Curriculum of
B.Sc. (Hons)/Integrated M.Sc.
Biological Sciences

School of Biological Sciences (SoBS)

Doon University
Dehradun – 248001
Uttarakhand, India

B.Sc. (Hons)/Integrated M.Sc.

Biological Sciences

(CBCS Structure)

(w.e.f. Academic Session 2021- 2022)

(Updated on: August 2024)

School of Biological Sciences

DOON UNIVERSITY

Dehradun-248001, Uttarakhand, India

www.doonuniversity.ac.in

B.Sc. (Hons)/Integrated M.Sc. Biological Sciences

About the Programme

The School of Biological Sciences offers an Undergraduate /Post-Graduate (integrated five years' masters) programme from the academic session 2021-22. The curriculum of the BSc. (Hons) programme is based upon UGC's choice-based credit system (CBCS) and provides an in-depth study of the subject and the related areas. The foundation of the subject is built through Core courses coupled with a choice-based specialization of different streams of modern biology with an interdisciplinary perspective through Elective courses. Core courses are rigorous in-depth courses that build on the foundation and develop critical thinking and problems solving skills. Since the subjects involve a lot of experimental work, therefore, substantial laboratory work is an integral part of almost all types of courses. All students have to undertake a research project under the guidance of highly qualified faculties and the outcome of the research will be reported in the form of a dissertation. Students will be encouraged to take up summer projects and visit institutes and universities of national repute such as IITs, NIT, IISER, CSIR Labs during the 5-year course.

Programme outcome (POC)

- **Critical Thinking:** Students will demonstrate an understanding of major concepts in biological sciences. Understand the basic concepts, fundamental principles, and the scientific theories related to various scientific phenomena and their relevancies in the day-to-day life.
- **Effective Communication**: Development of various communication skills such as reading, listening, speaking, etc., which will help in expressing ideas and views clearly and effectively.
- **Social Interaction**: Development of scientific outlook not only with respect to biological science subject but also in all aspects related to life.
- **Effective Citizenship**: Imbibe moral and social values in personal and social life leading to highly cultured and civilized personality.
- **Ethics**: Follow the ethical principles and responsibilities to serve the society.
- **Environment and Sustainability**: Understand the issues of environmental contexts and sustainable development.

- **Self-directed and Lifelong learning:** Students will be capable of self-paced and self-directed learning aimed at person

Programme Specific Outcome (PSOC)

After completing a degree in the School of Biological Sciences, graduates will be able to:

- Develop understanding of the basic principles of biological sciences
- Demonstrate proficiency in common lab and field techniques for biological sciences
- Integrate statistics, physical sciences and technology to answer biological questions and problems
- Students will be able to communicate scientific ideas effectively in both oral and written formats.
- Students will be able to think critically and evaluate, design, conduct and quantitatively assess innovative research in a biological discipline.
- Develop and communicate biological ideas and concepts relevant in everyday life for the benefit of society.
- Students will have acquired the skills and knowledge needed for employment or advanced graduate or professional study in discipline related areas.

B.Sc. (Hons)/Integrated M.Sc. Biological Sciences Course duration– 10 Semesters

Distribution of credits

Core Courses (CC) [17]	Ability Enhancement Compulsory Courses (AE) [2]	Skill Enhancement Courses (SEC) [2]	Discipline Specific Elective (DSE) [11]	Generic Elective (GE) [6]	Lab Course (LC) [3]	Summer Internship & Seminar (SIS) [1]	Dissertation (D) [1]	Total Credits
96	**4**	**10**	**52**	**30**	**12**	**2**	**20**	**226**

SEMESTER	Total Credits
Semester – I	20
Semester – II	20
Semester – III	28
Semester – IV	28
Semester – V	24
Semester – VI	24
Semester – VII	20
Semester – VIII	20
Semester – IX	22
Semester – X	20
Total	**226**

Nomenclature: CC: Core course; AE: Ability enhancement compulsory course; SEC: Skill enhancement courses; DSE: Discipline specific elective; GE: General elective; LC: Lab Course; SIS: Summer internship and seminar; D: Dissertation

SEMESTER	COURSEOPTED	COURSENAME	CREDITS
I (Total credits: 20)	Ability Enhancement Compulsory Course–I	Environmental Science/ English communication	2
	Core course–I	Chemistry	4
	Core course–I Practical	Chemistry	2
	Core course–II	Light and Life	4
	Core course–II Practical	Light and Life	2
	Generic Elective–1	GE–1	4
	Generic Elective–1 Practical	GE–1	2
II (Total credits: 20)	Ability Enhancement Compulsory Course–II	English communications/ Environmental Science	2
	Core course–III	Biophysics	4
	Core course–III Practical	Biophysics	2
	Core course–IV	Biodiversity	4
	Core course–IV Practical	Biodiversity	2
	Generic Elective–2	GE-2	4
	Generic Elective–2 Practical	GE-2	2
III (Total credits: 28)	Core course–V	Proteins and Enzymes	4
	Core course–V Practical	Proteins and Enzymes	2
	Core course–VI	Cell Biology	4
	Core course–VI Practical	Cell Biology	2
	Core course–VII	Ecology	4
	Core course–VII Practical	Ecology	2
	Generic Elective–3	GE-3	4
	Generic Elective–3 Practical		2
	Skill Enhancement Course	SEC-1	4

IV (Total credits: 28)	Core course–VIII	Systems Physiology	4
	Core course–VIII Practical	Systems Physiology	2
	Core course– IX	Molecular Biology	4
	Core course–IX Practical	Molecular Biology	2
	Core course–X	Metabolism and Integration	4
	Core course–X Practical	Metabolism and Integration	2
	Skill Enhancement Course-2	SEC-2	4
	Generic Elective–4	GE-4	4
	Generic Elective–4 Practical	GE-4	2
V (Total credits: 24)	Core course–XI	Growth and Reproduction	4
	Core course–XI Practical	Growth and Reproduction	2
	Core course–XII	Genetics	4
	Core course–XII Practical	Genetics	2
	Discipline Specific Elective–1	DSE-1	4
	Discipline Specific Elective–1 Practical	DSE-1	2
	Discipline Specific Elective–2	DSE-2	4
	Discipline Specific Elective–2 Practical	DSE-2	2
VI (Total credits: 24)	Core course–XIII	Immunology	4
	Core course–XIII Practical	Immunology	2
	Core course – XIV	Evolutionary Biology	4
	Core course – XIV Practical	Evolutionary Biology	2
	Discipline Centric Elective – 3	DSE-3	4
	Discipline Centric Elective – 3 Practical	DSE-3	2

	Discipline Centric Elective – 4	DSE-4	4
	Discipline Centric Elective – 4 Practical	DSE-4	2
VII (Total credits: 20)	Core course – XV	Genomics and Proteomics	4
	GE/DSE*	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses	4
			4
			4
	Lab Course – I		4
VIII (Total credits: 20)	Core course – XVI	Bioprocess Technology	4
	GE/DSE*	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses	4
			4
			4
	Lab Course – II		4
IX (Total credits: 22)	Core course – XVII	Cancer Biology	4
	GE/DSE*	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses	4
			4
			4
	Lab Course – III		4
	Summer Internship and Seminar		2
X (Total credits: 20)	Project/ Dissertation		20

B.Sc. (Hons) Biological Sciences

First Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS01C1	Chemistry	• Students will understand and apply the fundamental principles of chemistry to biological molecules. • Students will be able to identify the type of metabolic reaction and draw reaction mechanisms for key metabolic processes • Students will learn to recognize stereochemistry of a biomolecule and give a rational explanation of its biological reactivity based on stereochemistry. • The students will gain an insight into thermodynamics and basic principles of thermochemistry and successfully extend the concepts learnt in this course to biological systems
Core	BS01C2	Light & Life	• Students will understand and appreciate the dual nature of light. • Students will comprehend the impact of light on biodiversity. • Students will gain knowledge about the various photoreceptors in plants and animals and will appreciate and understand the mechanism of photosynthesis. • Students will understand bioluminescence, photoperiodism and biological rhythms. • Students will gain knowledge about the ecological and physiological responses to light.
Ability Enhancement Compulsory Course	BS01AE1	Environmental Sciences	• Create awareness among the students about the environment. • Understand natural processes that sustain life and encourage active participation in solving current environmental problems and preventing the future ones. • Adopt sustainability as a practice in life, society and industry.
Generic Elective	BS01GE1	Biostatistics	• Students will be acquainted with the concept of statistics and its application in biological sciences. • It will introduce students to statistical methods in order to understand the underlying principles, as well as practical guidelines of “how to do it” and “how to interpret it” statistical data particularly for biosystems.

Second Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS02C3	Biophysics	• Develop a basic understanding about the principles and concepts of Biophysics • Develop quantitative approaches to solve biological problems involving principles of physics • Understand the spectroscopic principles and their applications in biomolecules analysis • Understand the fundamental principles involved in the structure and function of biological membrane
Core	BS02C4	Biodiversity	• Impart knowledge of biodiversity and understand characteristic features of different plant and animal life forms. • Understand recent advances in technology used in mapping and conservation of biodiversity • Learn basic concepts of bioremediation and its applications in environmental remediation
Ability Enhancement Compulsory Course	BS02GE2	Macromolecules	• Gain knowledge on the importance, role and functions of biological macromolecules. • Acquire knowledge in the quantitative and qualitative estimation of biomolecule
Generic Elective	BS02AE2	English Communications	• Develop the communication and vocabulary skills in the students. • Acquire sufficient knowledge for professional communication

Third Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS03C5	Protein and Enzymes	• Acquire basic knowledge about the functional diversity of proteins and different levels of structural organization of proteins • Learn the relationship between protein structure and function and the protein purification techniques • Acquire insight into enzyme kinetics, inhibition, regulation and mechanism of action, and applications of enzymes
Core	BS03C6	Cell Biology	• Understand cell and its biology to get an insight into the origin of cells, cell diversity, cellular structure, survival and function. • Students will learn the basic difference between prokaryotic and eukaryotic cells, acquire knowledge of cell components and their functions, and cell cycle and division • Learn the role of receptors and ligands in cell signalling.
Core	BS03C7	Ecology	• Students will be able to comprehend the principles and applications of ecology and ecosystem. • Aware about the importance of ecosystem in general and the effects of changes in ecosystem. • Understand the principles and applications of ecology and ecosystem. • Learn the techniques used for the quantitative and qualitative estimation of biotic and abiotic components

			of an ecosystem. • Gain knowledge about the density, frequency and diversity of species in an ecosystem and key factors responsible for changes in natural ecosystem.
Generic Elective	BS03GE3	Environment and Public Health	• Learn major causes of environment and human health hazards • Get familiar with various public health management strategies. • Made aware about the increased pollution levels in the environment and its effect on human health. • Learn basic parameters of water, soil and air quality. • Gain knowledge about social and economic factors for different types of diseases.
Skill Enhancement Course	BS03SEC1	Biochemical Techniques	• Acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques. • Learn about the principles and applications of electrophoresis and centrifugation techniques. • Hands on experience to develop their laboratory skills expected of any biochemist working in a research lab.

Fourth Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS04C8	System Physiology	• Understand the unique role of various organs and organ systems in performing various vital functions. • Understand the role of physiology in adapting to various environments. • Appreciate the importance of homeostasis in different animals. • Learn to apply critical thinking and integrate scientific knowledge to understand the basic physiological principles which led to diverse evolutionary adaptations.
Core	BS04C9	Molecular Biology	• Acquire basic knowledge about the structure of DNA and RNA about organization of genome in various life forms. • Acquire basic knowledge about the process of replication, transcription, and translation in prokaryotes and eukaryotes. • Learn about the various ways in which the DNA can be damaged leading to mutations and lesions and different ways to repair DNA damage. • Learn about the various ways in which these biological processes are regulated and the significance of regulation in maintaining life forms
Core	BS04C10	Metabolism and Integration	• Understand the metabolic pathways operating in cell. • Understanding of the diversity of metabolic regulation and how this is achieved in different cell types. • Learn about and correlate the specific symptoms in clinical case presentations to metabolic disorders. • Learn how to perform and analyse various biochemical assays that will enable them to understand the concepts of clinical biochemistry

Generic Elective	BS04GE4	Bioethics and Biosafety	• Understand the scope and aspects of Bioethics and biosafety • Learn the ethical implications of biotechnology and need for biosafety, GLP and GMP, concernsrelated to GMO's and their regulation. • Analyze the safer use of biotechnology in agriculture, animal husbandry, pharmaceutics, andenvironment by implanting biosafety regulations. • Comprehend the ability to understand biosafety assessment procedure for biotech food,pharmaceuticals and other products
Skill Enhancement Course	BS04SEC2	Recombinant DNA Technology	• Learn various techniques used in recombinant DNA technology. • Learn about the biology of plasmids and phages and their uses in designing different cloning vectors. • Learn about the designing and application of expression vectors. • Get an insight into animal and plant biotechnology, creating transgenic animals and plants and its application in therapeutics. • Appreciate the ethical concerns related to genetically modified organisms and impact of biotechnology on the society.

Fifth Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS05C11	Growth and Reproduction	• Learn the path of development of plants from juvenile to senescent stages with the accompanying genetical, cellular, physiological and morphological changes. • Understand the role of pollinators and get hands on experience of observing patterns on pollen grains, pollen germination, embryo and endosperm dissection, and collect seeds with different dispersal mechanisms. • Understand the reproductive system in animals and human beings so as to relate with the control of population and environmental threats in the current scenario. • Apply experimental approaches to understand these developmental events in the laboratory
Core	BS05C12	Genetics	• Understand the concept of genotype and phenotype, describe the basic principles of Mendelian genetics and appreciate the various factors that confergenotypic and phenotypic variability. • Understand the inter relationship between environment (Nurture) versus inheritance (Nature) in determining the conversion of genotype to phenotype. • Understand resistance patterns and to create linkage and genetic maps. • Able to describe population structure by genetic variation, pedigree analysis and develop broad and balanced knowledge and understanding of key biological concepts, principles and theories related to evolution, genetic change and speciation.

Discipline Specific Elective	BS05DSE1	Microbiology	• The students will learn about the various types of microorganisms including bacteria, fungi and viruses and their structures • The students will learn about the growth and development of microorganisms; and also the effects of various environmental factors on its growth • The students will also learn about the applications of microorganisms in food and others pharmaceutical industries • The students will learn about the relationship between various types of microorganisms and diseases • The students will also learn about various anti-microbial compounds and their mechanism of action on the microbial biology
Discipline Specific Elective	BS05DSE2	Plant Biochemistry	• Understanding the structure and function of the plant cell components including organelles • Understanding about the regulation mechanisms of growth of the plants • Understanding the chemistry of various metabolites of plants and their functions in biological system • Learning about the various metabolic reactions of plants • Learning tissue culture techniques and its applications

Sixth Semester			
Course Type	**Course Code**	**Course Title**	**Course Outcome (COC)**
Core	BS06C13	Immunology	• Get an overview of the immune system and learn about the various cells, organs and tissues of the immune system. • Understand the basic mechanisms, differences and functional interplay of innate and adaptive immunity, and importance of immune system in health and disease. • Learn various pre-existing structural and induced defences in plants and how pathogens can cause disease in plants. • Understand the genetic basis of plant-pathogen interaction and learnabout the importance of genetic engineering in control of plant pathogens
Core	BS06C14	Evolutionary Biology	• Understand the fundamental principles of evolution • Study the patterns and processes that shape biodiversity • Study of the history of life on Earth • Investigate the mechanisms by which new species arise and diversify over time • Critical assessment of the evolutionary theory from various scientific disciplines.
Discipline Specific Elective	BS06DSE3	Wildlife Conservation and Management	• Students will learn about the importance of wildlife, its conservation and management. • Students will learn about major causes of wildlife

			depletion and important *in-situ* and *ex-situ* strategies for the conservation of their genetic diversity. • Students will learn about reasons of human-wildlife conflicts. • Students will gain knowledge about the Protected Area Networks in India, Ecotourism, Human-animal conflict and other challenges in wildlife management.
Discipline Specific Elective	BS06DSE4	Stress Biology	• The students will be able to learn regarding various environmental factors that induce stress in plants • The students will learn about various types of free radicals and their mechanism of action in the biological system • The students will learn about various protective mechanisms in plants • The students will learn about the various adaptation processes of plants towards external environment.

