Scheme and Syllabus of Examination

B.Sc Honours Biotechnology

Under

Choice based Credit System

Course Effective from Academic Session 2019-20

Department of Microbiology and Bioinformatics

Atal Bihari Vajpayee University, Bilaspur (CG)

MINIMUM COURSE CURRICULUM FOR UNDERGRADUATE COURSES UNDER CHOICE BASED CREDIT SYSTEM

Background/

Preamble: Ministry of Human Resource Development (HRD), Govt. of India, has already initiated the process for developing New Education Policy (NEP) in our country to bring out reforms in Indian education system. University Grants Commission (UGC) participates more actively in developing National Education Policy, its execution and promotion of higher education in our country. The UGC has already initiated several steps to bring equity, efficiency and academic excellence in National Higher Education System. The important ones include innovation and improvement in course- curricula, introduction of paradigm shift in learning and teaching pedagogy, examination and education system. The education plays enormously significant role in building of a nation. There are quite a large number of educational institutions, engaged in imparting education in our country. Majority of them have entered recently into semester system to match with international educational pattern. However, our present education system produces young minds lacking knowledge, confidence, values and skills. It could be because of complete lack of relationship between education, employment and skill development in conventional education system. The present alarming situation necessitates transformation and/or redesigning of education system, not only by introducing innovations but developing "learner-centric approach in the entire education delivery mechanism and globally followed evaluation system as well. Majority of Indian higher education institutions have been following marks or percentage based evaluation system, which obstructs the flexibility for the students to study the subjects/courses of their choice and their mobility to different institutions. There is need to allow the flexibility in education system, so that students depending upon their interests and aims can choose interdisciplinary, intra-disciplinary and skill-based courses. This can only be possible when choice based credit system (CBCS), an internationally acknowledged system, is adopted. The choice based credit system not only offers opportunities and avenues to learn core subjects but also exploring additional avenues of learning beyond the core subjects for holistic development of an individual. The CBCS will undoubtedly facilitate us bench mark our courses with best international academic practices. The CBCS has more advantages than disadvantages.

Advantages of the choice based credit system:

- Shift in focus from the teacher-centric to student-centric education.

- Student may undertake as many credits as they can cope with (without repeating all courses in a given semester if they fail in one/more courses).

- CBCS allows students to choose inter-disciplinary, intra-disciplinary courses, skill oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students).

- CBCS makes education broad-based and at par with global standards. One can take credits by combining unique combinations. For example, Physics with Economics, Microbiology with Chemistry or Environment Science etc.

- CBCS offers flexibility for students to study at different times and at different institutions to complete one course (ease mobility of students). Credits earned at one institution can be transferred.

Disadvantages:

- Difficult to estimate the exact marks

- Workload of teachers may fluctuate

- Demand good infrastructure for dissemination of education

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Program Outcome (PO):

The aim of this program is to prepare students to take up a career in biotechnology industry or research. The course curriculum is designed to strengthen the fundamentals in basic subjects and provide hands on practice inall the disciplines of biotechnology.
The program has following specific objectives:

1. To teach courses in basic sciences, communication skills, and introduce the concepts of biotechnology
2. To explain the fundamental concepts of the complexities of life, life functions, and diversity of life onthe planet
3. To impart knowledge about biochemical and molecular underpinnings of the cellular and metabolicfunctions
4. To impart knowledge about tools and techniques used for the genetic manipulation of bacteria, plantsand animals
5. To introduce basic skills required for statistical and biological sequence data analysis
6. To teach courses highlighting the importance of biotechnology for the society
7. To provide necessary training for conducting basic biotechnology experiments

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-1: BIOCHEMISTRY AND METABOLISM (THEORY)
SEMESTER –I

Course objective: This course is aimed to introduce the knowledge of biomolecules and their role in metabolic pathways. Also, it deals with the structure and function of enzymes.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to Biochemistry: (10 Periods)
A historical prospective. Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids, 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. 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 II (10 Periods)
Lipids: Structure and functions –Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol.

UNIT III (10 Periods)
Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines,. Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA

UNIT IV (20 Periods)
Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Biocatalysts from extreme thermophilic and hyperthermophilic archaea and bacteria. Role of: NAD+ , NADP+, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate,lipoic-acid, Biotin vitamin B12, Tetrahydrofolate and metallic ions

UNIT V (10 Periods)
Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.

CC-1: BIOCHEMISTRY AND METABOLISM LAB
(PRACTICALS)
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

1. To study activity of any enzyme under optimum conditions.
2. Design of Bimolecular structures using softwares
3. RasMol and JMol: Visualization of geometrical structure of simple molecules like carbohydrates, fatty acids, amino acids and proteins

4. To study the effect of pH, temperature on the activity of salivary amylase enzyme.
5. Determination of - pH optima, temperature optima, Km value, Vmax value, Effect of inhibitor (Inorganic phosphate) on the enzyme activity.
6. Estimation of blood glucose by glucose oxidase method.
7. Principles of Colorimetry: (i) Verification of Beer's law, estimation of protein. (ii) To study relation between absorbance and % transmission.
8. Preparation of buffers. 7. Separation of Amino acids by paper chromatography.
9. Qualitative tests for Carbohydrates, lipids and proteins

SUGGESTED READING

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants.American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

Course Learning outcome (CLO): At the end of the course the student will:

1. Understand the structure of biomolecules (proteins, carbohydrates, lipids, nucleic acid) and their different roles in biological systems
2. Develop an understanding of structure and function of enzymes
3. Understand the coordinated regulation of carbohydrate metabolic pathway.
4. Learn about energy generating pathways like lipid and protein metabolism and their regulation

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-2: CELL BIOLOGY (THEORY) SEMESTER –I

Course Objective: Cell is the structural and functional unit of life. It is often referred to as the building block of life as well. The course on cell biology aims to impart knowledge of cell structure and functions of diverse cellular organelles.

CREDITS: 4

TOTAL HOURS: 60

UNIT I (10 Periods)

Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II (10 Periods)

Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules, Microfilaments, Intermediate filaments. Endoplasmic reticulum: Structure, function including role in protein segregation. Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT III (20 Periods)

Lysosomes: Vacuoles and micro bodies: Structure and functions Ribosomes: Structures and function including role in protein synthesis. Mitochondria: Structure and function, Genomes, biogenesis. Chloroplasts: Structure and function, genomes, biogenesis Nucleus: Structure and function, chromosomes and their structure.

UNIT IV (10 Periods)

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction.

UNIT V (10 Periods)

Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer

C-2: CELL BIOLOGY Lab
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

1. Study the effect of temperature and organic solvents on semi permeable membrane.
2. Demonstration of dialysis.
3. Study of plasmolysis and de-plasmolysis.
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
5. Study of structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions

SUGGESTED READINGS

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. ASMPress & 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.

Course Learning Outcome (CLO) : Upon successful completion of the course, the student will:
1. Understand cellular organization and composition of prokaryotic and eukaryotic cells
2. Remember the concepts of Structure and functions of cellular organelles
3. Comprehend the role of different cell organelles and properties of cell membrane
4. Learn signal transduction in cells and introduction to cancer, its types and treatment

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
AECC-1: English Communication
(THEORY)
SEMESTER –I

Course Learning Objectives: 1. To define and explain various techniques of word formation; and develop skills of sensible writing and vocabulary building. 2. To illustrate and elaborate fundamental techniques and features of writing skills. 3. To demonstrate and discuss various types of common errors committed by users of English and solve exercises to develop their understanding in use of grammatically correct sentences. 4. To organize language lab activities and workshops to develop oral communication skills.

TOTAL HOURS: 60

CREDITS: 4

Unit 1. Introduction: Theory of Communication, Types and modes of Communication
Unit 2. Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication
Unit 3. Speaking Skills: Monologue Dialogue Group Discussion Effective Communication/ Mis-Communication Interview Public Speech
Unit 4. Reading and Understanding Close Reading Comprehension Summary Paraphrasing Analysis and Interpretation Translation(from Indian language to English and vice-versa) Literary/Knowledge Texts
Unit 5. Writing Skills Documenting Report Writing Making notes Letter writing

Recommended Readings:

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brati Biswas

Course Learning Outcomes (CLO): On completion of this course, the students will be able to:

1. Recall and explain different techniques of word formation; and demonstrate knowledge of synonyms, antonyms and skills of sensible writing.
2. Identify and analyze common errors in English and solve exercises based on them; apply acquired knowledge and skills of oral and written communication in personal and professional skills

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
GE-1: Biotechnology and Human Welfare (THEORY) SEMESTER –I

Course Objective: The course introduces students to the fundamentals of biotechnology, current trends and careers in biotechnology, regulatory, and ethical aspects of biotechnology. The knowledge and skills gained in this course will provide students with a broad understanding of biotechnology and its impact on society

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I- Industry [10 Hours]
Protein engineering; enzyme and polysaccharide synthesis, activity and secretion, alcohol and antibiotic formation.

UNIT II-Agriculture [10 Hours]
N2 fixation: transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock.

UNIT III-Environment [20 Hours]
Chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB.

UNIT IV- Forensic Science [10 Hours]
Solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.

