ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

MANGALORE UNIVERSITY

(Accredited by NAAC with 'A' Grade)

ಕ್ರಮಾಂಕ/ No. : MU/ACC/CR 41/2020-21/A2

ಕುಲಸಚಿವರ ಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:15.01.2021

NOTIFICATION

Sub: Revised syllabus of M.Sc. Biosciences programme.
Ref: Academic Council approval vide agenda
No.: ಎ.ಸಿ.ಸಿ:ಶೈ.ಸಾ.ಸ.2:19(2020–21)dtd 23.12.2020.

*****

The Revised syllabus of M.Sc. Biosciences programme which is approved by the Academic Council at its meeting held on 23.12.2020 is hereby notified for implementation with effect from the academic year 2020-21.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Chairman, Dept. of Biosciences, Mangalore University, Mangalagangothri
2. The Chairman, BOS in Biosciences, Dept. of Biosciences, Mangalore University.
3. The Registrar (Evaluation), Mangalore University.
4. The Superintendent (ACC), O/o the Registrar, Mangalore University.
5. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
6. Guard File.

MANGALORE UNIVERSITY
DEPARTMENT OF BIOSCIENCES
SCHEME andSYLLABUS for TWO YEAR (FOUR SEMESTERS) M.Sc. in BIOSCIENCES POST GRADUATE DEGREE PROGRAM UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

Preamble:

Based on directions of the University Grants Commission, New Delhi and Karnataka State Higher Education Council, the Choice Based Credit System (CBCS Semester Scheme) has been implemented. Mangalore University directedthe Board of Studies (BoS) to frame the syllabus as per the regulations governing the Choice Based Credit System for the Two Year (Four Semester) Post-Graduate Programme. Accordingly,a syllabus approved by the BoS was in place since 2016.

This syllabus has now been revised keeping in mind the recent advancements in the field of Biological Sciences, the knowledge- and skill-based profile expected from a Master's in Biosciences along with fulfilling the requirement for the students' career prospects and was duly approved by the BoS in 2020.

The present M.Sc. in Biosciences Programmeunder CBCSScheme has a total of 88credits with 52 (59.09%) credits from Hard Core courses, 30 (34.09%) credits from Soft Core courses and 06 (6.97%) credits from Open Electives.

Programme Outcomes (PO)

PO1. Enhancement of state-of-the-art knowledge: Upgrade knowledge to develop general competencies and analytical skills on an advanced level required for teaching, research, industry, entrepreneurship and public administration in the field of biologicalsciences.

PO2. Skill-based use of tools and techniques: Independently operate various tools and acquire skills for the application of appropriate techniques to assess samples and carry out innovative studies on basic or applied aspects ofbiology.

PO3. Social Responsibility: Apply the knowledge of life sciences to contextually address specific issues in society with special reference to health and environment for well-being and sustainable development.

PO4. Effective Communication: Effectively communicate on diverse aspects of biology through oral presentations, written proposals, dissertations, reports, data analysis, interpretation and documentation.

Programme Specific Outcomes (PSO)

PSO1. Gain basic to advanced level knowledge in various branches of life sciences thus enabling students to build the confidence to pursue careersin academics, industriesor become entrepreneurs in India andabroad.

PSO2. Empower with skill-based expertise and technical know-how in the field of biological sciences.

PSO3. Develop good communication skills with sound technical background in biological sciences, thus providing a strong foundation for both academic and industrial placements as well as setting up entrepreneurial ventures.

PSO4. Evolve in-depth scientific knowledge in various branches of biology.

PSO4. Explore, analyse and interpret lab- and field-based data using state-of-the-art techniques and tools in planning and executing innovative projects in lifesciences.

M.Sc. BIOSCIENCES - SCHEME

I SEMESTER	Hrs/week	Credits
HARD CORE COURSES - THEORY		
BSH401 Biochemistry	4	4
BSH402 Cell Biology	4	4
BSH403 Basic Microbiology	4	4
SOFT CORE COURSES - THEORY (Any ONE to be opted)		
BSS404 Genetics	3	3
BSS405 Biochemical Techniques	3	3
PRACTICAL COURSES		
BSP406 Biochemistry Lab	4	2
BSP407 Cell Biology Lab	4	2
BSP408 Basic Microbiology Lab	4	2
BSP409 Genetics Lab	4	2
BSP410 Biochemical Techniques Lab	4	2
II SEMESTER	**Hrs/week**	**Credits**
HARD CORE COURSES - THEORY		
BSH451 Molecular Biology	4	4
BSH452 Biostatistics and Bioinformatics	4	4
SOFT CORE COURSES - THEORY (Any ONE to be opted)		
BSS453 Applied Microbiology	3	3
BSS454 Aquatic Biology	3	3
BSS455 Metabolism and Bioenergetics	3	3
PRACTICAL COURSES		
BSP456 Molecular Biology Lab	4	2
BSP457 Biostatistics and Bioinformatics Lab	4	2
BSP458 Applied Microbiology Lab	4	2
BSP459 Aquatic Biology Lab	4	2
BSP460 Metabolism and Bioenergetics Lab	4	2
OPEN ELECTIVE COURSES (Any ONE to be opted)		
BSE461 Biodiversity and Conservation	3	3
BSE462 Cancer Biology	3	3
III SEMESTER	**Hrs/week**	**Credits**
BSH501 Animal Physiology	4	4
BSH502 Plant Physiology	4	4
SOFT CORE COURSES - THEORY (Any TWO to be opted)		
BSS503 Applied Ecology	3	3
BSS504 Immunology	3	3
BSS505 Ecotoxicology	3	3
PRACTICAL COURSES		
BSP506 Animal Physiology Lab	4	2
BSP507 Plant Physiology Lab	4	2
BSP508 Applied Ecology Lab	4	2
BSP509 Immunology Lab	4	2
BSP510 Ecotoxicology Lab	4	2
OPEN ELECTIVE COURSES (Any ONE to be opted)		
BSE511 Pollution and Bioremediation	3	3
BSE512 Stem Cell Biology and Regenerative Medicine	3	3
BSE513 Behavioural biology	3	3
IV SEMESTER	**Hrs/week**	**Credits**
HARD CORE COURSES - THEORY		
BSH551 Biotechnology	4	4
SOFT CORE COURSES - THEORY (Any TWO to be opted)		
BSS552 Environmental Physiology	3	3
BSS553 Developmental Biology	3	3
PRACTICAL COURSES		
BSP554 Biotechnology Lab	4	2
BSP555 Environmental Physiology Lab	4	2
BSP556 Developmental Biology Lab	4	2
PROJECT WORK BSP557 Project Work (Report/Dissertation)	4	4

M.Sc. BIOSCIENCES
(CBCS)
Scheme

I SEMESTER

Code	Title	Teaching Hrs/week	Exam Hrs	Marks Exams	Marks IA	Total Marks	Credits
HARD CORE COURSES - THEORY							
BSH401	Biochemistry	4	3	70	30	100	4
BSH402	Cell Biology	4	3	70	30	100	4
BSH403	Basic Microbiology	4	3	70	30	100	4
SOFT CORE COURSES – THEORY (Any ONE to be opted)							
BSS404	Genetics	3	3	70	30	100	3
BSS405	Biochemical Techniques	3	3	70	30		
PRACTICAL COURSES							
BSP 406	Biochemistry Lab	4	3	35	15	50	2
BSP 407	Cell BiologyLab	4	3	35	15	50	2
BSP 408	Basic MicrobiologyLab	4	3	35	15	50	2
BSP 409	Genetics Lab	4	3	35	15	50	
BSP 410	BiochemicalTechniques Lab	4	3	35	15		2
			Total			**600**	**23**

II SEMESTER

Code	Title	Teaching Hrs/week	Exam Hrs	Marks Exams	Marks IA	Total Marks	Credits
HARD CORE COURSES - THEORY							
BSH451	Molecular Biology	4	3	70	30	100	4
BSH452	Biostatisticsand Bioinformatics	4	3	70	30	100	4
SOFT CORE COURSES – THEORY (Any TWO to be opted)							
BSS453	Applied Microbiology	3	3	70	30	100	3
BSS454	Aquatic Biology	3	3	70	30	100	3
BSS455	Metabolism and Bioenergetics	3	3	70	30		
PRACTICAL COURSES							
BSP 456	Molecular Biology Lab	4	3	35	15	50	2
BSP 457	Biostatistics and Bioinformatics Lab	4	3	35	15	50	2
BSP 458	Applied Microbiology Lab	4	3	35	15		
BSP 459	Aquatic Biology Lab	4	3	35	15	50	2
BSP 460	Metabolism and Bioenergetics Lab	4	3	35	15	50	2
OPEN ELECTIVE COURSES (Any ONE to be opted)							
BSE461	Biodiversity and Conservation	3	3	70	30		
BSE462	Cancer Biology	3	3	70	30	100	3
			Total			**700**	**25**

III SEMESTER

Code	Title	Teaching Hrs/week	Exam Hrs	Marks Exams	MarksIA	Total Marks	Credits
HARD CORE COURSES - THEORY							
BSH501	Animal Physiology	4	3	70	30	100	4
BSH502	Plant Physiology	4	3	70	30	100	4
SOFT CORE COURSES – THEORY (Any TWO to be opted)							
BSS503	Applied Ecology	3	3	70	30	100	3
BSS504	Immunology	3	3	70	30	100	3
BSS505	Ecotoxicology	3	3	70	30		
PRACTICAL COURSES							
BSP 506	Animal Physiology Lab	4	3	35	15	50	2
BSP 507	Plant PhysiologyLab	4	3	35	15	50	2
BSP 508	Applied Ecology Lab	4	3	35	15	50	2
BSP 509	Immunology Lab	4	3	35	15	50	2
BSP 510	EcotoxicologyLab	4	3	35	15		
OPEN ELECTIVE COURSES (Any ONE to be opted)							
BSE 511	Pollution and Bioremediation	3	3	70	30		
BSE 512	Stem Cell Biology andRegenerative Medicine	3	3	70	30	100	3
BSE 513	Behavioural Biology	3	3	70	30		
			Total			**700**	**25**

IV SEMESTER

Code	Title	Teaching Hrs/week	Exam Hrs	Marks Exams	Marks IA	Total Marks	Credits
HARD CORE COURSES - THEORY							
BSH 551	Biotechnology	4	3	70	30	100	4
SOFT CORE COURSES - THEORY (Any ONE to be opted)							
BSS 552	EnvironmentalPhysiology	3	3	70	30	100	3
BSS 553	Developmental Biology	3	3	70	30		
PRACTICAL COURSES							
BSP 555	Biotechnology Lab	4	3	35	15	50	2
BSP 556	EnvironmentalPhysiology Lab	4	3	35	15		
BSP 557	Developmental Biology Lab	4	3	35	15	50	2
PROJECT WORK							
BSP 558	Project Work (Report/Dissertation)	-	-	70	30	100	4
			Total			**400**	**15**
			Grand Total			**2400**	**82 + 6***

IA = InternalAssessment; * Not included forCGPA
Total Credits: 88(82+6*)
Hard Core credit: 18 + 12 +12+06+04 (Project) = 52 (59.1%)
Soft Core credit: 05 + 10 + 10 +05 = 30 (34.1%)
Open Elective credit: 03 + 03 = 06 (6.82%)

NOTE:

BASIS FOR INTERNAL ASSESSMENT: Internal Assessment marks in theory papers shall be awarded on the basis of theory test (70 Marks), Objective Test (15 Marks), Seminars and Assignments (15 Marks). The marks obtained shall be reduced to 30. Practical Internal Assessment marks shall be based on practical test and records. 30 marks for Practical Test and 05 marks for Class Records. The marks obtained shall be reduced to 15. 30 marks for Project Work (Report/Dissertation and Presentation/Viva).

THEORY QUESTION PAPER PATTERN: Question Papers in all the four semesters consists of three sections (Model question paper enclosed). Section I: Write short notes on any four out of six: (4x4=16 Marks) Section II: Write explanatory notes on any five out of seven: (5x6=30 Marks). Section III: Write any essay on any two out of three: (2x12=24 Marks). Questions are to be drawn from all the units of the syllabus by giving equal weightage to all the units.

PRACTICAL QUESTION PAPER PATTERN:30 marks for practical exam proper (Major experiment - 10 marks, Minor experiments –5x2=10 marks, Identify and Comment-5x2=10marks) and 10 marks for Class Record.

PROJECT WORKmay be conducted either in the Department or any other Institution or in an Industry. Project Report/Dissertation carries 70 marks and is evaluated as perregulations.

Model Question Paper
First Semester M.Sc. BIOSCIENCES Degree Theory Examination(CBCS)

Time:3 Hours Max. Marks:70

Write short notes on **any four** of the following (not exceeding **2**pages **each**):**(4x4=16)**
1.a)
b)
c)
d)
e)
f)
Write explanatory notes on **any five** of the following (not exceeding **3** pages **each**): **(5x6=30)**
2.
3.
4.
5.
6.
7.
8.

Write essaysonany **two** of the following (not exceeding **8**pages **each**): **(2x12=24)**
9.

10.

11.

M.Sc. BIOSCIENCES (CBCS Semester Scheme) SYLLABUS
I SEMESTER
HARD CORE COURSES
BSH401 BIOCHEMISTRY

Course Outcomes:

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

CO 1. Have in-depth knowledge of biochemistry and appreciate the knowledge of biochemistry in the day-to-day life

CO 2. Demonstrate an understanding of basic biochemical principles with reference to structure and functions of proteins, carbohydrates and lipids, and their metabolic pathways.

CO 3. Understand the mechanisms of transport and excretion of cholesterol andsterols

CO 4. Know the clinical relevance of studying biomolecules and metabolicdisorders.

Unit I (13 hours)

Carbohydrates: Classification, chemistry and properties of monosaccharides - Pentoses, hexoses, deoxyglucoseamino sugars, muramic acid, neuraminic acid, disaccharides - Linkage in sucrose, lactose and maltose, polysaccharides– Homo-and hetero-poly saccharides -starch, cellulose, glycogen, hyaluronic acid, chondroitin sulphate chitin, xylans, bacterial cell wall and blood group polysaccharides, glycoproteins. Metabolism of carbohydrates: Pathways and regulation. Glycogenesis and Glycogenolysis. Anaerobic glycolysis, Citric acid cycle, Hexose monophosphate shunt. Gluconeogenesis. Coordinated control of metabolism.

Unit II (13 hours)

Amino acids and Proteins: Classification, chemistry and properties of amino acids and proteins. Primary, secondary (alpha helix, beta pleated sheets), tertiary (fibrous - Collagen, globular - Myoglobin) and domain structure of proteins.Reverse turn and Ramachandran plot. Helix - coil, transition. Quarternary structure – Hemoglobin. Energy terms in biopolymers. Conformational calculations, hydrogen bonding, hydrophobic, electrostatic and Vander Waalsinteractions.Lipoprotein metabolism and associated disorders.