Seventh Semester			
Core	BS07C15	Genomics and Proteomics	• Upon completing this course, students will be proficient in analyzing genomic and proteomic data using tools like PCR, RFLP, genome sequencing, and microarray technologies. • They will understand genome diversity, expression profiling, and proteome analysis techniques such as 2-D PAGE and mass spectrometry. • Students will be skilled in protein sequencing, studying protein structure and interactions, and using proteomics databases. • They will be capable of identifying disease-related proteins, contributing to drug discovery, and developing protein engineering solutions.
Generic Elective	BS07GE5	Research Methodology and Science Communication	• Upon successful completion of this course, students will have the expertise to effectively formulate and plan research projects, including defining research problems, designing experiments, and employing advanced methodologies. • They will demonstrate proficiency in conducting comprehensive literature reviews, analyzing data using statistical methods and ANOVA, and producing high-quality technical research articles. • Students will be well-versed in bioethics, understanding regulatory guidelines and ethical considerations relevant to biotechnology. • They will possess in-depth knowledge of biosafety practices, including containment levels, Good Laboratory Practices (GLP), and regulatory frameworks for GMOs, enabling them to manage and

			assess risks in research and industrial settings.
Discipline Specific Elective	BS07DSE5	Microbial Pharmaceutical Technology	• Upon completing this course, students will have a thorough understanding of antimicrobial chemotherapy, including the selection and mechanisms of action for various antimicrobial agents. • The students will gain expertise in microbial production and spoilage of pharmaceutical products, including the manufacturing and control of various vaccines and therapeutic enzymes. • They will be familiar with contamination control, biosensor applications, and regulatory practices, including FDA standards and the significance of IP, BP, and USP. • They will also be proficient in conducting microbial limit tests, sterility and pyrogen testing, and implementing various sterilization methods.
Discipline Specific Elective	BS07DSE6	Plant Biotechnology	• Upon completion of this course, students will have acquired a robust understanding of plant tissue culture techniques and their applications in crop improvement, including the production of virus-free plants and somatic hybridization. • They will be proficient in the principles of genetic engineering, capable of developing genetically modified crops for both biotic and abiotic stress tolerance. • Students will be adept at improving the quality of plant-derived proteins, lipids, carbohydrates, vitamins, and minerals, and utilizing plants as bioreactors. • They will also gain expertise in manipulating plant secondary metabolites for industrial and therapeutic purposes. • They will also be proficient in applying advanced molecular breeding techniques such as RFLP, RAPD, STS, SCAR, QTL, and map-based cloning for the enhancement of crop traits.
Laboratory	BS07LC1	Lab Course - I	• Experiments

Eight Semester			
Core	BS08C16	Bioprocess Technology	• Upon completing this course, students will have developed an understanding of bioprocess technology, enabling them to apply key principles of bioprocess engineering in real-world scenarios. • They will be adept at analyzing and optimizing microbial growth and product formation within various fermentation processes, including batch, fed-batch, and

			continuous modes. • Students will possess the skills to design and operate different types of bioreactors and production vessels, as well as to scale up bioprocesses from laboratory settings to industrial applications. • They will be proficient in upstream processing, including inoculum development and media formulation, and will have practical experience in downstream processing techniques for product recovery and isolation.
Discipline Specific Elective	BS08DSE7	Bioinformatics	• Upon completion of this course, students will have developed a robust skill set in bioinformatics, enabling them to effectively utilize computational tools and databases for biological data analysis. • They will be proficient in navigating and leveraging various biological databases for sequence identification and analysis, including DNA and protein sequences. • Students will be adept at performing DNA sequence analysis, including sequence alignment, motif discovery, and the identification of structural variants. • They will be capable of conducting multiple sequence alignments and phylogenetic analyses using tools such as FASTA3 and CLUSTALW.
Discipline Specific Elective	BS08DSE8	Animal Biotechnology	• Upon completing this course, students will possess a comprehensive understanding of animal biotechnology, including expertise in animal cell culture, reproductive biotechnology, and genomics. • They will be adept at using cell culture techniques, transfection methods, and stem cell applications. • Proficiency will be gained in cryopreservation, artificial insemination, embryo recovery, in vitro fertilization, and transgenic animal technology. • Students will be skilled in genome characterization, gene knock-out technology, and cloning for conservation. • They will understand the mechanisms for producing vaccines, monoclonal antibodies, and pharmaceutical proteins, and proficient in immunological and nucleic acid-based identification methods.
Discipline Specific Elective	BS08DSE9	Environmental Biotechnology	• Upon completion of this course, students will have a comprehensive understanding of environmental biotechnology applications, including advanced knowledge in wastewater treatment processes, such as primary, secondary, and tertiary methods, and various treatment technologies. • They will be proficient in assessing wastewater characteristics, conducting toxicity testing, and

			applying anaerobic digestion and composting techniques, including vermicomposting. • Students will be skilled in analyzing the biodegradation of organic pollutants and implementing bioremediation strategies for oil spills, heavy metals, and other contaminants. • The students will understand the role of microbial insecticides and biofertilizers in pest management and soil health, equipping them with practical skills for addressing environmental challenges through biotechnological solutions.
Laboratory	BS08LC2	Lab Course - II	• Experiments

Ninth Semester			
Core	BS09C17	Cancer Biology	• Upon completion of the course, the students will be able to understand the epidemiology of carcinogenesis. • Understand the complex pathways and molecular switches involved in the transformation of a normal cell to a cancer cell. • Understand the stages of cancer leading to the movement of cancer cells throughout the body. • Develop knowledge on the current strategies of cancer diagnosis and treatment. • Understanding the biology of cancer, its causes, its progression and its treatment
Generic Elective	BS09GE6	Intellectual Property Rights	• Understand the rationale for and against IPR and especially patents • Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations • Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents
Discipline Specific Elective	BS09DSE10	Neurobiology	• Basic understanding of Brain functioning and key concepts underlying neural functions. • To know the molecular and cellular components of the nervous systems. • Major landmarks that process neuronal development from zygote to brain. • Understand how regulation of neurotransmission contributes to neural plasticity. • Understand the mechanism of integration of the components of nervous systems to mediate motor activities and sensation perception.

	BS09DSE11	Nanobiotechnology	• Understand the foundational principles of nanobiotechnology, including the synthesis, characterization, and various applications of nanomaterials in biological and medical fields. • Understand the use of nanoparticles for drug delivery and diagnostics, focusing on strategies for cellular internalization, long circulation, and permeation through anatomical barriers. • Gain insights into the role of nanomaterials in catalysis, including the development and application of nanobio catalysts for drug production. • Enable assessment of the safety and toxicity of nanomaterials, using appropriate models and assays, while understanding their environmental impact.
	BS09DSE12	Vaccines	• Understanding the fundamental concepts of human immune system, basic immunology, and differentiation. • Understanding of immune responses in relation to infection and vaccination. • Understanding the requirements and designing of different types of vaccines • Understand the importance of conventional and new emerging vaccine technologies.
Discipline Specific Elective	BS09DSE13	Molecular Diagnostics	• Understanding the principles and techniques of molecular diagnostics in identifying and diagnosing genetic, infectious and chronic diseases. • Analysis of molecular diagnostic data and interpret results for disease management • Understanding the ethical and regulatory aspects of molecular diagnostics in healthcare and implications of genetic testing.
	BS09DSE14	Genetic Engineering	• Understanding the need of need and applications of genetic engineering in the present day. • Understanding the impact of genetic engineering in modern society and the environment • Understanding the mechanisms for executing genetic engineering of target organisms • The students will be prepared to take up biological research in the relevant field.
Laboratory	BS09LC3	Lab Course- III	• Experiments
Laboratory	BS09SIS	Summer Internship and Seminar	

Tenth Semester

Project/ Dissertation	BS10LC4		

SEMESTER –I **Total Credits: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1	**BS01C1**	**Chemistry**	**4-0-2**	**6**	**30-30-20-20**
2	**BS01C2**	**Light & Life**	**4-0-2**	**6**	**30-30-20-20**
3	**BS01GE1**	**Biostatistics**	**4-0-2**	**6**	**30-30-20-20**
3	**BS01AE1**	**Environmental Sciences**	**2-0-0**	**2**	**30-50-20-00**

Course Code	**:**	**BS01C1**
Course Title	**:**	**Chemistry**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**I**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Chemical Bonding and Molecular Structure Ionic Bonding No. of Hours: 15

Lattice energy and solvation energy. Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, Covalent Bonding: VB Approach,Lewis theory, VSEPR theory to explain the shapes of molecules, salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach, salient features of the MO theory.Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for s-s-, s-p and p-p combinations of atomic orbitals, nonbonding combinations of orbitals MO treatment of homonuclear diatomic molecules of 1st period and heteronuclear diatomic molecules such as CO, HF.

UNIT II: Chemical Thermodynamics No. of Hours: 15

Qualitative idea of thermodynamics. First Law of Thermodynamics: Calculation of work (w), heat (q), changes in internal energy (ΔE) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w,q, ΔE, and ΔH for processes involving changes in physical states. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchhoff's equation. Second law of thermodynamics, concept of entropy, Gibbs free energy and Helmoltz free energy. Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity, Gibbs Helmholtz equation. Maxwell's relations. Statements of Third Law of thermodynamics: calculation of absolute entropies of substances.

UNIT III: Fundamentals of Organic Chemistry No. of Hours: 15

Hybridization in organic compounds, cleavage of covalent bond, homolysis and heterolysis, Electronic effects: Electronic effects and their applications – inductive, resonance and hyperconjugation effects. Structure and relative stability of reactive carbon species – carbocations, carbanions, free radicals and carbenes, Molecular Forces: types of intermolecular and intra-molecular forces and their characteristics: dipole-dipole, dipoleinduced dipole and dispersion (London) forces. Hydrogen bond (both intramolecular and intermolecular), Effect of inter/intramolecular forces on physical properties such as solubility, vapour pressure, melting and boiling points of different compounds, Aromaticity.

UNIT IV: Stereochemistry **No. of Hours: 15**

Stereochemistry and its importance. Geometrical isomerism, cis-trans and E/Z nomenclature Optical isomerism – optical activity, plane polarized light, enantiomerism, chirality, specific molar rotation, Stereoisomerism with two chiral centrers: Diastereomers, mesoisomers, Resolution of racemic modification. Projection diagrams of stereoisomers: Fischer, Newman and Sawhorse projections. Relative Configuration: D/L designation. Absolute Configuration: R/S designation of chiral centres, Conformational isomerism – ethane, butane and cyclohexane, diagrams and relative stability of conformers.

Course Code	**:**	**BS01C1**
Course Title	**:**	**Chemistry**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**I**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Preparation of solutions based on molarity, normality, percentage, dilutions etc.
2. Preparation of buffers.
3. Estimation of Mohr's salt/ oxalic acid by titrating with $KMNO_4$.
4. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
5. To find pKa value of given acetic acid

Text and References:

1. R.L. Madam, Chemistry for degree students (2020). S. Chand Publishing, India
2. Arun Bahl, B. S. Bahl (2019). A Textbook Of Organic Chemistry (20th Edn). S Chand Publishing
3. J.D. Lee. A new concise inorganic chemistry, USA: Wiley-Blackwell
4. Patrick E. McMahon, Bohdan B. K.; Claes W., Organic Chemistry CRC Press, 2017
5. Clayden J., Greeves N.,Warren S., Organic Chemistry 2nd Edition Oxford University Press

Course Code	**:**	**BS01C2**
Course Title	**:**	**Light and Life**
Theory/Practical	**:**	**Theory**
Semester	**:**	**I**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: **No. of Hours: 15**

Nature of light, spectrum of light which is useful/ harmful (ionizing radiation) for various biological processes in life of plants and animals. Unit of light energy (Photon, quantum), the different Photo Biological reactions. Measurement of light (Lux, Foot Candle). Comparative account of chemistry and functional roles of pigments associated with harvesting light energy: pigments/receptors of light, chlorophylls, caroteniods, phycobilinoproteins, bacteriochlorophylls, phytochromes rhodopsin etc. Photoreception in animals, evolution of eye and visual processing in vertebrate retina.

UNIT II: **No. of Hours: 15**

Photosynthesis: History, Photosynthetic equation, Light and dark reactions, mechanism of photolysis of water and oxygen evolution, Q cycle, O2 evolving complex; C3, C4, CAM plants, spectrum of photoautotrophs, photoautotroph vs photoheterotrophs; Photoautotroph vs. chemoautotroph, structure of chloroplast and quantasome, Anoxygenic and oxygenic photosynthesis, reaction centers. Bacterial Photosynthesis

UNIT III: **No. of Hours: 20**

Bioluminescence: definition, discovery, diversity of organisms (plants and animals), photoreceptors - distribution, mechanism; General account of effect of light on morphology and physiology (stomatal opening and closing, transpiration, respiration, growth and differentiation) Phytochrome mediated photomorphogenesis phenomena - seed germination etc. Photoperiodism: LDP, SDP, DNP plants, vernalization, vernalin, etiolation and de- etiolation. Light as an ecological factor affecting distribution of plants and animals (Phyto and Zoo geography), in terrestrial and aquatic ecosystems: Morphological, Anatomical, Physiological and Behavioural adaptations to extreme light conditions by organisms. Changes during fruit ripening process as affected by light.

UNIT IV: **No. of Hours: 10**

Behavioural aspects of ecology and physiology: circadian rhythms, jetlag, rhythm of heart beat, melanocytes and skin colour, chromatophores and colour changes in animals. Light as an inducer for biosynthesis of enzymes, hormones and other biomolecules.

Course Code	**:**	**BS01C2**
Course Title	**:**	**Light and Life**
Theory/Practical	**:**	**Practical**
Semester	**:**	**I**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Demonstration of
    a. Etiolation and deetiolation;
    b. Light and CO_2 are essential for photosynthesis (Moll's half leaf experiment)and measure oxygen evolution during photosynthesis
    c. Oxygen liberation during photosynthesis using *Hydrilla*, Measurement of light using Luxmeter, light penetration in water using Secchidisc
    d. *Berlese* funnel experiment to demonstrate the effect of light on soil fauna
    e. Animal migration in aquatic ecosystems during day and night (pictures only)
    f. To study the estrous cycle of rat
2. Chemical separation of chloroplast pigments/ Chromatographic separation of chloroplast pigments.
3. Demonstration of Hill's reaction and study of the effect of light intensity (any two light conditions).
4. Study of the effect of red and blue light on seed germination and development of pigments during fruit ripening.
5. Photographs/ slides/ specimens of photoautotrophic and photosynthetic bacteria, chloroplast, quantasome, bioluminescent organisms (plants and animals)
6. To test/ survey for colour blindness using Ishihara charts

Text and References:

1. Hall D. O., Rao K. K. Photosynthesis (New Studies in Biology) Cambridge University Press
2. Kochhar S. L., Gujral Sukhbir Kaur. Plant Physiology: Theory and Applications October 2021. Cambridge University Press
3. Björn, L. O. (2015) 3rd Ed. Photobiology: Science of Light and Life, L.O. Bjorn., Springer
4. Shimomura O., (2012) *Bioluminescence: Chemical Principles and Methods*, World Scientific
5. Alison M. Smith George Coupland Liam Dolan Plant Biology Garland Science 2009
6. Singh V., Pande P.C., Jain D.K.- A Text Book Of Botany. Rastogi Publication
7. Hawes C & Satiat-Jeunemaitre - 2001 Plant Cell Biology : Practical approach
8. Buchanan B, Gruissem G & Jones R - 2000 - Biochemistry and Molecular Biology of Plants.
9. Randall, Burggren, French : Eckert , Animal Physiology-mechanisms and adaptations, W H Freeman and company
10. Elli Kohen, Rene Santus, Joseph G. Hirschberg: Photobiology Academic press Peter A. Ensminger Life under the sun , Yale University Press
11. Alcock John- Animal Behavior: An Evolutionary Approach, Publisher: Sinauer Associates Inc., U.S.
12. H.R. Singh & amp; Neeraj Kumar (2017). Animal Physiology & Biochemistry, Vishal Publishing Co.
13. Verma S.K., A Textbook of Plant Physiology, Biochemistry and Biotechnology, S Chand Publication.
14. Bajracharya, D., Experiments in Plant Physiology: A Laboratory Manual, Narosa Publishing House, 1999

Course Code	**:**	**BS01GE1**
Course Title	**:**	**Biostatistics**
Theory/Practical	**:**	**Theory**
Semester	**:**	**I**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: **No. of Hours: 12**

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

UNIT II: **No. of Hours: 18**

Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT III: **No. of Hours: 18**

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 goodness of fit and analysis of variance (ANOVA)

UNIT IV: **No. of Hours: 12**

Correlation and Regression. Emphasis on examples from Biological Sciences.

Course Code	**:**	**BS01GE1**
Course Title	**:**	**Biostatistics**
Theory/Practical	**:**	**Practical**
Semester	**:**	**I**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Based on graphical Representation
2. Based on measures of Central Tendency & Dispersion
3. Based on Distributions Binomial Poisson Normal
4. Based on t, f, z and Chi-square

Text and References:

1. Jan Lepš, Petr ŠmilauerBiostatistics with R: An Introductory Guide for Field Biologists Cambridge University Press 2000
2. Chap T. Le, Lynn E. Eberly Introductory Biostatistics 2nd Edition Wiley Publications 2012
3. John E. Havel, Raymond E. Hampton, Scott J. Meiners Introductory Biological Statistics, Fourth Edition 4th Edition Waveland Press, Inc. 2019.
4. Banerjee Pranab Kumar (2007). Introduction To Bio-statistics: A Textbook of Biometry. S Chand & Company
5. P.S.S. Sundar Rao and J. Richard (2012). Introduction to Biostatistics and Research Methods (5^{th} Edn). PHI Learning Pvt. Ltd.
6. Dutta, N. K. (2004). Fundamentals of Biostatistics, Kanishka Publishers.

