photographs)
7. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
8. To submit a Project Report on any related topic on life cycles/coral/ coral reefs.

ZOOB2010	**CHORDATES**	**4L:0T:0P**	**4 Credits**

COURSE OBJECTIVES

1. To understand what the chordates are.
2. To understand different categories of chordates.
3. To understand the general characters of chordates.
4. To understands the level of organization in chordate subphylum.
5. To understand the origin and evolutionary relationship in different subphylum of chordates.

UNIT 1:
1.1. General characters of Chordata
1.2 Prochordata
1.2.1 Salient features of Cephalochordata
1.2.2 Structure of Branchiostoma
1.2.3 Affinities of Cephalochordata
1.2.4 Salient features of Urochordata
1.2.5 Structure and life history of Herdmania
1.2.6 Significance of Retrogressive metamorphosis

Unit – 2:
2.1 Cyclostomata
2.1.1 General characters of Cyclostomata
2.1.2 Comparision of the Petromyzon and Myxine
2.2 Pisces
2.2.1 General characters of Fishes
2.2.2 Classification of fishes up to sub - class level with examples
2.2.3 Scoliodon - External features, Digestive system, Respiratory system, Heart, Brain
2.2.4 Migration in Fishes
2.2.5 Types of Scales

Unit – 3:
3.1 Amphibia
3.1.1 General characters of Amphibian
3.1.2 Classification of Amphibia upto orders with examples.
3.1.3 Rana hexadactyla - External features, Digestive system, Respiratory system, Heart, Brain
3.2 Reptilia
3.2.1 General characters of Reptilia
3.2.2 Classification of Reptilia upto orders with examples
3.2.3 Calotes - External features, Digestive system, Respiratory system, Heart, Brain
3.2.4 Identification of Poisonous snakes and Skull in reptiles

Unit :4 Aves
4.1 General characters of Aves
4.2. Classification of Aves upto subclasses with examples.
4.3 Columba livia - External features, Digestive system, Respiratory system, Heart, Brain
4.4 Migration in Birds
4.5 Flight adaptation in birds

Unit -5 Mammalia
5.1 General characters of Mammalia
5.2 Classification of Mammalia upto sub - classes with examples
5.3 Comparision of Prototherians, Metatherians and Eutherians
5.4. Dentition in mammals

COURSE OUTCOME

1. Student should be able to describe unique characters of urochordates, cephalochordates and fishes.
2. Student should be able to recognize life functions of urochordates to fishes.
3. To understand the ecological role of different groups of chordates.
4. To understand the diversity ofchordates

Text Books/ Reference Books

1. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.

2. Pough H. Vertebrate life, VIII Edition, Pearson International.
3. Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub. Co.
4. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

ZOOB2010	**CHORDATES LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS

1. Protochordata : Herdmania, Amphioxus, Amphioxus T.S. through pharynx
2. Cyclostomata : Petromyzon, Myxine
3. Pisces : Pristis, Torpedo, Channapleuronectes, Hippocampus, Exocoetus, Eheneis, Labeo, Catla, Clarius, Auguilla,Protopterus Placoid scale, Cycloid scale, Ctenoid scale
4. Amphibia : Ichthyophis, Amblystoma, Siren, Hyla, Rachophous Axolotl larva
5. Reptilia : Draco, Chemaeleon, Uromastix, Vipera russeli, Naja, Bungarus, Enhydrina, Testudo, Trionyx, Crocodilus
6. Aves : Passer, Psittacula, Bubo, Alcedo, Columba, Corvus, Pavo,
7. Study of different types of feathers : Quill, Contour, Filoplume down
8. Mammalia : Ornithorthynchus, Tachyglossus, Pteropus, Funambulus, Manis, Loris, Hedgehog Osteology : Appenducular skeletons of Varanus, Pigeon Rabbit - Skull, fore limbs, hind limbs and girdles

ZOOB3010	**ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEM**	**4L:0T:0P**	**4Credits**

COURSE OBJECTIVE

1. To know about the functioning of various system of organisms and their interrelationship for well-coordinated function.
2. To understand structure and functions of different animal tissues and endocrine glands

Unit 1: Tissues

1.1. Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue

1.2. Bone and Cartilage Structure and types of bones and cartilages, Ossification, bone growth and resorption

Unit 2: Nervous System

2.1. Structure of neuron, resting membrane potential,
2.2. Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers;
2.3. Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc;
2.4. Physiology of hearing and vision.

Unit 3: Muscle Histology of different types of muscle;

3.1. Ultra structure of skeletal muscle;
3.2 Molecular and chemical basis of muscle contraction;
3.3. Characteristics of muscle twitch; Motor unit, summation and tetanus

Unit 4: Reproductive System

4.1. Histology of testis and ovary;
4.2. Physiology of male and female reproduction; Puberty,
4.3. Methods of contraception in male and female

Unit 5 : Endocrine System

5.1. Histology of endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas, adrenal; hormones secreted by them and their mechanism of action;
5.2. Classification of hormones; Regulation of their secretion; Mode of hormone action, Signal transduction pathways for steroidal and non-steroidal hormones;
5.3. Hypothalamus (neuroendocrine gland) - principal nuclei involved in neuroendocrine control of anterior pituitary and endocrine system; Placental hormones

COURSE OUTCOME

1. Should be able to recognize and explain how all physiological systems work in unison to maintain homeostasis in the body and use of feedback loops to control the same i.e., should learn about an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body. e.g. Cardiovascular and Respiratory systems to meet the oxygen demand of the body.
2. Synthesize ideas to make connection between knowledge of physiology and real world situations, including healthy life style decisions and homeostatic imbalances i.e. how physiological mechanisms adapt in response to various external and internal stimuli in order to maintain health.
3. Knowledge of role of regulatory systems viz. endocrine and nervous systems and their amalgamation in maintaining various physiological processes

TEXT / REFERENCE BOOKS

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons
3. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

ZOOB3011	**ANIMAL PHYSIOLOGY: CONTROLLING AND COORDINATING SYSTEM LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS

1. Recording of simple muscle twitch with electrical stimulation (or Virtual)
2. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex)
3. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres and nerve cells
4. Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid
5. Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues (*Subject to UGC guidelines)

BCHB4210	**BIOCHEMISTRY OF METABOLIC PROCESSES**	**4L:0T:0P**	**4Credits**

COURSE OBJECTIVES

1. To understand The relationship between the structure and function of specific biological molecules and enzymes are regulated
2. To understand main principles of metabolic biochemistry concepts and homeostasis is controlled in the body
3. To understand function of specific anabolic and catabolic pathways and how these pathways are controlled and interrelated
4. To Understand the metabolism of carbohydrates and fates of various intermediate and end products

Unit 1: Overview of Metabolism

1.1 Catabolism vs Anabolism, Stages of catabolism,

1.2. Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; coupled reactions;

1.3. Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms

Unit 2: Carbohydrate Metabolism

2.1. Sequence of reactions and regulation of glycolysis, Citric acid cycle,

2.2. Phosphate pentose pathway,

2.3. Gluconeogenesis, Glycogenolysis and Glycogenesis

Unit 3: Lipid Metabolism

3.1. β-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms;

3.2.Biosynthesis of palmitic acid;

3.3. Ketogenesis

Unit 4: Protein Metabolism

4.1. Catabolism of amino acids: Transamination, Deamination,
4.2. Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids

Unit 5: Oxidative Phosphorylation

5.1.Redox systems; Review of mitochondrial respiratory chain,
5.2.Inhibitors and un-couplers of Electron Transport System

COURSE OUTCOME

1. Students gain knowledge and skill in the interactions and interdependence of physiological and biomolecules and the understand essentials of the metabolic pathways along with their regulation.
2. To understand the principles, instrumentation and applications of bioanalytical techniques.
3. To expose the students to various processes used in industries.
4. Be knowledgeable in classical laboratory techniques and be able to use modern instrumentation and be able to design and conduct scientific experiments and analyze the resulting data.