UNIT V- Health [10 Hours]
Development of nontoxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in E. coli, human genome project

GE-1: Biotechnology and Human Welfare Lab
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

1. Perform ethanolic fermentaion using Baker's yeast
2. Study of a plant part infected with a microbe
3. Perform quantitative estimation of residual chlorine in water samples
4. Isolation and analysis of DNA from minimal available biological samples (and demonstrate food adulteration)
5. Case studies on Bioethics
6. Study the interaction of probiotics bacteria with food
7. Demonstration of biofuel production via Virtual Lab
8. Study protein denaturation
9. Study plant diversity of the University campus
10. Demonstration of antibiotic production by video tutorials

SUGGESTED READING

1. Sateesh, MK 2010. Bioethics and Biosafety. IK International Pvt Ltd.
2. Dubey, RC 2010. A Textbook of Biotechnology. S Chand Publications.
3. Singh, BD 2013. Expanding Horizons in Biotechnology. Kalyani Publication.

Course Learning Outcome (CLO) : Upon successful completion of this course, the student will:
1. Recognize the importance of various molecular techniques used in biotechnological industry and the importance of modern agriculture and its application.
2. Understand the importance of biotechnology in relation to environment and pollution.
3. Learn about various applications-based techniques in biotechnology like forensic science and the related activities currently going on and that will lay the foundations for the future work in relation to crime.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-3: Mammalian Physiology (THEORY) SEMESTER –II

Course objective: The objectives of the course are as follows: 1. To examine basic concepts of mammalian physiology 2. To understand mechanisms of digestion, respiration, circulation and endocrine function 3. To explore the physico-chemical basis and operation of each organ system.

TOTAL HOURS: 60 CREDITS: 4

UNIT I: Digestion and Respiration (15 Periods)
Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice Respiration: Exchange of gases, Transport of O2 and CO2, Oxygen dissociation curve, Chloride shift

UNIT II: Circulation (10 Periods)
Composition of blood, Plasma proteins & their role, blood cells, Haemopoisis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT III: Muscle physiology and osmoregulation (15 Periods)
Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction. Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation

UNIT IV: Nervous and endocrine coordination (10 Periods)
Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction

UNIT V: Neurotransmitters (10 Periods)
Mechanism of action of hormones (insulin and steroids) Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions

C-3: Mammalian Physiology Lab
SEMESTER –II

TOTAL HOURS: 60 **CREDITS: 2**

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Determination of Haemoglobin
7. Analyze the action of catalase enzyme
8. Separation of plasma and serum from the whole blood
9. Study pulmonary function test via online video tutorial

SUGGESTED READING

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.

Course Learning outcomes (CLO): At the end of course the student will be able to: 1. Understand the working of digestive and respiratory systems of mammals. 2. Learn about the functioning and components of the circulatory system. 3. Comprehend the role of nervous system in coordinating the muscular and sensory functions of the mammalian body.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-4: PLANT ANATOMY AND PHYSIOLOGY (THEORY)
SEMESTER –II

Course Objective: The objectives of the course are as follows: 1. To provide detailed information about the basic principles of plant function 2. To teach the plant-water relationships 3. To teach principles of plant cell physiology and plant growth and development 4. To teach carbon and nitrogen metabolis

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Anatomy (10 Periods)
The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

UNIT II: Plant water relations and micro & macro nutrients (10 Periods)
Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing. Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

UNIT III: Carbon and nitrogen metabolism (10 Periods)
Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point

UNIT IV: Nitrogen metabolism (10 Periods)
inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants. Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene)

UNIT V: Secondary metabolites and Plant stress physiology (20 Periods)
Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism and vernalization. Definition of Secondary metabolites, classification (terpenes, phenolics, flavonoids, tannins, glycosides, alkaloids). Biosynthetic pathway of secondary metabolites. Stress physiology: Abiotic and biotic stress. Physiological role of secondary metabolites in plants during stress

C-4: PLANT ANATOMY AND PHYSIOLOGY Lab
SEMESTER –II

TOTAL HOURS: 60 **CREDITS: 2**

1.Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of plasmolysis by Tradescantia leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

SUGGESTED READING

1.Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.

8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4 th edition, Sinauer Associates Inc .MA, USA

Course Learning Outcome (CLO) : Upon successful completion of this course the student should be able to understand: 1. Understand the basics of plant physiology and physiological mechanisms governing plant growth and development 2. Learn the basics of transport in plants and movement of solutes and water 3. Remember the basics of photosynthesis, respiration and hormonal signalling as it impacts plant growth and development

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

AECC-2 Environmental Sciences (THEORY)

Course Objective: The basic objective of the environmental studies is to enable the students for interdisciplinary approach to complex environmental problems using basic tools of the natural and social sciences including ecosystem, geosystems, biology, chemistry and global process. They will acquire an attitude of concern for the environment and will be able to critically evaluate the science and policy ramifications of diverse portfolios on air and water quality, natural resources etc.

SEMESTER –II

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 : Introduction to environmental studies (10 Periods)

Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.

Ecosystems What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems :

a) Forest ecosystem
b) Grassland ecosystem
c) Desert ecosystem
d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 2 : Natural Resources : Renewable and Non---renewable Resources (10 Periods)

Land resources and landuse change; Land degradation, soil erosion and desertification.

Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations.

Water : Use and over--exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter---state).

Energy resources : Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 3 : Biodiversity and Conservation (10 Periods)

Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India;

Biodiversity patterns and global biodiversity hot spots

India as a mega---biodiversity nation; Endangered and endemic species of India

Threats to biodiversity : Habitat loss, poaching of wildlife, man--wildlife conflicts, biological invasions;

Conservation of biodiversity : In---situ and Ex---situ conservation of biodiversity.

Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 4 : Environmental Pollution (10 Periods)

Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution Nuclear hazards and human health risks

Solid waste management : Control measures of urban and industrial waste.

Pollution case studies.

Unit 5 : Human Communities and the Environment (10 Periods)

Human population growth: Impacts on environment, human health and welfare.

Resettlement and rehabilitation of project affected persons; case studies.

Disaster management : floods, earthquake, cyclones and landslides.

Environmental movements : Chipko, Silent valley, Bishnois of Rajasthan.
Environmental ethics: Role of Indian and other religions and cultures in environmental conservation.
Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

SUGGESTED READING

1. Text book of Environmental Studies for undergraduate courses by E. Bharucha (University PressPublication).
2. Environmental Studies: From Crisis to Cure by R. Rajagopalan (Oxford University Press).
3. Environmental Science by S.C. Santra (New Central Book Agency (P) Ltd., Kolkata).

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. To **tell** some introductory knowledge on concepts and general principles regarding environment.

2. To **illustrate** role of education, religions, cultures, movements and sustainable developmental activities in ecological preservation.

3. To aim at **understanding** the sources, effects and control measures of pollution of air, water, land, noise, solid wastes and also creating awareness on globally recognized environmental challenges.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
GE-2: BIOETHICS AND BIOSAFETY (THEORY) SEMESTER – II

Course Objectives: The objectives of the course are as follows:

1. To understand importance of bioethics and biosafety.
2. To understand legal social and economic impacts of biotechnology.
3. To understand regulatory guidelines and their importance.
4. To understand importance of patent.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to Bioethics and Biosafety (10 Periods)
Bioethics-Necessity of bioethics, different paradigms of bioethics- National and international ethicalissues against the molecular technologies. Institutional, social, Cultural, Business and Consumerissues.

UNIT II: Biosafety regulation guidelines (10 Periods)
Biosafety-Introduction to biosafety and health hazards concerning biotechnology. Introduction to theconcept of containment level and good laboratory practices (GLP) and good manufacturing practices(GMP). Implications of biotechnological products and techniques: Bioterrorism, transgenic science,GM crops.

UNIT III: Biosafety Regulation (10 Periods)
Genetically modified organisms and their release in environment. Experimental protocol approvals, Laboratory associated infections and other hazards, Risk groups and assessment and levels of biosafety. Pesticides preharvest residue management

UNIT IV: Bioethics towards Biodiversity protection and conservation (10 Periods)
Convention on biodiversity, Indian Biodiversity act, Legal implications, Biodiversity and farmers'rights. Human genome project and stem cells research: Introduction, Ethical, legal and socialimplications of HGP. Stem Cell Research- biosafety and its ethical issues

UNIT V: Food and pharma safety (20 Periods)
The GM-food debate and biosafety assessment procedures for biotech foods and related products, including transgenic food crops, Environmental aspects of biotech applications. Flavr Savr Tomato as model case, Biosafety assessment of biotech pharmaceutical products .

BIOETHICS AND BIOSAFETY Lab (PRACTICAL)
SEMESTER – II

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Study of basic laboratories: Biosafety Levels (BSL) 1 and 2
2. Case study on clinical trials of drugs in India with emphasis on ethical issues
3. Study of containment laboratories: Biosafety Level (BSL) 3
4. Case study on women health ethics
5. Planning of establishing a hypothetical biotechnology industry in India
6. Study the maximum containment laboratory: Biosafety Level (BSL) 4

7. Case study on medical errors and negligence
8. Case study on handling and disposal of radioactive waste
9. Study laboratory hazards: Fire hazards, Electrical Hazards, Noise, Ionizing hazards
10. Transgenic animals/plants: Their effects on environment and health of the consumer
11. Case studies on Bioethics (any two)

SUGGESTED READING

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd
2. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers
3. Thomas JA, and Fuch, RL. 2002. Biotechnology and Safety Assessment. 2002. Academic Press.
4. Fleming, DA, and Hunt, DL. 2000. Biological Safety Principles and Practices. ASM Press.