Course Code	**:**	**BS01AE1**
Course Title	**:**	**Environmental Science**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**I**

TOTAL HOURS: 45 **CREDITS: 4**

UNIT I: The Multidisciplinary nature of Environmental Studies **No. of Hours: 5**

Introduction, definition, Objectives, Scope and Importance of Environmental Studies. Segments of Environment: Atmosphere, Hydrosphere, Lithosphere and Biosphere. Need for public awareness.

UNIT II: Natural Ressources **No. of Hours: 6**

Renewable and Nonrenewable resources, Forest resources, water resources, mineral resources, Food resources, Energy resources, land resources. Role of an individual in conservation of natural resources.

UNIT III: Ecology and Ecosystem **No. of Hours: 6**

Introduction and Definition, Structure / Components of Ecosystem, Types of Ecosystems, Functional attributes of an ecosystem, Productivity, Food chain relationships, Food Web, Ecological pyramids, Energy flow and Material Cycling.

UNIT IV: Biodiversity and its Conservation **No. of Hours: 6**

Introduction and Definition, Types of biodiversity, Biogeographical classification of India, Value of biodiversity, Hot spots of biodiversity, Threats to biodiversity, IUCN classification of species. Conservation of biodiversity-In-situ and Ex-situ conservation, Biosphere Reserves, National Parks, Wild life Sanctuaries, Zoological Gardens, Botanical Gardens, Seed Banks, Tissue Culture etc.

UNIT V: Environmental Pollution: **No. of Hours: 12**

Pollutants, Types of pollutants, Effects of pollution on the environment, Types of environmental pollution, Air Pollution, Water Pollution, Soil Pollution, Noise Pollution, Thermal Pollution, Radioactive Pollution, Solid waste management (Definition, causes, effects and control of various pollution), Case studies, Disaster management: flood, earthquake, cyclone, landslides.

UNIT V: Social Issues and the Environment **No. of Hours: 10**

Sustainable Development, Water Conservation and management, Rain water Harvesting, Climate change, Global warming, Acid Rain, Ozone layer depletion, Wastelands, wetland and their reclamation, Human population and the environment, Environmental laws, Case studies

Text and References:

1. Wilson, E. O., (1998). *Biodiversity*. National Academic Press.
2. Cunningham, W.P. & Cunningham, M.A. 2003. Principles of environmental science, inquiry and applications. Tata McGraw-Hill Publ. Co. Ltd. 424 pages
3. Erach Bharucha (2022). Environmental Studies for Undergraduate courses. Universities Press (India) Private Limited.
4. Campbell N. A., (2008). Biology 8th Edition, Pearson
5. Chapman, J.L. & Reiss, M.J. Ecology: Principles and applications. Cambridge Univ. Press. 294 pages.
6. Faurie, Claude et al. 2001. Ecology: Science and practice. Oxford & IBH Publ. Co. Pvg. Ltd. 321 pages.

SEMESTER –II **Total Credits: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1	BS02C3	Biophysics	4-0-2	6	30-30-20-20
2	BS02C4	Biodiversity	4-0-2	6	30-30-20-20
3	BS02GE2	Macromolecules	4-0-2	6	30-30-20-20
4	BS02AE2	English Communications	2-0-0	2	30-50-20-00

Course Code	**:**	**BS02C3**
Course Title	**:**	**Biophysics**
Theory/Practical	**:**	**Theory**
Semester	**:**	**II**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Mechanics **No. of Hours: 14**

Galilean invariance and Newton's Laws of motion. Dynamics of a system of particles, Conservation of momentum and energy, work energy theorem. Conservation of angular momentum, torque, Motion of a particle in central force field. Kepler's Laws, Satellite in circular orbit and applications (Synchronous satellite, GPS, Artificial gravity, apparent weightlessness), Physiological effects of acceleration and angular motion. Special Theory of Relativity: Constancy of speed of light, postulate of Special theory of relativity, length contraction, time dilation, relativistic velocity addition, Mass-energy momentum relations.

UNIT II: Waves and Oscillations **No. of Hours: 12**

Simple harmonic motion, damped and driven harmonic oscillator, coupled oscillator, energy relation and energy transfer, normal modes, Wave equation, Travelling waves, superposition principle, pulses, Doppler effect, effects of vibrations in humans, physics of hearing, heartbeat. Modern optics: Two slit Interference, Diffraction, Resolving power, Resolution of the eye, Laser characteristics, Principle, Population inversion, Application of laser in medical science, Polarization of EM wave, Malus Law, Polarizing materials, Polarizer, Analyzer.

Unit 3 Biological membranes **No. of Hours: 16**

Colloidal solution, Micelles, reverse micelles, bilayers, liposomes, phase transitions of lipids, active, passive and facilitated transport of solutes and ions, Fick's Laws, Nernst Planck Equations, Diffusion, Osmosis, Donnan effect, permeabilily coefficient. Ionophores, transport equation, membrane potential, water potential.

Unit 4 Spectroscopic techniques **No. of Hours: 18**

Basic principles of electromagnetic radiation, energy, wavelength, wave numbers and frequency. Review of electronic structure of molecules (Molecular Orbital theory), absorption and emission spectra. Beer-Lambert law, light absorption and its transmittance. UV and visible spectrophotometry-principles, instrumentation and applications. fluorescence spectroscopy, static & dynamic quenching, energy transfer, fluorescent probes in the study of protein, nucleic acids, Infra-red spectroscopy, light scattering in biology, circular dichroism, optical rotatory dispersion, magnetic resonance spectroscopy.

Course Code	**:**	**BS02C3**
Course Title	**:**	**Biophysics**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**II**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Determination of acceleration due to gravity using Kater's Pendulum
2. Determination of the acceleration due to gravity using bar pendulum
3. Determination of the frequency of an electrically maintained tuning fork by Melde's Experiment
4. Determination of the coefficient of Viscosity of water by capillary flow method (Poiseuille's method)
5. Verification of Beer Law
6. Determination of Molar Extinction coefficient
7. Determination of CMC for a detergent
8. Effect of different solvents on UV absorption spectra of proteins.

Text and References:

1. Meyer B. Jackson Molecular and Cellular Biophysics 2006
2. Keith Wilson and John Walker, Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition, Cambridge University Press, 2005.
3. Donald L. Pavia Introduction to Spectroscopy 2015, Cengage India Private Limited
4. N. K. Bajaj (2017). The Physics of Waves and Oscillations. Tata McGraw Hill.
5. Nelson Philip Biological Physics: Energy, Information, 2007, W. H. Freeman
6. William Bialek Biophysics: Searching for Principles, Princeton University Press

Course Code	**:**	**BS02C4**
Course Title	**:**	**Biodiversity**
Theory/Practical	**:**	**Theory**
Semester	**:**	**II**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Defining Biodiversity **No. of Hours: 16**

Components of Biodiversity. Biodiversity crisis and biodiversity loss. Importance of biodiversity in daily life. Biodiversity and climate change. Types of Ecosystems: India as mega biodiversity Nation. Hot spots and biodiversity in India. Biodiversity and Ecosystem functioning. Plant and Animal systematic. Species concept in biodiversity studies.

UNIT II: Modern Tools in the study of Biodiversity **No. of Hours: 14**

Endemism, endemic plants and animals**;** Assessment of mapping of biodiversity**;** GIS/Remote sensing**;** Biotechnology and Conservation, IUCN**;** Germplasm banks, National Parks, Botanical Gardens**;** Wildlife Sanctuaries, Bioresources.

UNIT III: Crop Diversity **No. of Hours: 12**

Wild relatives of cultivated plant; Domesticated diversity; Spice diversity; Forest diversity and wild life.

UNIT IV: Bio-prospecting **No. of Hours: 18**

Representative type (one each) studies from Cryptogams, Phanerogams, Non-chordates and Chordates**;** Sacred flora and fauna. Bio-prospecting - Microorganisms as a source of novel enzymes, antibiotics, antiviral agents; Immunosuppressive agents and other therapeutic agents. Botanicals for Biocontrol, Health and biodiversity.

Course Code	**:**	**BS02C4**
Course Title	**:**	**Biodiversity**
Theory/Practical	**:**	**Practical**
Semester	**:**	**II**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments (Biodiversity)

1. Measuring biodiversity of ecological communities
2. Study of a simple ecosystem (suggested habitats: pond, river, estuarine, grassland, forest and desert) and description of the biotic and abiotic components of the ecosystem.
3. Study of five endangered plant species of India
4. Enlist the biodiversity of Localized area
5. Study of five endangered animal species of India

Text and References:

1. Wilson, E. O., (1998). *Biodiversity*. National Academic Press.
2. Cunningham, W.P. & Cunningham, M.A. 2003. Principles of environmental science, inquiry and applications. Tata McGraw-Hill Publ. Co. Ltd. 424 pages
3. Erach Bharucha (2022). Environmental Studies for Undergraduate courses. Universities Press (India) Private Limited.
4. Campbell N. A., (2008). Biology 8th Edition, Pearson
5. Chapman, J.L. & Reiss, M.J. Ecology: Principles and applications. Cambridge Univ. Press. 294 pages.
6. Faurie, Claude et al. 2001. Ecology: Science and practice. Oxford & IBH Publ. Co. Pvg. Ltd. 321 pages.
7. Aber, J.D.and Melillo J.M., Terrestrial Ecosystems: 1991, W.B.Saunders
8. Ingrowille, M. Diversity and Evolution of land plants 1992 chapman and Hall

Course Code	**:**	**BS02GE2**
Course Title	**:**	**Macromolecules**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**II**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Carbohydrates **No. of Hours: 15**

Structural aspects – Introduction & Occurrence, Classification of Mono-, Di- and Polysaccharides, Reducing & Non-reducing Sugars, Constitution of Glucose & Fructose, Osazone formation, Pyranose &Furanose forms, Determination of ring size, Inter-conversion of monosaccharides.

UNIT II: Lipids **No. of Hours: 10**

Structural aspects – General introduction, Classification & Structure of Simple & Compound lipids, Properties of Lipid aggregates (elementary idea), Biological membrane, Membrane protein – structural aspects, Lipoproteins (elementary idea).

UNIT III: Proteins **No. of Hours: 10**

Structural aspects – General introduction, Classification & General characteristics, Structure of Primary, Secondary, Tertiary & Quaternary proteins (elementary idea), α and β chains of proteins (elementary idea), Classification of Amino acids.

UNIT IV: Nucleic acid **No. of Hours: 10**

Structural aspects – Components of DNA and RNA, Nucleosides & Nucleotides (introduction, structure & bonding), Double helical structure of DNA (Watson-Crick model), various forms of DNA.

UNIT V: Chemical & Enzymatic Kinetics **No. of Hours: 15**

An introduction to enzyme; How enzyme works; Reaction rate; Thermodynamic definitions; Principles of catalytic power and specificity of enzymes; Enzyme kinetics – Approach to mechanism.

Course Code	**:**	**BS02GE2**
Course Title	**:**	**Macromolecules**
Theory/Practical	**:**	**Practical**
Semester	**:**	**II**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Effect of pH on the activity of an enzyme
2. Effect of temperature on the activity of an enzyme
3. Preparation of buffers
4. Determination of pKa value for acetic acid
5. Estimation of proteins by Biuret method
6. Estimation of proteins by Lowry's method
7. Separation of sugars by Thin Layer chromatography
8. Assay of the enzyme acid phosphatase from germinated mung dal or β-amylase from Sweet potato beams
9. Progress curve of an enzyme

Text and References:

1. Nelson, D. L. and Cox, M. M. (2021). Lehninger, Principles of Biochemistry, (8th Ed.). W.H. Freeman and Company (New York, USA).
2. Lubert Stryer (2019). Biochemistry (9th Edition). W.H. Freeman
3. Cooper, T. G. (2009). The tools of biochemistry. Chichester: John Wiley.
4. Voet, D. and Voet, J.G. (2020). Biochemistry. (4th Ed), John Wiley & Sons, Inc. USA
5. U. Satyanarayan and U. Chakrapani (2023). Biochemistry (6th Ed.). Elsevier publications

Course Code	**:**	**BS02AE2**
Course Title	**:**	**English communication**
Theory/Practical	**:**	**Theory**
Semester	**:**	**II**

TOTAL HOURS: 45 **CREDITS: 2**

UNIT I: Introduction **No. of Hours: 05**

Theory of Communication, Types and modes of Communication

UNIT II: Language of Communication **No. of Hours: 10**

Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication

UNIT III: Speaking Skills **No. of Hours: 10**

Monologue Dialogue; Group Discussion; Effective Communication/ Mis- Communication Interview; Public Speech

UNIT IV: Reading and Understanding **No. of Hours: 10**

Close Reading Comprehension; Summary Paraphrasing; Analysis and Interpretation; Translation(from Indian language to English and vice-versa) Literary/Knowledge Texts

UNIT V: Writing Skills **No. of Hours: 10**

Documenting Report Writing;Making notes Letter writing

Text and References:

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

SEMESTER –III **Total Credits: 28**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS03C5	Protein and Enzymes	4-0-2	6	30-30-20-20
2.	BS03C6	Cell Biology	4-0-2	6	30-30-20-20
3.	BS03C7	Ecology	4-0-2	6	30-30-20-20
4.	BS03SEC1	Biochemical Techniques	4-0-2	6	30-30-20-20
5.	BS03GE3	Environment and Public Health	4-0-0	4	30-50-20-00

Course Code	**:**	**BS03C5**
Course Title	**:**	**Protein and Enzyme**
Theory/Practical	**:**	**Theory**
Semester	**:**	**III**

TOTALHOURS: 60 **CREDITS: 4**

UNIT I: Biomolecules: Diversity and distribution **No. of Hours: 15**

Lipids: Role of lipids in cellular architecture and functions. Definition and classification of lipids. Structure and function of fatty acids, triacylglycerols, phospholipids ands terols.
Carbohydrates: Biological roles of carbohydrates. Structure of monosacharides- Hexosesandpentoses. Disacharides- Sucrose, lactose, maltose. Storage and structural polysacharides- Glycogen, starch and cellulose. Nucleic acids: Role of nucleic acids in living system. Composition of nucleic acids- the purine and pyrimidine bases.

UNIT II: Proteins **No. of Hours: 10**

Classification of proteins on the basis of composition, conformation and function-functional diversity of proteins. The amino acid building blocks-classification, structure and physical properties of the standard amino acids. Proteinaceous and non-proteinaceous, essential and non-essential amino acids. Primary, secondary, tertiary and quaternary structure of proteins. Structure of myoglobin and hemoglobin. Molecular physiology of myoglobin and hemoglobin, Bohreffect, Hill'scoefficient. Concerted and sequential models for all ostericproteins.

UNIT III: Enzymes **No. of Hours: 15**

Enzymes as biological catalysts. Enzyme classification and nomenclature. Chemical nature of enzymes, ribozymes. Concept of activesite, specificity. Coenzymes, cofactors and prosthetic groups. Kinetics of enzyme catalyzed reactions-Michaelis Menten equation. Determinationof Km and Vmax. Factors influencing the rate of enzyme catalyzed reactions. Enzyme inhibitions- competitive, non-competitive and uncompetitive inhibitions. Catalytic mechanism of lysozyme or chymotrypsin. Regulation of enzyme activity allosteric enzymes, feedback inhibition with AT case as an example.

UNIT IV: Isolation and purification of enzymes **No. of Hours: 10**

Methods of enzyme isolation and purification. Introduction to enzyme immobilization.

UNIT V: Role of Metal ions in Biology **No. of Hours: 10**

Metalloprotein, Metalloenzymes, metal base drug interaction and inhibition; metalloporphyrins, Redox. Carriers in mitochondrial electron transport chain.