Unit III (13 hours)

Lipids. Classification, chemistry and properties of lipids. Biological role of phospholipids, Sphingolipids, Glycolipids and Plasmalogens. Structure of cholesterol, Structure and function of essential fatty acids, Eicosanoids, Prostaglandins, Thromboxanes, Leukotrienes. Metabolism of lipids. Biosynthesis of fatty acids, oxidation of fat and fatty acids - beta, alpha and Omega oxidation. Ketogenesis and ketolysis. Biosynthesis ofphospholipids. Triacylglycerol biosynthesis and role of adipose tissues. Biosynthesis, transport and excretion of cholesterol and sterols.

Unit IV (13 hours)

Protein and amino acid metabolism. Nitrogen balance, transamination and deamination. Catabolism of phenylalanine, tyrosine, tryptophan, sulphur containing amino acids, creatine and creatinine. Urea cycle and disorders.

References:

1. Nelson, D. L., Cox, M. M. (2014). Lehninger Principles of Biochemistry, W.H. Freeman, New York.
2. Berg J.M., Tymoczko J.L., Stryer, L. (2010) Biochemistry, 6thEd., W.H. Freeman, New York.
3. Zubay, G. (1998) Biochemistry, 4th Ed., WBC/McGrawHill.

4. West, E.S., Todd, W.R., Mason, H.S., Bruggen J.T.V. (1974). Text BookofBiochemistry, 4th Ed., Oxford & IBH Publishing.
5. Murray, R.K., Granner, D.K. Mayer, P.A., Rodwell, V.W. (2009) Harper's Biochemistry 28th Ed., Appleton &Lange.
6. White, A., Handler, P., Smith, E. L. (2004)Principlesof Biochemistry, 6thEd.,Tata McGraw Hill, New Delhi.
7. Conn, E.E., Stumpf, P.K., Bruening, G., Doi, R.H. (2005) Outlines of Biochemistry, Wiley
8. Wilson K. Walker J. (Eds.) Principles and Techniques of Biochemistry & Molecular biology, 6th Ed, Cambridge UniversityPress.
9. Buchanan B. B., Gruissem, W., Jones, R. L. (2005) Biochemistry and Molecular Biology of Plants, Courier CompaniesInc
10. Skooge, A., Holler F. J., Nieman T. A. (2006) Principles of Instrumental Analysis, 6th Ed., Brooks/Cole
11. Voet, D., Voet, J. G., Pratt, C. W. (2006) Fundamentals of Biochemistry - Life at the Molecular Level, 2nd Ed., Wiley.
12. Lippard, S. J., Berg J.M. (1997) Principles of Bioinorganic Chemistry, Panama Publishing.
13. Jackson M. B. (2006) Molecular & Cellular Biophysics, Cambridge University Press.
14. van Holde, K. E., Johnson, W. C., Ho, P. S. (1998) Principles of Physical Biochemistry, PrenticeHall.
15. Harvey, R.A., Ferrier D. R., Champe P.C. (2007) Biochemistry, 4thEd., Lippincott Williams andWilkins
16. Satyanarayana U., Chakrapani U. (2008) Biochemistry, 3rdEd., Elsevier Publishers
17. Appling, D.R., Anthony-Cahill, S.J. and Mathews, C.K. (2016).Biochemistry: Concepts and Connections. Pearson Education.
18. Puri, D. (2018).Textbook of Medical Biochemistry, Elsevier Health Sciences.
19. Hames, D., Hooper, N. (2005).Biochemistry (BIOS Instant Notes). Taylor & Francis.

BSH402 CELL BIOLOGY

Course Outcomes:

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

CO 1. Know the ultrastructural organization and functions of organelles of prokaryotes and eukaryotes.

CO 2. Comprehend the general structure and molecular organization ofchromosomes.

CO 3. Gain theoretical knowledge how to use basic tools and techniques such as microscopy, centrifugation, autoradiography and centrifugation

CO 4. Explain the physiochemical properties of biological membranes with structural and functionalinsights.

CO 5. Understand the components of cell cycle control, mechanisms of cell division, apoptosisand senescence.

CO 6. Understand how cells communicate one another and role of various messenger molecules in signal transduction.

Unit I (13 hours)

Ultrastructure of prokaryotic and eukaryotic cells:Ultrastructure, organization and functions of cell organelles: Endoplasmic reticulum, liposomes, Golgi complex and protein sorting, ribosomes and nucleus; Structure of mitochondrion, chloroplast - their genetic organization and their semiautonomous nature. Secretory and endocytotic pathway. Cytoskeleton-microtubules, microfilaments, intermediary filaments. Centriole, cilia, flagella and cell motility.Eukaryotic chromosome - Ultrastructure and molecular organization. Nucleosome model of chromatin structure, Heterochromatin and Euchromatin, Ultrastructure of Giant chromosomes, Structure and function of centromere and telomere.Microscopy: principles andapplications of Light, Phase contrast, fluorescence, laser confocal, scanning and transmission electron microscopy. Autoradiography, cytophotometry and flowcytometry and centrifugation. Cytochemical and histochemical staining techniques.

Unit II (13 hours)

RBC as a Model membrane. Various models for membrane structure; Singer and Nicolson's model. Physicochemical properties of biological membranes – compositions, molecular organization, Membrane asymmetry – lipids, proteins and carbohydrates, lateral diffusion, membrane domains – caveolae, rafts. Transport across biomembranes- Energetics of membrane transport, Donnan membrane equilibrium, simple diffusion, osmosis, facilitated diffusion and active transport. Carrier proteins, Ion channels (voltage- and ligand-gated),BacterialK^+ leak channel & aquaporin channels. Electrical properties of membranes-Membrane potential, Mechanisms of nerve conduction.Transmission across electrical and chemical synapse. Mechanisms of endocytosis and exocytosis.

Unit III (13 hours)

Components in cell cycle control - Cyclins, CDKs in yeast and mammalian cells. Check points in cell cycle. Mechanics of Cell Division- Different stages of mitosis. Cohesins and Condensins in chromosome segregation, Microtubules in spindle assembly, Structure of kinetochore, centrosome and its functions, Sister Chromatid separation. Cytokinesis role of actin & myosin in the generation of contractile ring. Meiosis – Significance. Chiasma formation - Synaptonemal complex. Recombination during meiosis - recombination nodules. Apoptosis: Mechanisms by internal signals and external signals, factors affecting apoptosis. Cellsenescence.

Unit IV (13 hours)

Various types of cell signaling-endocrine, paracrine, juxtacrine and autocrine; Signalingmolecules – hormones, neurotransmitters, gases, lipids, peptides. Overview of receptors: types (membrane and intracellular receptors), structure and regulation - G-protein coupled receptors, Ion channel receptors, Tyrosine kinase linked receptors & Receptors with intrinsic enzyme activity (RTK) and nuclear receptors. General mechanisms of signal transduction by G protein coupled receptors and receptor tyrosine kinase, Second messengers- Ca^{2+}, IP_3, DAG, cAMP & cGMP – cellular effects. Signaling pathways in development and differentiation (overview). Cell-cell adhesion, cell junctions; Extracellular matrix, extracellular matrix receptors. Cell-cell and Cell-matrix interaction (Integrins and selectins and their interaction).

References:

1. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. (2007)Molecular cell biology, 6thEd., WH. Freeman and company, New York.
2. Karp, G. John Harris, D (ed) (2010). Cell and Molecular Biology-Concepts and experiments. 6thEd., Wiley & sons, New York.
3. Kleinsmith, L. J. & Kish, V.M. (1995). Principles of Cell and Molecular Biology, Mc Laughlin, S., Trost, K., Mac Elree, E. (ed.), 2ndEd., Harper Collins Publishers, NewYork.
4. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K, Watson, J. D. (2007) Molecular Biology of the cell. 5th Ed., Garland Publishing, Inc., New York.
5. Cooper, G.M. (2009) The Cell-A Molecular Approach. 5thEd., Sunderland (MA):SinauerAssociatesInc.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2001). Cell and Molecular Biology, 8th Ed., B. I. Waverly Pvt. Ltd., New Delhi.
7. Gilbert, S.F. (2006) Developmental Biology. 6th Ed., Sunderland (MA), Sinauer AssociatesInc.
8. Wilson K. Walker J. (Eds.) Principles and Techniques of Biochemistry & Molecular biology, 6th Ed., Cambridge University Press.
9. Alberts *et al.,* (2010). Essential Cell Biology, 3rdEd., Garland Publishing, Inc., New York.
10. Cassimeris, L., Lingappa, V.R., Plopper, G. (2011) Lewin's Cells 2ndEd., Jones and Bartlett Publ, Sudbury MA,USA.
11. Becker, W. M, Kleinsmith, L.J. Hardin J. (2012) Becker's World of the cell, 8thEd, Dorling Kindersley (India) PvtLtd
12. Avers, C.J.(1986).Molecular Cell Biology. Addison-Wesley Publ Co, England.
13. Brachet, J. (1985). Molecular Cytology. Vol.I&II. The cell cycles. Academic Press, Inc.
14. Culling, C.F.A.(1974).HandbookofHistopathologicalandhistochemicalTechniques. 3rdEd, Butterworths.
15. Darnell, J., Lodish, H., Baltimore D. (1995).MolecularCellBiology. Scientific American Books, NewYork.
16. Swanson,C.P., Webster,P.L. (1989).The Cell.5th Ed., Prentice Hall of India Pvt. Ltd., NewDelhi.
17. Sadova, E. (1993). Cell Biology. Jones and Bartlett Publishers,London.
18. Kleinsmith, L.J. and Kish, V.M. (1995). Principles of Cell and Molecular Biology. 2nd Ed. Harper Collins College Publishers,
19. Thorpe, N.O. (1984). Cell Biology. John Wiley and Sons, NewYork.
20. Lodish, H., Baltimore, D., Berk, A., Zipursky, S.W., Matsudaira, P. & Darnell, S. (1995). Molecular Cell Biology. Scientific American Books. Freeman & Company, NewYork.
21. Lowey, A.G., Siekevitz, P., Mesninger, J.R. and Gallant, J.A.N. (1987). Principles of Cell structure andfunction.
22. Thorpe, N.O. (1984). Cell Biology. John Wiley and Sons, NewYork.
23. Fraser, F.C., James J. N.(1986). Genetics ofMan.LeaandFebiger, Philadelphia.
24. Friefelder, D. (1987). Molecular Biology, 2ndEd.JonesandBartlett Pub. Inc.,Boston.

BSH403 BASIC MICROBIOLOGY

Course Outcomes:

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

CO 1. Understand basic concepts, historical perspectives and contributions in Microbiology.
CO 2. Understand evolution of prokaryotic and eukaryotic metabolism
CO 3. Learn about microbial nutrition and culture of microbes inthelaboratory.
CO 4. Discern various factors affecting growth and death ofmicroorganisms.
CO 5. Explain the microbial metabolic pathways with theirapplications.

UNIT I (13 hrs)

Introduction to microbiology, historical perspectives, contributions of early microbiologists, Koch Postulates. Branches and scope of microbiology. Origin and evolution of microorganisms, discovery of anaerobic life, evolutionary chronology, trends in evolution of archaebacteria, eubacteria and eukaryotes. Evolution of prokaryotic and eukaryotic metabolism. Modern methods of tracing and analysis of evolution.

UNIT II (13 hrs)

Microbial diversity, habitats, life cycles, structure and classification of bacteria, cyanobacteria, actinomycetes, fungiand viruses. Pathogenic microorganisms: bacteria, mycoplasmas, rickettsias, chlamydiasandprotozoa.

Microbial nutrition and cultivation: Nutritional categories of microorganisms, role of microbial nutrients; cultivation of aerobes, anaerobes and facultatives, obligate pathogens and viruses. Selective media, selective isolation and methods of preservation of microbes.

UNIT III (13 hrs)

Microbial growth, population and growth curves, generation time, batch and continuous cultures (e.g. chemostat, turbidostat), measurement of growth, microbiological assays (e.g. antibiotics, amino acids and vitamins).

Factors affecting growth and death of microorganisms: temperature, pH, water activity, O-R potential, salinity, hydrostatic pressure, disinfectants, antiseptics and chemotherapeutic agents. Methods ofsterilization.

UNIT IV (13 hrs)

Microbial metabolism: Energy sources and classification; metabolism in autotrophs, heterotrophs; hexose and pentose phosphate pathways; synthesis of peptidoglycan, intermediary metabolism and secondary metabolites. Aerobic and anaerobic respiration, fermentation, electron transport system and substrate phosphorylation.

References:

1. Brock, T.B. and Madigan (2003). Brock Biology of microorganisms. 10th Ed. Prentice Hall.
2. Pelczar, J. and Chan, E.C.S. (1988). Elements of microbiology. Mac Graw Hill NewYork.
3. Rosenberg E and Cohen IR (1983). Microbial biology Saunders Coll.Pub.
4. Stanier R.Y. (1990). The microbial world. Prentice Hall New Delhi, 5th ed.
5. Prescott, Harley & Klein (2002). Microbiology, 5th, 6th, 7th Eds.,McGrawHillPub.
6. Black, J.G. (2004). Microbiology, Principles & Exploration. 6th Ed, John Wiley & sons, Inc.
7. Rao, N.S.S. (1999). Soil Microbiology 4th Ed, Oxford IBHPub.
8. Flint, S. J. (2006). Principles of Virology, Molecular Biology, Pathogenesis &control ASMpress.
9. Pommerville, J. C. (2010) Alcamo's Fundamentals of Microbiology. 9th edition. Jones andBartlett.
10. Nester, E.W., Anderson, D.G., Roberts E.C. (2004) Microbiology: a Human Perspective, 4th Ed.
11. Talaro, K. P. and Chess, B. (2011) Foundations in Microbiology, 8th Ed. McGrawHill.