Text/ Reference Books

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
4. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

BCHB4211	**BIOCHEMISTRY OF METABOLIC PROCESSES LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Estimation of total protein in given solutions by Lowry's method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
3. To study the enzymatic activity of Trypsin and Lipase.
4. Study of biological oxidation (SDH) [goat liver]
5. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.

----------**MICROBIOLOGY**----------

MCRB2020	**BACTERIOLOGY**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To provide in-depth knowledge of bacterial cell structure, its cultivation, growth and reproduction.

2. To gives insight into bacterial diversity and its significance.
3. To give hands on training of basic and very important bacteriological techniques which will give the student a strong base in microbiology

Detailed Syllabus:

Unit 1 Bacteriological techniques Lectures: 5

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

Unit 2 Microscopy Lectures: 6

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope, Confocal microscopy, Scanning and Transmission Electron Microscope

Unit 3 Reproduction in Bacteria Lectures: 3

Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate

Unit 4Bacterial Systematics Lectures: 8

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria

Unit 5 Important archaeal and eubacterial groups Lectures: 16

Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (Nanoarchaeum), Crenarchaeota (Sulfolobus, Thermoproteus) and Euryarchaeota [Methanogens (Methanobacterium, Methanocaldococcus), thermophiles (Thermococcus, Pyrococcus, Thermoplasma), and Halophiles (Halobacterium, Halococcus)]

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups: Gram Negative: Non proteobacteria: General characteristics with suitable examples Alpha proteobacteria: General characteristics with suitable examples Beta proteobacteria: General characteristics with suitable examples Gamma proteobacteria: General characteristics with suitable examples

Delta proteobacteria: General characteristics with suitable examples Epsilon proteobacteria: General characteristics with suitable examples Zeta proteobacteria: General characteristics with suitable examples Gram Positive: Low G+ C (Firmicutes): General characteristics with suitable examples High G+C (Actinobacteria): General characteristics with suitable examples Cyanobacteria: An Introduction

Text /Reference Books:

1. Atlas RM. (1997). Principles of Microbiology.
2. 2nd edition. WM.T.Brown Publishers. 2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht

6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
9. Cappucino J and Sherman N. **(2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited**

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Will gain knowledge about morphology, structure and organisation of different cell components and be able to differentiate between cell walls of Gram positive and Gram-negative bacteria, cell walls and cell membranes of archaea and eubacteria.
2. Will also be able to explain gram and acid-fast staining reactions and effect of antibiotics and enzymes on cell wall structure.
3. Will get familiar with various techniques used for isolation, cultivation and preservation of different types of bacterial cultures. Will gain insight into working and importance of compound microscope.
4. understand nutritional requirements of different types of bacteria and formulation of media for bacterial growth.
5. Will be able to briefly explain methods of asexual reproduction in bacteria. Will understand different phases of growth curve and be able to define generation time and growth rate.
6. Can define and differentiate various types of classifications. Will gain insight into techniques used in polyphasic bacterial taxonomy.
7. Will get acquainted with differences between archaea and eubacteria and can list their important general characteristics along with ecological significance and economic importance.

MCRB2021	**BACTERIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Preparation of different media: synthetic media BG-11, Complex media-Nutrient agar, McConkey agar, EMB agar.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining-permanent slide only.
6. Capsule staining

7. Endospore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method/pour plate method.
11. Motility by hanging drop method.

MCRB3030	MEDICAL MICROBIOLOGY	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To introduce and acquaint the students with the key aspects of medical microbiology related to the diverse microbial pathogens, their virulence mechanisms, diagnostic methods and brief outline of the functional aspects of antimicrobial chemotherapy.
2. To deals with the recent development of new molecular diagnostic methods and the global spread and re-emergence of infectious diseases.

Detailed Syllabus:

Unit 1 Normal microflora of the human body and host pathogen interaction Lectures: 8

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS

Unit 2 Sample collection, transport and diagnosis Lectures: 5

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests,Complement fixation, PCR, DNA probes).

Unit 3 Bacterial diseases Lectures: 15

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Respiratory Diseases: Streptococcus pyogenes, Haemophilus influenzae, Mycobacterium tuberculosis Gastrointestinal Diseases: Escherichia coli, Salmonella typhi, Vibrio cholerae, Helicobacter pylori Others: Staphylococcus aureus, Bacillus anthracis, Clostridium tetani, Treponema pallidum, Clostridium difficie

Unit 4 Viral diseases Lectures: 14

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Polio,

Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine flu, Ebola, Chikungunya, Japanese Encephalitis

Unit 5 Protozoan and Fungal diseases Lectures: 5

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control Malaria, Kala-azar

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention Cutaneous mycoses: Tinea pedis (Athlete's foot) Systemic mycoses: Histoplasmosis Opportunistic mycoses: Candidiasis

Text /Reference Books:

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition**,** University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ. (2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Will have gained an in depth knowledge about the spectrum of diseases caused by bacterial pathogens, and an understanding of the course of disease development and accompanying symptoms.
2. Will become familiar with the methods of transmission, epidemiological aspects as well as prevention and control methods.
3. Will become acquainted with the spectrum of diseases caused by viral pathogens. Also will understand the course of disease development and symptoms seen in diseases of different organ systems.
4. Will understand the causation of fungal and protozoal diseases and methods of prevention and control.
5. Will learn about the current approaches to diagnosis of diseases.

MCRB3030	**MEDICAL MICROBIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

SUGGESTIVE LIST OF EXPERIMENTS:

1. Identify bacteria (any three of E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
7. Study of various stages of malarial parasite in RBCs using permanent mounts.

MCRB4020	**FOOD AND DAIRY MICROBIOLOGY**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. to acquaint students with the role of microorganisms in association with foods, highlighting both their beneficial and harmful activities and their applications in the food industry
2. to understand the concept of quality control of food.

Detailed Syllabus:

Unit 1 Foods as a substrate for microorganisms Lectures: 8

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general.

Unit 2 Microbial spoilage of various foods Lectures: 10

Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods

Unit 3 Principles and methods of food preservation Lectures: 12

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit 4 Fermented foods Lectures: 10

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit 5 Food borne diseases (causative agents, foods involved, symptoms and preventive measures) Lectures: 10

Food intoxications: Staphylococcus aureus, Clostridium botulinum and mycotoxins; Food infections: Bacillus cereus, Vibrio parahaemolyticus, Escherichia coli, Salmonellosis, Shigellosis, Yersinia enterocolitica, Listeria monocytogenes and Campylobacter jejuni

Text /Reference Books:

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Will be aware of the possible sources of contamination of foods and the parameters affecting microbial growth in foods.
2. Will gain insight into the microbial spoilage of some foods
3. Will acquire an in-depth knowledge of various physical and chemical methods used for food preservation.
4. Will be acquainted with microbial production of fermented dairy and non-dairy food products.
5. Will also be able to understand the health benefits of prebiotics, probiotics and synbiotics.