Course Code	**:**	**BS03C5**
Course Title	**:**	**Protein and Enzyme**
Theory/Practical	**:**	**Practical**
Semester	**:**	**III**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Preparation of buffers
2. Determination of pKa value for acetic acid
3. Estimation of proteins by Biuret method
4. Estimation of proteins by Lowry's method
5. Separation of sugars by Thin Layer chromatography
6. Assay of the enzyme acid phosphatase from germinated moong dal or β-amylase from sweet potato beams
7. Effect of pH on the activity of an enzyme
8. Progress curve of an enzyme

Text and References:

1. Nelson, D. L. and Cox, M. M. (2021). Lehninger, Principles of Biochemistry, (8th Ed.). W.H. Freeman and Company (New York, USA).
2. Voet, D. and Voet, J.G. (2020). Biochemistry. (4th Ed), John Wiley & Sons, Inc. USA.
3. U. Satyanarayan and U. Chakrapani (2023). Biochemistry (6th Ed.). Elsevier publications
4. Verma P.S. & Agarwal V.K. (2016). Cell Biology (Cytology, Biomolecules and Molecular Biology). S Chand

Course Code	**:**	**BS03C6**
Course Title	**:**	**Cell Biology**
Theory/Practical	**:**	**Theory**
Semester	**:**	**III**

TOTALHOURS: 60 **CREDITS: 4**

UNIT I: **No. of Hours: 10**

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: **No. of Hours: 15**

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: **No. of Hours: 20**

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: **No. of Hours: 15**

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction. Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

Course Code	**:**	**BS03C6**
Course Title	**:**	**Cell Biology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**III**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Cytochemical staining of RNA by Methyl Green Pyronin Cytochemical staining of polysaccharides by PAS Cytochemical staining of proteins by Bromophenol blue Cytochemical staining of histones by fast green.
2. Vital staining of mitochondria by Janus green B in cheek epithelial cells
3. Identification and study of types of cancer, cancer cells by permanent slides/ photographs.
4. Study of the following microscopic techniques by photographs: Fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting
5. Study of cell organelle such as (Cell wall, Primary and secondary pits, Plasodesmata, Gap junctions, Tight junctions, Plasma membrane, Nucleus, Nuclear Pore Complex, Chloroplast, Mitochondrion, Golgi bodies, Lysosomes, SER and RER), Prokaryotic and Eukaryotic cell, Plant and Animal Cell, Phages: TMV and Bacteriophage

Text and References:

1. Arnold Berk, Chris A. Kaiser, Harvey Lodish, Angelika Amon, Hidde Ploegh, Anthony Bretscher, Monty Krieger, Kelsey C. Martin 1 April 2016. Molecular Cell Biology Hardcover WH Freeman publication.
2. De Robertis, E. D. P. and De Robertis R. E. 2009. Cell and Molecular Biology, 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper G. M. Hausman R. E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press and Sunderland, Washington D. C.; Sinnauer Academic Press.
4. Becker W. M., Kleinsmith L.J. and Bertni G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San fransisco.
5. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition, John Wiley & Sons. Inc.

Course Code	**:**	**BS03C7**
Course Title	**:**	**Ecology**
Theory/Practical	**:**	**Theory**
Semester	**:**	**III**

TOTALHOURS: 60 **CREDITS: 4**

UNIT I: Introduction to Ecology **No. of Hours: 10**

Relevance of studying ecology, History of ecology, Autecology and synecology, levels of organization, major biomes (role of temperature and precipitation). Laws of limiting factors (Leibigs law of minimum, Shelfords law of tolerance), ecological range (Eury, Steno). Ecological factors (abiotic and biotic): detailed study of temperature and light as physical factors. Soil-characteristics and horizons,

UNIT II: Population Ecology **No. of Hours: 20**

Population: Unitary and Modular populations, metapopulation: Density, natality, mortality, lifetables, fecundity tables, survivorship curves, age ratio, sexratio, dispersal and dispersion; carrying capacity, population dynamics (exponential and logistic growth equation and patterns), r and K selection, density-dependent and independent population regulation; Competition, Niche concept, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation, functional and numerical responses. Phenotypic and genotypic plasticity, canalization. Species interactions in brief classified based on the irreciprocal effects.

UNIT III: Ecosystem and Community Ecology **No. of Hours: 20**

Concept, components, types of ecosystem with one example Pond ecosystem in detail (abiotic and biotic components, BOD, eutrophication). Energy flow (Grazing and Detritus food chain), linear and Y-shaped energy flow model, food web. Ecological pyramids and Ecological efficiencies. Nutrient cycle with one example of Nitrogen cycle. Community ecology: Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices; Ecotone and edge effect; Community dynamics (succession): Viewpoint of succession, Primary and secondary succession, Hydrarch and xerarch succession. Climax: monoclimax and polyclimax concepts (preclimax, postclimax,disclimaxetc.). Concept of keystone, indicator, umbrella and flagship species.

UNIT IV: Behavioral ecology **No. of Hours: 10**

Social, reproductive & territorial behavior, kin selection. Evolution of optimal life history, tradeoffs, semelparity and iteroparity, reproductive structure and mating system

Course Code	**:**	**BS03C7**
Course Title	**:**	**Ecology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**III**

TOTALHOURS: 45 **CREDIT: 2**

List of Experiments:

1. Study through specimens/ photographs/ slides of Parasitic angiosperms, Saprophytic angiosperms, VAM fungi, Root nodules, Corolloid roots, Mycorrhizal roots, Velamen roots, Lichen as pollution indicators.
2. Principle and function of Sechidisc, Atmometer, Anemometer, Hygrometer, Hair hygrometer, Luxmeter, Rain guage, Soil thermometer, Min-Max thermometer
3. To determine a minimal quadrat area for sampling in the given simulation sheet
4. To determine density/ frequency/ abundance of the vegetation by quadrat method in the field or on a given simulation sheet
5. To determine soil texture, soil density, bulk density, particle density and porespace.
6. To determine water holding capacity and percolation rate of soil.
7. To determine pH, Cl, SO_4, NO_3, based eficiency, organic matter, cation exchange capacity in the soil.
8. Plotting of survivorship curves from hypothetical life table data.

Text and References:

1. Barrick, M., Odum, E. P., Barrett, G. W., (2017). Fundamentals of Ecology (5^{th} Edition). Cengage India Private Limited.
2. Wilkenson DM - 2007 - Fundamental Processes in Ecology
3. PD Sharma (2017). *Ecology and Environment*.13th Edition.Meerut: Rastogi Publications.
4. Smith, T. M. & Smith, R. L. (2014). Elements of Ecology (8th Edition). Pearson
5. Aber J.D. & Melillo J M 1991- Terrestrial Ecosystems

Course Code	**:**	**BS03GE3**
Course Title	**:**	**Environment and Public Health**
Theory/Practical	**:**	**Theory**
Semester	**:**	**III**

TOTALHOURS: 45 **CREDITS: 4**

UNIT I: Introduction **No. of Hours: 10**

Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

UNIT II: Pollution **No. of Hours: 10**

Air, water, noise pollution sources and effects. Water, soil and air quality parameters.

UNIT III: Waste Management and hazards **No. of Hours: 10**

Types and characteristics of wastes, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants. Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.

UNIT IV: Diseases **No. of Hours: 15**

Social and economic factors of disease including role of health services and other organizations: Infectious (Bacterial- Tuberculosis, Typhoid; Viral-AIDS, Polio myelitis, Hepatitis; Protozoan- Leishmaniasis, Malaria); Lifestyle and Inherited/ genetic diseases, Immunological diseases; Cancer; Diseases impacting on Western versus developing societies.

Course Code	**:**	**BS03GE3**
Course Title	**:**	**Environment and Public Health**
Theory/Practical	**:**	**Practical**
Semester	**:**	**III**

TOTALHOURS: 45 **CREDITS: 2**

List of Experiments:

1. Determination of pH and turbidity of water samples.
2. Estimation of water alkalinity
3. Estimation of water hardness.
4. Determination of soil pH and EC.
5. Determination of Soil moisture content.
6. Determination of NPK in soil
7. Demonstration of air sampler.
8. Enrichment of microorganisms from air.

Text and References:

1. Cutter, S.L. (1999). Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Kolluru R., Bartell S., Pitblado R. and Stricoff, S. (1996). Risk Assessment and Management Handbook. Mc Graw Hill Inc., NewYork.
3. Kofi, A.D. (1998). Risk Assessment in Environmental management, John Wiley and sons, Singapore.
4. Joseph, F.L. and Louver, B.D. (1997). Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey.
5. APHA Standard Methods for the Examination of Water and Wastewater (twentieth ed.), American Public Health Association, Washington, DC (1998).
6. Metcalf and Eddy (2003) Wastewater Engineering: Treatment and Reuse, (4th Edition), Tata McGraw-Hills Comp. Inc., New York

Course Code	**:**	**BS03SEC1**
Course Title	**:**	**Biochemical Techniques**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**III**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Spectroscopic Techniques **No. of Hours: 12**

Principle of UV-Visible absorption spectrophotometry, instrumentation and applications, Flourimetry: Phenomena of fluorescence, intrinsic and extrinsic fluorescence, instrumentation and applications

UNIT II: Chromatography **No. of Hours: 12**

Basic principles of chromatography: Partition coefficient, concept of theoretical plates, various modes of chromatography (paper, thin layer, column), preparative and analytical applications, LPLC and HPLC. Principle and applications of: Paper Chromatography, Thin Layer Chromatography. Molecular Sieve Chromatography, Ion Exchange Chromatography, Affinity Chromatography

UNIT III: Electrophoresis **No. of Hours: 12**

Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native and denaturing gels. Agarose gel electrophoresis, buffer systems in electrophoresis. Electrophoresis of proteins and nucleic acids, protein and nucleic acid blotting, detection and identification. Molecular weight determination, Isoelectric Focusing of proteins

Unit 4: Centrifugation **No. of Hours: 9**

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, differential centrifugation, density gradient centrifugation (Rate zonal and Isopycnic)

Course Code	**:**	**BS03SEC1**
Course Title	**:**	**Biochemical Techniques**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**III**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Determination of concentration of unknown solution by spectrophotometry method
2. Separation of pigments by paper chromatography
3. Estimation of concentration of a given compound by HPLC method
4. Gel electrophoresis of proteins and nucleic acids
5. Separation of molecules of different densities by centrifugation method

Text and References:

1. Keith Wilson and John Walker (2005). Principles and Techniques of Biochemistry and Molecular Biology. 6th edition. Cambridge University Press
2. David Plummer (2017). An Introduction to Practical Biochemistry (3rd Edn). McGraw Hill Education
3. David Freifelder (2005). Physical Biochemistry- Applications to Biochemistry and Molecular Biology, 2nd Edition, W.H. freeman and Company
4. Beedu Sashidhar Rao, Vijay Deshpande (2020). Experimental Biochemistry. Dreamtech Press

SEMESTER IV **Total Credit: 28**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS04C8	System Physiology	4-0-2	6	30-30-20-20
2.	BS04C9	Molecular Biology	4-0-2	6	30-30-20-20
3.	BS04C10	Metabolism and Integration	4-0-2	6	30-30-20-20
4.	BS04GE4	Bioethics and Biosafety	4-0-0	6	30-30-20-20
5.	BS04SEC2	Recombinant DNA Technology	4-0-0	4	30-50-20-00

Course Code	**:**	**BS04C8**
Course Title	**:**	**System Physiology**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**IV**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Movements and Bulk Transport **No. of Hours: 12**

Cellular movements, ciliary and flagellar structure and function**;** Introduction to musculoskeletal system; Terrestrial, aquatic and aerial locomotion**;** Locomotory cost**;** Long distance transport of water and nutrients in plants (xylem and phloem transport)**;** General plan and physiology of circulatory system in vertebrates and invertebrates

UNIT II: Gas exchange inorganism; Generation and utilization of energy

No. of Hours: 15

Exchange in unicellular organisms and plants; Respiratory organs in aquatic and terrestrialsystems; Physiology of aquatic breathing and aerial breathing; Feeding patterns, digestive tract systems; Digestion of food

UNIT III: Regulatory Physiology **No. of Hours: 15**

Mechanism of opening and closing of stomata. Regulation of water and solutes in aquatic and terrestrial animals; Osmoregulatory organs. Transpiration in plants; Excretion of nitrogenous wastes in animals; Patterns of Thermoregulation: Ectotherms and Endotherms; Structural and functional adaptation to stress

UNIT IV: Integrative Physiology **No. of Hours: 18**

An overview of neuronal structure and function; Sensory physiology- mechano, chemo, thermo, photo and electro receptors; Endocrine systems in animals and their physiological effects; Plant hormones and their physiological effects; Regulation of metabolism and response to environmental cues.

Course Code	**:**	**BS04C8**
Course Title	**:**	**Systems Physiology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**IV**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Effect of isotonic, hypotonic and hypertonic salines on erythrocytes
2. Enumeration of RBC using haemocytometer
3. Estimation of total count of WBC using haemocytometer
4. Study of the effect of various environmental factors on transpiration in an excised twig/ leaf
5. Calculation of the stomatal index, stomatal frequency and percentage of leaf area open through stomata in amesophyte and axerophytes
6. Study of the mechanism of stomatal opening and closing

Text and References:

1. Knut Schmidt-Nielsen, Animal Physiology, Cambridge University Press
2. David Randall, Eckert's Animal Physiology, W.H.Freeman and Co.
3. Philips Withers; Comparative Animal Physiology. Books Cole Publishers
4. Moyes, C. D., & Schulte, P. M. (2008). Principles of Animal Physiology. San Francisco, CA: Pearson/Benjamin Cummings.
5. Schmidt-Nielsen, K. (2010). Animal Physiology: Adaptation and Environment. Cambridge: Cambridge University Press.
6. Randall, D. C., Burggren, W. W., & French, K. (2002). Eckert Animal Physiology. New York: W. H. Freeman.

Course Code	**:**	**BS04C9**
Course Title	**:**	**Molecular Biology**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**IV**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Genes and genomic organization **No. of Hours: 10**

Definition of a gene, organization of genes in viruses, bacteria and eukaryotes. Complexity of eukaryotic genes and chromosomes, supercoiling of DNA and its importance, linking number, to poisomerases, inhibitors of topoisomerases and their application in medicine, Nucleosome structure and packaging of DNA into higher order structures.

UNIT II: Replication of DNA **No. of Hours: 10**

Features of DNA Replication, chemistry of DNA synthesis, the replication fork, origin of replication, stages of DNA replication, enzymes and proteins involved in DNA replication, Ecoli DNA polymerases, replication in eukaryotes. Comparison of replication in prokaryotes and eukaryotes.

UNIT III: DNA repair **No. of Hours: 5**

Mutations and cancer, mismatch repair, base excision repair, nucleotide excision repair, directrepair, recombination repair, error-prone translesion DNA synthesis.

UNIT IV: DNA-dependent synthesis of RNA **No. of Hours: 10**

Types of RNAs, DNA-dependent RNA polymerase, sigma factor, bacterial promoters, identification of DNA bindingsites by DNA foot printing, the three stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Transcription in eukaryotes, inhibitors of transcription and applications as antibiotics.

UNIT V: RNA processing **No. of Hours: 5**

Modification of eukaryotic mRNA at the 5’ and the 3’end, splicing introns, differential RNA processing, processing of rRNAs and tRNAs, special function RNAs, RNAas enzyme.

UNIT VI: Proteins Synthesis **No. of Hours: 10**

The genetic code, cracking the genetic code, degeneracy, wobble hypothesis, features of the genetic code, translational frame shifting and RNA editing, the ribosome as a supramolecular machine, structure of tRNAs, the five stages of protein biosynthesis, aminoacyl-tRNA synthetases, initiation in prokaryotes and in eukaryotes, elongation, termination, folding and processing, inhibitors of protein synthesis and their application in medicine.

UNIT VII: Regulation of gene expression **No. of Hours: 10**

Principles of gene regulation, negative and positive regulation, concept of operons, regulatoryproteins, activators, repressors, DNA binding domains. Regulation of gene expression inbacteria, lac operon and trpoperon, induction of SOS response, synthesis of ribosomal proteins. Overview of regulation of gene expression in eukaryotes, heterochromatin, euchromatin, chromatin remodeling, DNA binding activators and co-activators, regulation of galactose metabolism genes in yeast, post-transcriptional gene-silencing by RNA interference.

Course Code	**:**	**BS04C9**
Course Title	**:**	**Molecular Biology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**IV**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Isolation of DNA by CTAB method.
2. Estimation of DNA by DPA method.
3. Estimation of RNA by Orcinol method.
4. Separation of nucleotide bases by paper chromatography.
5. Extraction of total nucleic acids from plant tissue.
6. Isolation of chromosomal DNA from E. coli cells.
7. Purity of isolated DNA by A260/A280 Ratio

Text and References:

1. George M Malacinski (2015) Freifelders Essentials of Molecular Biology (4th Edition) Jones and Bartlett
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey C. Martin (2016). Molecular Cell Biology (8th Edition). W. H. Freeman
3. James D. Watson (2021). Molecular Biology of The Gene (7th Edition). Pearson
4. Gerald Karp, James G. Patton (2013). Cell and Molecular Biology: Concepts and Experiments (7th Edition). John Wiley & Sons Inc
5. T.A. Brown, Essential Molecular Biology, Oxford University Press.
6. Verma P.S. & Agarwal V.K. (2010) Molecular Biology. S Chand
7. Nitin Suri (2010). Molecular Biology and Biochemistry. Oxford Book Company

Course Code	**:**	**BS0410**
Course Title	**:**	**Metabolism and Integration**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**IV**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Concept of Metabolism **No. of Hours: 10**

Principles of bioenergetics-Standard free energy change, metabolic roles of ATP Phosphoryl group transfer, nuleotidyl group transfer. Experimental approaches to study of metabolism; Primary and secondary metabolism. Energetics.