Course Learning Outcome (CLO) : Upon successful completion of this course the student shouldbe able to:

1. Understand the scope and aspects of Bioethics and biosafety
2. Learn the ethical implications of biotechnology and need for biosafety, GLP and GMP, concernsrelated to GMO's and their regulation.
3. Analyze the safer use of Biotechnology in agriculture, animal husbandry, pharmaceutics, andenvironment by implanting biosafety regulations.
4. Comprehend the ability to understand biosafety assessment procedure for biotech food ,pharmaceuticals and other products.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

ECA: General ---Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others
SEMESTER –II

TOTAL HOURS: 60 **CREDITS: 2**

Marks Based on activities

B.Sc (HONOURS) BIOTEHNOLOGY (CBCS STRUCTURE)
CC-5: GENETICS (THEORY) SEMESTER –III

Course objectives: The objectives of the course are as follows: 1. To make the student understand the Mendelian and non-Mendelian genetics of inheritance. 2. To make the student understand the allele and gene interactions. 3. To make the student learn the fundamentals of chromosome and gene organization. 4. To impart the knowledge about sex determination among humans and animals. 5. To teach the concepts of extra-chromosomal inheritanc

CREDITS: 4

TOTAL HOURS: 60

UNIT I (10 Periods)

Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance. Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms. Mendelian genetics : Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity

UNIT II (10 Periods)

Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes. Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA. Genetic organization of prokaryotic and viral genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III (20 Periods)

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abonormalities– Aneuploidy and Euploidy. Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT IV (10 Periods)

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping. Extra chromosomal

inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting.

Unit V Evolution and population genetics: (10 Periods)
In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

CC-5: GENETICS Lab (PRACTICAL)
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body -Rhoeo translocation.
5. Karyotyping with the help of photographs
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting
7. Study of polyploidy in onion root tip by colchicine treatment.

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:
1. Understand the differences between Mendelian and non-Mendelian inheritance.
2. Learn about different types of allele and gene interactions.
3. Understand mutations and chromosomal aberrations.
4. Learn different kinds of sex determination systems found in different organisms.
5. Understand the fundamentals of population genetics

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-6: GENERAL MICROBIOLOGY **(THEORY) SEMESTER –III**

Course objectives: This course is designed to be an introduction to microbiology that will familiarize students with the diversity within the microbial world, biology of bacteria, their metabolism and genetics, and their control. The specific objectives are:

1. To illustrate the criteria used for classification of microorganisms
2. To explain the structure of a prokaryotic cell

To give an overview of growth, nutrition and metabolism in bacteria

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I (10 Periods)

Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria. Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses

UNIT II (10 Periods)

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

UNIT III (20 Periods)

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria

UNIT IV (10 Periods)

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.

Unit V (10 Periods)

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

CC-6: GENERAL MICROBIOLOGY Lab

SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry.
5. Enumeration of microorganism - total & viable count.
6. Preparation of bacterial growth curve.
7. Antimicrobial sensitivity test.
8. Demonstration of flagella staining.

SUGGESTED READING

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

Course Learning Outcome (CLO): Upon successful completion of this course the student will: 1. Be able to differentiate between different kinds of microorganisms. 2. Understand the structural organization of a prokaryotic cell. 3. Learn the differences between Gram +ve and Gram –ve bacteria. 4. Understand and be able to differentiate between different modes of genetic recombination in bacteria.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-7: Green Chemistry**(THEORY) SEMESTER –III**

Course objectives: The course aims to teach the principles of green chemistry. The specific objectives of the course are:

1. To teach students the basic concepts of green chemistry.
2. To make students understand the importance of green chemistry in sustainable development.
3. To teach students the fundamental principles of biocatalysis, photochemistry andelectrochemistry.

To teach students about green chemistry in daily practice

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction and principles (10 Periods)

Introduction to green chemistry and its guiding principles; green chemistry and industry; waste minimization and atom economy; reduction of material use, reduction of energy requirement; energy efficiency improvements; alternative energy sources; alternative solvents.

UNIT II: Green chemistry and sustainable development (10 Periods)

The concept of sustainability; green chemistry and sustainability's parameters; sustainable use of chemical feedstock; sustainable use of water; sustainable use of energy; environmental resilience; life-cycle assessment: Identification of more sustainable products and processes.

UNIT III: Biocatalysis (10 Periods)

Introduction to biocatalysis; chemical production by biocatalysis: bulk chemicals, pharmaceuticals, flavor and fragrance compounds, carbohydrates, enantiomerically pure synthons, polymers; green biocatalytic processes: biocatalysis in supercritical CO_2, biocatalysis in waste treatment, biodesulfurisation.

UNIT IV: Photochemistry, electrochemistry and fuel cells (10 Periods)

Photons as clean reagents; reduced usage of reagents; photochemical reactors; introduction to green electrochemistry; electrochemical cells; electrochemical waste minimization; recovery and recycling of metal ions; fuel cell electrochemistry; fuel cell applications.

UNIT V: Green chemistry in practice (20 Periods)

Impact of green process technology on the chemical industry; heterogeneous catalysis in practice; homogeneous catalysis in practice; renewables as chemical feedstock and biocatalysis use of renewable feedstock for the production of chemicals; bioproduction of chemicals in industry.

CC-7: Green Chemistry Lab **(PRACTICAL)**
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Acetylation of primary amine by alternative green procedure: Preparation of acetanilide.
2. Bromination of *trans*-stilbene.
3. Base catalyzed aldol condensation by green chemistry method.

4. Separation of food dyes by paper chromatography.
5. Perform Pechmann condensation for coumarin synthesis.
6. Photoreduction of benzophenone to benzopinacol: Study green photochemical reaction.
7. Perform the nitration of phenol by green method.
8. Study synthesis of diesel fuel from vegetable oil.
9. Perform extraction of iron from oatmeal by microwave-induced method.
10. Demonstration of synthesis of green reagents.

SUGGESTED READINGS

1. Clark, J and Macquarrie, D 2002. Handbook of Green Chemistry and Technology, 1st ed.Blackwell Science Ltd.
2. Lancaster, M 2010. Green Chemistry: An Introductory Text, 1st ed. Royal Society of Chemistry
3. Sharma, SK and Mudhoo, A 2010. Green Chemistry for Environmental Sustainability, 1st ed.CRC Press, Boca Raton.
4. Torok, B and Dransfield, T 2017. Green Chemistry: An Inclusive Approach, 1st ed. Elsevier.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the concepts of green chemistry.
2. Learn about the use of biocatalysis for chemical production
3. Know about the diverse applications of green chemistry.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

SEC-1: Molecular Diagnostics SEMESTER – III

Course objectives: The course is designed to give an overview and applications of different molecular biology techniques used in disease diagnosis. The specific objectives of the course are:

1. To teach students different molecular techniques used for disease diagnosis.
2. To make students understand the utilization of these techniques in disease diagnosis.
3. To teach the use of different enzyme immunoassay based diagnostic methods.
4. To impart the knowledge about the molecular diagnostic of different human diseases.

TOTAL HOURS: 30 **CREDITS: 2**

UNIT I: Enzyme immunoassays (20 Periods)

Comparison of enzymes for enzyme immunoassays; conjugation of enzymes; homogeneous and heterogeneous enzyme immunoassays; enzyme immunoassays after immunoblotting; polyclonal or monoclonal antibodies in enzyme immunoassays; immunoassays in diagnostic microbiology.

UNIT II: Molecular methods in clinical microbiology (10 Periods)

Applications of PCR, RFLP, nuclear hybridization methods; single nucleotide polymorphism and plasmid finger printing in clinical microbiology; micro-dilution and macro-dilution broth procedures; diffusion test procedures.

UNIT III: Advanced methods of microbial diagnosis (10 Periods)

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.

UNIT IV: Use of techniques in microbial study (10 Periods)

Immunodiagnostic tests; immunofluorescence; radioimmunoassay; GLC, HPLC; electron microscopy; flow cytometry and cell sorting

UNIT V: Molecular biology based diagnostics(10 Periods)

Molecular diagnostics for infectious diseases; molecular testing for Neisseria; molecular diagnosis for HIV-1; genetic counselling and molecular diagnosis; genetic testing: Need and uses; case studies in molecular diagnostics.

SUGGESTED READING

1. Bruns, DE, Ashwood, ER and Burtis, CAF 2007. Fundamentals of Molecular Diagnostics, 1st ed.Elsevier.
2. Tokas, J 2015. Immunology and Molecular Diagnostics. 1st ed. University Science Press.
3. Wilson, K and Walker, J Editors, S 2010. Principles and Techniques of Biochemistry and Molecular Biology, 7th ed. Cambridge University Press

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Gain an understanding of the principles governing molecular diagnostics.
2. Be able to apply the knowledge and skills gained in the course in developing new moleculardiagnostic kits.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
GE-3: Entrepreneurship Development (THEORY) SEMESTER – III

Course Learning Objectives:

1. To understand the meaning and importance of Entrepreneurship .
2. To understand the various forms of business organisation .
3. To analyze the importance of finance in an enterprise .
4. To analyze the importance of marketing management in an enterprise.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I:Introduction (10 Periods)

Meaning, needs and importance of entrepreneurship;promotion of entrepreneurship;factors influencing entrepreneurship;features of a successful entrepreneurship.