6. Will be conversant with some food-borne diseases and will be able to explain methods for detection of food borne pathogens.

MCRB4021	**FOOD AND DAIRY MICROBIOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any food borne bacteria from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt/Dahi.

----------BIOINFORMATICS ----------

BINB2010	**INTRODUCTION TO BIOINFORMATICS**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To Learn and understand basic concepts of Bioinformatics
2. To understand various databases.
3. To learn and understand protein databases.
4. To understand nucleic acid databases.
5. To learn about genomic databases.

Unit 1: Introduction (12 Lectures)

1.1. Definition ,History , branches , scope and research areas in Bioinformatics
1.2. Human genome project
1.3. Role of computer in bioinformatics
1.4. Applications and BIO-IT

Unit 2: Introduction to databases (12 Lectures)

2.1. Introduction to genomics and proteomic data, post genomic era.
2.2. Data acquisition- functions and purposes.
2.3. Biological databases- relational and object oriented concepts.
2.4. Information retrieval from biological databases- ENTREZ and SRS.
2.5. Methods for presenting large quantities of data- sequence and strucrure viewer

Unit 3: Introduction to Nucleic acid Databases (12 Lectures)

3.1. Primary and secondary database, genebanks.
3.2. EVBC nucleotide, sequence data bank-DDBJ.
3.3. RNA sequence databases: 16S & 23S rRNA, mutation databases, HIV sequence database.

3.4. NON CODE sequence submission tools- Sequin, Webin , Sakura, bankIT.

Unit 4: Protein Sequence Databases (12 Lectures)

4.1. Protein Sequence Databases- PIR, SWISSPORT, UNIPORT, EMBL,EXPASY, NCBI MIPS.

4.2. Motiff databases- eblocks, PROSITE

4.3. Protein domain databases-ADDA, INTERPRO, Pfam.

Unit 5: Structural Databse (12 Lectures)

5.1. PDB, PDB sum, CATH/SCOP,MMDB, SWISS- MODEL.

5.2. Repository ModBase, Protein Model Portal.

5.3. Eurocarb DB, DIP, BIND, STRING.

Text /Reference Books:

2. Orpita basu & Sinninder kaur, Thakural ,"Bioinformatics databases tools, Alogrithm, 2007, Oxford University Press.
3. Higgins D, Willie Taylor " Bioinformatics, Sequence, Structure and data bank, A practical approach, 2000, First edition, Oxford University Press.

Allwood T, david Parry Smith; Introduction to bioinformatics, 2008, Pearson education, Singapore

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Gain an understanding of the basic concepts of Bioinformatics and Biostatistics
2. Understand the tools used in Bioinformatics.
3. Apply the various Statistical tools for Analysis of Biological Data

BINB2011	**INTRODUCTION TO BIOINFORMATICS LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. To explore NCBI.
2. To explore gene bank.
3. To explore PDB.
4. To perform sequence alignment using BLAST.
5. To access the SCOP and CATH databse to study protein classification.
6. To visualize protein using Rasmol.
7. To explore STRING database.
8. To explore secondary databse- prosite and Pfam.
9. To find protein motifs.

BINB3010	**CONCEPTS IN BIOINFORMATICS**	**4L:0T:0P**	**4 Credits**

1. Course learning objectives:

The objectives of this course are

1. List the concepts and applications of sequence searching
2. Define the concepts of homology, identity, orthologues, paralogues
3. Provide examples of basic sequence alignment, introducing concepts of point mutations, deletions, insertions etc.

4. Provide an outline of the different approaches to sequence alignment - exhaustive vs. heuristic

Detailed Syllabus:

Unit 1: Introduction (12 lectures)

1.2. Introduction, Sequence alignment
1.3. Scoring Matrix- PAM and BLOSUM
1.4. Gaps and Gap penalties
1.5. Different types of Gap weights and Application of Gaps**.**

Unit 2: Alignments (12 lectures)

2.1. Pairwise alignment: DotPlot analysis.
2.2. Dynamic programming- Needleman- Wunch Algorithm, Smith- Waterman algorithm, Edit distance dynamic program ming.
2.3. Clusrtal W, TCOFFEE, Profile methods- Gribskov profile, PSI_BLAST
2.4. Multiple segment alignment- sum of pairs, Divide and conquer, Progressive and Iterative alignment

Unit 3: Cluster detection (12 lectures)

3.1. Phylogenetic relationships, Clustering and Phylogeny
3.2. Phylogenetic analysis- concept of Phylogenetic tree, Methods of Phylogeny analysis- Diastance and character based methods.
3.3. Motif detection
3.4. Protein family databases.

Unit 4: Data Mining(12 lectures)

4.1. Data Mining- introduction and definition.
4.2. Data Mining problem and Data Mining Techniques, Tools and Methods.
4.3. Management of databases.
4.4. DBMS. Difference between DBMS and file system.

Unit 5 Metabolomics (12 lectures)

5.1. metabolic pathway database (KEGG pathway database)
5.2. Concept of Metablome and Metabolomics
5.3. Drug discovery and Design- target identification, target validation, lead identification, lead optimization, Priclinical Pharmacology and Toxicology.
5.4. Chemoinformatics tools for drug discovery- Chemical structure representation(SMILE & SMART), Chemical datatbases (CSD,ACD,WDI, PUBCHEM and Chembank)

Text /Reference Books:

1. Orpita basu & Sinninder kaur, Thakural ,"Bioinformatics databases tools, Alogrithm, 2007, Oxford University Press.
2. Higgins D, Willie Taylor " Bioinformatics, Sequence, Structure and data bank, A practical approach, 2000, First edition, Oxford University Press.
3. Allwood T, david Parry Smith; Introduction to bioinformatics, 2008, Pearson education, Singapore.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Extract and generate pairwise sequence alignments for a protein sequence of interest
2. Describe and interpret the metrics used to assess the quality of a pairwise sequence alignment, identity versus similarity
3. Describe the differences between homologues, paralogues and orthologues
4. Use a pairwise sequence approach to identify mutations between two sequences

BINB3011	**CONCEPTS IN BIOINFORMATICS LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

2. To perform sequence alignemt using clustal W.
3. To study phylogenetic relationship using PHYLIP/MEGA.
4. To find motif using motif search.
5. To explore pathway database: KEGG database.

BINB4010	**COMPUTER AIDED DRUG DESIGN.**	**4L:0T:0P**	**4 Credits**

Course learning objectives:

The objectives of this course are

1. To design potential lead molecules against any disease that may be explored further as a potential candidate for the drug development.
2. To learn QSAR and SAR
3. To understand the concept of molecular docking
4. To learn the details of molecular modeling

Unit 1: Introduction to Drug Discovery and Development (12 lectures)

1.1.Stages of drug discovery and development

1.2. Lead discovery and Analog Based Drug Design Rational approaches to lead discovery based on traditional medicine,

1.3. Random screening, Non-random screening, serendipitous drug discovery, lead discovery based on drug metabolism, lead discovery based on clinical observation.