12. Ananthanarayan R. and Paniker C.K.J., (2009) Medical Microbiology. 8th Ed., UniversitiesPress.
13. Tortora G.J; Funke B.R., Case, C.L. (2010) Microbiology: An Introduction, 10thEd. Benjamin Cummings.
14. Hall FR &Menn JJ, (1998) Biopesticides: Use and Delivery. Methods in BiotechnologyHumanaPress
15. Brooks, G. F., Carroll, K. C., Butel, J. S., Morse, S. A. (2008) Jawetz, Melnick &Adelberg'sMedical Microbiology,24th Ed.,McGrawHill
16. Faruque,S. M. (Ed.) (2012) Foodborne and Waterborne Bacterial Pathogens: Epidemiology, Evolution and Molecular Biology CaisterAcademicPress
17. Kayser, F. H., Bienz, K. A., Eckert, J. and Zinkernagel, R. M. (2005). Medical Microbiology, Thieme.
18. Bauman, R.W. (2012) Microbiology with Diseases by Body System, 3rdEd. BenjaminCummings
19. Ryan, K. J. and Ray, C. J. (2004)Sherris Medical Microbiology – An Introduction to Infectious Diseases, 4th Ed. McGrawHill
20. Gillespie, S. and Hawkey, P. (2006) Principles and Practice of Clinical Bacteriology, 2ndEd.Wiley,
21. Microbenet: the Microbiology od the Built Environment network (http://microbe.net/microbenet-social-media/microbiology-blogs/)
22. http://www.microbiologymaven.com/
23. http://twistedbacteria.blogspot.in/2011/09/microbiology-blogs-list-of-20-great.html
24. Bauman, R. W. (2016).Microbiology with diseases by taxonomy. Pearson.
25. Pollack, R. A., & Findlay, L. (2009).Laboratory exercises in microbiology. John Wiley & Sons, Inc.
26. Anderson, D. G., Salm, S., & Allen, D. P. (2016).Nester's Microbiology: A Human Perspectivep. 896. McGraw-Hill.
27. Mitchell, R., & Gu, J. D. (Eds.). (2010).Environmental microbiology. John Wiley & Sons.

SOFT CORE COURSES
BSS404 GENETICS

Course Outcomes:

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

CO 1. Gain in-depth knowledge in Genetics

CO 2. Understand principles governing the inheritance and variations

CO 3. Comprehend recombination in bacteria and development of rDNA technology.

CO 4. Understand the phenomenon of mutation and learn skills to detectmutations

Unit I (13 hours)

Historical perspectives and scope of Genetics; Principles of Mendelian inheritance; Modifications of Mendelian monohybrid and dihybrid ratios-Incomplete dominance, Codominance, Lethal genes and Multiple alleles. Applications of Mendel's principles- the punnet square method, forked-line method, probability method; Formulating and testing genetic hypothesis-the chi-square-test, linkage and crossing over. Cytological basis of inheritance: Linkage and crossing over; Genetic mapping of chromosomes. Sex determination, Dosage compensation in mammals and drosophila. Sex linked inheritance (*Drosophila* and Human). Sex related traits, genetic disorders.

Unit II (13 hours)

Genetics of Bacteria: Transformation, transduction, Conjugation - Plasmids. Extra chromosomal inheritance with examples; Genomic organization in prokaryotes and eukaryotes; Laws of DNA constancy and C - value paradox.Mutations: Classification, types of mutations-deletion, duplication, translocation and inversion,spontaneous and induced mutations, molecular mechanisms of mutations. Biochemical basis for mutations; Detection of mutations – mutagenicity testing - Ames test, tests in drosophila (DLT, ClB, SLRL, SMART, ARLT) and mouse (DLT, MNT, Mitotic and meiotic, specific locus test, HMA)

Unit III (13 hours)

Genetic recombination at Molecular level: Reciprocal recombination, site specific recombination, models of recombination (Holliday model), Role of Rec A in Recombination. Transposable genetic elements: Bacterial transposons, Is elements, Composite transposons, Tn3 elements, Eukaryotic transposons-Ac and Ds elements in maize; P elements and Hybrid dysgenesis, Retrotransposons. Alusequences. Human genetics: Human chromosomes, Chromosomal abnormalities-Sex chromosomal and autosomal; Genetic diseases, Pedigree analysis and genetic counseling, gene therapy.

References:

1. Gardner, E.J., Simmons M.J. & Snustad, D.P.(1991). Principles of Genetics. 8thEd. John Wiley and Sons, Inc., NewYork.
2. Hartl, D. L., Freifelder D. and Snyder, L.A.(1988). Basic Genetics. Jones andBartlettPublishers,Boston.
3. Hollaender A. (Ed.). (1971-76). Chemical Mutagens.PrinciplesandMethods for their Detection. Vols. 1, 2 & 3. Plenum Press, NewYork
4. Jha, A.P. (1993). Genes and Evolution. MacMillanIndiaLtd.,NewDelhi.
5. Lewin, B. (1997). Genes VI, Oxford University Press, NewYork
6. Marther, K. andJinks, J.L. (1977). Introduction to Biometrical Genetics. Chapman andHall.
7. Russell P.J. (1998). Genetics. The BenjaminCummings Publ.Co.Inc.

BSS405 BIOCHEMICAL TECHNIQUES

Course Outcomes:

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

CO 1. Know the principle and applications of basic biochemical techniques.
CO 2. Understand the role of biological solutions and calculations
CO 3. Understand principle, instrumentation, applications and types of chromatography
CO 4. Know the principle, instrumentation, applications and types of centrifugation
CO 5. Understand the principle, instrumentation, applications and types of electrophoretic techniques

Unit I (13 hours)

Biological Solutions: preparation of solutions-Normality, molarity and molality: Acids and Bases, Buffers, salting in, salting out, Osmosis, Dialysis, Donnan Membrane Equilibrium, Viscosity **o**f macromolecules, relationship with conformational changes, Density. **Chromatography** Principles of partition chromatography, paper, thin layer, column chromatography, ion exchange and affinity chromatography, gas chromatography, gel permeation chromatography, HPLC andFPLC.

Unit II (13 hours)

Centrifugation Principles of centrifugation, Svedberg's constant, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, subcellular fractionation. Filtration methods: Invention of filtration method. Various types of filter membranes and their applications.

Unit III (13hours)

Electrophoretic techniques Principles of electrophoretic separation. Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, pulse field gel electrophoresis, PAGE, SDS- PAGE and Iso electro focusing.

References:

1. Pattabhi, V. & Gautham, N. (2003). Biophysics - NarosaPublHouse,
2. Khopkar, S. M. (2008). Basic Concepts of Analytical Chemistry, 3rd Ed., New Age Publications.
3. Upadhyay, A., Upadhyay, K., Nath, N. (2009). Biophysical Chemistry-Principles and Techniques, Himalaya Publ House
4. Cantor, C.R., Schimmel, P.R. (1980)Biophysical Chemistry Part II. Techniques for the study of biological structureandfunction, W.H.Freeman
5. Lippard S. J., Berg, J. M. (1997). Principles of Bioinorganic Chemistry, Panama Publ.
6. Jackson M. B. (2006).Molecular& Cellular Biophysics, Cambridge Universitypress.
7. van Holde, K. E., Johnson, W. C., Ho,P.S.(1998)Principles of Physical Biochemistry, PrenticeHall.
8. Freifelder D. (1982) Physical Biochemistry, 2ndEd.
9. Segal I. H. (1976) Biochemical calculation, 2ndEd.
10. Wilson, K. and Walker, J.(1996). Practical biochemistry.PrinciplesandTechniques. Cambridge Low PriceEditions
12. Shrikant, L. P. (2013) Understanding Biophysics. 4thEd., Suman Publications.
13. Krishna A. P. (2014) Text book of Medical Physiology, 2ndEd, Suman Publications.
14. Ghosal, S., &Avasthi, A. S. (2018).Fundamentals of bioanalytical techniques and instrumentation. PHI Learning Pvt. Ltd.
15. Gault, V. A., & McClenaghan, N. H. (2013).Understanding bioanalytical chemistry: principles and

applications. John Wiley & Sons.
16. Van Emon, J. M. (Ed.). (2016).Immunoassay and other bioanalytical techniques. CRC Press
17. Manz, A., Pamme, N., &Iossifidis, D. (2004).Bioanalytical chemistry. World Scientific Publishing Company.
18. Ramesh, V. (Ed.). (2019).Biomolecular and Bioanalytical Techniques: Theory, Methodology and Applications. John Wiley & Sons.
19. Hoppe, W., Lohmann, W., Markl, H., & Ziegler, H. (Eds.). (2012).Biophysics. Springer Science & Business Media.
20. Jackson, M. B. (2006).Molecular and cellular biophysics. Cambridge University Press.

PRACTICAL COURSES
BSP406 BIOCHEMISTRY LAB

Course Outcomes:

After undergoing the course, students will be able to:

CO 1. Develop skills required for biochemical qualitative and quantitative work
CO 2. Learn methods to proteins, carbohydrates, lipids and NPN substances.
CO 3. Operate instruments used in biochemistry labs
CO 4. Conduct biochemical tests to diagnose some metabolicdiseases.

1. Handling of pipette and understanding accuracy and precision of pipette
2. Qualitative analysis of carbohydrates: monosaccharides, disaccharides andpolysaccharides
3. Qualitative tests for theproteins,
4. Qualitative tests for lipids and NPNsubstances.
5. Preparation of buffers and its pHdetermination
6. Preparation of normal, molar and percentsolutions
7. Understand serial dilutions
8. Estimation of amino acids and nitrogen analysis by Micro-Kjeldahlmethod
9. Enzyme activity: Effect of temperature, pH, Kmdetermination
10. Spectrophotometric estimation of metabolites: serum protein, sugar, creatinine, urea, uric acid
11. Colorimetric analysis of vitamins, ascorbic acidetc.,
12. Estimation of plantphenolics
13. Tests to measure glycosuria, proteinuria etc

BSP407 CELL BIOLOGY LAB

Course Outcomes:

After undergoing the course, students will be able to :

CO 1. Acquire skills required in Cell Biology
CO 2. Learn methods to study cell division and cell cycle
CO 3. Develop skills in histological staining techniquesisolate the sub-cellular organelles.
CO 4. Perform experiments in cell biology

1. Micrometry and camera lucida drawings
2. Cell (RBC) counting using haemocytometer
3. Study of plasmolysis in cells of *Rheo*leaves.
4. Determination of mitotic index in onion root tips
5. Preparation of tissues for histology, Sectioning &Staining - Differential staining of tissue sections
6. Histochemistry-localization of a) Carbohydrates b) Proteins c) Nucleic acids
7. Hematoxylin staining and study on histology of liver, intestine, stomach, ovary, etc.,
8. Study of mitotic stages in onion roottip
9. Study of meiosis in Onion inflorescence/grasshopper testis
10. Study of chromosomal aberration in *Allium cepa* after chemical induction
11. Cell viability assays
12. Isolation of Sub cellular organelles
13. Measurement of Na-K ATPase in membrane fractions
14. Determination of osmotic fragility of erythrocyte membranes

BSP408 BASIC MICROBIOLOGY LAB.

Course Outcomes:

After undergoing the course, students will be able to :

CO 1. Understand basic techniques and instrumentation inmicrobiology.
CO 2. Apply the techniques of sterilization of media and glassware.
CO 3. Isolate, identify and culture microorganisms
CO 4. Perform microbial motilitytests.
CO 5. Execute the filter sterilization and microbialisolation.

1. Introduction to basic techniques and instrumentation inmicrobiology
2. Microscopic observations of microorganisms andmicrometry
3. Staining techniques: Properties of stains, microbial smear preparation, simple and differential staining for morphological studies, Gram's staining, endospore staining, intracellular lipids, acid-fast staining, flagella, viability tests and relief (negative)staining;
4. Microbial motilitytests.
5. Microbial culture media, microbialgrowth
6. sterilization of media and glassware, filtersterilization
7. stock culture, subculture, maintenance ofculture.
8. Techniques of microbialisolation.

BSP409 GENETICS LAB

Course Outcomes:

After undergoing the course, students will be able to:

- Understand the importance of *D. melanogaster* as an excellent model in Genetics.
- Maintain and conduct experiments using*D. melanogaster*.
- Conduct crossing experiments to learn Mendelian and non-Mendelian Genetics
- Solve genetic problems such as legal issues like paternity and maternity disputes.

1. Salient features and method of maintenance of *Drosophila melanogaster* culture.
2. Techniques for handling and examining the flies.
3. Preparation of salivary gland chromosomes of *D. melanogaster* and identification of different arms.
4. Preparation of salivary gland chromosomes in *D. nasuta*
5. Identification of blood types in human.
6. Experiments to demonstrate patterns of inheritance of a few characters (Crossing).
7. Study of (i) mating behaviour in *Drosophila* (ii) somatic mitosis in *Drosophila*.
8. Biochemical separation of eye pigments in *Drosophila*
9. Genetic problems.

BSP410 BIOCHEMICAL TECHNIQUES LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Separate the mixtures by planar and column chromatographic techniques.
CO 2. Undertake quality analyses required in food industry by identifying additives, vitamins, preservatives, proteins, sugars and aminoacids.
CO 3. Use UV-Vis spectrophotometry forestimation.
CO 4. Operate flame photometry.
CO 5. Perform electrophoretic techniques forseparationanddeterminationofmolecularweight.
CO 6. Perform immune-diffusion techniques and ELISA for detecting presence and

quantityofantigens.

CO 7. Use centrifugation for separation ofmolecules.

1. Ascending, descending and circular paper chromatography for separation ofamino acids/carbohydrates
2. TLC of amino acids (1D and 2D)/carbohydrates
3. UV-Visible Spectrophotometry-verification of Beer Lambert'slaw
4. Flame photometry and its application in the estimation of serum, calcium, potassium and lithium and sodium.
5. HPLC(Demonstration)
6. Gel electrophoresis- native and SDS-PAGE and estimation of molecular weight of Proteins
7. ELISA for quantification of anantigen.
8. Immunodiffusion
9. Centrifuge use and application of centrifugations techniques forseparation
10. Separation by filtration technology

II SEMESTER

HARD CORE COURSES
BSH451 MOLECULAR BIOLOGY

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Understand the molecular basis oflife.
CO 2. Know the role of various enzymes involved in DNAreplications.
CO 3. Comprehendgene transcription and its regulation in prokaryotes andeukaryotes.
CO 4. Understandprotein synthesis and post-translationalmodifications
CO 5. Understand the role of non-coding RNAs andmiRNAs.