UNIT II:Establishing an enterprise (10 Periods)

Forms of business organization;project identification;selection of the product; project formulation;assessment of project feasibility.

UNIT III:Financing the enterprise (10 Periods)

Importance of finance, loans and repayments;characteristics of business finance;fixed capital management; working capital, its sources and how to move for loans;inventory; raw materials and their management.

UNIT IV:Marketing management (10 Periods)

Meaning and Importance;marketing-mix; product management: product line, product mix; marketing research and importance of survey;physical distribution and stock management.

UNIT V:Entrepreneurship and international business (20 Periods)

Meaning of international business;selection of a product for international market;selection of a marketfor international business;export financing;institutional support for exports.

GE-3: Entrepreneurship Development Lab (PRACTICAL)
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Visit note of successful Enterprise and prepare summary
2. Visit to successful Agri-entrepreneur and prepare summary
3. prepare summary by exposure to *entrepreneurship development* institution
4. Collect information about the different E.D.P. in your Town/City.
5. Conduct and report Training programme in - • Catering • Handicraft • Child care (Day care, Play house) • Health care (Yoga, aerobics, beauty care)

SUGGESTED READINGS

1. Holt, DH 2006. Entrepreneurship: New Venture Creation, Prentice Hall of India Pvt Ltd.
Kaplan,JM and Warren, AC 2016. Patterns of Entrepreneurship Management, 5thed

Learning Outcome: Upon successful completion of this course the student will:

1. Understand the scope and relevance of entrepreneurship.
2. Know the detailed process of establishing and running an enterprise.
3. Have a sound knowledge of loans and their repayment policies.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

ECA: General ---Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others

SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

Marks Based on activities

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-8: Molecular Biology (THEORY) SEMESTER –IV

Course objectives: Molecular biology has witnessed a paradigm shift after the discovery of double helical structure of DNA. This course on molecular biology aims to teach the fundamental role of DNA molecule as a blueprint of life.

CREDITS: 4

TOTAL HOURS: 60

UNIT I: DNA structure and replication [20 Hours]
DNA as the genetic material; DNA: structure, types and replication in prokaryotes and eukaryotes;semiconservative nature of DNA replication, bi-directional replication, DNA polymerases; rolling circle replication;unique aspects of eukaryotic DNA replication;fidelity of replication.

UNIT II: DNA damage, repair and homologous recombination [10 Hours]
DNA damage and repair: causes and types of DNA damage; mechanism of DNA repair:photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining;models and mechanism of homologousrecombination.

UNIT III: Transcription and RNA processing [10 Hours]
RNA structure and types of RNA;transcription in prokaryotes: prokaryotic RNA polymerase, role of sigma factor;transcription in eukaryotes: eukaryotic RNA polymerases, transcription factors, promoters, enhancers; mechanism of transcription initiation, promoter clearance and elongation;processing of pre-mRNA: 5' cap formation, polyadenylation; RNA splicing.

UNIT IV: Translation [10 Hours]
Genetic code and its characteristics; Eukaryotic translation: ribosome structure and assembly;charging of tRNA, aminoacyltRNAsynthetases;mechanism of initiation, elongation and termination of polypeptides;fidelity of translation;inhibitors of translation; post translational modifications and their importance; methods of post translational modifications.

UNIT V: Gene expression regulation [10 Hours]
Fundamental role of gene expression regulation in prokaryotes and eukaryotes; regulation of geneexpression in prokaryotes: Operon concept (inducible and repressiblesystems);*lac* and *trp* operons;gene expression regulation in eukaryotes.

CC-8: Molecular BiologyLab (PRACTICAL)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Genomic DNA isolation from animal tissue.
2. Genomic DNA isolation from E. coli.
3. Isolation of DNA From coconut endosperm.

4. Characterization of DNA by spectrophotometric analysis.
5. Purification of DNA.
6. Melting point determination of DNA.
7. Isolation of RNA from human blood using TRIzol reagent.
8. Determination of amount of RNA by the Orcinol method.
9. Agarose gel electrophoresis for the separation of nucleic acids.
10. Study Hershey-Chase experiment to prove that DNA is the genetic material.

SUGGESTED READING

1. De Robertis, EDP and De Robertis, EMF 2006. Cell and Molecular Biology, 8th ed. LippincottWilliams and Wilkins, Philadelphia.
2. Krebs, JE, Goldstein, ES and Kilpatrick ST 2017. Lewin's Genes XII, 12th revised ed. Jones andBartlett Publishers, Inc.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the structure and function of biological system at the molecular level.
2. Understand molecular mechanisms.
3. Learn different kinds of gene expression regulation

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-9: Immunology (THEORY) SEMESTER –IV

Course objectives: The specific objectives of the course are as follows:

1. To familiarize students with the structure and function of the immune system.
2. To impart knowledge about the key components participating in fighting the disease.
3. To make students understand immunodiagnostic methods like RIA and ELISA.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to immunology [20 Hours]

Immune Response: An overview; components of mammalian immune system;humoralandcellular immune responses; T- lymphocytes and 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 II: Antibodies [10 Hours]

Molecular structure of immunoglobulins; regulation of immunoglobulin gene expression; clonal selection theory, allotypesandidiotypes; allelic exclusion; immunologic memory; heavy chain gene transcription; genetic basis of antibody diversity, hypotheses (germ line and somatic mutation).

UNIT III: Major histocompatibility complex [10 Hours]

Major Histocompatibility complexes:class I and class II MHC; antigen processing;immunity to infection and different organisms; pathogen defense strategies; avoidance of recognition;autoimmune diseases; immunodeficiency: AIDS.

UNIT IV: Complement system [10 Hours]

Complement system: Classical, Lectin, Alternate;nomenclature and characteristic features of complement system;modes of activation, formation of membrane attack complex; role of complementsystem in immunology.

UNIT V: Vaccines [10 Hours]

Vaccines
andvaccination; adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents; passive and active immunization;introduction to immunodiagnostics: RIA, ELISA.

CC-9: Immunology **Lab(PRACTICAL)**
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Determination of human blood groups.
2. Perform and study differential leucocyte count.
3. Perform and study total leucocyte count.
4. Separation of serum from blood.
5. Study haemagglutination assay.

6. Perform bacterial agglutination assay.
7. Perform rocket immunoelectrophoresis.
8. Double immunodiffusion test using specific antibody and antigen.
9. Perform and study ELISA.
10. Perform Widal test for the identification of typhoid infection.

SUGGESTED READINGS

1. Gangal, S and Sontake, S 2013. Textbook of Basic and Clinical Immunology, Orient BlackswanPrivate Limited, New Delhi.
2. Kindt, TJ, Osborne, BA and Goldsby, RA, and 2006.Kuby Immunology, 6th ed. WH Freemanand Company, New York.

Course learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the role of immune cells.
2. Learn about the most fundamental of antigens, antibodies and their functional role.
3. Understand immunodiagnostic methods like RIA and ELISA

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-10: Medicinal Chemistry (THEORY) SEMESTER –IV

Course objectives: The objectives of the course are as follows:

1. To make students understand the fundamental concepts of drug metabolism.
2. To teach students about different kinds of drugs, drugs acting on nervous system, cholinergicneurotransmitters, etc.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to medicinal chemistry [10 Hours]

History and development of medicinal chemistry; physicochemical properties in relation to biological action: ionization, solubility, partition coefficient, hydrogen bonding, protein binding, chelation,bioisosterism;optical and geometrical isomerism.

UNIT II: Drug metabolism [20Hours]

Drug metabolism principles: Phase I and Phase II;factors affecting drug metabolism including stereo chemical aspects;causes for drug resistance; genetic principles of drug resistance.

UNIT III: Drugs acting on autonomic nervous system [10 Hours]

Adrenergic neurotransmitters: biosynthesis and catabolism of catecholamine; adrenergic receptors (Alpha and Beta) and their distribution.

UNIT IV: Sympathomimetic agents: SAR of sympathomimetic agents [10 Hours]

Direct acting: Norepinephrine, Epinephrine, Phenylephrine, Dopamine; indirect acting agents: hydroxyamphetamine;pseudoephedrine;propylhexedrine;agents with mixed mechanism: ephedrine,metaraminol.

UNIT V:Cholinergic neurotransmitters [10 Hours]

Biosynthesis and catabolism of acetylcholine; cholinergic receptors (muscarinic andnicotinic) and theirdistribution;parasympathomimetic agents: SAR of parasympathomimetic agents; direct acting agents: Acetylcholine, Carbachol; indirect acting/cholinesterase inhibitors (Reversible and Irreversible).