1.4. Analog Based Drug Design: Bioisosterism, Classification, Bioisosteric replacement. Any three case studies

Unit 2: QSAR and SAR (12 lectures)

2.1.Quantitative Structure Activity Relationship (QSAR)

2.2. SAR versus QSAR, History and development of QSAR,

2.3. Types of physicochemical parameters, experimental and theoretical approaches for the determination of physicochemical parameters such as Partition coefficient, Hammet's substituent

constant and Tafts steric constant. Hansch analysis, Free Wilson analysis, 3D-QSAR approaches like COMFA and COMSIA.

Unit 3: Molecular docking (12 lectures)

3.1. MolecularModelingandVirtual Screening techniques: Drug likeness screening,

3.2. Concept of pharmacophore mapping and pharmacophore based Screening,

3.3. Molecular docking: Rigid docking, flexible docking, manual docking, Docking based screening.

3.4. *De novo* drug design.

Unit 4: Informatics (12 lectures)

4.1.Informatics & Methods in drug design

4.2. Introduction to Bioinformatics, chemoinformatics.

4.3. ADME databases, chemical, biochemical and pharmaceutical databases.

Unit 5: Molecular Modeling (12 lectures)

5.1. Molecular Modeling: Introduction to molecular mechanics and quantum mechanics.

5.2. Energy Minimization methods and Conformational Analysis,

5.3. Global conformational minima determination.

Text /Reference Books:

1. Advanced Concepts in Structural Bioinformatics: Structural Bioinformatics: Philip E. Bourn (Editor), HelgeWeissig (Editor). ISBN: 978-0-471-20199-1
2. Protein Structure Prediction: A Practical Approach (The Practical Approach Series , No 170) by Michael J. E. Sternberg
3. Computer-aided Drug Design: Practical Application of Computer-Aided Drug Design (Hardcover) by Charifson (Author)
4. Computer-Aided Drug Design. Methods and Applications. Edited by Thomas J. Perun and C. L. Propst Marcel Dekker

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Feasibility study of a drug development project
2. Design and optimize lead molecules against drug target, andusing ligand-basedapproach
3. Determination of pharmacophore from lead molecules and active sites and use of pharmacophore for lead discovery
4. Development of potential drug molecule and pharmacophore databases for virtual screening
5. Use of molecular fragments for lead discovery and implementation of statistical approaches for lead molecule discovery

BINB4011	**COMPUTER AIDED DRUG DESIGN. LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Installation of various drug design software and assignment ‘Project’
2. Generation of 3D optimized structure of a “Ligand” molecule
3. Preparation of target and ligand molecules for docking
4. Virtual library Preparation” of lead molecules
5. Docking of ligands into a receptor (active site)
6. Flexible docking of ligand with target
7. Fragment docking using ‘*De Novo’* Receptor and ‘*De Novo’* Links (LUDI algorithm)

8. Pharmacophore modeling of ligands
9. Pharmacophore-based database searching and *de novo* design of ligand against an active site
10. Development of 3D QSAR model by using "Discovery Studio"
11. ADME property and toxicity predictions of lead molecule (usingTOPKAT)

----------CHEMISTRY----------

CHYB1010	**Inorganic Chemistry**	**4L:0T:0P**	**4 Credits**

Course Learning Objectives:

The objective of this course is:
1. To make student learn about wave mechanics.
2. To study about periodic properties of S,P,D & F block elements
3. To impart knowledge of covalent and ionic bond.
4. To impart knowledge of metallic bonds and weak Chemical Forces
5. To make student learn about oxidation and reduction.

Unit 1: **Atomic Structure:** L:14

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit 2: **Periodicity of Elements:** L:16
s, *p*, *d*, *f* block elements, the long form of periodic table. Properties of the elements with reference to *s*&*p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) Ionic and crystal radii. Covalent radii (octahedral and tetrahedral) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling's/ Mulliken's/Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Unit 3: **Chemical Bonding I:** L:16

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment.

Unit 4: **Chemical Bonding II:** L:10
Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Unit 5:**Oxidation-Reduction:** L:4
Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Text/Reference Books:

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

Course Outcomes:

At the end of this course students will be able to:

1. Understand the concept of wave mechanics.

2. Know the variations of periodic properties in S, P, D and F block elements.

3. Have knowledge of different types of bond nature.

4. Understand the weak chemical forces interactions.

5. To solve problems related to oxidation and reduction.

CHYB1010	**Inorganic Chemistry Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To have knowledge of calibration of different glassware's.
2. To prepare different normal and molar solution.
3. To have knowledge of acid base reaction.
4. To Estimate free alkali present in different soaps/detergents.

5. Understand concept of oxidation and reduction based reactions.

CHYB2010 Organic Chemistry 4L:0T:0P 4 Credits

Course Learning Objectives:

The objective of this course is:

1. To impart knowledge of hybridization, Electronic Displacements reactions.
2. To make students learn about chemistry of alkanes.
3. To make students understand carbon-carbon pi bonds.
4. To impart knowledge of cycloalkanes and conformational Analysis.
5. To make students understand aromatic character of cyclic compounds.

Unit 1: **Organic Compounds:** L: 16

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocation's, Carbanion, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit 2: **Carbon-Carbon sigma bonds::**L: 8

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Unit 3: **Carbon-Carbon pi bonds::**L: 14

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylicbromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit 4: **Cycloalkanes and Conformational Analysis** : L: 10
Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Unit 5: **Aromaticity:** L: 12
Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Text/Reference Books:

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Apply the knowledge of hybridization and molecular displacements in molecular modeling.
2. Learn the preparation and properties of alkanes.
3. Have knowledge of chemical reactions of alkenes and alkynes.
4. Understand the concept of Conformation analysis of alkanes.

5. Understand concept of aromaticity.

CHYB2011 Organic Chemistry Lab 0L:0T:4P 2 Credits

LIST OF EXPERIMENTS:

1. Checking the calibration of the thermometer

2. Purification of organic compounds by crystallization using the following solvents:

a. Water
b. Alcohol
c. Alcohol-Water

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

6. Chromatography

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
b. Separation of a mixture of two sugars by ascending paper chromatography
c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To purify organic compounds by crystallization.

2. To determine the melting points of unknown organic compounds.
3. To determine mixed melting point of two unknown organic compounds
4. To determine boiling point of liquid compounds.
5. Separate a mixture of various compounds by the help of chromatography.

CHYB3010 Physical Chemistry 4L:0T:0P 4 Credits

Course Learning Objectives:

The objective of this course is:

1. To impart knowledge of phase and binary solutions.
2. Students will learn about molecularity, rate laws and kinetics of complex reactions.
3. To gain knowledge of collision theory of reaction rates and temperature dependence of reaction rates.
4. To impart knowledge of enzyme catalysis.
5. To make students learn about surface chemistry.