UNIT II: Metabolic Pathways **No. of Hours: 20**

Carbohydrates metabolism - Glycolysis, alcoholic and lactic acid fermentation, PasteurEffect, gluconeogenesis, Coricycle, glucose-alanine cycle, futile cycle. TCA cycle, HMPshunt, glycogenolysis & glycogensynthesis. Disorders associated with defects in carbohydrate metabolism- a brief account on fructose intolerance, lactose intolerance, lacticacidosis, disorders related to glycogen metabolism, genetic deficiency of Glucose-6-phosphate dehydrogenase, Galactosemia, Diabetes Mellitus (NIDDM and IDDM). Lipid metabolism- Mobilization of triglycerides, metabolism of glycerol, β-*oxidation* of saturated, monounsaturated and poly-unsaturated fatty acids, even and odd chain fatty acids. Ketogenesis and significance. Biosynthesis of C-16 palmitic acid. Nutritional disorder- PEM (Kwashiorkar and Marasmus), Obesity. Metabolic disorders-Diabetes. Inborn errors of metabolism- i) Protein-PKU, Alkaptonuria and Maple syrup and Gauchers. Protein catabolism - Transamination and deamination, Urea cycle, glucogenic and keogenic amino acids.

UNIT III: Metabolic Integration **No. of Hours: 10**

Metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse.

UNIT IV: Oxidative phosphorylation **No. of Hours: 10**

Components, properties and function ofelectron transport system, chemiosmotic hypothesis, inhibitors and uncouplers, Shuttle systems.

UNIT V: **No. of Hours: 10**

Role of microbes in metabolic tasks - alternate metabolic cycles. Carbon metabolism of intracellular bacterial pathogens, environmental cleansing, metabolic handling of xenobiotics and drug resistance, photo and lithotrophic metabolic capabilities; Myporia

Course Code	**:**	**BS04C10**
Course Title	**:**	**Metabolism and Integration**
Theory/Practical	**:**	**Practical**
Semester	**:**	**IV**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Estimation of blood glucose–Glucose Oxidase method
2. Estimation of Cholesterol–Hyper Cholesteremia samples
3. Estimation of SGPT and SGOT
4. Estimation of Bilirubin
5. Estimation of creatinine
6. Identification of organelles by marker enzymes– SDH, LDH and acid phosphatase

Text and References:

1. U. Satyanarayan and U. Chakrapani (2023). Biochemistry (6th Ed.). Elsevier publications
2. Nelson, D. L. and Cox, M. M. (2021). Lehninger, Principles of Biochemistry, (8th Ed.). W.H. Freeman and Company (New York, USA).
3. Lubert Stryer (2019). Biochemistry (9th Edition). W.H. Freeman
4. Voet, D. and Voet, J.G. (2020). Biochemistry. (4th Ed), John Wiley & Sons, Inc. USA
5. Thomas M. Devlin (2002). Textbook of Biochemistry with Clinical Correlations (5th edition). John Wiley & Sons

Course Code	**:**	**BS04SEC2**
Course Title	**:**	**Recombinant DNA Technology**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**IV**

TOTAL HOURS: 60 **CREDIT: 4**

UNIT I: Introduction to recombinant DNA technology **No. of Hours: 15**

Overview of recombinant DNA technology. Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules, separation of DNA by gel electrophoresis. Extraction and purification of plasmid DNA.

UNIT II: Cloning vectors for prokaryotes and eukaryotes **No. of Hours: 15**

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli* plasmids, pBR322, pUC8, pGEM3Z. Joining of DNA fragments: **l**igation of DNA molecules. DNA ligases, sticky ends, blunt ends, linkers and adapters.

UNIT III: Introduction of DNA into cells **No. of Hours: 15**

Uptake of DNA by cells, preparation of competent cells. Selection for transformed cells. Identification for recombinants - insertional inactivation, blue-white selection. Introduction of phage DNA into bacterial cells. Identification of recombinant phages. Methods for clone identification: The problem of selection, direct selection, marker rescue. Gene libraries, identification of a clone from gene library, colony and plaque hybridization probing, methods based on detection of the translation product of the cloned gene.

UNIT IV: Applications of RDT **No. of Hours: 15**

Applications in medicine, production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII. Recombinant vaccines. Gene therapy. Applications in agriculture - plant genetic engineering, herbicide resistant crops, problems with genetically modified plants, safety concerns. Introduction to DNA sequencing, polymerase chain reaction, expression vectors.

Text and References:

1. Brown, T.A. (2010). Gene Cloning and DNA Analysis (6th Edn). Wiley-Blackwell publishing (Oxford, UK).
2. Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics (7th Edn) Blackwell publishing (Oxford, UK).
3. Bernard R. Glick, Jack J. Pasternak (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th Edn). American Society for Microbiology
4. K Rajagopal (2012). Recombinant DNA Technology and Genetic Engineering. McGraw Hill Education
5. Keya Chaudhuri (2012). Recombinant DNA Technology. The Energy and Resources Institute, TERI.

Course Code	**:**	**BS04GE4**
Course Title	**:**	**Bioethics and Biosafety**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**IV**

TOTAL HOURS: 60 **CREDIT: 4**

UNIT I: **No. of Hours: 15**

Introduction to Indian Patent Law. Intellectual property rights. Patents, Copyrights, Trademarks, Trade secrets, Patenting of GMOs. Process of filing a patent: Process and product patent, patent application and guidelines, Prerequisites of filing a patent, Novelty, Utility.

UNIT II: **No. of Hours: 15**

Entrepreneurship: Selection of a product, line,design and development processes, economics on material and energy requirement, stock the product and release the same for making etc. The basic regulations of excise: Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations export potential etc.

UNIT III: **No. of Hours: 15**

Bioethics – Guidelines, different paradigms of Bioethics – National & International.

Ethical issues against the molecular technologies. Release of Genetically modified Organisms and Recombinant drugs, Regulating Agencies.

UNIT IV: **No. of Hours: 15**

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

Course Code	**:**	**BS04GE4**
Course Title	**:**	**Bioethics and Biosafety**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**IV**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Proxy filing of Indian Product patent.
2. Proxy filing of Indian Process patent.
3. Case study on women health ethics.
4. Case study on medical errors and negligence.
5. Case study on handling and disposal of radioactive waste.

Text and References:

1. Brigitte Anderson. Intellectual Property Rights, Edward Elgar Publishing
2. Graham Dutfield. Intellectual Property Rights and the Life Sciences Industries. Ashgate Publishing
3. WIPO Intellectual Property Handbook
4. William Rodelph Cornish, David Clewelyn. Intellectual Property Rights
5. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
6. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers
7. World Intellectual Property Organisation. http://www.wipo.int
8. International Union for the Protection of New Varieties of Plants. http://www.upov.int
9. National Portal of India. http://www.archive.india.gov.in
10. National Biodiversity Authority. http://www.nbaindia.org

SEMESTER V **Total Credit: 24**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS05C11	Growth and Reproduction	4-0-2	6	30-30-20-20
2.	BS05C12	Genetics	4-0-2	6	30-30-20-20
3.	BS05DSE1	Microbiology	4-0-2	6	30-30-20-20
4.	BS05DSE2	Plant Biochemistry	4-0-2	6	30-30-20-20

Course Code	**:**	**BS04C11**
Course Title	**:**	**Growth and Reproduction**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**V**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction **No. of Hours: 20**

General growth patterns in animals and plants: the plant cell as a model of growing system; biophysical basis of plant cell growth; the role of cell wall in cell growth; extension growth of multicellular organs in plants. Juvenile, vegetative and reproductive phases in growth: Primary meristem: concept of stem cell; shoot apical meristem- dynamics of shoot apical meristem; homeobox genes and meristem identity; root apical meristem as an organized structure; post-embryonic meristems in plants with special reference to Arabidopsis embryogenesis. Analysis of plant growth: kinetics and kinematics. Senescence, ageing, abscission, and programmed cell death: a general account, with special reference to hyperplasia and hypertrophy in animals and tumours in plants.

UNIT II: Pre Fertilization Changes **No. of Hours: 15**

Alternation of generations and reproductive patterns in animals and plants; Asexual and sexual reproduction- an overview (regeneration, archegonium, heterospory, siphonogamy, apogamy, apospory, apomixis etc.). Pre- fertilization events- gametogenesis- spermatogenesis and oogenesis, types of eggs in animals; relative sexuality in plants and heterothallism in fungi.

UNIT III: Post Fertilization Changes and Early Development **No. of Hours: 15**

Post Fertilization Events; Types of Cleavages; Blastula; Fate Maps, Morphogenetic movements during gastrulation; Gastrulation in frog and chick and humans; Fate of Germ layers; Neural tube formation, brief account on embryonic induction, Extra Embryonic membranes in chick and mammal, Placenta: Functions and types

UNIT IV: Differentiation **No. of Hours: 10**

Organogenesis: Formation of CNS, Organogenesis of secondary girth

Course Code	**:**	**BS05C11**
Course Title	**:**	**Growth and Reproduction**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**V**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Study of whole mounts of frog and chick- early developmental stages
2. Study of chick development from live eggs (window viewing)
3. Study of section of chick embryo through selective developmental stages
4. Videos showing selective embryonic events like cleavage; gastrulation
5. Measurement of animal/plant cell size using ocular and stage micrometer.
6. Micro and mega sporogenesis in higher plants-slides only
7. Pollen germination in vivo and in vitro
8. Study of gamete/spores in algae, moss, liverwort, pteridophyte and gymnosperm
9. Embryo development in flowering plant-slides only; dissection of endosperm and embryo
10. Study of apical and lateral meristem, hypertrophy and hyperplasia
11. Survey of dispersal mechanisms of seeds

Recommended Texts:

1. Scott F. Gilbert, Susan R. Singer (2020). Developmental Biology (8th Edition). Sinauer Associates Inc.,U.S.
2. Bruce M. Carlson (2014). Patten's Foundation of Embryology (6th Edition). McGraw Hill Education.
3. Wolpert, L., & Tickle, C. (2011). *Principles of Development* (4 edition). Oxford; New York: OUP Oxford.
4. Gerald P. Schatten (2006). Current Topics in Developmental Biology. Academic Press
5. Kalthoff, K. O. (2000). *Analysis of Biological Development* (2 edition). Boston: McGraw-Hill.
6. S. L. Kochhar and Sukhbir Kaur Gujral (2020) Plant Physiology: Theory and Applications (2ndEdn). Cambridge University Press
7. S.K. Verma and Mohit Verma (2007). A Textbook of Plant Physiology, Biochemistry and Biotechnology (6th Edition). S Chand.

Course Code	**:**	**BS05C12**
Course Title	**:**	**Genetics**
Theory/Practical	**:**	**Theory**
Semester	**:**	**V**

TOTAL HOURS: 45 **CREDIT: 2**

UNIT I: **No. of Hours: 15**

Introduction: Genetics & heredity. Mendelian genetics: monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, incomplete dominance, co-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity. Non allelic interactions: Complementary genes, Epistasis (dominant & recessive), duplicate genes and inhibitory genes.

UNIT II: **No. of Hours: 10**

Genetic organization of prokaryotic and viral genome. Chromosome and genomic organization of eukaryotes: unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, VNTRs, transposons, noncoding DNA. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, packaging, karyotype, giant chromosomes.

UNIT III: **No. of Hours: 15**

Chromosome and gene mutations: Definition and types of mutations, causes of mutations, chromosomal aberrations in human beings.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: **No. of Hours: 10**

Genetic linkage, crossing over and chromosome mapping. Introduction to Pedigree analysis.Extra chromosomal inheritance: maternal effects, maternal inheritance, cytoplasmic inheritance, genomic imprinting. Basics of bacteriophage genetics: Lytic cycle & Lysogenic cycle.

UNIT V: **No. of Hours: 10**

Population genetics: Gene pool; gene/allele frequency; genotypic frequency; phenotypic frequency (simple problems for calculation). Conservation of gene frequencies (when selection does not operate) – Hardy-Weinberg's Law of Genetic Equilibrium.

Course Code	**:**	**BS05C12**
Course Title	**:**	**Genetics**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**V**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Preparation of pre-treating / fixing agents/ stains for cytological studies.
2. Study of Mitosis using root tips
3. Study of Meiosis using flower buds/ grasshopper testes
4. Blood grouping and Rh in humans
5. Blood typing in humans for multiple alleles and Rh factor
6. Histological study of Cancer types using permanent slides
7. Genetic Problems on Monohybrid cross,
8. Genetic Problems on Dihybrid cross
9. Demonstration of prenatal diagnosis
10. Detection of inborn errors of metabolism– mucopolysaccharidosis, Galactosemia, PKU.
11. Construction and analysis of Pedigree
12. Risk calculation
13. Assessment of inheritance of quantitative characters

Text and References:

1. Pierce, B. A. (2012). Genetics: a conceptual approach. Macmillan publication.
2. Roberts, K., Alberts, B., Johnson, A., Walter, P., & Hunt, T. (2002). Molecular biology of the cell. New York: Garland Science.
3. Lodish, Harvey, et al. Molecular cell biology. Macmillan, 2008.
4. Snustad, D. P., & Simmons, M. J. (2015). Principles of genetics. John Wiley & Sons.
5. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons
6. Cooper, G. M., Hausman, R. E., & Hausman, R. E. (2007). The cell: a molecular approach. Washington, DC: ASM press.
7. Gupta, P.K. (2010). Cytogenetics. Rastogi Publications, Meerut, India.
8. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). Lewin's genes X. Jones & Bartlett Learning.

Course Code	**:**	**BS05DSE-1**
Course Title	**:**	**Microbiology**
Theory/Practical	**:**	**Theory**
Semester	**:**	**V**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: History of Microbiology and classification **No. of Hours: 12**

History of development of microbiology as a discipline, Spontaneous generation versus biogenesis, development of various microbiological techniques, concept of fermentation, establishment of fields of medical microbiology, immunology, and environmental microbiology Molecular methods of assessing microbial phylogeny- molecular chronometer, phylogenetic trees, rRNA, DNA and proteins as indicator of phylogeny. Major Divisions of life- Domains, Kingdoms.

UNIT II: Microbial Nutrition and Growth **No. of Hours: 12**

Nutritional types of microorganisms, growth factors, culture media- synthetic and complex, types of media; isolation of pure cultures, growth curves, mean growth rate constant, generation time; general concept of effect of environmental factors on growth of microbes; sterilization and disinfection; activity, use of physical methods (heat, low temperature, filtration, radiation)and chemical agents (phenolics, halogens, heavy water, sterilization gases).

UNIT III: Microbial Cell organization **No. of Hours: 12**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, fimbriae and pili; Cell-wall: Composition and detailed structure of Gram positive and Gram-negative cell walls, Archaebacterial cell wall, Gram and acid-fast staining mechanisms, lipopolysaccharide (LPS) and protoplasts. Effect of antibiotics and enzymes on the cell wall; Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes; Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids; Endospore: Structure, formation, stages of sporulation.

UNIT IV: Viruses **No. of Hours: 12**

Induction - general properties of viruses; Structure of viruses - viral envelopes and enzymes; Isolation, purification, and cultivation of viruses; Viral Taxonomy; Bacteriophages - diversity, classification, lytic and lysogenic phages; Viral multiplication and replication strategies – replication and transcription in DNA viruses-Influenza virus, retroviruses-HIV; Viroids, Virusoids and Prions.

UNIT V: Applied Microbiology **No. of Hours: 12**

Importance of microbiology in food and industry; basic design of fermenter – continuous and discontinuous; treatment of wastewater (municipal treatment plant) and sewage; Microbial diseases of plants and animals, antimicrobial chemotherapy.

Course Code	**:**	**BS05DSE-1**
Course Title	**:**	**Microbiology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**V**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. To study disinfectants and sterilization techniques.
2. To study types of Media and perform media preparation.
3. To perform subculturing- streaking techniques (T streaking).
4. To study Growth Curve of bacteria.
5. To study the effect of pH/temperature/UV light on bacterial growth.
6. To perform Gram's staining.
7. To perform Negative staining
8. To perform Antibiotic resistance assay.
9. Enumeration of CFU of E. coli by serial dilution and spread plate method.
10. Conjugation experiment
11. Milk quality testing by Methylene Blue dye reductase test.

Text and References:

1. Michael Pelczar, Jr. (2001). Microbiology (5th Edn). McGraw Hill Education
2. Lansing Prescott, John Harley, Donald Klein (2004). Microbiology (6th Edn). McGraw-Hill Education
3. D.K. Maheshwari (2015). A Textbook of Microbiology. S Chand
4. Madigan Michael T. , Martinko John M. , Bender Kelly S. , Buckley Daniel H. , Stahl David A. (2017) . Brock Biology of Microorganisms (14th Edition). Pearson Education

Course Code	**:**	**BS05DSE-2**
Course Title	**:**	**Plant biochemistry**
Theory/Practical	**:**	**Theory**
Semester	**:**	**V**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction to Plant cell structure **No. of Hours: 15**

Plasma membrane, Vacuole and tonoplast membrane, cell wall, plastids and peroxisomes.

UNIT II: Regulation of plant growth **No. of Hours: 15**

Introduction to plant hormones and their effect on plant growth and development, regulation of plant morphogenetic processes by light.

UNIT III: Secondary metabolites **No. of Hours: 15**

Representatives alkaloid group and their amino acid precursors, function of alkaloids, Examples of major phenolic groups; simple phenylpropanoids, Coumarins, Benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids.