CC-10: Medicinal Chemistry Lab (PRACTICAL)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Assay of Thiamine in Vitamin B Complex Tablets
2. Determination of Vitamin C Content of Commercial Tablets
3. Determination of Molarity of acetic acid in Vinegar
4. Isolation of citric acid from lemon
5. Color Spot Tests for Detection of Alkaloids
6. Synthesis of paracetamol from p-aminophenol
7. Determination of dissociation constant of benzoic acid

8. Determination of percentage purity of Aspirin
9. Determination of percentage purity of Ibuprofen.
10. Determination of percentage purity of Sulphamethoxazole

SUGGESTED READINGS

1. Lemke, TL, Williams, DA, Roche, VF and Zito, SW 2012.Foye's Principles of MedicinalChemistry, 7th ed. Lippincott Williams and Wilkins, Philadelphia.
2. Singh,H and Kapoor,VK1996. Medicinal and Pharmaceutical Chemistry,Vallabh Prakashan Publishers, Delhi.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the concepts of drugs and their actions.
2. Learn about the fundamentals of various receptors and signalling processes.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
SEC-2: Enzymology
SEMESTER – IV

Course objectives: The course aims to impart the knowledge about fundamental principles ofenzyme reactions, and applications of enzyme engineering. The specific objectives of the course are:

1. To make students understand the mechanism of enzyme action.
2. To teach students Michaelis-Menten equation for enzyme kinetics.
3. To teach students the regulation of enzyme kinetics

TOTAL HOURS: 60 **CREDITS: 2**

UNIT I: Enzyme classification and mechanism of enzyme action [20 Hours]

Enzyme classification; zymogens and their activation; coenzymes, cofactors, holoenzyme and prosthetic group; concept of enzyme-substrate complex; active site, specificity; factors affecting the rate of enzyme-catalyzed reactions; mechanism of enzyme action; enzyme units.

UNIT II: Enzyme kinetics and their inhibition [10 Hours]

Concept of order of reactions; kinetics of enzyme activity, Michaelis-Menten equation and its derivation; different plots for the determination of K_m and V_{max} and their physiological significance; two substrate reactions; enzyme inhibition: types of inhibition.

UNIT III: Regulatory enzymes and multienzyme complex [10 Hours]

Kinetics of allosteric enzymes and its cooperativity effect; allosteric enzymes; enzyme-enzyme interaction; protein-ligand binding; isoenzymes: multiple forms of enzymes with special reference to lactate dehydrogenase; multienzyme complexes e.g. fatty acid synthase; ribozymes.

UNIT IV: Enzyme technology and its applications [10 Hours]

Methods for large-scale production of enzymes; immobilized enzymes and their comparison with soluble enzymes; methods for immobilization of enzymes; applications of immobilized and soluble enzymes in health and industry; applications to fundamental studies of biochemistry.

UNIT V: Enzyme engineering [10 Hours]

Thermal stability and catalytic efficiency of enzyme; site directed mutagenesis and enzyme engineering: modification of active site of an enzyme; delivery system for protein pharmaceuticals; structure function relationship in enzymes, structural motifs and enzyme evolution.

Suggested Readings

1. Voet, D and Voet, J 1995. Biochemistry, 2nd ed. John Wiley and Sons.
2. Nelson, DL and Cox, MM 2005. Lehninger Principles of Biochemistry, 4the ed. WH Freemanand Company, New York.
3. Rodwell, VW, Bender, DA, Botham, KM, Kennelly, PJ and Weil, PA 2015. Harper's IllustratedBiochemistry, 30th ed. McGraw Hill Education

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Be able to differentiate between the six classes of enzymes.
2. Understand the mechanism of enzyme action.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
GE-4: Developmental Biology (THEORY) SEMESTER – IV

Course objectives: The course aims to teach the principles and molecular biology of eukaryotic development, from zygote to embryo development and differentiation. The specific objectives of the course are:

1. To understand the history and basic concepts of embryology
2. To become familiar with the process of fertilization, spermatogenesis and oogenesis
3. To understand the process of organogenesis.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Gametogenesis and fertilization [10 Hours]

Definition, scope and historical perspective of development biology; gametogenesis: spermatogenesis and oogenesis; fertilization: mechanism and types of fertilization; different types of eggs on the basis of yolk.

UNIT II: Early embryonic development [10 Hours]

Embryo cleavage types, patterns and mechanism; process, types and mechanism of blastulation; gastrulation; cell movements: epiboly, emboly, extension, invagination, convergence, de-lamination; formation and differentiation of primary germ layers; fate maps in early embryos.

UNIT III: Embryonic differentiation [10 Hours]

Differentiation; cell commitment and determination; the epigenetic landscape: a model of determination and differentiation; control of differentiation at the level of genome, transcriptional and post-translational levels; concept of embryonic induction: primary, secondary and tertiary embryonic induction; neural induction and induction of vertebrate lens.

UNIT IV: Organogenesis [10 Hours]

Neurulation, notogenesis, development of vertebrate eye; fate of different primary germ layers; development of behaviour: constancy and plasticity; extra embryonic membranes; placenta in mammals.

UNIT V: Molecular biology of development [20 Hours]

Role of homeotic genes (*Hox* gene) and maternal effect genes (*bicoid* and *nanos*) in *Drosophila* development; axis specification in amphibians: concept of primary organizer; role of *β-catenin* gene and the origin of Nieuwkoop centre; vulval induction in *C. elegans*; role of *TBX* 4, *TBX*5 and *Sonic hedgehog* genes in the development of tetrapod limb in vertebrates; development symbiosis; genomic imprinting; role of maternal effect genes in plant development.

SUGGESTED READING

1. Balinsky, BI 2012. An introduction to Embryology, 5th ed. Cengage Learning India.
2. Gilbert, SF 2006. Developmental Biology, 8th ed. Sinauer Associates, Inc., Publishers,Sunderland, Massachusetts, USA.

CC-10: Developmental Biology Lab**(PRACTICAL)**
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of different types of eggs.
2. Development of fate maps in the early embryos.
3. Observation of frog embryos, different developmental stages and life cycle of frog.
4. Identification of developmental stages of chick embryo using permanent mounts.
5. Preparation of a temporary stained mount of chick embryo.
6. Study developmental stages of Anopheles.
7. Demonstration of developmental stages of Drosophila.
8. Study of different types of placenta.
9. Examine the sections of mammalian skin, salivary glands, cartilage and bones.
10. Stages of flower development in plants.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

ECA: General ---Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

Marks Based on activities

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-11: BIOPROCESS TECHNOLOGY (THEORY) SEMESTER –V

Course objectives: The specific objectives of the course are as follows:

1. To impart the knowledge of cultivation and growth kinetics of microorganisms.
2. To make students understand the basic concept of sterilization and different parts of a bioreactor.
3. To teach the application of bioprocess technology in industries.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I (10 Periods)

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fedbatch and Continuous culture

UNIT II (20 Periods)

Design of bioprocess vessels- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in production processes. Principles of upstream processing – Media preparation, Inocula development and sterilization.

UNIT III (10 Periods)

Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control

UNIT IV (10 Periods)

Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of ethanol, amylase, lactic acid and Single Cell Proteins.

UNIT V (10 Periods)

Downstream processing - filtration, centrifugation, cell disruption, solvent extraction.
Microbial production of industrial products - citric acid, ethanol and penicillin.
Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases large scale applications of immobilized enzymes glucose isomerase and penicillin acylase)

CC-11: BIOPROCESS TECHNOLOGY Lab
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Estimation of Biomass Production.
2. Determination of the specific growth rate and generation time of a bacterium during submergedfermentation.
3. Estimation of the effect of temperature and pH on the growth of microbes.
4. Estimation of the effect of substrate concentration on the growth of *E.coli.*
5. Estimation of Monod Parameters for microbial growth kinetics.
6. Calculation of thermal death point (TDP) of a microbial sample.
7. Isolation of industrially important microorganisms from natural resource.
8. Screening of microbes for the production of enzymes.
9. Optimization of production and analysis of ethanol.
10. Biological treatment of wastewater originating from an industrial source.

SUGGESTED READINGS

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

Learning Outcome: Upon successful completion of this course the student will:

1. Get an overview of the basic concepts of bioprocess technology and process of culture of microorganisms.
2. Understand the parts and functions of the bioreactor.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-12: Recombinant DNA Technology **(THEORY) SEMESTER –V**

Course objectives: The specific objectives of the course are as follows:

1. To impart knowledge about different components such as vectors, restriction enzymes, ligases,polymerases, alkaline phosphatases used for making recombinant DNA molecule.
2. To make students understand the different techniques such as PCR, transformation, site-directedmutagenesis, etc.
3. To teach the basics of gene transfer technique in plants.

CREDITS: 4

TOTAL HOURS: 60

UNIT I: Components of gene cloning and strategies [10 Hours]

Molecular tools and applications; restriction enzymes, ligases, polymerases, alkaline phosphatase; episomes, plasmids and other cloning vectors; bacteriophage-derived vectors, artificial chromosomes; restriction mapping; Southern and Northern hybridization; preparation and comparison of genomic and cDNA libraries; screening of recombinants.

UNIT II: Gene transfer techniques and PCR [10 Hours]

Gene recombination and gene transfer: transformation, microinjection, electroporation, ultrasonication; principle and applications of Polymerase Chain Reaction (PCR); primer design for PCR; Reverse Transcription-Polymerase Chain Reaction (RT-PCR).

UNIT III: Site-directed mutagenesis [10 Hours]

Random mutagenesis and site-directed mutagenesis; primer extension and PCR based methods of site directed mutagenesis; gene shuffling; production of chimeric proteins; protein engineering concepts and examples (any two).