Unit I (13 hours)

Central dogma of molecular biology and its modification. Structure of nucleic acids; structure of DNA, topology, forms of DNA, repetitive DNA, DNA polymerases, DNA ligases, topoisomerases, gyrases, methylases, nucleases and restriction endonucleases, Ribonucleoproteins, Structure of m-RNA, Three dimensional structure of t- RNA, Heterochromatization, transposition, regulatory sequences and transacting factors, homologous recombination

Unit II (13 hours)

Organization of transcriptional units, Mechanism of DNA transcription in prokaryotes and eukaryotes, RNA processing (capping, polyadenylation, splicing, introns and exons), RNA polymerase, types, promoter initiation and transcription, DNA replication (Eukaryotes and prokaryotes) - Semi conservative, replication in *E.coli* and Eukaryote, control of replication, Replication in phage, plasmid and mitochondria, inhibitors of RNA synthesis and their mechanism of action, polycistronic and monocistronic RNAs, post transcriptional modification

Unit III (13 hours)

Protein synthesis in prokaryotes and eukaryotes, role of ribosomes and different types of RNA in protein synthesis, basic feature of genetic code - Triplet codon, Assignment of codons, degeneracy, variation in codon usage, universality, Amino acid activation, mechanism of initiation, elongation and termination, post translational modifications - Protein folding, role of chaperons. O and N glycosylation, Fatty acylation, attachment of glycosyl anchor, phosphorylation, other modifications, inhibitors of protein synthesis

Unit IV (13 hours)

Molecular basis of signal transduction in bacteria, plant and animals, Regulation of gene expression in bacteria and eukaryotes - fine structure of eukaryotic gene, exons, introns, repetitive DNA, Promoters enhancers, silencers, regulatory sequences, DNA-binding Proteins. Organization of Prokaryotic and eukaryotic genes, gene families, tandemly repeating genes, pseudogenes. **Operon Model**: Lac operon, catabolite repression. Negative and positive control, Trp operon attenuation, antitermination. Non-coding RNAs, microRNAs, Genome editing technologies.

References:

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K, Watson, J. D. (Eds.) (2007). Molecular biology of the cell. 5thEd.,Garland Publishing, Inc., NewYork.
2. Cooper, G.M. (2009) The cell-A molecular approach. 5th ed. Sunderland (MA), Sinauer

Associates,Inc.
3. Gilbert, S.F. (2006) Developmental biology. 6thEd., Sunderland (MA), Sinauer AssociatesInc.
4. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., & Baltimore, D. (2007). Molecular cell biology, 6thEd., W.H. Freeman and company, New York.
5. Karp, G. (2010). Cell and molecular biology-Concepts and experiments. 6thEd, John Harris, D. (ed.) Wiley & sons, New York.
6. Krebs, J. E., Goldstein E. S., Lewin T.(2011) Genes X 5th ed.Jones& Bartlett Publisher
7. Tropp, B. E., Freifelder, D. (2007). Molecular Biology: Genes to Proteins, Jones & Bartlett Learning,
8. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., Losick R. (2004) Molecular biology of the gene, 5thEd., Cold Spring Harbor Laboratory Press
9. Voet, D., Pratt, C.W., Voet J.G. (2008) Fundamentals of biochemistry: Life at the molecular level, 3rdEd. John Wiley & Sons

BSH452 BIOSTATISTICS AND BIOINFORMATICS

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Apply statistical methods to analyse and interpret the biologicaldata.
CO 2. Represent the data of experimental and field studies through graphs anddiagrams.
CO 3. Understand statistical conceptsand learn to use a variety of statistical tests
CO 4. Know how to use bioinformatics for DNA and protein sequence analysis through bioinformatics tools and databases
CO 5. Understand microarray technique for gene expressionanalysis.
CO 6. Understand theconcept of protein folding and structure based targeted drug design

Unit I (13 hours)

Biological data-frequency distribution, graphical and diagrammatic representations; Measures of Central tendency - Mean, Median and Mode; Measure of Dispersion - Range, Variance, Standard deviation, Coefficient of variation, DiversityIndex.

Populations versus sample - sampling techniques; Standard error, Confidence limits. Random experiment-probability. Binomial, poissonandNormal distributions and their applications ingenetics.

Unit II (13 hours)

Simplelinear Regression andCorrelationanalysis.Analysisof variance, principles of experimental design. Multipleregression.

Tests of significance- Normal, X^2, (Chi-square), `t' and F tests; Testing for goodness of fit. One-way analysis of variance (ANOVA) and Two-way analysis of variance. Statistical packages.

Unit III (13 hours)

Introduction to bioinformatics, databases, search engines, internet tools and World Wide Web (WWW). Molecular modeling database at NCBI, major web resources for bioinformatics - Biological database types and their functioning, microbiological databases, primary sequence databases, carbohydrate databases, RNA databases, genome databases, organism databases, biodiversity. Sequence database: Introduction, nucleotide sequence database, protein sequence databases, EMBL nucleotide sequence databases, structure databases. Phylogeny - Tree definitions, distance matrix methods and parsimony and bootstrapping. DNA and protein sequence Analysis, FASTA, BLAST and GCG Wisconsin/Emboss packages. Genomics and proteomics.

Unit IV (13 hours)

Microarray techniques, Gene Expression analysis, Protein Folding, Lattice models, Comparative modeling, threading, folds and function, Distributed Computing approach, genome@home, folding@home, proteomics, protein structure based targeted drug design – small molecular interactions and docking.

References:

1. Norman, T.J. and Bailey. (1981) Statistical methods in Biology. 2nd Ed. Hodder and StoughtonLtd.
2. Arnold, E. (1979). Introductory statistics for Biology, 2nd Ed. London.
3. Campbell, R.C. (1983). Statistics for Biologists 2nd Ed. CambridgePress.
4. Higgans, D. and Taylor, W. (2000). Bioinformatics, Sequence and Structure. Oxford

University Press,USA.

5. Sillince, J.A. and Sillince, M. (1991). Molecular databases for protein sequence and structure studies.Springer-Verlag
6. Stephen, M. and Stephen, K. (2001). Bioinformatics – Methods and Protocols. Humana Press,USA.
7. Tisdall J. D. (2001) Beginning Perl for Bioinformatics, O'Reilly Press
8. Mount D. W. (2004) Bioinformatics: Sequence and Genome Analysis, CSHL Press
9. Misener, S., Krawetz S. A., (Eds.) (1999) Bioinformatics: Methods and protocols. HumanaPress
10. Krane, D. E.& Raymer, M. L. (2002) Fundamental Concepts of Bioinformatics. Pearson.
11. Branden C. and Tooze J. (1991) Introduction to Protein Structure., GarlandPub.
12. Attwood, T.&Parry-Smith, D. (1999) Introduction to Bioinformatics., PearsonEd.
13. Rosner, B. (2015).Fundamentals of biostatistics. Nelson Education.
14. Le, C.T., & Eberly, L.E. (2016).Introductory biostatistics. John Wiley & Sons.
15. Kaps, M., &Lamberson, W.R. (Eds.). (2017).Biostatistics for animal science. Cabi.
16. Forthofer, R. N., Lee, E. S., & Hernandez, M. (2006).Biostatistics: a guide to design,analysis and discovery. Elsevier.
17. Pevsner, J. (2015).Bioinformatics and functional genomics. John Wiley & Sons.
18. Xiong, J. (2006).Essential bioinformatics. Cambridge University Press.
19. Lesk, A. (2019). Introduction to bioinformatics. Oxford university press

SOFT CORE COURSES
BSS453 APPLIED MICROBIOLOGY

CourseOutcomes:

After successful completion of the course, students will be able to :

CO 1. Understand the applications of Microbiology in biomedical and industrial fields.
CO 2. Comprehend the beneficial and harmful interactions of microbes with other organisms.
CO 3. Use fermentation for production of ethanol, lactic acid and other industrialproducts.
CO 4. Gain theoretical knowledge of food microbiology, prevention of air- and food-bornediseasesandfood poisoning.
CO 5. Gain the basics of soil microbiology and its allied applications inagriculture.
CO 6. Know the importance of aquaticmicrobiology and learn water purification and assessment of drinking water quality.

UNIT I (13 hrs)

Microbial Ecology: Microbial symbiosis, mutualism, plant-microbe interactions (e.g. mycorrhizas), animal-microbe interactions (human, ruminants and non-ruminants). Microbes in extreme environments - hydrothermal vents and coral reefs.Microorganisms as bio-indicators. Microbial bioremediation - role in environmental management, advantages and disadvantages. Ecological implications of genetically modified microorganisms.

Fermentation: Ethanol, lactic acid, mixed acids, 2-3 butanidiol, costridial and propionic acid fermentation with emphasis on their ecological niches, merits and demerits.

UNIT II (13 hrs)

Food Microbiology: Classification of foods and oriental foods; Basic principles of food spoilage and methods of food preservation; Milk and milk products, milk microflora and their estimation, milk-borne diseases and prevention; Food poisoning, food-borne diseases and prevention.

Air Microbiology: Microflora of air and methods of their estimation, monitoring air allergens, air-borne diseases and prevention.

UNIT III (13 hrs)

Soil Microbiology: Soil microflora and methods of their estimation, role of soil microorganisms, bioconversion and decomposition. Biological nitrogen fixation (symbiotic and non-symbiotic), microbial phosphorus solubilization and their importance in soil fertility and agriculture.

Aquatic Microbiology: Microbes in water and wastewaterand methods of their estimation (e.g. MPN), drinking water microbial standards and water purification; Water-borne diseases and prevention.

References:

1. Brock T.B. and Madigan M.T. (1991) Biology of microorganisms, PrenticeHall.
2. Pelczar J. and Chan E.C.S. (1981) Element of Microbiology, Mac Graw Hill,NewYork
3. Schlegel H.G. (2008)General Microbiology, 7th Ed., Cambridge Univ. Press.
4. Rosenberg E. and Cohen I.R. (1983) Microbial Biology, Saunders Coll.Pub.
5. Stanier R.Y., Adelberg, E. A., Ingraham, J. L. (1976) The Microbial World, Prentice Hall,NewDelhi.
6. Atlas R.M. and Bartha R. (2000) Microbial Ecology, 4th Ed., Benjamin-Cummings Sci. Press,USA
7. Cruickshank R., Livingstone C.(1973) Medical Microbiology. London
8. Doelle H.W. (1975) Bacterial Metabolism, Academic Press,London
9. Nicklin, J., Paget, T., Graeme-Cook, K., Killington, A. (2011) Instant Notes in Microbiology. Via

Books Pvt. Ltd., NewDelhi
10. Norris J.R., Ribbons, D. W. (1981) Methods in Microbiology. Academic Press,London
11. Adams M.R and Moss M.O.(2003), Food Microbiology, 2nd Ed.,Panima Publ. Corp., NewDelhi
12. Barrett J.T. (1998Microbiology and Immunology Concepts, Lippincott-Raven,PA, USA
13. Casida Jr., L.E. (1968) Industrial Microbiology. Wiley Eastern Ltd., New Delhi
14. Elgert, K.D. (2009) Immunology. John Wiley and Sons,USA
15. Subba Rao N.S. (1982) Advances in Agricultural Microbiology. Oxford and IBH Pub., New Delhi.
16. Arora, D.R. and Arora, B. 2012. Text Book of Microbiology, CBS Publ. & Dist. Pvt. Ltd., New Delhi.
17. Dubey, R.C. (1993) Text book of Biotechnology, S Chand Publ.
18. Maier, R.M., Pepper, I.L. and Gerba, C.P. (2008) Environmental Microbiology, Academic Press
19. Jjemba, P. K. (2004) Environmental Microbiology - Principles and Applications, Science Publ., USA

BSS454 AQUATIC BIOLOGY

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Gain theoretical knowledge in hydrobiology, abiotic factorsandaquaticorganisms.
CO 2. Know how aquatic organisms adapted during the course ofevolution.
CO 3. Comprehend the importance of estuaries, mangroves, marshes, tidal flats, coastal wetlands and coral reef community.
CO 4. Realize the impacts of aquatic pollution and how to use the biological strategies to prevent thepollution.
CO 5. Know the basic concepts of biological productivity of both flora andfauna.
CO 6. Gain the knowledge how to collect, separate and classify planktons, and their importance.
CO 7. Appreciate the economic importance of hydrophytes andhalophytes.

UNIT I (13 hrs)

Hydrobiology: Properties of water including sea water. Hydrological cycle. Ocean water movement - El nino effects. Structural and functional adaptations of aquatic organisms to the abiotic factors such as temperature, light, salinity, pressure and dissolvedoxygen.

UNIT II (13 hrs)

Aquatic ecosystems: Freshwater habitats - wetland and swamps, tank/pond, river, lake/reservoir. Physico-chemical conditions and biological composition of estuaries, mangroves/marshes, tidal flats and coastal wetlands. Marine habitats - types of sea shore environmental parameters and adaptations of pelagic, benthic and deep sea organisms. Coral reef community.Aquatic pollution: characteristics, sources and types; eutrophication, red tide, shellfish poisoning; Biological control of aquatic pollution.

UNIT III (13 hrs)

Biological productivity: Basic concepts. Factors affecting productivity, measurement of productivity: Leibig's law of minimum, Shelford's law of tolerance. Production and distribution of aquatic fauna; Planktonology-classification, distribution, collection and separation of plankton; blooms/ swarms of plankton and algal production. Hydrophytes - types, adaptations, distributions and economic importance. Halophytes - types, adaptations, economic importance. Sea weed -types and their distribution and economicimportance.

References:

1. APHA.(1992). Standard methods for examination of water and waste water. 19th Ed. APHA, New York,USA.
2. Edmondson, W.T. (1965). Freshwater Biology. John Wiley and Sons, NewYork.
3. Hynes, H.B.N. (1970). Ecology of running waters. Liverpool University, Press,U.K.
4. Hutchinson, G.E. (1967). A treatise on Limnology. John Wiley and Sons, NewYork.
5. Brown, J., Colling, A. (1989). Sea water: Its composition properties and behaviour. Open University Publications, Pergamon Press,England.
6. Maitland, P.S. (1978). Biology of Freshwater, Blockie, Glasgow and London,U.K.
7. Munshi,J.D. and Munshi, J.S.D. (1995).Fundamentals of freshwater biology. Narendra Publishing House,Delhi.
8. Wetzel, R.G. (1975). Limnology, 2nd ed. W.B.Saunders.
9. Nybakkan, J.N. (1982). Marine Biology – An ecological approach. Harper and Raw Publ., NewYork.
10. Thompson, M.F. and Tirmizi, N.M. (1995). The Arabian sea: living marine resources and the environment. A.A. Balkema, Rotterdam. 730pp.

11. Qasim, S.Z. (1998). Glimpses of the Indian Ocean. Universities Press, Hyderabad. 206 pp.
12. Raffaelli, D. and Hawkins, S. (1996). Intertidal ecology. Chapman & Hall, London. 356 pp.
13. Reddy, P.A. (2000). Wetland ecology. Cambridge University Press, London. 614pp.
14. Davis, C.C. (1995). The marine and freshwater plankton. Michigan State University, Michigan. 502pp.

BSS455 METABOLISM AND BIOENERGETICS

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Understand the mechanisms and regulation of anabolic and catabolic processes

CO 2. Know various disorders associated with metabolicpathways.

CO 3. Understand the physiological importance and metabolism of vitamins.

CO 4. Comprehend the concept of bioenergetics and thermodynamic principles inbiology.