Unit 1: **Phase Equilibria:** L:28

Concept of phases, components and degrees of freedom, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, two and three component systems. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Unit 2: **Chemical Kinetics I:** L:10

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate

expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Unit 3: **Chemical Kinetics II:** L:8
Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Unit 4: **Catalysis:**L:8
Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Unit 5: **Surface chemistry:**L:6
Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

Text/Reference Books:

1. Peter Atkins & Julio De Paula, *Physical Chemistry9th Ed.*, Oxford University Press (2010).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.:
4. New Delhi (2004).
5. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
6. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
7. Zundhal, S.S. *Chemistry concepts and applications*Cengage India (2011).
8. Ball, D. W. *Physical Chemistry*Cengage India (2012).
9. Mortimer, R. G. *Physical Chemistry3rd Ed.*, Elsevier: NOIDA, UP (2009).
10. Levine, I. N. *Physical Chemistry6th Ed.*, Tata McGraw-Hill (2011).
11. Metz, C. R. *Physical Chemistry2nd Ed.*, Tata McGraw-Hill (2009).

<u>Course Outcomes:</u>

At the end of this course students will demonstrate the ability to:

1. Students will learn about phase equilibria and binary solutions.
2. Will have idea of molecularity and rate laws.

3. Students will have idea about collision theory of reaction rates.
4. Students will understand about enzyme catalytic reaction.
5. Solve problems related to surface chemistry.

CHYB3011 Physical Chemistry Lab 0L:0T:4P 2 Credits

LIST OF EXPERIMENTS:

I. Determination of critical solution temperature and composition of the PHBEnol-water system and to study the effect of impurities on it.

II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:
simple eutectic and
congruently melting systems.

III. Distribution of acetic/ benzoic acid between water and cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n$

V. Study the kinetics of the following reactions.
1.Initial rate method: Iodide-persulphatereaction 2.Integrated rate method:

a. Acid hydrolysis of methyl acetate with hydrochloric acid.

b. Saponification of ethyl acetate. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption
Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Text/Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R.

Chand & Co.: New Delhi (2011).

- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry3rd Ed.;* W.H. Freeman & Co.: New York (2003).

CHYB4010	Basic Analytical Chemistry	4L:0T:0P	4 Credits

Course Learning Objectives:

The objective of this course is:

1. To introduce students about analytical chemistry and its concept.
2. To impart knowledge of analysis of soil and water.
3. To make students study about food products and preservatives.
4. To make students learn about chromatography and constituents of cosmetics.
5. To study the use spectrophotometer and flame photometer for performing different experiments.

Unit 1: **Introduction:** L: 5

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Unit 2: **Analysis of soil and water:**L: 7 Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators Determination of pH of soil samples. Estimation of Calcium and Magnesium ions as Calcium carbonate by Complexometric titration. Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample.

Unit 3: **Analysis of food products**: L:6

Nutritional value of foods, idea about food processing and food preservations and adulteration.

Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

Unit 4: **Analysis of preservatives and colouring matter:** L: 6

Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible). Analysis of cosmetics: Major and minor constituents and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by Complexometric titration.

Unit 5: **Suggested Applications(Any one):** L:6

To study the use of PHBEnolphthalein in trap cases.
To analyze arson accelerants.
To carry out analysis of gasoline.
Suggested Instrumental demonstrations:
Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Text/ Reference Books:

1. Willard, H. H. *Instrumental Methods of Analysis*, CBS Publishers.
2. Skoog &Lerry. *Instrumental Methods of Analysis*, Saunders College Publications, New York.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6th Ed.*, Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. *Quantitative Chemical Analysis*, W. H. Freeman.
5. Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
6. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry *2nd Ed.*, W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall.
10. Vogel, A. I. Vogel's *Quantitative Chemical Analysis6th Ed.*, Prentice Hall.
11. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.*, Marcel Dekker, Inc., New York (1995).

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To develop the knowledge of analytical chemistry.
2. To analyse composition and concepts of soil and water.
3. To understand some food products and identification of some common food items.
4. To develop the knowledge of ion exchange chromatography.
5. Handle flame photometer and spectrophotometer.

CHYB4011	**Basic Analytical Chemistry Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Determination of pH of soil samples.
2. Estimation of Calcium and Magnesium ions as Calcium carbonate by Complexometric titration.
3. Determination of pH, acidity and alkalinity of a water sample.

4. Determination of dissolved oxygen (DO) of a water sample.
5. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
6. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
7. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
8. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Generic Electives offered by Department of Biotechnology for students in B.Sc. (Hons.) in Allied Programmes etc.)

Semester	Course Code	Generic Electives	(L-T-P)	Credits
I	BCHB1010+BCHB1011	Biochemistry & Metabolism	4-0-2	6
I	BINB1020+BINB1021	Biomolecules and Cell Biology	4-0-2	6
II	MCRB3020+MCRB3021	General Microbiology	4-0-2	6
II	BTEB3020+BTEB3021	Immunology	4-0-2	6
III	BTEB4030+BTEB4031	Molecular Biology	4-0-2	6
III	BTEB4020+BTEB4021	Bioprocess technology	4-0-2	6
IV	BTEB5010+BTEB5011	Principles of Genetics	4-0-2	6
IV	BTEB5030+BTEB5031	Bioanalytical tools	4-0-2	6

*** Detailed Syllabus for these courses are the same as the courses of the same names and codes offered as DSC courses of the B.Sc. (Hons.) Physics Programme.**

List of Discipline Specific Elective Papers: (Credit: 06 each)

Semester	Course Code (T+P)	Course Name	(L-T-P)	Credits
V	BTEB5020 +BTEB5021	Plant Biotechnology	4-0-2	6
V	BINB5320+ BINB5321	Bioinformatics	4-0-2	6
V	BTEB5310+BTEB5311	Agriculture Biotechnology	4-0-2	6
VI	BTEB6310+BTEB6311	IPR & Biosafety	4-0-2	6
VI	BTEB6320+BTEB6321	Environment Biotechnology	4-0-2	6
VI	BTEB6330+BTEB6331	Nanobiotechnology	4-0-2	6

BTEB5020	PLANT BIOTECHNOLOGY	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To Understand the concept of *in vitro* micropropagation and its various techniques
2. To Understand the various mechanisms of transfer of desired DNA into plant cells
3. To Appreciate the benefits of protoplast isolation and fusion
4. To Understand the benefits of somaclonal variations in crop improvement
5. To Know the basic experimental designs required for a successful transfer of plantlets from labs to farms
6. To Understand the importance of secondary metabolites and their production for commercial use

Detailed Syllabus

UNIT I Micropropagation **15 Lectures)**

Introduction, Cryo and organogenic differentiation, Types of culture: Seed , Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem andshoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation.

UNIT- II In vitro techniques **(20 Lectures)**

In vitro haploid production Androgenic methods: Anther culture, Microspore culture andogenesis Sgnificance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

UNIT - III. Proptoplast culture(15 Lectures)

Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatichybridization, identifiation and selection of hybrid cells, Cybrids, Potential of

somatichybridization limitations.Somaclonal variationNomenclautre, methods, applications basis and disadvantages)

UNIT – IV PGPB (10 Lectures)

Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria.