UNIT IV: Transgenic technology in plants [20 Hours]

Genetic engineering in plants; use of *Agrobacterium tumefaciens* and *A. rhizogenes*; Ti plasmid; plant transformation vectors; strategies for gene transfer to plant cells; direct DNA transfer to plants; gene targeting in plants; use of plant viruses as episomal expression vectors.

UNIT V: Applications of genetic engineering [10Hours]

Genome mapping; DNA fingerprinting; applications of genetic engineering in animals; production and applications of transgenic mice; role of embryonic stem cells (ES cells) in gene targeting in mice; therapeutic products produced by genetic engineering: blood proteins, human hormones, immune modulators and vaccines.

CC-12: Recombinant DNA Technology Lab **(PRACTICAL)**
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Plasmid DNA isolation and electrophoresis of DNA from *E. coli*.
2. Restriction digestion of plasmid DNA.
3. Restriction mapping of DNA.
4. Ligation of DNA molecules.

5. Preparation of competent cells.
6. Transformation of competent cells.
7. Designing of primers for polymerase chain reaction (PCR).
8. Perform PCR to amplify a DNA fragment.
9. Isolation of recombinant protein from bacterial cells.
10. DNA fingerprinting using RAPD.

SUGGESTED READINGS

1. Brown, TA 2010. Gene Cloning and DNA Analysis, 6th ed. Wiley-Blackwell.
2. Rastogi, S and Pathak, N 2009. Genetic Engineering, 1st ed. Oxford University Press.

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Course learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the role of enzymes specifically required for gene manipulation.
2. Learn about the most fundamental techniques like PCR, genomic and cDNA library preparation,

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-1: BIOINFORMATICS (THEORY) SEMESTER –V

Course objectives: The aim of the course is to introduce students to the basic tenets of bioinformatics. The course provides a strong foundation for developing skills in using biological sequence databases, and tools for biological sequence analysis. The specific objectives of the course are as follows:

1. To teach students about biological sequence data storage.
2. To make students understand about various bioinformatics tools used for DNA, RNA and proteinsequence analysis.
3. To impart knowledge about biological sequence alignment.
4. To teach the fundamental principles of molecular phylogeny

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to Computer Fundamentals RDBMS - Definition of relational database **Hours: 10**

Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer

Unit 2 Introduction to Bioinformatics and Biological Databases Hours: 15

Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB

Unit 3 Sequence Alignments, Phylogeny and Phylogenetic trees Hours: 15

Local and Global Sequence alignment, pairwise and multiple sequence alignment.
Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices
Types of phylogenetic trees, Different approaches of phylogenetic tree construction - UPGMA, Neighbour joining, Maximum Parsomony, Maximum likelihood

Unit 4 Genome organization and analysis Hours: 10

Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes
Genome, transcriptome, proteome, 2-D gel electrophoresis, Maldi Toff spectroscopy
Major features of completed genomes: *E.coli*, *S.cerevisiae*, *Arabidopsis*, Human

Unit 5 Protein Structure Predictions Hours: 10

Hierarchy of protein structure - primary, secondary and tertiary structures, modeling
Structural Classes, Motifs, Folds and Domains
Protein structure prediction in presence and absence of structure template
Energy minimizations and evaluation by Ramachandran plot
Protein structure and rational drug design

DSE-1: BIOINFORMATICS LAB (PRACTICAL)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Introduction to different operating systems - UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustalW & phylip
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)
7. Prediction of different features of a functional gene

SUGGESTED READING

1. Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House
2. Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications
3. Lesk M.A.(2008) Introduction to Bioinformatics . Oxford Publication, 3rd International Student Edition
4. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication
5. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Be able to retrieve biological sequence data from various databases.
2. Understand the differences between local and global sequence alignments.
3. Be able to build phylogenetic trees and infer about molecular phylogeny from them.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-2: Animal Biotechnology (THEORY) SEMESTER –V

Course objectives: The course aims to make students gain knowledge in the current trends andtechniques in animal biotechnology. The specific objectives of the course are as follows:

1. To develop an understanding about animal cell culture and gene delivery methods in animals.
2. To provide an overview of in-vitro fertilization, embryo transfer methods and other relatedtechniques.
3. To gain knowledge about the stem cells and their various applications

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Animal cell culture [10 Hours]

Introduction to basic tissue culture techniques; chemically defined and serum free media; animal cell cultures, their maintenance and preservation; culture types: suspension, continuous flow and immobilized cultures; somatic cell fusion; cell cultures as a source of valuable products; organcultures.

UNIT II: Gene transfer methods in animals [10 Hours]

Microinjection, embryonic stem cell, gene transfer, retroviral gene transfer, integration of foreign genes and their validation; gene targeting; methods and strategies; improving transgene integration efficiency.

UNIT III: Assisted reproductive technologies [10 Hours]

Artificial insemination; cryopreservation of semen and embryos; multiple ovulation, *in-vitro*
fertilization and embryo transfer techniques, nuclear transfer and cloning.

UNIT IV: Stem cell and its applications [10 Hours]

Stem cells: types and sources; characteristics of stem cells, potency and plasticity of stem cells; stemcell markers; induced pleuripotent stem cells; applications of stem cells in disease cure.

UNIT V: Transgenic animals and gene therapy [20 Hours]

Strategies for the production of transgenic animals; applications of transgenic animals; gene therapy,types of gene therapy; vectors in gene therapy; human gene therapy.

DSE-2: ANIMAL BIOTECHNOLOGY (PRACTICAL)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Preparation of animal cell culture media.
2. Inoculation of cells in animal cell culture media.
3. Trypsinizing and subculturing cells from a monolayer.
4. Perform animal cell counting.
5. Determine the percentage of viable cells by trypan blue exclusion test.
6. MTT cell proliferation assay.
7. Establishment of primary cell culture.
8. Giemsa staining of animal cells.
9. DPPH (2,2 Diphenyl-1-Picryl Hydrazyl) radical scavenging assay.
10. Preservation of animal cells.

SUGGESTED READING

1. Pinkert, C 2014. Transgenic Animal Technology, 3rd ed. Elsevier
2. Ranga, M 2010. Animal Biotechnology, 3rd ed. Agrobios.

Course Learning Outcome (CLO) : Upon successful completion of this course the student will:

1. Comprehend the fundamental concepts of animal cell culture and its applications.
2. Understand the significance of transgenesis with reference to animals.
3. Remember the stem cells and their various applications
4. Learn the fundamentals of gene therapy and its applications.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-3: Animal Diversity (THEORY) SEMESTER –V

Course objectives: This course presents an overview of invertebrates, ranging from protozoa tohemichordata. The specific objectives of the course are as follows:

1. To make the student understand the classification invertebrates of animal kingdom.
2. To make the student understand the characteristics of invertebrates.
3. To make the student learn the diversity of protozoa to hemichordata.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Protozoa and porifera [20 Hours]

Outline of classification of non-chordates upto subclasses; coelomata, acoelomata; deutrostomes, protostomes; features of protozoa; locomotion and reproduction in protozoa; general features of *Paramoecium* and *Plasmodium*; pathogenic protozoans; features of porifera; classification of porifera;canal system of sponges.

UNIT II: Coelenterata, platyhelminthes, and aschelminthes [10 Hours]

Characteristics and classification of coelenterate; stinging cells of coelenterata; coral reefs and their formation; characteristics and classification of platyhelminthes; pathogenic flatworms; parasitic adaptations in flatworms; characteristics and classification of aschelminthes; pathogenic roundworms and their vectors in relation to humans.

UNIT III: Annelida and arthropoda [10 Hours]

Characteristics and classification of annelida; segmentation in annelids; coelom; features of earthworm; use of earthworm in vermicomposting.

Characteristics and classification of arthropoda; diversity of arthropoda; larval forms of crustacean; respiration in arthropoda; metamorphosis in insects; social insects; insect vectors of diseases; apiculture and sericulture.

UNIT IV: Mollusca, echinodermata and hemichordate [10 Hours]

Characteristics and classification of mollusca; shell diversity in molluscs; torsion in gastropoda, characteristic features of echinodermata; characteristic features of echinodermata hemichordata.