UNIT IV: Plant tissue culture **No. of Hours: 15**

Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Plant regeneration pathways: organogenesis and somatic embryogenesis. Applications of cell and tissue culture and somoclonal variation.

Course Code	**:**	**BS05DSE-2**
Course Title	**:**	**Plant biochemistry**
Theory/Practical	**:**	**Practical**
Semester	**:**	**V**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Organizing Plant tissue culture Laboratory
2. Preparation of Tissue Culture Media
3. Callus Induction
4. Shoot tip culture
5. Embryo / Endosperm Culture
6. Somatic Embryogenesis
7. Hardening and Planting infield
8. Isolation of protoplasts
9. Cell suspension culture
10. Economics of micropropagation project

Text and References:

1. Hamish A Collin, Sue Edwards (1998). Plant Cell Culture
2. Chawla H S, Introduction to Plant Biotechnology by, Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, 3rd Ed., ISBN- 9788120417328.
3. Gupta P K, 2004. Biotechnology and Genomics.
4. Primrose and Twyman. Principles of Gene Manipulation & Genomics (7th Ed.).
5. Singh BD and Shekhawat NS, 2018. Molecuar Plant Breeding, Scientific Pub.
6. Rastogi Smita and Pathak Neelam (2009) Genetic Engineering, 1st Ed. Oxford.
7. John H Dodds; Lorin W Roberts, 3rd edition, 2004. Experiments in Plant tissue Culture
8. Plant tissue culture by MK Razdan & SS Bhojwani(1996) Elsevier.
9. Robert H Smith, 3rdedition. Plant Tissue Experiments
10. Plant physiology by L Tiaz & E Zeiger 4th edition (2006) Sinauer Associates Inc publishers.
11. Plant Biotechnology and transgenic plants, Edited by Kirsi Marja Oksman-Caldentey, Wolfgang Barz Marcel Dekker 2002.
12. Plant tissue culture concepts and laboratory exercises, Second edition, Robert N Trigiano, Dennis J Gray, CRC Press November 1999.

SEMESTER VI **Total Credit: 24**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS06C13	Immunology	4-0-2	6	30-30-20-20
2.	BS06C14	Evolutionary Biology	4-0-2	6	30-30-20-20
3.	BS06DSE3	Wildlife Conservation and Management	4-0-2	6	30-30-20-20
4.	BS06DSE4	Stress Biology	4-0-2	6	30-30-20-20

Course Code	**:**	**BS06C13**
Course Title	**:**	**Immunology**
Theory/Practical	**:**	**Theory**
Semester	**:**	**VI**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction **No. of Hours: 12**

Overview of defence mechanisms in plants and animals; Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues (MALT).

UNIT II: Innate immunity in animals **No. of Hours: 18**

Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, cell adhesion molecules, chemokines, leukocyte extravasation, localized and systemic response. Complement activation by classical, alternate and MBL pathway, biological consequences of complement activation, regulation and complement deficiencies.

UNIT III: Adaptive Immunity in Animals **No. of Hours: 18**

Antigens and haptens, Factors that dictate immunogenicity, B and T cell epitopes. Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family. Generation of antibody Diversity. Monoclonal antibodies; Immunological methods- Antigen-antibody interactions; Histocompatibility antigens - HLA and Disease; T cell differentiation – Positive and Negative selection, Antigen Presentation, Activation of T and B cells. Cytokines and Chemokines.

UNIT IV: Immune dysfunction and applications **No. of Hours: 12**

Immunological tolerance; Immunological disorders – Hypersensitivity and Autoimmune diseases. Immunodeficiencies; Transplantation Immunology; Immune response against major classes of pathogens. Applications in agriculture, pharmaceuticals, and biopest control.

Course Code	**:**	**BS06C13**
Course Title	**:**	**Immunology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**VI**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Characterization of diseases symptoms and identification of pathogenic organisms (at least one each from viral, fungal, pest and nematodes injection).
2. Partial purification of Immunoglobulin's by Ion Exchange chromatography
3. Immunodiffusion – DID and SRID.
4. Immunoelectrophoresis (IEP)
5. Countercurrent IEP, Rocket IEP

Recommended Texts:

1. Jenni Punt, Sharon Stranford, Patricia Jones, Judith A Owen (2018). Kuby Immunology (8th Edition). WH Freeman
2. David Male, R.S. Peebles, Victoria male (2020). Immunology (9th Edition). Elsevier
3. Leslie Hudson & Frank C. Hay (1980). *Practical Immunology*. Oxford: Blackwell Scientific
4. Madhavee P. Latha (2012). A Textbook of Immunology. S Chand
5. K. Murphy, P. Travers, M. Walport. 2008. Janeway'sImmunobiology, Garland Science, Taylor and Francis Group, LLC
6. Brian J. Deverall (2009). Defence Mechanisms of Plants (1st Edn). Cambridge University Press

Course Code	**:**	**BS06C14**
Course Title	**:**	**Evolutionary Biology**
Theory/Practical	**:**	**Theory**
Semester	**:**	**VI**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Historical Review of Evolutionary Concept **No. of Hours: 7**

Pre-Darwinian ideas – List of contributors influencing Darwin indicated as a *timeline.* Lamarckism – Merits and demerits. Darwinism – Merits and demerits, post-Darwinian era – Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism.

UNIT II: Life's Beginnings **No. of Hours: 6**

Chemogeny – An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny – RNA first hypothesis. Biogeny – Cellular evolution based on proto-cell models (coacervates and proteinoid micro-spheres). Origin of photosynthesis – Evolution of oxygen and ozone build- up. Endosymbiotic theory – Evolution of Eukaryotes from Prokaryotes.

UNIT III: Evidences of Evolution **No. of Hours: 4**

Paleobiological – Concept of Stratigraphy and geological timescale; fossil study (types, formation and dating methods). Anatomical – Vestigial organs; Homologous and Analogous organs (concept of parallelism and convergence in evolution). Taxonomic – Transitional forms/evolutionary intermediates; living fossils. Phylogenetic – a) Fossil based – Phylogeny of horse as a model. b) Molecule based – Protein model (Cytochrome C); gene model (Globin gene family).

UNIT IV: Sources of Evolution – Variations as Raw Materials of Change No. of Hours: 7

Types of variations – Continuous and discontinuous; heritable and non-heritable. Causes, classification, and contribution to evolution – Gene mutation; chromosomal aberrations; recombination and random assortment (basis of sexual reproduction); gene regulation. Concept of micro- and macro-evolution – A brief comparison

UNIT V: Forces of Evolution – Qualitative Studies Based on Field Observations

No. of Hours: 8

Natural selection as a guiding force- Its attributes and action, basic characteristics of natural selection. Colouration, camouflage and mimicry, co-adaptation, and co-evolution; man-made causes of change- Industrial mechanism; brief mention of drug, pesticide, antibiotic, and herbicide resistance in various organisms. Modes of selection, Polymorphism, Heterosis and

Balanced lethal systems. Genetic Drift (Sewall Wright effect) as a stochastic/random force- Its attributes and action. Basic characteristics of drift; selection vs drift, Bottleneck effect. Founder principle.

UNIT VI: Forces of Evolution – Quantitative Studies Based on Biomathematics

No. of Hours: 5

Population genetics – Gene pool; gene/allele frequency; genotypic frequency; phenotypic frequency (simple problems for calculation). Conservation of gene frequencies (when selection does not operate) – Hardy-Weinberg's Law of Genetic Equilibrium. Alterations in gene frequency (when selection operates) – Calculation based on Selection Coefficient and Fitness). Fluctuations in gene frequency (when drift operates) – Calculation based on standard deviation

UNIT VII: Product of Evolution – Speciation **No. of Hours: 6**

Concept of species as a real entity, Mechanisms of speciation – Allopatric; sympatric; peripatric, Patterns of speciation – Anagenesis and Cladogenesis; Phyletic Gradualism and Punctuated Equilibrium (Quantum Evolution), Basis of speciation – Isolating mechanisms

UNIT VIII: End of Evolution – Extinction **No. of Hours: 2**

Periodic extinctions, Mass-scale extinctions – Causes and events

UNIT IX: Evolution of Plants and Fungi **No. of Hours: 9**

Origin of land plants – Terrestrial algae and Bryophytes; alternation of generations. Early vascular plants – Stelar evolution; Sporangium evolution. Angiosperms – Phylogeny of major groups. Fungi

UNIT X: Human Ancestry and Phylogeny **No. of Hours: 6**

Primate characteristics and unique Hominin characteristics. Primate phylogeny leading to Hominin line. Human migration – Theories. Brief reference to molecular analysis of human origin – Mitochondrial DNA and Y-chromosome studies.

Course Code	**:**	**BS06C14**
Course Title	**:**	**Evolutionary biology**
Theory/Practical	**:**	**Practical**
Semester	**:**	**VI**

TOTAL HOURS: 45 **CREDITS: 2**

(A) Evidences of fossils

1. Study of types of fossils (e.g. trails, casts and moulds and others) and Index fossils of Palaeozoic era

2. Connecting links/transitional forms - Eg. Euglena, Neopilina, Balanoglossus, Chimaera, Tiktaalik, Archaeopteryx, Ornithorhynchus

3. Living fossils - Eg. *Limulus, Peripatus,Latimeria, Sphaenodon*

4. Vestigial, Analogous and Homologous organs using photographs, models or specimen

(B) Variations

1. Sampling of human height, weight and BMI for continuous variation

2. Sampling for discrete characterstics (dominant vs recessive) for discontinuous variations e.g hitch-hiker's thumb, dexterity, tongue rolling, ear lobe (data categorization into 16 groups based on the combination of 4 traits; assigning each subject to the respective group)

(C) Selection Exemplifying Adaptive strategies (Colouration, Mimetic form, Co-adaptation and co-evolution; Adaptations to aquatic, fossorial and arboreal modes of life**)** using Specimens

(D) Neo-Darwinian Studies

1. Calculations of genotypic, phenotypic and allelic frequencies from the data provided

2. Simulation experiments using coloured beads/playing cards to understand the effects of Selection and Genetic drift on gene frequencies

(E) Phylogeny

1. Digit reduction in horse phylogeny (study from chart),

2. Study of horse skull to illustrate key features in equine evolution

3. Study of monkey and human skull - A comparison to illustrate common primate and unique Hominin features.

Text and References:

1. Ridley, M. (2004) Evolution. III Edn. Blackwell

2. Hall, B. K. and Hallgrimson, B. (2008) Strickberger’s Evolution. IV Edn. Jones and Barlett

3. Zimmer, C. and Emlen, D. J. (2013) Evolution: Making Sense of Life. Roberts & Co.

4. Futuyma, D. (1998) Evolutionary Biology. III Edn. Sinauer Assoc. Inc.

5. Barton, Briggs, Eisen, Goldstein and Patel. (2007) Evolution. Cold Spring Harbor Laboratory Press

Course Code	**:**	**BS06DSE3**
Course Title	**:**	**Wildlife Conservation and Management**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**VI**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction: **No. of Hours: 10**

Definition of Wildlife: Causes of wildlife depletion; values and ethics for wildlife conservation; rare, endangered, threatened and endemic species of fishes, amphibians, reptiles, birds and mammals in India- India as a mega wildlife diversity country.

UNIT II: Habitat analysis **No. of Hours: 10**

Evaluation and management of wild life - Physical parameters and Biological Parameters; Standard evaluation procedures: Faecal analysis of ungulates and carnivores: Faecal samples,slide preparation, Hair identification, Pug marks and census method, Geographical Information System (GIS), Global Positioning System (GPS), and Remote Sensing (RS).

UNIT III: Human-wildlife conflict **No. of Hours: 10**

Poaching, illegal trading, conflict management and shifting from extraction to preservation; effect of extinction of a species on ecosystem; Forest landscape restoration.

UNIT IV: Modern concepts of management **No. of Hours: 15**

Protected Area Network (PAN), WWFN, IUCN, and CITES. Wildlife Legislation – Wild life Protection act (1972), its amendments and implementation. IUCN Red data book and red list categories (only names), Protected areas National parks & sanctuaries, Community reserve; Important features of protected areas in India; Project Tiger and Project Elephant.

UNIT V: Management and conservation **No. of Hours: 15**

Bio- telemetry; Common diseases of wild animal; Quarantine; Population Viability and Habitat Analysis (PVHA), captive breeding and propagation, rescue, rehabilitation and reintroduction, gene banks, ex-situ and in-situ conservation. Various Environmental movements in India: Bishnoi movement, Chipko movement, Narmada bachaoandolan, Silent valley movement, Baliyapal movement.

Course Code	**:**	**BS05DSE-3**
Course Title	**:**	**Wildlife Conservation and Management**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VI**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Identification and Study of any five endangered mammalian fauna, avian fauna, herpeto-fauna
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance
3. (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)
4. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers.
5. PCQ, Ten tree method, Circular, Square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment,
6. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)

Text and References:

1. Reena Mathur. Wildlife conservation and management
2. Caughley, G., and A.R.E. Sinclair, editors. 1994. Wildlife Ecology and Management, Blackwell Science.
3. Woodroffe R., S. Thirgood and A. Rabinowitz. 2005. People and Wildlife, Conflict or Coexistence? Cambridge University.
4. Bookhout, T.A. 1996. Research and Management Techniques for Wildlife and Habitats, 5th edition. The Wildlife Society, Allen Press.
5. Sutherland, W.J. 2000. The Conservation Handbook: Research, Management and Policy.
6. Blackwell Sciences
7. Hunter M.L., J.B. Gibbs and E.J. Sterling. 2008. Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing

Course Code	**:**	**BS06DSE4**
Course Title	**:**	**Stress Biology**
Theory/ Practical	**:**	**Theory**
Semester	**:**	**VI**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Defining plant stress **No. of Hours: 10**

Acclimation and adaptation.

UNIT II: Environmental factors **No. of Hours: 15**

Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

UNIT III: Stress sensing mechanisms in plants **No. of Hours: 10**

Role of nitric oxide. Calcium modulation, Phospholipid signaling

UNIT IV: Developmental and physiological mechanisms that protect plants against environmental stress **No. of Hours: 15**

Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; osmotic adjustment; Compatible solute production.

UNIT V: Reactive oxygen species **No. of Hours: 10**

Production and scavenging mechanisms.

Course Code	**:**	**BS06DSE4**
Course Title	**:**	**Stress Biology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VI**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Determination of antioxidant activity of the plants
2. Identification and quantification of plant stress markers
3. Induction of Abiotic stress condition on plant such as drought, salinity, temperature etc.
4. Analysis of stress induced morphological changes in plants.
5. Evaluation of plant growth under stress conditions such as Measurement of plant growth parameters including root and shoot length, biomass content.
6. Analysis of osmolyte accumulation (Eg. proline, glycine betaine) in plants under stress condition
7. Treatment of plants with hormones and growth regulators such as abscisic acid (ABA) or salicylic acid (SA) and study of their effects on stress mitigation.
8. Assessment of Reactive Oxygen Species (ROS) in stressed plants (Eg. Hydrogen peroxide).

Recommended Texts:

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology (4th ed.). John Wiley and Sons. U.S.A.
2. Taiz, L., Zeiger, E. Moller, I.M. and Murphy, A. (2015). Plant Physiology and Development (6th ed), Sinauer Associates Inc. U.S.A.
3. Nobel, P.S. (2009). Physicochemical and Environmental Plant Physiology (4th ed), Academic Press.
4. Noggle, G.R. and Fritz, G.J. (1986). Introduction to Plant Physiology, (2nd Ed). Prentice- Hall of India Ltd., New Delhi.
5. Uprety, D.C. and Reddy, V.R. (2016). Crop response to global warming, Springer

SEMESTER VII **Total Credit: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS07C15	Genomics and Proteomics	3-1-0	4	30-50-20-00
2.	BS07GE5	Research Methodology and Science Communication	3-1-0	4	30-50-20-00
3.	BS07DSE5	Microbial Pharmaceutical Technology	3-1-0	4	30-50-20-00
4.	BS07DSE6	Plant Biotechnology	3-1-0	4	30-50-20-00
5.	BS07LC1	Lab Course - I		4	

Course Code	**:**	**BS07C15**
Course Title	**:**	**Genomics and Proteomics**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Basics of genomics and proteomics **No. of Hours: 10**

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

UNIT II: Genome mapping & Genome sequencing projects **No. of Hours: 15**

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping.Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

UNIT III: Comparative genomics **No. of Hours: 10**

Identification and classification of organisms using molecular markers-16S rRNA typing/ sequencing, SNPs; use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

UNIT IV: Proteomics **No. of Hours: 10**

Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

UNIT V: Functional genomics and proteomics **No. of Hours: 15**

Transcriptome analysis for identification and functional annotation of gene, PCR, Gene expression analysis (relative quantitation and absolute quantitation using qRT PCR), Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome, gene function-forward and reverse genetics, gene ethics; Protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics;introduction to metabolomics, lipidomics, metagenomics and systems biology.