Text /Reference Books:

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
4. Raven, P.H., Johnson, GB., Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and
6. Organ Culture. Narosa Publishing House.
7. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rd edition. Benjamin Co.
8. Sambrook & Russel. Molecular Cloning: A laboratory manual. (3rd edition)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Contributing towards developing high yielding and good quality crops to meet demands of the farmers and population
2. Contributing towards developing plants for bioremediation and sustaining in stressed climatic conditions
3. Start small scale companies with products that can cater to the agricultural sector
4. Carry out basic research in developing new products
5. Work in institutions and industries contributing to agribiotech sector

PHYB5311	PLANT BIOTECHNOLOGY LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Preparation of simple growth nutrient (knop's medium), full strength, half strength, solid and liquid.
2. Preparation of complex nutrient medium (Murashige & Skoog's medium)
3. To selection, Prune, sterilize and prepare an explant for culture.
4. Significance of growth hormones in culture medium.
5. To demonstrate various steps of Micropropagation.

BINB5320	BIOINFORMATICS	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To provide students with the theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

UNIT I. Introduction (10 Lectures)

History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL,

GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the Web

UNIT II Data generating techniques (20 Lectures)

Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry.

UNIT III Sequence and Phylogeny analysis (20 Lectures)

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

UNIT IV Data bases (10 Lectures)

Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission.

Genome Annotation: Pattern and repeat finding, Gene identification tools.

COURSE OUTCOME

1. Develop an understanding of the basic theory of these computational tools.
2. Gain working knowledge of these computational tools and methods.
3. Appreciate their relevance for investigating specific contemporary biological questions. Critically analyse and interpret the results of their study.

Reference Books:

Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.

2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition.
4. Benjamin Cummings. and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.

BINB5321	**BIOINFORMATICS LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene,
3. Protein information resource (PIR)
4. Understanding and using: PDB, Swissprot, TREMBL
5. Using various BLAST and interpretation of results.
6. Retrieval of information from nucleotide databases.
7. Sequence alignment using BLAST.
8. Multiple sequence alignment using Clustal W.

BTEB5310	AGRICULTURE BIOTECHNOLOGY	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To acquire knowledge about the range of approaches to manipulate and improve plants. Students will demonstrate the ability to develop, interpret, and critically evaluate modern approaches to scientific investigation in field of agriculture.
2. To provide information as how to develop and use biofertilizers in agriculture alongwith utilization of microbes as PGPR.

Detailed Syllabus

Unit1 Introduction to Agricultural biotechnology. 13 Hrs

Crop improvement hybridization and plant breeding techniques. Micropropagation and plant tissue culture technique and its application in agriculture. Somatic hybridization, haploid production and cryopreservation. Study of biopesticides used in agriculture (neem as example). integrated pest management.

Unit2 Mechanism of biological nitrogen fixation process.

study of NIF, NOD and HUP genes in nitrogen fixation process. Production of biofertilizers and applications of rhizobium, azotobacter, azolla and mycorrhiza. Use of plant growth regulators in agriculture and horticulture.

Unit 3 Green House technology

Green house Technology-- Types of green house, importance, functions and features of green house, Design criteria and calculation Construction material, covering material and its characteristics, growing media, green house irrigation system. Nutrient management Greenhouse heating, cooling and shedding and ventilation system, Computer controlled environment, Phytotrons, fertigation and roof system **,** Precision Cultivation- tools, sensors for information acquisition

Unit 4 Plant stress biology

Abiotic stress –Physiological and molecular responses of plants to water stress, salinity stress, temperature stress – heat and cold, Photooxidative stress, stress perception and stress signalling pathways, Ionic and osmotic homeostasis, reactive oxygen species scavenging,

Biotic stress - plant interaction with biology bacterial, viral and fungal pathogens, plant responses to pathogen–biochemical and molecular basis of host-plant resistance , toxins of fungi and bacteria , systemic and induced resistance –pathogen derived resistance, signaling

Unit 5 Molecular markers in Plant Breeding

Genetic markers in plant breeding—Classical markers DNA markers(RFLP, RAPD, AFLP, SSR, SNP) Applications of molecular markers to plant breeding [quantitative trait locus (QTL) mapping] Plant DNA Barcoding- BarcodingMarkers (matK, rbcl, ITS, tmH-psbA), steps, recent advances, Benefits, Limitations

Text Books/ Reference Books

COURSE OUTCOME

2. Acquire knowledge about the range of approaches to manipulate and improve plants, animals and microorganisms.
3. Demonstrate the ability to develop, interpret, and critically evaluate modern approaches to scientific investigation.
4. understand the relationship between society and science and the justification for biotechnological manipulation of plants, animals, and microorganisms.

BTEB5311	**AGRICULTURE BIOTECHNOLOGY Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. RAPD analysis demonstration experiment
2. Isolation of Rhizobium
3. Isolation of Azotobacter
4. Isolation of Phosphate solubilising bacteria
5. Study of effect of abiotic stress on plants.
6. Rapid screening tests for abiotic stress tolerance (drought, - PEG, Mannitol &salinity NaCl)
7. Estimation of antioxidants and antioxidant enzymes - Ascorbate, Catalase, and Peroxidase
8. Visit to green house facility and submission of field visit report.

BINB5320	**I.P.R. ENTREPRENEURSHIP BIOETIHCS& BIOSAFETY**	**4L:0T:0P**	**4 Credits**

Course Learning Objective:

The objectives of this course are:

1. To provide an insight and understanding about different aspects of protection of inventions and research developments
2. Learn about procedures for filling protection through Intellectual Property Rights.
3. To provide scopes of protection of diverse intellectual properties and its commercialization forsocio-economic improvement.

Detailed Syllabus

Unit 1. Introduction (12 lectures)

1.1.Introduction to Indian Patent Law.
1.2.World Trade Organization and its related intellectual property provisions.
1.3.Intellectual/Industrial property and its legal protection in research, design anddevelopment.
1.4. Patenting in Biotechnology, economic, ethical and depository considerations.

Unit 2. Entrepreneurship (12 lectures)

2.1. Entrepreneurship: Selection of a product, line, design and development processes
2.2. economics on basic regulations of excise:
2.3. Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations export potential etc.

Unit 3 . Bioethics (12 lectures)

3.1. Bioethics – Necessity of Bioethics
3.2. Different paradigms of Bioethics – National & International.
3.3. Ethical issues against the molecular technologies.

Unit 4. Biosafety (12 lectures)

4.1. Biosafety– Introduction to biosafety and health hazards concerning biotechnology.
4.2. Introduction to the concept of containment level
4.3. Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To enable students with basic concepts and knowledge of intellectual property rights.
2. To apply and execute different types of IP protection in research and academics.
3. Able to understand about the mechanisms of different IP protections, registrations and applications Technical
4. To be capable of tackling issues related to IP and its commercialization
5. To learn the strategies for effective IP management and commercialization Analytical skills

Reference Books:

1. Entrepreneurship: New Venture Creation : David H. Holt
2. Patterns of Entrepreneurship : Jack M. Kaplan
3. 3Entrepreneurship and Small Business Management: C.B. Gupta, S.S. Khanka, Sultan Chand & Sons.
4. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
5. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international

BINB5321	**I.P.R. ENTREPRENEURSHIP BIOETIHCS& BIOSAFETY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Proxy filing of Indian Product patent
2. Proxy filing of Indian Process patent
3. Planning of establishing a hypothetical biotechnology industry in India
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence.
7. Case study on handling and disposal of radioactive waste

BTEB6320	**ENVIRONMENT BIOTECHNOLOGY**	**5L:1T:0P**	**6 Credits**

Course Learning Objective:

The objectives of this course are:

1. To Gain an understanding of the types of renewable sources of energy and its production.
2. To Study the different xenobiotic compounds and its degradation

3. To Discuss the various bioremediation strategies.

Detailed Syllabus

UNIT I Conventional fuels (18 Lectures)

Conventional fuels and their environmental impact – Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact – Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol

UNIT II Bioremediation (20 Lectures)

Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents. Degradation of lignin and cellulose using microbes. Phyto-remediation. Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinates hydrocarbons and petroleum products.