Unit I (13 hours)

Overview of metabolism, Metabolism of carbohydrates, pathways and regulation, gluconeogenesis, glycogenolysis, anaerobic glycolysis, citric acid cycle, hexose monophosphate shunt. Metabolism of lipids, Biosynthesis of fatty acids, Oxidation of fat and fatty acids, beta, alpha and omega oxidation, ketogenesis and ketolysis, metabolisms of acylglycerols and sphingolipids, cholesterol synthesis, transport and excretion, lipoprotein metabolism

Unit II (13 hours)

Protein and aminoacid metabolism, nitrogen balance, transamination and deamination, catabolisms of aromatic and sulphur containing aminoacids, urea cycle and disorders, Metabolisms of purines and pyrimidines, metabolism and functions of fat soluble A, D, E and K and water soluble B complex (B1, B2, B3, B5, B6, B7, B9 and B12) & C vitamins

Unit III (13 hours)

Bioenergetics, Thermodynamic principles in biology, Concept of free energy. Energy rich bonds, Coupled reactions, Electron transport chain, oxidative phosphorylation, group transfer, Biological energy transducers, inhibitors of electron transport chain, uncouplers

References:

1. Voet, D., Voet, G. (1994). Biochemistry. 2nd Ed., John Wiley and Sons
2. Stryer, L. (2004). Biochemistry. 4th Edition
3. Harper Biochemistry. Lange publications. 26^{th}ed.
4. Lehninger, A.L., Nelson, D.L., Cox M.M.(2001). Principles of Biochemistry. CBS Publications
5. Devlin, T. M. (2005)Text-book of Biochemistry with clinical correlations 2^{nd} Ed.

PRACTICAL COURSES
BSP456 MOLECULAR BIOLOGYLAB

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Perform agarose gel electrophoresis and realize its applications in biologicalresearch.
CO 2. Isolate plasmid DNA, genomic DNA and total RNA from bacteria and othersources and determine their purity
CO 3. Execute restriction digestion and mapping ofDNA.
CO 4. Design primers and run the PCRreaction.
CO 5. Become skilled in gel documentation instrument (Geldoc) and image development.

1. Agarose gelelectrophoresis
2. Isolation of plasmid DNA from bacteria and its identification byelectrophoresis
3. Isolation of genomic DNA from various sources and itsidentification
4. Restriction digestion and mapping ofDNA
5. Isolation of total RNA from various sources and gelelectrophoresis
6. Design of primers and PCR
7. Determination of DNA/RNA purity by UV-Visiblespectrophotometry
8. Demonstration of gel documentation and imaging

BSP457 BIOSTATISTICS AND BIOINFORMATICS LAB

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Perform suitable statistical tests for evaluation of data
CO 2. Make suitable graphical representations of data
CO 3. Perform statistical tests - t test, F-test, ANOVA
CO 4. Develop the skill to use search engines, internet tools anddatabases.
CO 5. Gain the practical knowledge of restriction mapping and microarraytechniques.

Biostatistics

1. Measurement of Central tendencies, mean, median,mode
2. Measures of dispersion range SD, CV&SE
3. Scatter plot, Simple Correlation & Regression, MultipleCorrelations
4. Construction of frequencytable
5. Theoretical distribution, Binomial poison &normal
6. Statistical inference, normal, t test, chi-square &Ftest
7. Analysis of Variance

Bioinformatics

1. Introduction to bioinformatics
2. Basic feature of computers; flow charts and problems.
3. Search engines and internettools.
4. Biological databases
5. Use of databases (e.g. BLAST,FASTA)
6. Restriction mapping
7. Micro arraytechniques
8. Searchengines
9. Web lab viewer and Ras mols

BSP458 APPLIED MICROBIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Carry out quantitative and qualitative assessments of microflora of soil, water andair.
CO 2. Selectivelyisolateand identify microbes using morphological and biochemical tools.
CO 3. Understand the symbiotic association of microorganisms throughexperiments.
CO 4. Assess microbial quality of drinking water andmilk.
CO 5. Perform microbiological assays for antibiotics and aminoacids.

1. Quantitative and qualitative assessment of microflora of soil, water and air by direct and indirectmethods.
2. Selective isolation of microbes (bacteria, actinomycetes, yeasts andfungi)
3. Studies on symbiotic association of microorganisms (rhizobia, cyanobacteriaandarbuscularmycorrhizae)
4. Simple and special morphological and biochemical tests for identification of bacteria, fungi
5. Assessment of microbial quality of drinking water andmilk
6. Microbiological assays (antibiotics and aminoacids)

BSP459 AQUATIC BIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Perform qualitative analyses of water samples for various parameters.
CO 2. Identify freshwater, marine and benthic organisms
CO 3. Estimate the productivity of aquaticecosystems.
CO 4. Understand the food and feeding habits infish.

1. Water qualityparameters
2. Freshwater, marine and benthicorganisms.
3. Preparation of temporary and permanent slides ofplankton.
4. Estimation ofproductivity.
5. Hydrophytes, halophyes and seaweeds.
6. Food and feeding habits infish.
7. Sewageorganisms.
8. Instrumentation in aquaticbiology and field trips

BSP460 METABOLISM AND BIOENERGETICS

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Perform spectrophotometric estimation of variousmetabolites.
CO 2. Diagnose some of the metabolic diseases through biochemicaltests.
CO 3. Quantify vitamins and phenolics in plantsamples.
CO 4. Calculate standard free energy change, redox potential, and mitochondrialrespiration.

1. Spectrophotometric estimation of metabolites: serum protein, sugar, creatinine, urea, uric acid
2. Colorimetric analysis of vitamins, ascorbic acidetc.,
3. Estimation of plantphenolics
4. Tests to measure glycosuria, proteinuria etc
5. Calculations in Bioenergetics: standard free energy change, redox potential, mitochondrial respirationetc

OPEN ELECTIVE COURSES
BSE461 BIODIVERSITY AND CONSERVATION

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Understand the relevance of biodiversity andconservation.
CO 2. Describe the levels of biodiversityorganizations.
CO 3. Understand Indian ecological/geographical diversity, including Himalayan region, Desert, Western Ghats, Coastal region and Hotspots of biodiversity.
CO 4. Understandmicrobial diversity and itsimportance.

Unit I (13 hours)

Basic concepts and definitions, scope, biosphere, habitats, food chain, food web. Levels of biodiversity organizations – Genetic diversity, Species diversity and Ecosystem diversity. Indian ecological/geographical diversity: Himalayan Region, Deserts, Semiarid region, Gangetic plains, Western Ghats, Coastal region; Hotspots of biodiversity,
Microbial diversity: Bacteria, Cyanobacteria, Fungi and Lichens, Algae, Protozoa and viruses, habitat. Mushrooms – edible and nonedible. Plant and animal association with microbes. Beneficial and harmful microbes, Culture, Cultivation of bacteria. Microbial products.

Unit II (13 hours)

Plant diversity: Lower and higher group of plants, plant ecosystem and its classification. Major ecosystem types, tropical forests, temperate forests. Arid and Semiarid ecosystems, boreal forests, Arctic and Alpine systems, grasslands, wetland ecosystem. Marine ecosystems, Epiphytes, parasites and orchids. Values and uses of plantdiversity.Animal diversity: Lower and higher group of animals, their ecological niches.Zoogeographical regions of the world and India. Animals in temperate, tropical and boreal forests, cave and mountains, Coastal ecosystems, mangrove and estuaries, coral reefs.

Unit III (13 hours)

Biodiversity Conservation: Causes and prevention of Plant and Animal biodiversity loss; IUCN Red List Categories and Criteria. Conservation strategies – *Ex-situ* and *In-situ* conservation, Protected ecosystems – Biosphere reserves, National parks, Sanctuaries, Botanical gardens, Sacred groves; Wildlife conservation and wildlife conservation act; Centers of diversitystudy.

References:

1. Daniel, J.C.A century of natural history. Bombay natural History Society, Bombay, 697pp.
2. Dwivedi,A.P. (1993). Forests. International book Distributors, Dehra Dun. 352pp.
3. OdumE. P. (1983). Basic Ecology. Saunders College,London.
4. Gugjisberg, C.A.W. (1970). Man and Wildlife, Arco Publishing Company Inc., NewYork.
5. Haywood, V.H. and Watson, R.T. (1995). Global biodiversity assessment. United Nations Environmental Programme,New York.
6. Korringa, P. (1976). Farming of marine organisms law in the food chain. Elsevier, Amsterdam. 264pp.
7. Levinton, J.S. (1982). Marine ecology, Prentice Hall, Englewood Cliffs. 526pp.
8. Lieth, H. (1989). Tropical rain forest ecosystems. Elsevier, Amsterdam. 713pp.
9. Southwood, T.R.E. (1978). Ecological methods, Chapman and Hall, London. 524pp.
10. Tiwari, S.K. (1985). Readings in Indian Zoogeography. Today and Tomorrow's Printers and Publishers, New Delhi. 604pp.

11. Nybakkan, J.N. (1982). Marine Biology – An ecological approach. Harper and Raw Publ., NewYork.
12. Reddy, P.A. (2000). Wetland ecology. Cambridge University Press, London. 614pp.
13. Krishnamoorthy, K.V. (2003). An advanced textbook on Biodiversity. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. pp.260.
14. Brummit, R.K. (1992). Vascular Plant Families and Genera, Royal Botanic Gardens, Kew, England.
15. IUCN, (1992). Protected Areas of the World: A Review of National Systems (4 Vols.) WCMC, Cambridge and IUCN Commission on National Parks and Protected Areas, IUCN, Gland, Switzerland.
16. IUCN, (1993). Draft IUCN Red List Categories. IUCN, Gland, Switzerland.
17. IUCN, (1994). Guidelines for Protected Area Management Categories. WCMC, Cambridgeand IUCN Commission on National Parks and Protected Areas. Gland, Switzerland.
18. IUCN, (1995). IUCN Red List Categories. IUCN, Gland,Switzerland.
19. Janzen, D. H. (1986). Tropical dry forests- the most endangered major tropical ecosystem. In: Wilson, E.O. and Peters, F.M. (eds.) Biodiversity. National Academy Press, Washington DC, pp. 130-137.
20. Kushalappa, C.G. and Bhagwat, S.A. (2001). Sacred groves: Biodiversity, threats and conservation. In: Uma Shanker, R., Ganeshaiah, K.N. and Bawa, K.S. (Eds.) Forest genetic resources: Status, threats and conservation strategies. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, pp.21-29.
21. Lovelock, J. E. (1988). The Earth as a living system. In: Wilson, E.O. and Peters, F.M. (Eds.) Biodiversity. National Academy Press, Washington DC, pp.486-489.
22. Magurran, A.E. (1998). Ecological diversity and its measurement. Princeton Univ. Press, Princeton,NJ.
23. Pearce, D.W. and Moran D. (1994). The economic value of biological diversity. Earthscan, London.
24. Krishnamurthy, K. V. (2018).Advanced Textbook on Biodiversity: Principles and Practice. CBS Publ.& Dist. Pvt. Limited.
25. Lindenmayer, D. (2009).Large-scale landscape experiments: lessons from Tumut. Cambridge University Press.
26. Lkr, L. (2013). Indigenous techniques and practices for management of bio-resources: a Naga experience.International journal of Bio-resource and Stress Management,4(4), 648-650.
27. Guisan, A., Thuiller, W., & Zimmermann, N. E. (2017).Habitat suitability and distribution models: with applications in R. Cambridge University Press.
28. Bindra, P. S. (2017).The Vanishing: India's Wildlife Crisis. Penguin Random House India.
29. Ninan, K. N. (2012).The economics of biodiversity conservation: valuation in tropical forest ecosystems. Routledge.
30. Morand, S., Lajaunie, C., &Satrawaha, R. (Eds.). (2017).Biodiversity conservation in Southeast Asia: challenges in a changing environment. Routledge.
31. Madhusudan, M. D., & Shankar Raman, T. R. (2003). Conservation as if biological diversity matters: preservation versus sustainable use in India.Conservation and Society,1(1), 49-59.
32. Kannaiyan, S., & Gopalam, A. (Eds.). (2007).Biodiversity in India: Issues and Concerns. Associated Publishing Company.

BSE462 CANCER BIOLOGY

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Understand the molecular biology and etiology of cancer.

CO 2. Understand cell transformation mechanisms and role of oncogenes and tumoursuppressorgenes.

CO 3. Perform the tests for identification of different types ofcancers.

CO 4. Describe carcinogenic agents

CO 5. Understand diagnosis and conventional and advanced cancer therapies.

CO 6. Understand mechanisms of neoplasia and signalingpathways.

Unit I (13 hours)

Cellular hallmarks of cancer, Molecular biology of cancer development, Cell transformation mechanisms, benign and metastatic tumour, Protooncogenes, Oncogenes and tumour suppressor genes, Cellular senescence, Telomeres, cellular immortalization and tumorigenesis, Carcinogen- types and identification tests

Unit II (13 hours)

Multistep tumorigenesis, Mechanisms of neoplasia and signaling, tumor virology, Growth factors, receptors and cancer, cytoplasmic signaling circuitry programs and cancer, Cell cycle control, Genome integrity and cancer, pRb and control of cell cycle clock, DNA damage checkpoints and repair, Mismatch repair pathway and cancer.

Unit III (13 hours)

Tumor immunology and immunotherapy, rational design of Cancer therapeutics and diagnostics, Cancer nanotechnology, sequelae of cancer and its treatment, Genomic and proteomic technologies and application of new technologies in prevention, assessing risk, diagnostics and treatment of cancer.

References:

1. Weinberg R. A. (2006). Cancer Biology, GarlandScience.
2. Mckinnell R. G., Parchment R. E., Perantoni, A. O. and Pierce B. (1998), The Biological Basis of Cancer. Cambridge UniversityPress.
3. Kleinsmith, J. L. (2005), Principles of Cancer Biology, Benjamin CummingsPublication.
4. Franks L. M. and Teich N. M. (1997), Introduction to the Cellular and Molecular Biologyof Cancer (3^{rd}Ed.), Oxford UniversityPress.
5. Ruddon R. W. (2007). Cancer Biology, 4^{th}Ed. Oxford University Press
6. Roger John Benjamin King, Mike W. Robins, Cancer Biology, Pearson/Prentice Hall, 2006.
7. Pelengaris, S.& Khan, M. (Eds.). (2013).The molecular biology of cancer: A bridge from bench to bedside. John Wiley & Sons.
8. Pecorino, L. (2016).Molecular biology of cancer: mechanisms, targets, and therapeutics. Oxford University Press, USA.