Course Code	**:**	**BS07C15**
Course Title	**:**	**Genomics and Proteomics**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VII**

TOTAL HOURS: 45 **CREDITS: 2**

List of Experiments:

1. Isolation of genomic DNA from various biological samples.
2. Targeted DNA amplification using polymerase Chain reaction (PCR).
3. Visualization of DNA fragments using agarose gel electrophoresis.
4. Quantification of DNA or RNA using quantitative PCR (qPCR).
5. Protein extraction and estimation.
6. Transformation of GFP plasmid in chemically competent *E.coli* cells.
7. Separation of proteins based on molecular weight using SDS-PAGE.

Text and References:

1. T.A. Brown. Gene Cloning and DNA Analysis – An introduction (Fourth Edition).
2. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). Principles of Gene Manipulation and Genomics.Malden, MA: Blackwell Pub.
3. Campbell, A. M., & Heyer, L. J. (2003). Discovering Genomics, Proteomics, and Bioinformatics. San Francisco: Benjamin Cummings.
4. Arthur M. Lesk. Database Annotation in Molecular Biology: Principles and Practice
5. Lesk, A. M. (2010) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
6. Branden, C. I. and Tooze, T. (1999) Introduction to Protein Structure. Garland Publishing, USA.
7. Daniel C. Liebler. Introduction to proteomics: Tools for new biology. Humana Press.
8. Smith and Albala. Protein array, Biochips and Proteomics. Marcel Dekkar, New York.
9. James D. Watson and Mark Zoller. Recombinant DNA (Second Edition).
10. D.W. Mount. Bioinformatics: Sequence and genomic analysis. Cold Spring Harbour Laboratory Press.

Course Code	**:**	**BS07GE5**
Course Title	**:**	**Research Methodology and Science Communication**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VII**

TOTAL HOURS: 60 **CREDITS: 4**

Unit I: Formulating research problem and effective research communication

No. of Hours: 18

Formulating research problem and experimental planning selection of an area for research; Importance and need of research in that field; Literature survey; Planning of experimental work: Importance and designing of the problem to be undertaken, Defining the aim and objectives of the research work planned, Importance of prior collection of protocols, Time bound frame of work plan, Designing of experimental protocol; Description of strategies to meet the objectives using state-of-the-art techniques and proper citation of standard procedures. Types of research articles and technical writing skills.

Unit II: 1. Data Collection and Analysis **No. of Hours: 12**

Understand the basics of data types, sampling techniques, and data analysis. Probability: Grasp the basic concepts of probability and their application. Statistical Basis of Biological Assay. Learn the statistical methods used in biological assays. Analysis of Variance (ANOVA) Understand principles of experimental design and variance analysis.

Unit III: Bioethics **No. of Hours: 12**

Introduction and historical background, terminology, and regulations, Bioethics Guidelines, different paradigms of Bioethics – National & International standards, A brief account of bioethics in Biotechnology, Rules and regulations, Necessity of Bioethics. Ethical issues against molecular technologies. Release of Genetically modified Organisms and Recombinant drugs, Regulating Agencies regarding ethical committees.

Unit IV: Biosafety **No. of Hours: 18**

Importance of biosafety in biotechnology**,** Health hazards related to biotechnology)**.** Concept of containment levels**,** Good Laboratory Practices (GLP)**,** Good Manufacturing Practices (GMP). Evolution of biosafety practices**,** Biological Safety Cabinets: purpose and types. Primary containment methods for biohazards**,** Understanding different Biosafety Levels (BSL)**,** Specific biosafety levels for various microorganisms. Biosafety guidelines by the Government of India**,** Recommended biosafety levels for infectious agents and animals**.** Definitions of GMOs and Living Modified Organisms (LMOs)**,** Roles of Institutional Biosafety Committee, RCGM, GEAC in GMO regulation**.** Environmental release of GMOs**,** Risk Analysis: assessment, management, and communication.

Text and References:

1. Bhattacharyya, D.K. Research methodology. Excel Books, New Delhi.
2. Kumar, R. Research methodology: A step-by-step guide for beginners. SAGE Publications, California.
3. Singh, Y.K. Research methodology. APH Publishing Corporation, New Delhi.
4. Khan, J.A. Research methodology. APH Publishing Corporation, New Delhi.
5. Gupta, S. Research methodology and statistical techniques. Deep and Deep Publications, New Delhi.
6. Khanzode, V.V. Research methodology. APH Publishing Corporation, New Delhi.
7. Goddard, W. and Melville, S. Research methodology: An introduction. Juta and Company Limited, Landsdown.
8. Dawson, C. Practical research methods: A user-friendly guide to mastering research techniques and projects. How to Books Limited, London.
9. Daniel, P.S. and Sam, A.G. Research methodology. Gyan Publishing House, New Delhi.
10. Murray, R. How to write a thesis. McGraw-Hill, New York.

Course Code	**:**	**BS07DSE5**
Course Title	**:**	**Microbial Pharmaceutical Technology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: **No. of Hours: 12**

Principles of Antimicrobial chemotherapy. Introduction of antimicrobial agents. Introduction of Bioassay, therapeutic index, MIC and LD50. Definition, classification, Mechanism of action and examples of chemical disinfectants, antiseptic and preservatives. Definition, classification, Mechanism of action and examples of antiviral, Antifungal and Antitumor antibiotics.

UNIT II: **No. of Hours: 18**

Microbial Production and spoilage of Pharmaceutical Products. Manufacturing procedure and in-process control of Pharmaceutical products: Bacterial and Viral vaccine, New Vaccine production. Microbial production and applications of therapeutic/diagnostic enzymes: Asparaginase, Streptokinase, beta lactamases. Microbial production contamination and spoilage of Pharmaceutical products and their sterilization. Applications of Biosensors in pharmaceutical industries.

UNIT III: **No. of Hours: 15**

Regulatory Practices and Policies in Pharmaceutical Industries. FDA, Govt. regulatory practices and policies. Significance of IP, BP and USP. Rational drug design (Quantitative structure activity relation QSAR of drug) and computational aspect of drug design. Screening and utilization of bioactive phytochemicals.

UNIT IV: **No. of Hours: 15**

Quality Assurance and Validation. ISO, WHO, USFDA certification. Microbial Limit test of Pharma products. Sterility testing, pyrogen testing and LAL test of Sterile Pharma products. Sterilization- heat, D-value, Z-value and survival curve, radioactive, gaseous and filtration. Chemical and biological indicators.

Course Code	**:**	**BS07DSE5**
Course Title	**:**	**Microbial Pharmaceutical Technology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VII**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Spectrophotometeric/ Microbiological methods for the determination of Fungus.
2. Microbial production and Bioassay of Penicillin.
3. Bioassay of Chloramphenicol/ Streptomycin by plate assay method or turbitometric assay methods.
4. Determination of MIC.
5. Sterility testing by using B. sterothermophilus/ B. subtilis.
6. Testing for microbial contamination.
7. Determination of antimicrobial activity of chemical compounds (like phenol, resorcinol and formaldehydes) Comparison with standard products.

Text and References:

1. Pharmaceutical Microbiology- Edited by W. B. Hugo & A.R. Russel Sixth Edition. Blackwell Scientific Publications.
2. Lippincott's illustrative Reviews: Pharmacology Edition: 02 Maryjnycck by Lippincott's review Publisher Pheladelphia 1997.
3. Principles of medicinal chemistry Vol. 1 by Kadam S.S., Mahadik K.R., Bothra K.G. Edition: 18, Nirali Publication.
4. Pharmacognosy by Gokhle S.D., KoKateC.K.. Edition: 18, Nirali Publication.
5. Biotechnology – Expanding Horizon by B.D. Singh ., First Edition, Kalyani Publication, Delhi.
6. Analytical Microbiology- Edited by Fredrick Kavanagh volume I &II. Academic Press New York.

Course Code	**:**	**BS07DSE6**
Course Title	**:**	**Plant Biotechnology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: **No. of Hours: 10**

Introduction to the techniques of plant tissue culture, Cellular totipotency, Single cell culture, Somoclonal variation, Embryogenesis, protoplast isolation and culture, Somatic hybridization, cybrid production and their application in crop improvement, production of virus free plants using meristem culture.

UNIT II: **No. of Hours: 15**

Basic of tumor formation, hairy root culture, Ti plasmids mechanisms of DNA transfer and use of vectors, Genetically modified crops, plants and Genetic engineering for biotic stress tolerance (insects,fungi,bacteria, virus and fungi) Genetic engineering for abiotic stress (Drought, flooding, Salt and temperature).

UNIT III: **No. of Hours: 15**

Genetic improvement for quality improvement of proteins, lipids, carbohydrates, vitamins and mineral nutrients , plants as bioreactor, molecular breeding, constructing molecular maps,(molecular tagging of traits), Marker assisted selection of Qualitative and quantitative traits), physical maps of chromosomes and concept of map based cloning and their use in transgenics.

UNIT IV: **No. of Hours: 10**

Plant secondary metabolites: Control mechanisms and manipulation of alkaloids and industrial enzymes (Shikimate and PHA pathway), biodegradable plastics, therapeutic proteins, edible vaccines, Green house technology.

UNIT V: **No. of Hours: 10**

Molecular aided breeding, RFLP maps, RAPD, STS, SCAR QTL, Map based cloning, molecular assisted selection.

Course Code	**:**	**BS07DSE6**
Course Title	**:**	**Plant Biotechnology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VII**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Organizing Plant tissue culture Laboratory
2. Preparation of Tissue Culture Media
3. Callus Induction
4. Shoot tip culture
5. Embryo / Endosperm Culture
6. Somatic Embryogenesis
7. Hardening and Planting infield
8. Isolation of protoplasts
9. Cell suspension culture
10. Economics of micropropagation project

Text and References:

1. Hamish A Collin, Sue Edwards (1998). Plant Cell Culture
2. Chawla H S, Introduction to Plant Biotechnology by, Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, 3rd Ed., ISBN- 9788120417328.
3. Gupta P K, 2004. Biotechnology and Genomics.
4. Primrose and Twyman. Principles of Gene Manipulation & Genomics (7th Ed.).
5. Singh BD and Shekhawat NS, 2018. Molecuar Plant Breeding, Scientific Pub.
6. Rastogi Smita and Pathak Neelam (2009) Genetic Engineering, 1st Ed. Oxford.
7. John H Dodds; Lorin W Roberts, 3rd edition, 2004. Experiments in Plant tissue Culture
8. Plant tissue culture by MK Razdan & SS Bhojwani(1996) Elsevier.
9. Robert H Smith, 3rdedition. Plant Tissue Experiments
10. Plant physiology by L Tiaz & E Zeiger 4th edition (2006) Sinauer Associates Inc publishers.
11. Plant Biotechnology and transgenic plants, Edited by Kirsi Marja Oksman-Caldentey, Wolfgang Barz Marcel Dekker 2002.
12. Plant tissue culture concepts and laboratory exercises, Second edition, Robert N Trigiano, Dennis J Gray, CRC Press November 1999.

SEMESTER VIII **Total Credit: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS08C16	Bioprocess Technology	3-1-0	4	30-50-20-00
2.	BS08DSE7	Bioinformatics	3-1-0	4	30-50-20-00
3.	BS08DSE8	Animal Biotechnology	3-1-0	4	30-50-20-00
4.	BS08DSE9	Environmental Biotechnology	3-1-0	4	30-50-20-00
5.	BS08LC2	Lab Course - II		4	

Course Code	**:**	**BS08C16**
Course Title	**:**	**Bioprocess Technology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VIII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Basic principles of Bioprocess Technology **No. of Hours: 18**

Introduction to concepts of bioprocess engineering, Overview of bioprocesses with their various components, Microbial growth and death kinetics with respect to fermenters, optimization of bioprocesses, yield coefficient, doubling time, specific growth rate, metabolic and biomass productivities, effect of temperature, pH and salt concentration on product formation. Application of Bioprocess Technology.

UNIT II: Concepts of basic mode of fermentation processes **No. of Hours: 18**

Bioreactor designs; Types of fermenters; Concepts of basic modes of fermentation - Batch, fed batch and continuous; Solid substrate, surface and submerged fermentation; Fermentation media; Design and types of culture/production vessels- Batch, Fed batch, CSTBR, airlift, packed bed and bubble columnfermentor; Impeller, Baffles, Sparger.

UNIT III: Upstream Process **No. of Hours: 12**

Inoculum development, formulation of production media, scale up of the process from shake flask to industrial level. Growth of culture in fermenter, choosing cultivation methods, Modifying batch and continuous reactors, immobilization cell systems, active and passive immobilization, solid state fermentation process.

UNIT IV: Downstream processing **No. of Hours: 12**

Introduction, Recovery of particulates filtration, centrifugation, sedimentation, emerging technologies for cell recovery, product isolation, extraction, solvent extraction, aqueous two phase system, sorption, precipitation, reverse osmosis, ultra-filtration.

Course Code	**:**	**BS08C16**
Course Title	**:**	**Bioprocess Technology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VIII**

TOTAL HOURS: 45 **CREDITS: 4**

List of Experiments:

1. Bacterial growth curve.
2. Calculation of thermal death point (TDP) of a microbial sample.
3. Production and analysis of ethanol.
4. Production and analysis of amylase.
5. Production and analysis of lactic acid.
6. Isolation of industrially important microorganism from natural resource.

Text and References:

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. Jackson AT., Bioprocess Engineering in Biotechnology, Prentice Hall, Engelwood Cliffs, 1991.
5. Shuler ML and Kargi F., Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, Engelwood Cliffs, 2002.
6. Stanbury RF and Whitaker A., Principles of Fermentation Technology, Pergamon press, Oxford, 1997.
7. Baily JE and Ollis DF., Biochemical Engineering fundamentals, 2nd Edition, McGraw-Hill Book Co., New York, 1986.
8. Aiba S, Humphrey AE and Millis NF, Biochemical Engineering, 2nd Edition, University of Tokyo press, Tokyo, 1973.
9. Comprehensive Biotechnology: The Principles, Applications and Regulations of Biotechnology in Industry, Agriculture and Medicine, Vol 1, 2, 3 and 4. Young M.M., Reed Elsevier India Private Ltd, India, 2004.
10. Mansi EMTEL, Bryle CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007.

Course Code	**:**	**BS08DSE7**
Course Title	**:**	**Bioinformatics**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VIII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Bioinformatics basics **No. of Hours: 10**

Bioinformatics basics: Computers in biology and medicine; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTDs; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

UNIT II: DNA sequence analysis **No. of Hours: 10**

DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

UNIT III: Multiple sequence analysis **No. of Hours: 10**

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centers; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

UNIT IV: Protein modeling **No. of Hours: 15**

Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment- methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

UNIT V: Protein structure prediction **No. of Hours: 15**

Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques, sequence-sequence scoring; protein function prediction; elements of in silico drug design.

Course Code	**:**	**BS08DSE7**
Course Title	**:**	**Bioinformatics**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VIII**

TOTAL HOURS: 45 **CREDIT: 2**

List of experiments:

1. Understanding the use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR).
2. Pair wise sequence alignment using BLAST
3. Multiple sequence alignment (MSA) using various tools (ClustalW, BioEdit, MEGA).
4. Protein structure visualization using various tools (eg. PyMOL)

Text and References:

1. Lesk, A. M. (20014). Introduction to Bioinformatics. Oxford: Oxford University Press.
2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.
4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.
5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.
6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press
7. Jin Xiong (2006). Essential Bioinformatics, Cambridge University Press.
8. Primrose SB, Twyman RM, Blackwell Science (2002). Principles of Genome analysis and genomics.
9. Teresa Attwood, David Parry-Smith, (2016). Introduction to Bioinformatics. Addison Wesley Longman ltd.
10. Bryan Bergeron. Bioinformatics Computing, Publisher: Prentice Hall PTR.
11. Rastogi, Mendritta and Rastogi (2013). Bioinformatics: Methods and Applications. PHI earnin publishers.
12. Des Higgins, Willie Taylor, (2000). Bioinformatics: Sequence, Structure and Databanks: A Practical Approach (The Practical Approach Series, 236), Oxford Univ Press.

Course Code	**:**	**BS08DSE8**
Course Title	**:**	**Animal Biotechnology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VIII**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Animal cell culture **No. of Hours: 10**

History; Basic requirements; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Transfection andtransformation of cells; Stem cells and their application; Induced Pluripotency.

UNIT II: Animal reproductive biotechnology **No. of Hours: 10**

Structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; embryo recovery and in vitro fertilization; cryopreservation of embryos; embryo transfer technology. Transgenic Animals: applications of transgenic animal technology; Techniques of gene transfer: Microinjection, Lipofection, Electroporation, Chemical based transformation, Viral Vectors.

UNIT III: Animal Genomics **No. of Hours: 15**

Introduction to animal genomics; Different methods for characterization of animal genomes, SNP, STR, RFLP, RAPD, proteomics, metabolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders. Animal cloning - basic concept, cloning for conservation for conservation endangered species

UNIT IV: Applications of Animal Cell Cultures **No. of Hours: 15**

Cell Culture based products, Vaccines, Hybridoma technology, Monoclonal antibodies, In vitro testing of drugs; Production of pharmaceutical proteins; Stem Cells and their Use, Using Animals Cells for heterologous gene expression. Introduction to the concept of vaccines, conventional methods of animal vaccine production.