UNIT III Waste Treatment (12 Lectures)

Treatment of municipal waste and Industrial effluents. Bio-fertilizers
Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM)

UNIT IV Bioleaching (10 Lectures)

Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium).
Environmental significance of genetically modified microbes, plants and animals.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Domestic waste water treatment, Classification Of Waste water treatment
2. Biodegradation-Concept, Biodegradation of hydrocarbon, Measurement of biodegradation Bioremediation-Concept, Methods of Bioremediation (In-situ and Ex-situ Bioremediation)
3. Phytoremediation-Concept(Rhizofiltration,Phytotransformation,Phytostimulation)
4. Xenobiotics and recalcitrant ,Generalize Fate of xenobiotic Degradation
5. Xenobiotic biodegradation, Herbicide Degradation ,Metabolism of Xenobiotics

Reference Books:

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mohapatra
3. Environmental Biotechnology – Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology : Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright
8. Principles of Environmental Engineering, Gilbert Masters
9. Wastewater Engineering – Metcalf & Eddy

BTEB6321	**ENVIRONMENT BIOTECHNOLOGY LAB**	**0L:0T:2P**	**4 Credits**

LIST OF EXPERIMENTS:

1. Calculation of Total Dissolved Solids (TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. Bacterial Examination of Water by MPN Method

BTEB6330	NANOBIOTECHNOLOGY	4L:0T:0P	4Credits

Course Learning Objective:

The objectives of this course are:

1. Introduction to Nanomaterial and various material used for obtaining nano-materials
2. Learn various approaches or methods used for nanomaterial synthesis.
3. To learn various analytical techniques used for nanomaterial characterization.
4. Learn various applications of nanomaterial in health care, agriculture and environmental monitoring

Detailed Syllabus

Unit 1 Introduction, History &Applications:

1.1. Various definitions and Concept of Nano-biotechnology & Historical background. Fundamental sciences and broad areas of Nano-biotechnology.

1.2.Va rious applications of Nanobiotechnology, Cell – Nanostructure interactions

Unit 2 Synthetic methodologies:

2.1. Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterials:

2.2. Lithography method, Electrochemical method, Mechanical Method, Chemical Synthesis, Chemical vapour deposition, Molecular self-assembly, Laser Induced assembly.

Unit 3 Techniques used for the characterization of nanoparticles:

3.1. Principles of microscopy-light, electron, fluorescent confocal, scanning and transmission microscopes, different fixation and staining techniques for EM.

3.2. Principles of spectroscopy-UV, visible, CD, FTIR, NMR, and ESR spectroscopy, structure determination using X-ray diffraction, analysis using light scattering

Unit 4 Nano-biotechnologicalapplications in health and disease:

4.1. Properties of different types of nanoparticles normally used in health and disease. Diagnostics and theranostics application of nanomaterials in health Sciences

Unit 5 Nanobiotechnological applications in Environment and food - detection and mitigation:

5.1. Properties of different types of nanoparticles normally used in environmental and food sciences. 5.2 Detection and removal of toxic metal ion from polluted sample and detection and removal of pathogen form food sample.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Introduction to Nano (Basics to Nanoscience and Nanotechnology)

2. Introduction to the two approaches (bottom up and top down) followed for the synthesis of nanomaterial and fundamental properties of Nano-materials(Nano-effect)
3. Introduction to various technique used for the characterization of nanostructures and nanomaterial.
4. Fundamental understanding of nanomaterial/nanobiotechnological application in health and disease.
5. Fundamental understanding of nanomaterial/nanobiotechnological application in Environment and food – detection and mitigation

Reference Books:

1. C. A. Mirkin and C. M. Niemeyer. Nanobiotechnology - II more concepts and applications. (2007) - Wiley VCH.
2. P. Boisseau, P. Houdy, M. Lahmani, Nanoscience: Nanobiotechnology and Nanobiology

BTEB6331	**NANOBIOTECHNOLOGY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

Synthesis of Al2O3 nanoparticles using Sol Gel method.
Synthesis of semiconductor (ZnS, CdS etc.) nanoparticles by Chemical method
Synthesis of nanoparticles using Biological process
Detection of nanoparticles in colloidal solutions using UV-Vis absorption technique.
Analysis of AFM, SEM and TEM pictures.

List of Skill Enhancement Course (any Two, 1 in each Sem III & Sem IV) (Credit: 02 each)

Semester	Course Code	Course Name	(L-T-P)	Credits

III	BTEB3210+BTEB3211	Basics Of Forensic Science	2-0-0	2
III	BTEB3210+ BTEB3211	Molecular Diagnostics	2-0-0	2
IV	BTEB4210+BTEB4211	Basics of Neuroscience	2-0-0	2
IV	BTEB4220+ BTEB4221	Animal Biotechnology	2-0-0	2

BTEB3210	**BASICS OF FORENSIC SCIENCE**	**2L:0T:0P**	**2 Credits**

Course Objective:

The objectives of this course are:

1. To organize students' abilities to evaluate competing explanations.
2. Inculcate moral value, professional ethics and business communication skills in the students.
3. To organise students with skills in reconstructing events surrounding an incident and form an opinion based on scientific evidence.
4. To interpret scientific data in the laboratory and the Crime scene.

Detailed Syllabus

Unit 1 Introduction to forensic science (12 lectures)

1.1.Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science,

1.2. branches of forensic science, causes of crime, role of modus operandi in criminal investigation.

1.3. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit 2 Chemicals and explosives (12 lectures)

2.1 Classification of fire arms and explosives, introduction to internal, external and terminal ballistics.

2.2.Chemical evidence for explosives.

2.3. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit 3 Toxicology 12 lectures)

3.1.Role of the toxicologist, significance of toxicological findings,

3.2. Fundamental principles of fingerprinting, classification of fingerprints,

3.3.development of finger print as science for personal identification,

Unit 4 Techniques in forensic science (12 lectures)

5.1.Principle of DNA fingerprinting, application of DNA profiling in forensic medicine,

5.2.Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers,Introduction to Cyber security

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Demonstrate competency in the collection, processing, analyses, and evaluation of evidence.
2. Demonstrate competency in the principles of crime scene investigation, including the recognition, collection, identification, preservation, and documentation of physical evidence.
3. Demonstrate an understanding of the scientific method and the use of problem-solving within the field of forensic science.
4. Identify the role of the forensic scientist and physical evidence within the criminal justice system.
5. Demonstrate the ability to document and orally describe crime scenes, physical evidence, and scientific processes.
6. Identify and examine current and emerging concepts and practices within the forensic science field.