UNIT V: Chordata [10 Hours]

Proto-chordates: Outline of classification, General features and important characters of Herdmania, Branchiostoma Origin of Chordates Pisces: Migration in Pisces, Outline of classification Amphibia: Classification, Origin, Parental care, Paedogenesis
Reptelia: Classification, Origin
Aves: Classification, Origin, flight- adaptations, migration
Mammalia: Classification, Origin, dentition

DSE-3: Animal Diversity lab **(PRACTICAL)**
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of protozoa using permanent slides.
2. Identification and classification of porifera: *Euspongia*, *Scypha*.
3. Study of hydra by permanent slides.
4. Identification and classification of platyhelminthes: *Taenia, Fasciola*.
5. Dissection of nerve ring of earthworm.
6. Study digestive system of earthworm using models.
7. Dissection of salivary glands of cockroach.
8. Glycerin preparation of hastate plate.
9. Permanent preparation of gill lamella.
10. Dissection of *Pila*.
11. Identification & Classification upto order of the following: Proto-chordata: Salpa, Doliolum, Herdmania, Branchiostoma Cyclostomata: Myxine, Petromyzon Chondrichthyes: Scoliodon, Zygnea, Pristis, Trygon, Raja, Chimaera Ostiechthyes: Labeo, Mystus, Catla, Hippocampus, Anabas, Echeneis, Lophius, Polypeterus Amphibia: Rana, Hyla, Amblystoma, Necturus, Proteus. Reptiles: Hemidactylus, Calotes, Draco, Phrynosoma, Naja Vipera, Bungarus Aves: Columba, Alcedo, Passer Mammalia: Ornithorhynchus, Macropus, Didelphes, Dasypus

SUGGESTED READING

1. Barnes, RSK, Calow, P, Olive, PJW, Golding, DW and Spicer, JI 2002. The Invertebrates: ANew Synthesis, 3rd ed. Blackwell Science.
2. Kotpal, RL 1996. Modern Textbook of Zoology: Invertebrates, Rastogi Publications.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Learn about the diversity of invertebrates.
2. Learn about the distinguishing features of different invertebrate phyla.
3. Learn about parasitic adaptation of organisms.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-4: Plant Diversity (THEORY) SEMESTER –V

Course objectives: This course presents an overview of lower plants, ranging from algae to pteridophytes. The specific objectives of the course are as follows:

1. To make students understand the organization of plant kingdom.
2. To teach the characteristics of lower plant genera.
3. To make students learn the economic importance of lower plants.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Algae **[20 Hours]**

General characters and classification; life histories of algae belonging to various classes: Chlorophyceae: *Volvox, Oedogonium,* Xanthophyceae: *Vaucheria*, Phaeophyceae: *Ectocarpus* and Rhodophyceae: *Polysiphonia*; economic importance of algae.

UNIT II: Fungi and Lichens **[10 Hours]**

General characters and classification; life histories of fungi: Mastigomycontina: *Phytophthora*, Zygomycotina: *Mucor*, Ascomycotina: *Saccharomyces*, Basidiomycotina: *Agaricus* and Deutromycotina: *Colletotrichum*; economic importance of fungi; lichens: classification, structure and reproduction; economic importance of lichens.

UNIT III: Bryophytes and Pteridophytes **[10 Hours]**

General characteristics of bryophytes; classification of bryophytes; life histories of *Riccia, Marchantia, Anthocerose,* and *Funaria*; economic importance of bryophytes.

General characters of pteridophytes; affinities of pteridophytes with bryophytes and gymnosperms; distribution of cryptogams in India and their ecological and economic importance

UNIT IV: Gymnosperms: Type studies **[10 Hours]**

General features of Coniferophyta; Cycadophyta; Ginkgophyta and Gnetophyta; life histories of *Cyca; Pinus* and *Ephedr;* economic importance of gymnosperms.

UNIT V: Angiosperms **[10 Hours]**

General characters of angiosperms, systematics, anatomy, embryology, palynology and phylogeny; taxonomic hierarchy; international code of botanical nomenclature: numerical taxonomy and chemotaxonomy; evidence from anatomy, embryology and palynology.

DSE-4: Plant Diversity Lab (PRACTICAL)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Collection of algae, fungi, bryophytes and pteridophytes from nearby localities and the campus.
2. Slide preparation of *Volvox* and *Oedogonium* to study their vegetative and reproductivestructures.
3. Preparation of temporary mounts of fungi to study hyphae.
4. Prepare sections of the gills of *Agaricus*.

5. Preparation of temporary mount of *Saccharomyces cerevisiae* (Baker's yeast).
6. Section cutting and lectophenol mount of plant disease materials.
7. Section cutting of lichen to study the anatomy.
8. Study of growth forms of lichens (crustose, foliose and fruticose).
9. Comparative study of thalli of various bryophytes.
10. Section cutting of pteridophyte to study their anatomy and vascular system.

SUGGESTED READINGS

1. Kumar, HD 1999. Introductory Phycology, 2nd ed. Affiliated East-West Press Pvt Ltd., NewDelhi.
2. Pandey, BP 1979. College Botany Volume I, S Chand Publishing.
3. Pandey, BP 2013. College Botany Volume II, Vikram Jain Books, New Delhi.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Understand the diversity of lower plants.
2. Learn about the differences in characteristic features of lower plants.
3. Learn about the economic importance of lower plants.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)

ECA: General ---Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

Marks Based on activities

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
CC-13: BIO-ANALYTICAL TOOLS (THEORY) SEMESTER –I

Course objectives: The broad objective of the course is to make students aware about the importance and significance of the diverse tools and techniques used to study and understand the biologicalworld. The specific objectives of the course are as follows:

1. To introduce the basic principle, types and application of microscopy.
2. To study concepts applications and types of centrifugation.
3. To acquaint students with chromatography and spectroscopy techniques.
4. To makes students understand the techniques of electrophoresis and blotting.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I (10 Periods)
Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

UNIT II (10 Periods)
Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared),

UNIT III (10 Periods)
centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT IV (10 Periods)
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 V (20 Periods)
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.

CC-13: BIO-ANALYTICAL TOOLS Lab
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

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.

SUGGESTED READINGS

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
2. 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. 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. 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.

Course Learning Outcome(CLO): Upon successful completion of this course the student will:

1. Understand the principles and applications of microscopy.
2. Remember the concepts applications and types of centrifugation.
3. Comprehend techniques used for chromatography and spectroscopy.
4. Appreciate the relevance of electrophoresis and blotting technology in modern biology.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)

CC-14: Genomics and Proteomics (THEORY) SEMESTER –VI

Course objectives: The broad objective of the course is to make students aware about the importance of the modern methods of genome and proteome analysis and the significance of these on the changing paradigm in genetics, medicine and agriculture. The specific objectives of the course are as follows:

1. To introduce the basic concepts of genomics and next generation sequencing.
2. To acquaint students with various genome databases and their applications.
3. To make students aware about the applications of genomics in various industries.

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to genomics [20 Hours]

Introduction to Genomics, DNA sequencing methods: Maxam & Gilbert; Sangers method; Next generation sequencing: Pyrosequencing, Nanopore sequencing; Genome Sequencing: Shotgun & Hierarchical (clone contig) methods; Genome sequence assembly software: Newbler.

UNIT II: Genome databases [10 Hours]

Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organism's Genomes and Databases: *E.coli*, *Mus musculus*, *Homo sapiens*, *Arabidopsis thaliana*; Human genome project.

UNIT III: Application of genomics [10 Hours]

Comparative genomics: comparison of genomes; pharmacogenomics: variable drug response of individuals; metagenomics; epigenomics: New tool in studying complex diseases.

UNIT IV: **Introduction to proteomics [10 Hours]**

Introduction to Proteomics, Two-dimensional polyacrylamide gel electrophoresis (2D-PAGE): isoelectric focusing and SDS-polyacrylamide gel electrophoresis, staining methods of 2D gels; mass- spectrometry: Matrix Assisted Laser Desorption Ionization Time of Flight (MALDI-ToF); peptide mass fingerprinting; Edman degradation.

UNIT V: Applications of proteomics [10 Hours]

Clinical application of proteomics; proteomic biomarkers for disease diagnosis; plasma proteome; cancer proteomics; applications of proteomics in toxicology; plant proteomics in plant development, plant physiology and ecology; interaction proteomics and protein networks.

CC-14: Genomics and Proteomics (PRACTICAL) SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Identification of unknown sequence by BLAST and its functional annotation.
2. SNP analysis using SNP database of NCBI.
3. Comparison of genomes of two organisms using SynMap of CoGe.

4. Demonstration of microarray applications and analysis of microarray data.
5. Computation of pI and molecular weight of a protein using ExPASy ProtParam tool.
6. Demonstration of 2D PAGE and data analysis.
7. Generation of protein interaction networks using STRING software.
8. Subcellular protein localization study using CELLO tool.
9. Protein motif identification using MEME software.

SUGGESTED READING

1. Primrose, SB and Twyman, RM 2006. Principles of Gene Manipulation and Genomics, 7th ed.Blackwell Publishing.
2. Pennington, SR and Dunn, MJ 2002. Proteomics: From Protein Sequence to Function, 1st ed.Viva Books Private Limited.
3. Liebler, DC and Yates III, JR 2002. Introduction to Proteomics: Tools for New Biology, 1st ed.Humana Press.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Be able to differentiate between eukaryotic and prokaryotic genomes and will be able to usegenome databases.
2. Remember and apply the basic concepts of next generation sequencing.
3. Learn techniques used to analyze genome and proteome.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-5: Project work / Dissertation SEMESTER –VI

TOTAL HOURS: 90 **CREDITS: 10**

Marks based on external evaluation

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-6: INTELLECTUAL PROPERTY RIGHTS (THEORY) SEMESTER –VI
TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to IPR **[10 Hours]**

Basic understanding of intellectual property rights; utility of IPRs; different types of IPRs; introduction to Indian patent law; world trade organization and its related intellectual property provisions world organizations: WIPO and TRIPS agreement, international treaties and conventions on intellectual property.

UNIT III: Protection of IPRs **[20 Hours]**

Intellectual/industrial property and its legal protection in research, design and development. Forms of protection of IPRs: Introduction to copyrights and its applicability; fundamental concepts and importance of trademarks and trade secrets; geographical indications; design layout design of integrated circuits.