II SEMESTER
HARD CORECOURSES
BSH501ANIMAL PHYSIOLOGY

52hrs

Course Outcomes:

After successful completion of the course, students will be able to :

CO 1. Gain in-depth understanding of gastrointestinal system, associateddisorders, digestive processes and mechanism of absorption of nutrients.
CO 2. Comprehend ultrastructure and functioning ofnervesand muscles.
CO 3. Understand the importance of various endocrine glands, associated disorders,hormonesand their mode of action
CO 4. Understand osmoregulation and excretion mechanisms and modes across organisms.
CO 5. Comprehend the concept of thermoregulation and adaptive features.
CO 6. Develop in-depth understanding of sensory receptors

Unit I (13 hours)

Gastrointestinal System: Digestive processes and mechanisms of absorption of dietary carbohydrates, proteins and lipids; coordination of digestive and absorptive activities; gastrointestinal disorders.

Nervous system: Neuron and nerve impulse conduction synapses, synaptic transmission and neurotransmitters; reflex mechanisms; functions of the sensory and motor areas of the CNS; autonomic nervoussystem.

Unit II (13 hours)

Endocrine system: Hypothalamus. Endocrine glands - pituitary, thyroid, parathyroid, adrenals, pancreas, ovary, testis, pineal, GI tract and placenta: hormones - release, transport, mechanism of action and biological action; Neurohormones of the hypothalamus; endocrine disorders, Neuroendocrine system in Insecta and Crustacea.

Muscular system: Contraction of skeletal muscle; molecular basis of muscle contraction; energetics of muscular contraction; neuromuscular transmission and excitation contraction coupling; muscle atrophy and dystrophy.

Unit III (13 hours)

Osmoregulation and excretion: Biological significance of water; Osmoregulation in aquatic and terrestrial vertebrates; regulatory mechanisms; Major functions of excretory system; Organs of excretion- Basic processes responsible for the formation of the excreted fluid; Functional types- Generalized excretory organs and Specialized excretory organs;

Classification of excretory organs and their distribution in the animal Kingdom; General patterns of nitrogen and non-protein nitrogen excretion; physiology of urine formation in mammals; renal diseases.

Unit IV (13 hours)

Thermoregulation: Thermoregulation-a phenomenon of homeostasis; Thermoregulatory adaptations-Physiological, Physical and Behavioral adaptations; Thermoregulation in aquatic and terrestrial invertebrates; Thermoregulation in Vertebrates-Fishes, Amphibians, Reptiles, Birds and Mammals.

Receptor system: Sensory receptors-classification and properties; Receptor Mechanisms: Chemoreceptors- gustatory receptors and olfactory receptors, Mechanoreceptors- Touch or pressure receptors, Pain receptors, Receptors concerned with equilibrium, gravity, acceleration and vibration, Phonoreceptors; Electromagnetic receptors- Photoreceptors

Thermoreceptors; Special Senses- Neurophysiology of Vision, Hearing and Chemicalsenses.

References:

1. Berne, R.M. & Levy, M.N. (1991). Physiology. The C.V. Mosby Company, St.Louis.
2. Ganong, W.F. (1999).Review of Medical Physiology (19^{th}Ed) Kotheri Book Depot,Bombay.
3. Wilson, J.A. (1979). Principles of Animal Physiology. MacMillan Pub., NewYork.
4. Hopkins, W.G. (1995). Introduction to Plant Physiology. John Wiley and Sons Inc. NewYork.
5. Guyton, A.C. & Hall, J.E. (1996). Text Book of Medical Physiology. 9th Ed. W.B. Saunders Company, Philadelphia.
6. Jenson, D. (1976). Principles of Physiology, Appleton CenturyCrafts.
7. Gorbman, A & Bern, H.A. (1974). A text book of Comparative Endocrinology. Wiley Eastern.
8. Prosser, C.L. & Brown (1983). Comparative Animal Physiology. W.B. Saunders Company.
9. Vander, A.J., Sherman, J.H. and Luciano, D.S. (1994). Human physiology – The mechanisms of body function, 6^{th}Ed. McGraw Hill, Inc. New Delhi.
10. Rastogi, S. C. (2007).Essentials of animal physiology. New Age International.
11. Schmidt-Nielsen, K. (1997).Animal physiology: adaptation and environment. Cambridge University Press.
12. Schulte, P. M. (2013).Principles of Animal Physiology: Pearson New International Edition. Pearson Education Limited.
13. Sapolsky, R. M. (2017).Behave: The biology of humans at our best and worst. Penguin.
14. Kurpad, A., Vaz, M., & Raj, T. D. (2013).Guyton& Hall: Textbook of Medical Physiology-A South Asian Edition. Elsevier India

BSH502PLANTPHYSIOLOGY

52hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand the role of various nutrients in plant growth
CO 2. Comprehend the various conceptsof water relation in plants and physiologicalprocesses.
CO 3. Gain in-depth knowledge on photosynthesis and regulatory mechanisms.
CO 4. Understand role of various growthregulators in plant growth
CO 5. Gain knowledge on different methods and tools of plant breeding
CO 6. Understand plant pathology

Unit I (13 hours)

Plant nutrition: Trace elements and their role, major and minor elements in soil and plants; Essentiality of elements- Sand culture, Soil culture, Hydroponics, Aeroponics; Mineral deficiencies and their rectification, nitrogen, phosphorus and sulfur metabolism.

Unit II (13 hours)

Water relations in plants: water requirements, Physical forces involved in water absorption, Osmotic system, Water potential, Site and path of water absorption; Ascent of Sap, mechanism of translocation of water and solutes; Factors affecting water absorption; Transpiration- Types of transpiration, structure and functions of stomata, mechanism of stomatal movement, Factors affecting transpiration, Guttation, anti-transpirants.Photosynthesis: Chloroplast and photosynthetic pigments; Concept of photosynthetic unit; Oxygenic and anoxygenic photosynthesis; Concept of pigment system; Stages of photosynthesis- cyclic and non-cyclic photophosphorylation; Hill reaction, Photorespiration; carbon dioxide fixation in C_3 and C_4 plants, CAM plants; Factors affecting photosynthesis.

Unit III (13 hours)

Plant Growth and Growth Regulators- Plant growth, Growth curve, measurement of growth, Phytohormones: Biosynthesis, Mechanism of action and application of auxins, gibberellins, cytokinins, ethylene, abscisic acid; Vernalin, Florigen, Morphactins; Phytochromes. Plant breeding: Objectives – high yield, improved quality, disease and pest resistance, early maturity, photosensitivity, varieties for new seasons, resistant varieties. Breeding in self-pollinated crops. Methods of breeding- Selection, Backcross method, Hybridization-objectives, types, procedure. Mutagenesis.

Unit IV (13 hours)

Plant pathology- Plant pathology in relation to important diseases of crop plants. Important plant diseases: Plant diseases caused by viruses, mycoplasma, bacteria, fungi, protozoa, nematodes, parasitic angiosperms - symptoms, etiology, life cycle, transmission etc.

Seed borne diseases and transmission: Pollination, fertilization, embryogenesis, morphology and physiology in relation to seed infection. Seed-borne pathogens and their importance - viruses, bacteria, fungi and nematodes; seed infection and contamination.

References:

1. Hopkins, W.G. (1995). Introduction to Plant Physiology, JohnWiley and Sons, Inc. NewYork.
2. Devlin, R.M. (1983). Plant Physiology. CBS Publications & Distributors, NewDelhi.

3. Kochhar, P.L. (1978). Plant Physiology. Atmaram, NewDelhi.
4. Noggie, Ray G. (1986). Introductory Plant Physiology. Prentice Hall of India Pvt. Ltd. New Delhi.
5. Prasad M. (1997). Plant Ecophysiology. John Wiley & Sons, NewYork.
6. Salisbury, F.B. and Ross C. W. (1992). Plant Physiology. Wordsworth Publishing Company,California.
7. Verma, V. (1975). Plant Physiology. Embkay, NewDelhi
8. Agrios, N. (1997). Plant Pathology, Academic Press, New York.
9. Bedel, P. E. (1998). Seed Science and Technology. New Delhi, Allied, pp. 346.
10. Maude, R. B. (1996). Seed borne diseases and their control. Wallingford: Cab International, Lowman, pp. 280.
11. Rangaswami and Mahadevan, A. (2001). Diseases of crop plants in India. Prentice Hall of India, Pvt. Ltd., New Delhi.
12. Singh, R. S. (1990). Plant diseases, 6^{th} Ed., New Delhi, Oxford & IBM.
13. Sharma, J. R. (1994). Principles and practice of Plant Breeding. Tata McGraw Hill Publishing Co. Ltd. New Delhi. pp 599.
14. Chaudhari, H. K. (1974). Elementary Principles of Plant Breeding, Oxford and IBH, New Delhi.

SOFT CORE COURSES
BSS 503APPLIEDECOLOGY

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Understandbiodiversity, hotspots, conservation and management

CO 2. Develop knowledge of forest and landscape ecology and watershedmanagement.

CO 3. Understand fisheries and aquaculture methods for commercial production of sea food

CO 4. Learn about the impacts of aquaticpollution.

CO 5. Develop in-depth knowledge in population ecology, prey-predatory dynamics, life-history strategies,energybudgetsandreproductivestrategies.

Unit I (13 hours)

Biodiversity: types, significance, distribution and measurements-Species richness: Simpson index, Shannon Wiener index, Evenness.Megadiversity countries, hot spots, biodiversity of Western Ghats and EasternHimalayas.Wildlife management: Present status of threatened wildlife of Western Ghats; Conservation, Administrative and Judicialmeasures.Forest and landscape ecology: types of forests and their distribution with reference to Western Ghats; Vegetation mapping; Plant-animal interactions; Integrated pest management. Landscape Ecology –watershedsmanagement.

Unit II (13 hours)

Fisheries: Aquatic resources - fish, mollusca and crustaceans. Aquatic wildlife; Conservation and management of aquatic wildlife. Aquaculture - prawns, seaweeds, oysters, mussels, fin fishes and the environment. Aquaponics. Aquatic pollution – Eutrophication, algal blooms, coral reefs – bleaching, shellfish poisoning. Ganga action plan

Unit III (13 hours)

Population ecology: Demography-life tables; population structure-recruitment patterns, settlement and migration; population growth-growth patterns, age and growth, allometry, growth parameters; biotic parameters-predation, pray-predatory dynamics, competition, mutualism and population regulation; life history strategies-life history traits, longevity and survival rates, energy budgets, and reproductive strategies, *k*-selection and*r*-selection.

References:

1. Burn, A.J., Coaker, T.H. and Jepson, P.C. (1987). Integrated pest management. Academic Press, London. 474pp.
2. Daniel, J.C.A century of natural history. Bombay natural History Society,Bombay. 697 pp.
3. Dwivedi,A.P. (1993). Forests. International book Distributors, Dehra Dun. 352pp.
4. Eugene, P. Odum(1983). Basic Ecology. Saunders College,London.
5. Govardhan Veerelapati (1993). Remote sensing and water management incommend areas. International Book Distributors, Lucknow. 353pp.
6. Green, R.H. (1979). Sampling design and statistical methods for environmental biologists. Wiley, New York. 257pp.
7. Gugjisberg, C.A.W. (1970). Man and Wildlife, Arco Publishing Company Inc., NewYork.
8. Gulland, J.A. (1971). The fish resources of the Ocean, FAO/Fishery News(Books) Limited, England. 255pp.
9. Gulland, J.A. (1977). Fish population dynamics. John Wiley & Sons, London. 372pp.

10. Gulland, J.A. (1983). Fish stock assessment: A manual of basic methods. FAO/Wiley New York. 223pp.
11. Gutierrez, A.P. (1996). Applied population ecology. John Wiley and Sons, Inc.New York. 300pp.
12. Hanski, I.A. and Gilpin, M.F. (1997). Metapopulation ecology. Academic Press, San Diego. 512pp.
13. Haywood, V.H. and Watson, R.T. (1995). Global biodiversity assessment. United Nations Environmental Programme,New York.
14. Jhingran, V.G. (1988). Fish and Fisheries of India. Hindustan Publishers, New Delhi. 666 pp.
15. Korringa, P. (1976). Farming of marine organisms law in the food chain. Elsevier, Amsterdam. 264pp.
16. Levinton, J.S. (1982). Marine ecology, Prentice Hall, Englewood Cliffs. 526pp.
17. Lieth, H. (1989). Tropical rain forest ecosystems. Elsevier, Amsterdam. 713pp.
18. MacArthur, R.H. and Nilson, E.O., (1967). The theory of Island biogeography. Princeton University Press,Princeton.
19. Otto Kinne (1976). Marine ecology. Vol.III – Cultivation. John Wiley &Sons,London. 577 pp.
20. Paul-Wostl, C. (1995). The dynamic nature of ecosystems. John Wiley &Sons,New York. 267pp.
21. Pianka, E.R., (1983). Evolutionary ecology. Harper and Rav, New York. 416pp.
22. Pielou, E.C., mathematical ecology. Wiley, New York, 385pp.
23. Pook, R.W., (1974). An introduction to qualitative ecology. McGraw Hill, Tokyo. 532pp.
24. Qasim, S.Z. (1999). The Indian Ocean Images and realities. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 340 pp.
25. Roughgarden, J.J., 1987 Science of ecology. MacMillan, New York. 710pp.
26. Sivaraju, V.V., and Balachandran, I. (1994). Ayurvedic drugs and their plant sources. 27. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 570pp.
27. Southwood, T.R.E. (1978). Ecological methods, Chapman and Hall, London. 524 pp.
28. Techniques to maintain biological diversities, 1988. SIRC,London.
29. Tiwari, S.K., (1985). Readings in Indian Zoogeography. Today and Tomorrow's Printers and Publishers, New Delhi. 604pp.
30. Zaika, V.E., (1970). Specific productivity of aquatic invertebrates. Wiley, New York, 154 pp.

BSS504IMMUNOLOGY

39 hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Gain an in-depth knowledge of immunology.
CO 2. Understand the structure and functions of various immune cells and organs
CO 3. Comprehend antigen and antibody structure and the mounting of immune responses.
CO 4. Understand autoimmunity, hypersensitivity and immunodeficiencies
CO 5. Understand the principles and application of various immunological techniques.

UNIT I (13 hrs)

Immunology: History and scope of immunology; Immunity, classification of immunity; Host defence: cellular, tissue and humoral immunity; Acquired immunity; Primary and secondary lymphoid organs; Immune response of T and B cells; Cytokines – structure and functions. Microbial defence: invasion, antigens, toxins. Antibodies: Production, structure, classification and functions; hyper variable region, Isotypic, allotypic and idiotypic variations. Antigenicity and immunogenicity, haptens. Complement.

UNIT II (13 hrs)

Autoimmune diseases:Thyrotoxicosis, Systemic Lupus Erythematosus, Antinuclear antibodies. Hypersensitivity - reactions. Tumor immunology– tumor antigens, immunosurveillance,immunological escape. Immune deficiency diseases– AIDS; Immunological tolerance, Immunization and Vaccines: Types and production.