UNIT V: Immunological, Biochemical and molecular based applications No. of Hours: 10

Immunological and nucleic acid based methods for identification of animal species; DNA Barcoding; Detection of adulteration in meat using DNA based methods; Detection of food/ feed adulteration with animal protein; Identification of wild animal species using DNA based methods.

Course Code	**:**	**BS08DSE8**
Course Title	**:**	**Animal Biotechnology**
Theory/ Practical	**:**	**Practical**
Semester	**:**	**VIII**

TOTAL HOURS: 45 **CREDIT: 2**

List of Experiments:

1. Sterilization techniques and biosafety
2. Preparation of media for animal cell culture.
3. Prerequisites for starting animal cell culture lab.
4. Peripheral blood lymphocyte culture
5. Nuclear and Mitochondrial staining of cells
6. Passaging of cultured cells.
7. Determination of viable cells by trypanblue test or MTT Assay
8. Observation of permanent slides- CHO Cells, BHK, Vero, HEK, SP2/0-Ag14.
9. Effect of drugs on cell culture
10. Growth kinetics of animal cells

Text and References:

1. T. A. Brown. (2020) Gene Cloning and DNA Analysis: An Introduction, 8th Edition. Wiley-Blackwell
2. Primrose S.B. (2014) Principles of Gene Manipulation and Genomics, 7th Edn. John Wiley Blackwell
3. Smita Rastogi , Neelam Pathak. (2009). Genetic Engineering. Oxford University Press.
4. Razdan M.K. “Introduction to Plant Tissue Culture”, Science Publishers, Third Edition (2005).
5. Slater A, Scott N.W and Fowler M.R. “Plant Biotechnology: The Genetic Manipulation of Plants”, Oxford University Press, Third Edition (2008).
6. Gelvin S (2003) Agrobacterium-Mediated Plant Transformation: The Biology behind the Gene-Jockeying Tool, Microbiology and Molecular Biology Reviews, 67: 16-37.
7. Voytas D.F and Gao C (2014) Precision Genome Engineering and Agriculture: Opportunities and Regulatory Challenges, Plos One. 12, e1001877.

Course Code	**:**	**BS08DSE9**
Course Title	**:**	**Environmental Biotechnology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**VIII**

TOTAL HOURS: 60 **CREDITS: 4**

Unit I: **No. of Hours: 18**

Issues and scopes of environmental biotechnology. Waste water treatment-Waste water characterization and its significance: COD, BOD, Inorganic constituents, solids, biological components. Primary, secondary and tertiary treatment of waste water. Principles and aims of biological wastewater treatment processes. Biochemistry and microbiology of inorganic phosphorus and nitrogen removal. Suspended growth technologies: Activated sludge, oxidation ditches, waste stabilization ponds. Fixed film technologies: Trickling filters, rotating biological contactors, fluidized bed and submerged aerated filters

Unit II: **No. of Hours: 12**

Toxicity testing in waste water treatment plants using microorganisms. Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion. Anaerobic waste water treatment systems: RBC, UASB, anaerobic filters. Merits and demerits of anaerobic treatment of waste.Composting: Objectives, fundamentals, microbiology, factors influencing composting and composting systems. Compost quality and uses. Vermicomposting.

Unit III: **No. of Hours: 18**

Biodegradation of organic pollutants: Mechanisms and factors affecting biodegradation. Pollution problems and biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes, lignin and pesticides. Bioremediation: Intrinsic bioremediation, Biostimulation and Bioaugmentation. In situ and ex situ bioremediation technologies. Bioremediation of oil spills. Bioremediation of heavy metal pollution, Phytoremediation. Use of GMO in bioremediation. Biological treatment of waste gas (polluted air): biofilters, bioscrubbers, membrane bioreactors, biotrickling filters.

Unit IV: **No. of Hours: 12**

Biogeotechnology- Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. Biobeneficiation of gold ores. Microbially enhanced oil recovery. Biodesulfurization of coal: Removal of organic and inorganic sulfur from coal. Microbial Insecticides: Bacterial, fungal and viral insecticides in pest management. Biofertilizers: Nitrogen fixing and phosphate solubilizing biofertilizers.

Text and References:

1. MurrayMoo Young. Comprehensive Biotechnology Vol-4.
2. Rehm and Reid. Biotechnology.
3. G. Bitton. Waste water microbiology
4. M. Alexander. Biodegradation and bioremediation
5. Arceivala. Waste water treatment for pollution control, 2nd edition.
6. H. Jordening and Josef Winter. Environmental Biotechnology.

SEMESTER IX **Total Credit: 22**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-P
1.	BS09C17	Cancer Biology	3-1-0	4	30-50-20-00
2.	BS09GE6	Intellectual Property Rights	3-1-0	4	30-50-20-00
3.	BS09DSE10	Neurobiology syllabus	3-1-0	4	30-50-20-00
4.	BS09DSE11	Nanobiotechnology	3-1-0	4	30-50-20-00
5.	BS09DSE12	Vaccines	3-1-0	4	30-50-20-00
6.	BS09DSE13	Molecular Diagnostics	3-1-0	4	30-50-20-00
7.	BS09DSE14	Genetic Engineering	3-1-0	4	30-50-20-00
8.	BS09LC3	Lab Course - III		4	
9.	BS09SIS	Summer Internship and Seminar		2	

Course Code	**:**	**BS09C17**
Course Title	**:**	**Cancer Biology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Fundamentals of cancer biology **No. of Hours: 12**

Epidemiology of cancer: Environmental factors, Viruses, Life style habits, Mutations and DNA repair. Regulation of cell cycle, Modulation of cell cycle in cancer: pRb, p53. Classification of cancer forms and hallmarks of cancers.

UNIT II: Principles of carcinogenesis **No. of Hours: 12**

Theory of carcinogenesis, Chemical carcinogenesis, Physical carcinogenesis; X-ray radiation: mechanisms of radiation carcinogenesis. Mutations that cause changes in signal molecules. Geneticbasis of cancer: DNA repair.

UNIT III: Oncogene regulations and diseases **No. of Hours: 12**

General idea of Oncogenes and Tumor suppressor genes, Molecular mechanisms of tumorogenesis Cell cycle check-point defects, Tumor specific markers, Chromosomal basis of Cancer, Philadelphia chromosome, Retinoblastoma, Burkitt's lymphoma, Oncogene amplification (HSR & DM), Aneuploidy in neoplasia, Epigenetic Mechanisms: Methylation, Acetylation, Histone modification, Epigenetics and Cancer, Epigenetic inheritance and gene expression, Epigenetic regulation in cancer

UNIT IV: Cancer Genetics **No. of Hours: 12**

Mutagenesis & Mutation, Types & origin, Mechanisms, Detection and isolation, DNA damage and repair mechanisms, Chromosomal Instability and DNA damage response, Cancer Biology, Cancer & environment, Biochemical & structural Changes in cancer cells, Tumor progression: angiogenesis & metastasis

UNIT V: Cancer Detection and Therapy **No. of Hours: 12**

Cancer screening and early detection, Detection using biochemical assays, Tumor markers. Advances in cancer detection. Different forms of therapy- Chemotherapy, Radiation therapy, Immunotherapy, Molecular therapy, Use of signal targets towards therapy of cancer; Gene therapy.

Text and References:

1. Stella Pelengaris, Michael Khan, “The Molecular Biology of Cancer”, Blackwell Publishing1st edition, 2006.
2. Robert A. Weinberg, “The Biology of Cancer”, Garland Science, 2nd edition, 2014.
3. R. W. Ruddon, “Cancer Biology”, Oxford, Oxford University Press, 2007.
4. C. Athena Aktipis, Randolph M Nesse, “Evolutionary foundations for cancer biology”, Evol Appl. 2013 January; 6(1): 144–159.
5. Molecular Biology of the Cell, 4th Ed., Alberts et al, Garland, 2002

Course Code	**:**	**BS09GE6**
Course Title	**:**	**Intellectual Property Rights**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

Unit I: Introduction to Intellectual Property Rights and Protection Mechanisms

No. of Hours: 15

Types of IP**:** Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs. International Framework for IPProtection**:**History and Overview of GATT, WTO, WIPO, and TRIPS, Plant Variety Protection and Farmers' Rights Act. Concept of "Prior Art": Invention in the Context of Prior Art.

Unit II: Entrepreneurship in Biotechnology and Research **No. of Hours: 15**

IP as a Factor in R&D: Intellectual Property Rights (IPRs) of Relevance to Biotechnology, Case Studies, Patent Databases and Analysis, Country-wise Patent Searches (USPTO, EPO, India), Analysis and Report Formation.

Unit III: Fundamentals of Patenting and Legal Framework **No. of Hours: 15**

Basics of Patents: Types of Patents, Overview of the Indian Patent Act 1970 and Recent Changes, Introduction to WIPO, Budapest Treaty, and Patent Cooperation Treaty (PCT), Role of National Patent Offices, Steps to File a PCT Application and a Patent Application. Patent Applications and Procedures: Important Precautions Before Applying: What to Disclose and What Not to, Overview of Patent Application Forms, Guidelines, Fees, and Deadlines, Types of Patent Applications: Provisional vs. Complete Specifications, Understanding PCT and Conventional Patent Applications.

Unit IV: International Patenting, Commercialization, and Legal Considerations

No. of Hours: 15

International Patenting:Requirement, Procedures, and Costs of International Patenting, Financial Assistance for Patenting: Introduction to Existing Schemes, Publication of Patents: Gazette of India, Status in Europe and US. Patent Infringement and Commercialization**:**Patent Infringement: Meaning, Scope, Litigation, Case Studies, and Examples,Commercialization of Patented Innovations, Licensing: Outright Sale, Licensing, Royalty.

Text and References:

1. Brigitte Anderson. Intellectual Property Rights, Edward Elgar Publishing
2. Graham Dutfield. Intellectual Property Rights and the Life Sciences Industries. Ashgate Publishing
3. WIPO Intellectual Property Handbook
4. William Rodelph Cornish, David Clewelyn. Intellectual Property Rights
5. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
6. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers
7. World Intellectual Property Organisation. http://www.wipo.int
8. International Union for the Protection of New Varieties of Plants. http://www.upov.int
9. National Portal of India. http://www.archive.india.gov.in
10. National Biodiversity Authority. http://www.nbaindia.org

Course Code	**:**	**BS09DSE10**
Course Title	**:**	**Neurobiology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT 1: Neurobiology- Function & Dysfunction **No. of Hours: 10**

Brain Anatomy, Different Lobes/ Cortex,Brain OrganisationCNS, PNS, ANS,Structure of Cerebellum and Basal Ganglia, Histology of Brain Sections, (Coronal/sagittal)Normal vs. Diseased, Neuro-developmental Biology, Blood Brain Barrier

UNIT 2: Cell Biology **No. of Hours: 15**

Neurons and Glial Cells, Detection of different neuronal cells (by IHC/ICC), Neuronal Transmission, Electrical Impulse Action Potential, Excitatory and Inhibitory Postsynaptic, Potentials (EPSP and IPSP), Chemical Impulse, Neurotransmitters and their metabolism, Different Pathways (Dopaminergic, Adrenergic, Serotonergic, etc.)Examples of malfunctions of pathways, Neuronal study in Cell/Organ,Isolation and culturing of primary neurons and means of manipulation, Culturing and methods of differentiation of cultured neuronal cells, Organotypic brain cultures

UNIT 3: Sensation and Sensory Processing **No. of Hours: 10**

Somatic Sensory System: Touch and Proprioception, Pain, Vision – The Eye and Central Visual Pathways, The Auditory System, Olfactory System, Gustatory System,

UNIT 4: Neuropathology **No. of Hours: 15**

Clinical, Cellular and Molecular Mechanisms of the Neurological Diseases:Alzheimer's Disease, Parkinson's Disease, Huntington Disease, Dystonia, Wilson, Disease, Epilepsy, Autism, Multiple Sclerosis, Amyotrophic Lateral Sclerosis (ALS),Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Depression, Dementia,Cerebro-vascular Disease (Stroke)Techniques and tools applicable in neuroscience: MRI, PET, Fluorescence microscopy,FACS, Electron Microscopy, Patch Clamp, etc., Database sequence information andmutation information on specific neurodegenerative diseases

UNIT 5: Behavioural Studies Animal behavior **No. of Hours: 10**

Behavioural studies by using animal model of C. elegans, Fruit fly, Zebra Fish, Mouse (Rodents) Testing motor functions Rotarod Test, Force Swimming Test, Beam Walking Test, Grip Strength Test Testing Cognitive Functions Learning and memory related test (Any-arm Maze, Water Maze, etc.) Human behaviour Approaches of studies human behaviour, Psychological & Physiological tools, Clinical investigation

Text and References:

1. Gray's Anatomy; Gray's Anatomy for Students, Drake, Vogl, Mitchell
2. Text Book of Medical Physiology, Guyton and Hall
3. Ganong's Reviews of Medical Physiology, Barrett, Barman
4. Principles of Anatomy and Physiology, G. J. Tortotora, B. Derrickson
5. Neuroscience, Dale Purves
6. The Human Nervous System, Mai Paxinos
7. Handbook of Neuroendocrinology, George Fink
8. Principles of Neural Science, Kandel, Koester, Mack & Siegelbaum (K), 6th Edition, Elsevier (2021).
9. Principles of Neurobiology, Luo (L), 2nd edition, Garland (2020).

Course Code	**:**	**BS09DSE11**
Course Title	**:**	**Nanobiotechnology**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

Unit I: Introduction to Nano-biotechnology **No. of Hours: 15**

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II: Nano – particles and its application **No. of Hours: 15**

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit III: Nano – materials and Nano Toxicity **No. of Hours: 15**

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment.

Unit IV: Nano – toxicity **No. of Hours: 15**

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

Recommended Texts:

1. T.Pradeep, NANO, 2006.Tata Mc Graw Publishers. India
2. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
3. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
4. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
5. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
6. Recent review papers in the area of Nanomedicine

Course Code	**:**	**BS09DSE12**
Course Title	**:**	**Vaccines**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Fundamentals of immune system **No. of Hours: 10**

Overview of Immune system; Human Immune system: Effectors of immune system; Innate & Adaptive Immunity; Activation of the Innate Immunity; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Correlates of protection.

UNIT II: Immune response to infection **No. of Hours: 15**

Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen presenting cells: Dendritic cells in immune response; Innate immune response; Humoral (antibody mediated) responses; Cell mediated responses: role of CD4+ and CD8+ T cells; Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells.

UNIT III: Immune response to vaccination **No. of Hours: 10**

Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.

UNIT IV: Vaccine types & design **No. of Hours: 10**

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.

UNIT V: Vaccine technologies **No. of Hours: 15**

New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika, SARS).

Text and References:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

Course Code	**:**	**BS09DSE13**
Course Title	**:**	**Molecular Diagnostics**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Enzyme Immunoassays **No. of Hours: 15**

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

UNIT II: Enzyme immuno histochemical techniques **No. of Hours: 15**

Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology; Molecular methods in clinical microbiology: Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology

UNIT III: Laboratory tests in chemotherapy **No. of Hours: 10**

Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

UNIT IV: Automation and rapid diagnostic approach **No. of Hours: 10**

Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies.

UNIT V: Idiotypes and immunodiagnostic **No. of Hours: 10**

Concepts and methods in idiotypes. Antiidiotypes and molecular mimicry and receptors.Epitope design and applications.Immunodiagnostic tests- Immuno florescence. Radioimmunoassay.

Text and References:

1. Lela Buckingham , Maribeth L. Flaws . Molecular Diagnostics: Fundamentals, Methods and Clinical Applications. F.A. Davis Company
2. Carl A. Burtis , Edward R. Ashwood , David E. Bruns . Tietz Textbook of Clinical Chemistry and Molecular Diagnostics. Saunders
3. William B. Coleman , Gregory J. Tsongalis. Molecular Diagnostics: For the Clinical Laboratorian. Humana Press Inc.
4. George Patrinos, Wilhelm Ansorge. Molecular Diagnostics. Acad Pr

Course Code	**:**	**BS09DSE14**
Course Title	**:**	**Genetic Engineering**
Theory/ Practical	**:**	**Theory 45; Tutorial 15**
Semester	**:**	**IX**

TOTAL HOURS: 60 **CREDITS: 4**

UNIT I: Introduction and tools for genetic engineering **No. of Hours: 12**

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, southwestern and far-western and colony hybridization, fluorescence in situ hybridization.

UNIT II: Different types of vectors **No. of Hours: 12**

Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

UNIT III: Different types of PCR techniques. **No. of Hours: 12**

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP

UNIT IV: Gene manipulation and protein-DNA Interaction **No. of Hours: 12**

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of proteinDNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; proteinprotein interactions using yeast two-hybrid system; phage display.

UNIT V: Gene silencing and genome editing technologies **No. of Hours: 12**

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies(Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Text and References:

1. Primrose, S. B., & Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.
4. Selected papers from scientific journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.