UNIT III: Patents **[10 Hours]**

Methods of patenting and general concept of patent; patenting agencies; use of technical information in patent documents; revocation of patent; patenting of biological material like microorganisms, plant and animal, patenting in biotechnology, economic, ethical and depository considerations.

UNIT IV: Copyright **[10 Hours]**

Nature of Copyright; subject matter of copyright: original literary, dramatic, musical, artistic works; cinematograph films and sound recordings; registration, procedure, term of protection; ownership of copyright; assignment and licence of copyright.

UNIT V: Trademarks **[10 Hours]**

Concept of Trademarks; different kinds of marks (brand names, logos, signatures, symbols, well known marks, certification marks and service marks); non-registrable trademarks; registration of trademarks; rights of holder and assignment and licensing of marks.

E-6: INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)
SEMESTER-VI
TOTAL HOURS: 60 **CREDITS: 2**

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
4. Study of steps of a patenting process
5. A case study

Suggested Reading

1. Pandey, N and Dharni, K 2014. Intellectual Property Rights, 1st ed. PHI Learning Pvt. Ltd.
2. Tomkowicz, R 2011. Intellectual Property Overlaps: Theory, Strategies and Solutions, 1st ed.Routledge.

Course Learning Outcome (CLO) : Upon successful completion of this course the student will:

1. Understand types of IPRs and their utility.
2. Understand the procedure of filing a patent.
3. Gain knowledge about the bioethical and biosafety practices related to biotechnology.

B.Sc (HONOURS) BIOTECHNOLOGY (CBCS STRUCTURE)
DSE-7: Biostatistics (THEORY) SEMESTER –VI

Course objectives: This is an introductory course on statistics. The specific objectives of the courseare as follows:

1. To teach students the basic principles of statistics, data types and collection of data.
2. To make students understand the various methods of data presentation and measures of centraltendency.
3. To make students understand the basic concepts of probability and Probability distribution

CREDITS: 4

TOTAL HOURS: 60

UNIT I: Data types and collection [20 Hours]

Types of data, collection of data; primary and secondary data; classification and graphical representation of statistical data; methods of classification of data; collection of data-methods and source; sampling-methods; types, size and determination of sample size.

UNIT II: Presentation of data. [10 Hours]

Data organization: Classes, class intervals, class limits, mid value- inclusive and exclusive method; data-types of graph: line frequency graph, histogram, frequency polygon, kite diagram, Frequency curves, cumulative frequency curve, scatter diagram; diagrammatic presentation of data: bar graph and pie diagram.

UNIT III: Measures of central tendency and dispersion. [10 Hours]

Arithmetic mean, median, mode; range, coefficient of range; mean deviation, standard deviation; variance, coefficient of variance; degree of freedom; measures of skewness moments and kurtosis.

UNIT IV: Probability and Probability distribution [10 Hours]

Definition of probability, simple event, mutually exclusive event, non-mutually exclusive event; theorems of probability: additive and multiplicative rule; permutation and combination; compound probability; Bayes theorem, elementary ideas of binomial, Poisson and normal distributions- assumption, mean and standard deviation for all distribution.

UNIT V: Test of hypothesis [10 Hours]

Methods of sampling; confidence level, critical region, testing of hypothesis and standard error; large sample test and small sample test; problems on test of significance; t-test; chi-square test for goodnessof fit and analysis of variance (ANOVA).

DSE-7: Biostatistics (PRACTICAL)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Biostatistics: (a) Graphical and tabular presentation of data (b) Problems on mean, mode and median.
2. Practical related to word, spreadsheet and presentation software
3. Practical's on Probability
4. Practical's on Correlation coefficient and regression lines
5. Practical's on students t-test
6. Practical's on Chi-square test
7. Practical's on ANOVA

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SUGGESTED READINGS

1. Le, CT 2003. Introductory Biostatistics, 1st ed. USA, John Wiley.
2. Glaser, AN. 2013. High Yield TM Biostatistics, 4th ed. Lippincott Williams and Wilkins.

Course Learning Outcome (CLO): Upon successful completion of this course the student will:

1. Learn the basic principles of statistics, data types and collection of data
2. Understand the various methods of data presentation and measures of central tendancy
3. Understand probability and Probability distribution

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)

ECA: General ---Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

Marks Based on activities

Semester I																		
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**											
							Theory						**Practical**					
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total	
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
CC-1	BT-101	Biochemistry & Metabolism	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-2	BT-102	Cell Biology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
AECC-1	BT-103	English Communication	3	--	1	4	75	30	25	10	100	40	--	--	--	--	--	--
GE-1	BT-104	Biotechnology and Human Welfare	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
ECA	BT-105	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20
			Total Credit- 24				**Total Theory Marks - 400**						**Total Practical Marks:200**					
Total Marks:600																		

Abbreviations :- CC – Core Course, AECC – Ability Enhancement Compulsory Course, GE – General Elective, ECA – Extra Curricular Activity, L – Lecture, P – Practical, T – Tutorial, ESE – End Semester Exam, IA – Internal Assessment .

Note:

1. Student can obtain online course of any one subject from the list of the SWAYAM courses selected by the department before the commencement of each semester in lieu of that particular subject.
2. The credit earned from the MOOC course will be reflected under the CBCS as per the credit assigned to that particular subject.

Semester II																		
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**											
							Theory						**Practical**					
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total	
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
CC-3	BT-201	Mammalian Physiology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-4	BT-202	Plant Anatomy and Physiology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
AECC-2	BT-203	Environmental Sciences	3	--	1	4	75	30	25	10	100	40	--	--	--	--	--	--
GE-2	BT-204	Bioethics and Biosafety	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
ECA	BT-205	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20
			Total Credit- 24				**Total Theory Marks - 400**						**Total Practical Marks:200**					
																	Total Marks:600	

Abbreviations :- CC – Core Course, AECC – Ability Enhancement Compulsory Course, GE – General Elective, ECA – Extra Curricular Activity, L – Lecture, P – Practical, T – Tutorial, ESE – End Semester Exam, IA – Internal Assessment .

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Semester III																		
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**											
							Theory						**Practical**					
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total	
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
CC-5	BT-301	Genetics	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-6	BT-302	General Microbiology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-7	BT-303	Green Chemistry	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
SEC-1	BT-304	Molecular Diagnostics	3	-	1	4	75	30	25	10	100	40	-	-	-	-	-	-
GE-3	BT-305	Biotechnology and Human Welfare	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
ECA	BT-306	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20
			Total Credit- 30				**Total Theory Marks - 500**						**Total Practical Marks:250**					
																	Total Marks:750	

Abbreviations :- CC – Core Course, SEC – Skill Enhancement Course, GE – General Elective, , L – Lecture, P – Practical, T – Tutorial, ESE – End Semester Exam, IA – Internal Assessment .

Note:

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Semester IV																		
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**											
							Theory						**Practical**					
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total	
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
CC-8	BT-401	Molecular Biology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-9	BT-402	Immunology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC-10	BT-403	Medicinal Chemistry	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
SEC-2	BT-404	Enzymology	3	0	1	4	75	30	25	10	100	40	-	-	-	-	-	-
GE-4	BT-405	Developmental Biology	3	2	1	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
ECA	BT-406	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20
			Total Credit- 30				**Total Theory Marks -500**						**Total Practical Marks:250**					
																	Total Marks:750	

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Note:

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2. The credit earned from the MOOC course will be reflected under the CBCS as per the credit assigned to that particular subject.

Semester V																			
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**												
							Theory						**Practical**						
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total		
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
CC-11	BT-501	Bioprocess Technology	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20	
CC-12	BT-502	Recombinant DNA Technology	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20	
DSE-1/2 (Any One group)	BT-503	Bioinformatics	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20	
	BT-504	Animal Biotechnology																	
DSE-3/4 (Any One group)	BT-505	Animal Diversity	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20	
	BT-506	Plant Diversity																	
ECA	BT-406	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20	
Total Credit- 26							**Total Theory Marks - 400**						**Total Practical Marks:250**						
Total Marks 650																			

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Note:

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2. The credit earned from the MOOC course will be reflected under the CBCS as per the credit assigned to that particular subject.

Semester VI																		
Course Opted	**Course Code**	**Subject Name**	**Credit**			**TOTAL**	**Marks**											
							Theory						**Practical**					
			L	**P**	**T**		ESE		IA		Total		ESE		IA		Total	
							Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
CC 13	BT-601	Bio Analytical Tools	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
CC 14	BT-602	Genomics and Proteomics	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
DSE-5	BT-603	Project Work / Dissertation	-	6	-	6	-	-	-	-	-	-	150	60	--	--	150	60
DSE-6/7 (Any Onegroup)	BT-604	Intellectual Property Rights	4	2	-	6	75	30	25	10	100	40	37.5	15	12.5	5	50	20
	BT-605	Biostatistics																
ECA	BT-406	ECA/ General Interest/Hobby/ Sports/NCC/NSS/ Swachh Bharat internship/ Others	-	2	-	2	-	-	-	-	-	-	-	-	50	20	50	20
Total Credit- 26							**Total Theory Marks - 300**						**Total Practical Marks:350**					
																	Total Marks:650	
Grand Total Credit - 160																	**Grand Total Marks: 4000**	

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2. The credit earned from the MOOC course will be reflected under the CBCS as per the credit assigned to that particular subject.