UNIT III (13 hrs)

Major Histocompatibility Complex (MHC), HLA polymorphism. Tissue haplotypes and disorders, Tissue and organ grafting, graft rejection, Immune suppression. Immunological techniques: Antigen-antibody reactions. Precipitation and agglutination, immunodiagnosis, ELISA, RIA, immunoblotting and immunofluorescence and chemiluminescence; Fluorescent activated cell sorter (FACS); Hybridoma technology, production and application of monoclonal antibodies.

References:

1. Abul K. Abba, Andrew H. Lichtman, Jordan S. Pober (year) Cellular and molecular immunology –- SaundersCo.
2. Ivan Riott (1988) Essential immunology –8thedition Blackwell publishers,
3. Wier DM (year) Handbook of expt. Immunology vol.1,2. Blackwell scientificPub.
4. Janis Kuby. (year) Immunology –Freeman and co publishers,2000
5. Ivan Riott, Jonathan Brostoff and David Male. (year) Immunology – 3rdedition. Mosbypublishers
6. Janeway and Travers. (year) Immunobiology- 3rdedition Churchill Livingstonepubl.
7. Hudson et al (year) Practical immunology. Blackwell scientific Pub.,1986
8. Elgert KD. (year) Immunology. Jon Wiley and Sons,USA
9. Barrett JT, (year) Microbiology and Immunology Concepts. Lippincott-Raven,USA

BSS505ECOTOXICOLOGY

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Know the principle of bioassays for assessment oftoxicity.
CO 2. Understand how the biotransformation and detoxification of xenobiotics occurs
CO 3. Gain the knowledge how to do the toxic risk and environmental impactassessments.
CO 4. Understand various atmospheric toxicants and consequences of air pollution, acid rain, photochemical smog, global warming, ozone depletion and haze.
CO 5. Gain in-depth knowledge of the adverse effects of alcohol, tobacco, food additives, petroleum and petroleumproducts
CO 6. Understand the impact ofpesticides and metal toxicity
CO 7. Know antidotetherapiesforpesticidepoisoning.

Unit I (13 hours)

Introduction, definition and various facets of ecotoxicology; Kinds of toxicity; time & dose-response relationships; factors influencing the toxicity;Bioassay- toxicity testing; Role of US-FDA.Metabolism of toxic substances: biomagnification, biotransformation and detoxification; Effects of environmental toxicants- sub cellular, cellular, individual, population and ecosystem levels. Toxic risk assessment: Methods, monitoring, importance and surveillance of risk assessment; Environmental ImpactAssessment.

Unit II (13 hours)

Atmospheric toxicants: Major sources, types and standards; Primary pollutants- Carbon monoxide, sulphur oxides, nitrogen oxides, particulate matter, hydrocarbons, asbestos and CFCs; Secondary pollutants; Impact of air pollutants on climate-Acid rain, photochemical smog, global warming, ozone depletion andhaze.Toxicity of Alcohol, tobacco & its products, food additives, petroleum & petroleum products.

Unit III (13 hours)

Pesticides: Definition, classification, usage and exposure; Insecticides: Organochlorines - DDT, cyclohexane, aldrin and endosulfanpoisoning and treatment; Organophosphates and carbamates-Examples, sources, effects and treatment; herbicides, fungicides, rodenticides, endocrine disrupters. PCBs andDioxins.Metal toxicity - History, sources, emissions, effect of mercury, cadmium, arsenic and lead on metabolism and environment. Poisoning - antidote.

References:

1. Boudou, A. (1997). Aquatic toxicology. Vol. I and II.
2. Diwakar Rao, P.L. (1990).Pollution control Hand book, Utility Publications Ltd., Secunderabad, India.
3. Eaton, A.D., Clesceri, L.S. & Greenberg, A.E.(1995).Standard Methods for the Examination of Water and Wastewater. APHA,Washington.
4. Gupi P.K. and Salunke, D.K. (1985). Modern Toxicology. Vol.I, II and III. Metropolitan Publications, Delhi.
5. Hommadi, A.H. (1990). Environmental and Industrial safety.IndianBibliographicsBureau,Delhi.
6. Jorgensen, S.E., Modelling inEcotoxicology.Elsevier,Amsterdam.
7. Lewin, S.A. et al., (1989). Ecotoxicology: Problems and approaches. Springer - Verlag, Tokyo, NewYork.
8. Moriarty, F. (1975). Pollutants and animals: A factual perspective. George Allan &Unwin

Ltd.,London
9. Omkar, (1995). Concepts of Toxicology. Chand &Co.,Jallandhar.
10. Schmitz, R.J. (1996). Introduction to water pollution biology.Asian Books Pvt. Ltd., NewDelhi.
11. Trivedi, P.R. and Sudarshan, K. (1995). Global environmental issues. Commonwealth Publications, New Delhi.
12. Vernberg et al. (1981). Biological monitoring of marine pollutants. Academic Press, NewYork

PRACTICAL COURSES
BSP 506 ANIMAL PHYSIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Perform experiments to estimate enzyme activity and understand factors affecting enzyme activity

CO 2. Perform experiments on hormonal control of reproductive biology.

CO 3. Perform experiments in muscle physiology and osmoregulation.

CO 4. Conduct qualitative tests for excretoryproducts and demonstrate active transport

1. Gastrointestinal function–
   1.1. Factors affecting enzyme activities in digestion of foodstuffs.
   1.2 Quantitative estimation of Enzyme (amylase)activity.
2. Neuroendocrinology–
   2.1 Effect of hormones on blood glucose inrats.
   2.2 Study of estrous cycle in mice
   2.3 Study of sperm count, sperm morphology and sperm motility
3. Muscle Physiology-
   3.1 Histochemical detection of SDH activity in red and white musclefibres.
4. Osmoregulation-
   4.1 Estimation of Fluid balance in ananimal.
   4.2 Osmotic relationship in animals at the level of cell as wellasentire organism.
5. Excretion-
   5.1 Qualitative tests for excretoryproducts.
   5.2 Demonstration of activetransport.

BSP507 PLANT PHYSIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Realize the importance each nutrient in plant growth through experimentation and observation.

CO 2. Observe mineral deficiency symptoms inplants.

CO 3. Know how to perform the tests for understanding waterrelations.

CO 4. Understand the photosynthesis by conducting some alliedexperiments.

CO 5. Understand the role of growth hormones inplants.

1. Plant nutrition-
   1.1 Observation of mineral deficiency symptoms inplants.
2. Water relations-
   2.1Experiments to demonstrate the diffusion pressure deficit in plantcell.
   2.2Determination of stomatal index, stomatal frequency and measurement of stomatalaperture.
   2.3Determination of waterpotential
3. Photosynthesis -
   3.1 Separation and estimation of chloroplastpigments.
   3.2 Demonstration of Kranz anatomy
4. Growth hormones and their regulation-
   4.1 Experiments to demonstrate the effect of hormones on shootapex.
5. Plant pathology
   5.1 Pathogens in crop plants

BSP508 APPLIED ECOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Enhance the theoretical knowledge of applied ecology with lab experiments and fieldvisits.
CO 2. Understand plant-animal interactions and pray-predatorrelationship.
CO 3. Unravel medicinal properties of plants and significance of conservation
CO 4. Develop skills of remote sensing.
CO 5. Identify the freshwater and marine fisheryresources.
CO 6. Estimate growth parameters and determine the probability ofdeath.

1. Biodiversity
2. Terrestrialbiodiversity
3. Aquaticbiodiversity
4. Plant-animalinteractions
5. Endangered medicinalplants.
6. Landscapes analysis through remote sensingdata.
7. Freshwater fisheryresources
8. Marine fisheryresources
9. Estimation of growth parameters
10. Life-tables
11. Prey-predatorrelationships

BSP509 IMMUNOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Develop skills in immunology lab experiments.
CO 2. Isolate lymphocytes and identify different blood cells
CO 3. Understand hemolymph cells in insects
CO 4. Perform immunoassays using various immunodiffusion methods
CO 5. Detect and quantify antigens and allergens using established methods

1. Study of immune system inrats
2. Blood film preparation and study of immunecells
3. Isolation oflymphocytes
4. Study of insecthemocytes
5. Ouchterlony double diffusionassay
6. Radial Immunodiffusiontechnique
7. Immunological diagnosis of pregnancy andinfection
8. DOT- ELISAtechnique
9. Rocket immunoelectrophoresismethod
10. Detection of allergens: Pollen Count by sticky slidemethod

BSP 510 ECOTOXICOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Learn and practice safety measures to be taken inlaboratories.
CO 2. Determine acute and chronic toxicities throughbioassays.
CO 3. Estimate oil and grease from water and differentiate between clean and polluted watersamples

CO 4. Perform tests for detection of metals and other toxicpollutants and foodadulterants.
CO 5. Assess effect of metals on plant growth

1. Good LaboratoryPractices
2. Safety notices in environmental toxicologicalstudies.
3. Bioassay experiments using different testsystems.
4. Behavioural study of the fish under exposure totoxicants.
5. Experiments on solidwaste
6. Estimation of oil and grease in watersample.
7. Demonstration of catalase activity in pollutedwaters.
8. Spot test for detection of metals, residual chlorine, nitrite poisoning, fluoride toxicity, food adulterants and pesticide residues.
9. Effect of $CdCl_2$on germination of Bengalgram.
10. Effect of toxicants in meristematic tissue (Onion roottips).
11. GC analysis of pesticide residues in foodsamples.

OPEN ELECTIVE COURSES
BSE 511 POLLUTIONANDBIOREMEDIATION

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand causes and effects of environmental pollution andbioremediation.
CO 2. Know about air, water and land pollutants and theirimpact.
CO 3. Realize the impacts of water pollution on aquatic biota and humanhealth.
CO 4. Know the causes of acid rain, photochemical smog, global warming, ozone depletion and haze.
CO 5. Understand the concept of bioremediation and howtouse microorganisms, plantsandenzymes to detoxifycontaminants.
CO 6. Know about biological treatment of liquid wastes and solidwastes.

UNIT I (13 hours)

Environmental pollution: Types of pollution – Air, water, land, sound and radioactive pollution.

Water pollutants: Major sources- Domestic, municipal, industrial and agriculture; types and standards; Impact of water pollution on aquatic biota and human health.

UNIT II (13 hours)

Atmospheric Pollutants: Major sources, types and standards; Primary pollutants- Carbon monoxide, sulphur oxides, nitrogen oxides, particulate matter, hydrocarbons, asbestos and CFCs; Secondary pollutants; Impact of air pollutants on climate-Acid rain, photochemical smog, global warming, ozone depletion andhaze.

UNIT III (13 hours)

Remediation: Types of remediation- Physical, chemical and biological; Bioremediation- *in-situ* and *ex-situ* bioremediation; Phytoremediation; Microbial remediation; Biological treatment of liquid wastes and solid wastes.

References:

1. Diwakar Rao, P.L. (1990). Pollution control Hand book, Utility Publications Ltd., Secunderabad,India.
2. Eaton, A.D., Clesceri L.S. & Greenberg, A.E. (1995). Standard Methods for the Examination of Water and Wastewater, APHA,Washington.
3. Moriarty, F. (1975). Pollutants and animals; A factual perspective. George Allan & Unwin Ltd.,London.
4. Schmitz, R.J, (1996). Introduction to water pollution biology. Asian Books Pvt. Ltd., New Delhi.
5. Trivedi, P.R. and Sudarshan, K. (1995). Global Environmental issues, Commonwealth Publications, NewDelhi.
6. Vernberg*et al*. (1981). Biological monitoring of marine pollutants, Academic Press, New York.
7. George, A. (2000). The Ecology of sea shores, CRCPress.
8. Agrawal, K.C. (2002). Environmental Pollution: Causes, Effects andControls.
9. Binoda C. Sabata (1995). River Pollution inIndia.
10. Khetan S.K. (2000). Microbial PestControl.
11. James, G.A. (1999). Ethical Perspective on Environmental issues inIndia.

BSE512 STEM CELL BIOLOGY ANDREGENERATIVEMEDICINE

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Gain in-depth knowledge in the field of stem cell biology and regenerative medicine

CO 2. Understand the different types of stem cell and theirapplications.

CO 3. Learn about state-of-the-art technologies, applications and ethics in research of stem cellbiology.

CO 4. Understand the legal and ethical aspects of stem cell research andapplications.

CO 5. Know the principles and applications of tissueengineering and nanotechnology.

Unit 1 (13 hours)

Basics of stem cell biology, origin, development, types and properties of stem cells, embryonic stem cells and induced pluripotent stem cells (iPSCs), foetal (amniotic, umbilical cord blood and stem cells from other embryonic tissues), adult stem cells- Hematopoietic stem cells, mesenchymal stem/stromal cells, neural stem cells, hepatic stem cells and skeletal muscle stem cells, cancer stem cells, state-of-the-art technologies, applications and ethics in research of stem cell biology anddifferentiation

Unit II (13 hours)

Introduction and principles of regenerative medicine, cell based therapies, pluripotency and regenerative medicine, Cell-cell interactions in tissue regeneration, Isolation and culture of stem cells, Viral and non viral vectors in stem cell research, Genome editing and use of genetically engineered stem cells. Applications of stem cell based therapies in bone, blood, cardiovascular regeneration, musculoskeletal repair, hepatocyte and neuronal transplantation, legal and ethical aspects of stem cell research and applications

Unit III (13 hours)

Nanotechnology: Definition, nanomaterials and their applications; Regenerative medicine, biomaterials and scaffolds in regenerative medicine, principles and applications of tissue engineering, modes of cell and tissue delivery, *in situ* tissue engineering and bioartificial organs, GMP and regenerative medicine

References:

1. Appasani K., Appasani, R.K.(2013) Stem cells and regenerative medicine, Humana Press, 2013
2. Lanza R., Atala, A. (2014) Essentials of stem cell biology, 3rd Ed., Academic Press

OPEN ELECTIVE COURSE

BSE 513 BEHAVIOURAL BIOLOGY

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand the evolution of social behaviour and types of social behaviours

CO 2. Discern various types of social behaviours across organisms

CO 3. Understand communication and the adaptive significance of these behaviours

CO 4. Appreciate how epigenetics mouldsbehaviour

UNIT 1 (13 hours)

Sociobiology: Definition, introduction, history, scope, and significance. Basics of ecology and society; The evolution of animal societies. Instinctive, or intuitive behavior; Evolutionarily stable strategy hypothesis. Social behaviors: Aggregation, reproductive behaviour, territoriality, pack hunting, dominance interactions, parental care, and cooperative interactions within families.

UNIT II (13 hours)

Eusociality in insects: Hive society of social insects (ants, bees, and wasps); Eusociality in crustaceans (shrimps); mammals (mole rats); Cooperative breeding in birds,parental care. Social interactions in microbes - cooperation, conflict, and population. Spatial structure. Plant-pollinator networks.