Reference Books:

1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press,Washington.
2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001). _
3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002). _
4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005). _
5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997). _
6. R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004). _
7. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013).

BTEB3210	**MOLECULAR DIAGNOSTICS**	**2L:0T:0P**	**2 Credits**

Course Objective:

The objectives of this course are:

To sensitize the students about the recent advances in molecular biology and various facets of molecular medicine which has the potential to profoundly alter many aspects of modern medicine including the pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

UNIT I Enzyme Immunoassays: **(15 Lectures)**

Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme

immunoassays. Enzyme immunoassays after immuno blotting. Enzyme immuno histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology

UNIT II Molecular methods in clinical microbiology: (15 Lectures)

Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphismand plasmid finger printing in clinical microbiology

Laboratory tests in chemotherapy:Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibilitytests:Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automatedprocedures for antimicrobial susceptibility tests.

UNIT III –Microbial Diagnostics (18 Lectures)

Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies. Concepts and methods in idiotypes. Antiidiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immuno florescence. Radioimmunoassay.

UNIT IV Clinical Techniques (12 Lectures)

GLC, HPLC, Electron microscopy, flowcytometry and cell sorting.

COURSE OUTCOME

1. Gain an understanding of the basic Principles used in Molecular Diagnosis.
2. Gain critical thinking and analytical skills to understand new Diagnostic Methods.
3. Apply the knowledge and skills gained in the course should be useful in developing new Diagnostic Kits

Reference Books:

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker Bioinstrumentation, Webster
2. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic
3. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
4. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
5. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
6. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. Appleton- Centuary-Crofts publication.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's
8. Microbiology. 7th edition. McGraw Hill Higher Education.
9. Microscopic Techniques in Biotechnology, Michael Hoppert

BTEB4210	**BASICS OF NEUROSCIENCE THEORY**	**2L:0T:0P**	**2 Credits**

Course Objective:

1. To Describe the cellular composition of the nervous system and the process of communication between these cells.
2. To Demonstrate a basic understanding of the functional anatomy of the nervous system.

3. To Explain the neural basis of sensation and perception.
4. To Apply knowledge of the functional anatomy of the nervous system to the analysis of human behaviour.
5. To Discuss the process of development and change in the nervous system

Detailed Syllabus:

Unit 1: Introduction to Neuroscience

1.1.Origins of Neuroscience; Neuroanatomy,

1.2. Neurophysiology, and Systems Neurobiology

Unit 2: The Nervous system

2.1. Introduction to the structure and function of the nervous system:

2.2. Cellular components: Neurons; Neuroglia; Neuron doctrine; The prototypical neuron – axons and dendrites as unique structural components of neurons.

2.3. The ionic bases of resting membrane potential; The action potential- its generation and properties; The action potential conduction.

Unit 3: Cellular and Molecular Neurobiology

3.1. Molecular and cellular approaches used to study the CNS at the level of single molecules,

3.2. Synapse: Synaptic transmission, Types of synapses; synaptic function; Principles of chemical synaptic transmission;

3.3.Principles of synaptic integration; EPSPs and IPSPs. Ion channels, Neural transmission, **Unit 4. Neurotransmitters**

4.1. Different types of neurotranmitters– catecholamines, amino acidergic and peptidergic neurotransmitters; Transmitter gated channels;

4.2. G-protein coupled receptors and effectors, neurotransmitter receptors; Ionotropic and metabotropic receptors.

Unit 5: Neurobiology And Neuropharmacology Of Behaviour

5.1. The principles of signal transduction and information processing in the vertebrate central nervous system, and the relationship of functional properties of neural systems with perception and behavior; sensory systems, molecular basis of behavior including learning and memory.

5.2. Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, etc.

Course Outcomes:

1. Understand major advances in neuroscience, neural basis of emotions, behaviour, learning and memory, and how brain and behaviour can be trained/ modified by experience ever since its emergence as a major field of science, understand the,
2. Discuss how the hypothalamus controls various behavioural patterns by releasing neurohormones/ neuropeptides in brain and periphery in response to various signals,
3. Construe neural mechanisms of learning and memory (spatial and episodic memory etc.) and how specific circuits contribute to learning and memory,
4. Develop an understanding as to what is cognition and how it enables us to react to various situations appropriately and how neurological diseases affect cognition,

5. Understand cellular and molecular mechanisms that underlie cognition such as synaptic plasticity and organisation of memory, memory persistence and forgetfulness, the role of sleep in cognition etc

Reference Books:

1. Neuroscience: Exploring the brain by Mark F. Baer; Barry W. Connors. 2015
2. From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience by John H. Byrne. Ruth Heidelberg and M. Neal Waxham
3. Neuroscience-Eds. Dale Purves et. al. (3rd Edn)-Sinauer Associates, Inc.-2004
4. Principles of Neural Science-4th Edn-Eds. Kandel, Schwartz and Jessell- McGrawHill Companies-2000
5. Nerve Cells and Animal Behaviour-2nd Edn-Peter J Simmons and David YoungCUP-2003
6. Essential Psychopharamacology- Neuroscientific Basis and Practical Applications2nd Edn.-Stephan M. Stahl-CUP-2000
7. Phantoms in the Brain - Vilayanur S. Ramachandran and Sandra Blakeslee-1998
8. The Human Brain Book - Rita Carter-2009

BTEB4220	ANIMAL BIOTECHNOLOGY THEORY	2L:0T:0P	2 Credits

Course Objective:

1. To provides a toolkit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine.
2. To Equips students with basic tools of biotechnology which are a must for everyone interested in pursuing a career in biotechnology.
3. To makes one aware of the scope of this field which encompasses almost every field of science like engineering, research, commercialization and academics

Detailed Syllabus:

Unit 1. Introduction

Concept and scope of biotechnology

Unit 2. Molecular Techniques in Gene manipulation

2.1.Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics).

2.2. Restriction enzymes: Nomenclature, detailed study of Type II.

2.3. Transformation techniques: Calcium chloride method and electroporation.

2.4. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

2.5. Southern, Northern and Western blotting DNA sequencing: Sanger method Polymerase Chain Reaction, DNA Finger Printing and DNA micro array

Unit 3. Genetically Modified Organisms

3.1. Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection

3.2. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.

3.3. Production of transgenic plants: Agrobacterium mediated transformation.
3.4. Applications of transgenic plants: insect and herbicide resistant plants.

Unit 4. Culture Techniques and Applications

4.1. Animal cell culture, Expressing cloned genes in mammalian cells,
4.2. Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)
4.3. Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

Unit 5 Transgenesis

5.1. Introduction to transgenesis.
5.2. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect.
5.3. Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. It gives insight into various cell/tissues culture techniques
2. Understanding of in vitro culturing of organisms and production of transgenic animals.
3. Understanding of cloning of mammals, large scale culture and production from recombinant microorganisms
4. Gains skills in medical, environmental biotechnology, biopesticides, Biotechnology of aquaculture and use of animals as bioreactors
5. This insight allows students to take into consideration about ethical issues involved in production transgenic animals and BT products.

Reference Books:

1. Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
2. Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
3. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
4. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. V Edition, John Wiley and Sons Inc.

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