UNIT III (13 hours)

Communication for social interactions: plumage, morphological characters, vocalizations, pheromones, vibrations; The adaptive significance of social organization; altruism; cooperation; courtship and reproductive behavior; the genetics, development, and epigenetics of social behavior.

References:

1. Aronson, E., & Aronson, J. (2018). The social animal. Worth Publishers, Macmillan Learning.
2. Brooks, D. (2012). The social animal: The hidden sources of love, character, and achievement. Random House Incorporated.
3. Buss, D. M. (Ed.). (2005). The handbook of evolutionary psychology. John Wiley & Sons.
4. Martin, P., Bateson, P. P. G., & Bateson, P. (1993). Measuring behaviour: an introductory guide. Cambridge University Press.
5. Peterson, G. R. (2005). Sociobiology: The new synthesis. 25th Anniversary edition.
6. Wilson, E. (2000). Sociobiology: the new synthesis, 25th anniversary edition.

III SEMESTER
HARD CORE COURSES

BSH551BIOTECHNOLOGY

52hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Understand how organisms and biological processes are used in biotechnology.
CO 2. Gain in-depth knowledge of useful microorganism,bioreactors and fermentationtechnologies.
CO 3. Learn about production of bioplastics, biofertilizers andbiopesticides.
CO 4. Learn about the application of plant tissueculture and production of various hybridplants.
CO 5. Become familiar with animal cell culture, production of transgenicanimals and assisted reproductive techniques
CO 6. Understand rDNA technology, principles and applications of PCR, RT-PCR and DNAfingerprinting.

UNIT I (13 hrs)

Aims and scope of biotechnology, basic concepts of biotechnology, traditional and modern biotechnology. Microbial Biotechnology: Fermentation techniques: Fermenters and bioreactors. Batch, submerged (SmF), solid substrate (SSF) and continuous fermentation. Fermented foods, oriental foods, silage, probiotics, single cell proteins, production of hormones and growth factors. Microbial polysaccharides, bioplastics, cell immobilization and its applications. Biopesticides (fungi, bacteria and viruses). Biofertilizers, plant-growth promoting microorganisms, biocontrol agents and bioprotectants. Transgenic microbes and theirapplications.

UNIT II (13hrs)

Plant Biotechnology: Plant tissue culture laboratory and aseptic techniques, culture media, callus induction, organogenesis, somatic embryogenesis, micropropagation, production of secondary metabolites, selective markers, somaclonal variation, synthetic seeds and cryopreservation. Haploid production: pollen, anther and ovule cultures. Cell suspension culture, protoplast culture, protoplast fusion and hybridoma technology. Transgenic plants, production of disease-, salinity-, pest-, herbicide-, drought-resistant and high yielding varieties of plants. Production of improved varieties using Ti plasmids. Application of rhizobia and mycorrhizas in plant tissue culture. Plant-derived vaccines andantibodies.

UNIT III (13 hrs)

Animal Biotechnology: Animal cell culture techniques, culture media, primary and secondary cell cultures, cell lines and cell strains and growth factors. Stem cells, gene expression in cell culture, organ culture, histotypic culture; Natural and synthetic cell culture media composition; cytotoxicity and cell viability assays; Transgenic animals and their uses. Animals as bioreactors. Assisted Reproductive Techniques: *In-vitro* fertilization, embryo transfer, super ovulation and cloning.

UNIT IV (13 hrs)

Molecular Biotechnology: Gene manipulation, restriction enzymes, DNA insertion through vectors, clone selection and expression of cloned genes. Expression systems and their applications: Escherichia coli, Streptomyces, yeast, baculovirus and animal cells as cloning hosts. Analysis of DNA-DNA sequences, mutagenesis and gene expression, DNA extraction methods and amplification using PCR and RT PCR techniques; DNA fingerprinting. Overview of next generation sequencing and digital PCR highlights.

References:

1. Moo-Young, M. (2011) Comprehensive Biotechnology, Vol. 1, 2, 3 & 4, PergamonPress
2. Cruger, W.&Cruger, A. (1990) A textbook ofIndustrial Biotechnology
3. Glazer, A. G. (1994) Microbial Biotechnology, WH Freeman andCo.
4. Peppler, H. J. (1979) Microbial Technology., Vol. 1 &2, Academic Press
5. Bajaj, Y. P. S.(2007) Biotechnology in Agriculture and Forestry, Springer VerlagPubl.
6. Russell, G. E. (1988)Biotechnology of Higher Plants, Intercept Publ.
7. Reinert J., Yeoman, M. M. (1982)Plant Cell and Tissue Culture. A Lab manual. NarosaPubl.
8. Mantell, S. H. and Smith H. (1983) Plant Biotechnology. Cambridge Univ.Press.
9. Houdebine, L.-M. (2003) Animal Transgenesis and Cloning by John Wiley &Sons.
10. Butler, M.(2004) Animal Cell Culture and Technology, BIOS ScientificPublishers.
11. Davis, J. M. (2002) Basic Cell Culture: A Practical Approach (Practical Approach Series), Oxford university press, Oxford

SOFT CORE COURSES
BSS 552ENVIRONMENTALPHYSIOLOGY

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Enhance the knowledge how the organisms are physiologically adapted to various environmentalconditions.
CO 2. Know the basic principles of plant responses toenvironment.
CO 3. Understand the physiology of flowering, senescence andabscission.
CO 4. Gain the knowledge about stress physiology; how the plants response to various biotic and abiotic stress. how plant adapted to the radiation environment.
CO 5. Comprehend the physiology of circulation and respiration, including under special environmental conditions, such as high altitude and deep seadiving.
CO 6. Know how some respiratory diseases arecaused.

Unit I (13 hours)

Principles of plant responses to environment; Problems of environment; Ecotypes - the role of genetics.Photoperiodism and its significance, endogenous clock and its regulation and development. Physiology of flowering, Senescence- types, causes, physiology of senescence and its significance,Abscission.

Unit II (13 hours)

Stress physiology: Plant response to biotic and abiotic stress. Stress tolerance, heat resistance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress; Plant adaptation to the radiationenvironment.

Unit III (13 hours)

Circulation: Types of heart and body fluids (blood and lymph); buffering properties of blood; blood circulation; Physiology and patterns of circulation; Circulatory physiological features in special environment viz., high altitude, deep seadiving.Respiration: Transport of oxygen and carbon dioxide; regulatory mechanisms of respiration, respiratory physiological features in special environments viz. high altitude, deep sea diving; respiratorydiseases.

References:

1. Schmidt-Nielson, K. (1981).AnimalPhysiologyAdaptationsandEnvironment. Cambridge University Press,Cambridge.
2. Prosser, C.L. & Brown (1983). ComparativeAnimalPhysiology.W.B.Saunders.
3. Hoar, W.S. (1976). General andComparativePhysiology,2nd Ed., Prentice Hall of India, New Delhi.
4. Wilson, J.A. (1979).Principles of Animal Physiology.MacMillan Pub., New York.
5. Hopkins, W.G. (1995). Introduction to Plant Physiology.JohnWiley and Sons, Inc. NewYork.
6. Galston, A.W. (1989). Life processes inplants. Springer-Verlag, NewYork.
7. Nobel P.S. (1999). Physico-chemical andEnvironmentalplantphysiology, Academic Press, San Diego, U.S.A.
8. TaizandZeiser,E. (1998).Plantphysiology.WordsworthPublishingCo., California,U.S.A.
9. Baldwin,E.(1964).AnIntroductiontocomparativebiochemistryCambridgeUniv. Press,Cambridge.
10. Berne, R.M. & Levy, M.N.(1991). Physiology. TheC.V. MosbyCompany, St. Louis.
11. Ganong, W.F.(1971).Review of Medical Physiology, 5thEd., KotheriBookDepot,Bombay.

12. Guyton, A.C.& Hall, J.E. (1996). Text Book ofMedicalPhysiology.9th Ed. W.B. Saunders Company, Philadelphia.
13. Jenson, D. (1976). Principles of Physiology, Appleton CenturyCrafts.

BSS 553DEVELOPMENTALBIOLOGY

39hrs

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Gain in-depth knowledge in the field of developmental biology
CO 2. Understand how gametes are produced, both in plants andanimals.
CO 3. Comprehend the process of cell differentiation at the molecularlevel.
CO 4. Understand how the early developmental events occur invertebrates.
CO 5. Know how the genes play a role in axis specification andembryogenesis.

Unit I (13 hours)

Introduction: Chief events in animal development; History of thoughts and conceptual developments; experimental embryology; the concepts of differential gene activity. Gametogenesis in animals: Spermatogenesis; Oogenesis; Molecular events during fertilization. Gametogenesis in a few plant systems; early development in a typical plant.

Unit II (13 hours)

Cell differentiation: Definition and concept, Mechanism of gene action during cell differentiation; Factors influencing cellular differentiation. Creating multicellularity Cleavage types; gastrulation; Fate maps; Concepts of determination; Morphogenetic cell movements- cell adhesion and contact inhibition. Competence and induction, totipotency; Nuclear transfer experiments.

Unit III (13 hours)

Morphogenetic determinants in egg cytoplasm; Germ cell determinants and germ cell migration; Early vertebrate development-cell movements, Gastrulation, germ layers – ectoderm, endoderm and mesoderm. Neurulation and organogenesis; Developmental patterns in metazoans; Body axes - establishment of body axes in mammals; Genetics of axis specification in *Drosophila*; Homeobox concept - homeotic genes

References:

1. Davidson, E. H.(1976). Gene activity in Early Development. Academic Press. NewYork.
2. Browder, L.W., Erickson, C.A., Jeffery, W.R.(1991). Developmental Biology, 3rdEd. Saunders, Philadelphia.
3. Russo, V.E.A., Brody, S., Cove, D., Ottolenghi, S.(1992). Development - the Molecular Genetic Approach. Springer Verlag-Berlin.
4. Cartwright, T. (1994). Animal cells as Bio-reactors. Cambridge University Press, New York.
5. Malacinski, G. M. (1988) Development genetics of higher organisms, as primer in developmental biology. MacMillan Press, NewYork
6. Berrill, N.J. (1981) Developmental Biology. Tata McGrawHill.
7. Tyler, M. S. (2000) Developmental Biology: A guide for experimental study. Sinauer Associates, MA,USA.
8. Sussman M. (2011) Animal growth and development. PrenticeHall
9. Buttery P.J., Lindsay, D. B., Haynes, N, B.(1986) Control and Manipulation of animal growth.Elsevier, London.

PRACTICAL COURSES
BSP 554 BIOTECHNOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Develop laboratory skills in biotechnology
CO 2. Use solid surface fermentation technique for production of antibiotics.
CO 3. Carry out PCR and do the analysis
CO 4. Do vermicomposting and mushroomcultivation.
CO 5. Perform plant tissue culture techniques and check the nutritional and anti-nutritional qualities of edible seeds.

1. Production and analysis ofvermicompost
2. Identification, collection and cultivation ofmushrooms
3. Submerged and solid-substratefermentation.
4. Production and assessment of enzymes, mycotoxins, organic acids andantibiotics.
5. Isolation and induction of root nodules byrhizobia
6. Isolation and mass production of arbuscular mycorrhizalspores.
7. Plant tissueculture
8. Evaluation of nutritional and antinutritional qualities of edibleseeds.
9. Evaluation of soil qualities (e.g. texture, bulk density and water holdingcapacity)
10. Evaluation of soil components (e.g. nitrogen, phosphorus, organiccarbon)
11. Pattern of decomposition of organic matter (e.g. leaf and woodylitter)
12. Biogasproduction
13. Functional properties of food (e.g. water absorption capacity, gelation, foaming and emulsion)
14. DNA extraction methods and PCR /RT PCR confirmation
15. Analysis of RT PCR data in terms of copy number or quantification.
16. Analysis of DNA and protein sequences.

BSP555 ENVIRONMENTAL PHYSIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Conduct experiments in environmental physiology
CO 2. Determine blood indices, blood pressure and thermal stress.
CO 3. Demonstrate rate of transpiration, effect of temperature on the rate of respiration and plant responses to salinity and metal stress..
CO 4. Know how to check the seed health and effect of salinity on seedgermination.
CO 5. Check viability of seeds, inducers and inhibitors ofgermination.

1. Haematology-
   - 1.1 Determination of bloodindices
   - 1.2 Determination of bloodpressure.
2. Respiration-
   - 2.1 Estimation of oxygen consumption by the organism under stressed condition (thermal stress).
   - 2.2 Demonstration of rate of transpiration byphotometry.
   - 2.3 Effect of temperature on the rate ofrespiration.
3. Seed physiology–
   - 3.1 Seed healthtesting.

3.2 Determination of percent viability of seeds by germinationmethod.
3.3 Germination inducers andinhibitors
3.4 Determination of β-amylase activity in germinatingseeds.
3.5 Effect of salinity on seedgermination.
4. StressPhysiology-
4.1 Plant responses against salinity and metalstress
4.2 Radioisotope methodology and its principles (GM Counter and Scintillationunter)

BSP 556 DEVELOPMENTAL BIOLOGY LAB

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Develop practical skillsusing model organisms in developmental biology
CO 2. Gain the skills to isolate and mount the imaginal discs, sex comb, genitalplate.
CO 3. Carry out practicals on developmental mutants in Drosophila andArabidopsis.
CO 4. Carry out staining techniques for gametes and embryo.

1. Study of model organisms used in developmentalBiology.
2. Isolation and mounting of imaginaldiscs.
3. Structure of sperms and eggs.
4. Isolation and mounting of sex comb and genital plate in*Drosophila.*
5. Study of developmental mutants in *Drosophila* and*Arabidopsis*.
6. Spiral cleavage and general development in snail.
7. Study of hemimetabolous and holometabolous development ininsects.
8. Life cycle and metamorphosis infrogs.
9. Structure of *Drosophila* and chickegg.
10. Study of chick embryo by vital stainingtechnique.
11. Developmental stages in frog.
12. Developmental stages inchick.
13. Study of spermatogenesis in rat.

BSP 557 PROJECT WORK

Course Outcomes:

After successful completion of the course, students will be able to:

CO 1. Carry out a research-based study - select a problem, frame the objectives, conduct literature review, tabulate, represent and interpret the results.
CO 2. Do field work for collection of samples, questionnaire-based surveys.
CO 3. Apply research methodologies, techniques and tools to conduct lab- / field-basedresearch
CO 4. Understand different types of standard methods of citation and references.
CO 5. Write the dissertation, presentand interpret the researchdata scientifically.
CO 6. Build up the capacity to carry out a research projectindependently.
CO 7. Get skilled to be appointed/absorbed based on the theme of the projectwork.
