Bachelor of Microbiology (B.Sc. Hons)
Syllabus

FIRST SEMESTER

BIO1101: DIVERSITY OF LOWER PLANTS [2 1 0 3]

Algae: Occurrence, general characteristics, classification system, thallus structure, pigments, reproduction and importance. Study of life cycle of the following genera: Volvox, Chara, Vaucheria. Bryophytes: Occurrence, distribution, general characteristics, alternation of generation, classification and economic importance. Study of life cycle of the Marchantia. Pteridophytes: Occurrence, general characteristics, classification, stele system, seed habit and heterospory, apospory and apogamy. Study of life cycle of the Marsilea. Comparative study of the algae, bryophytes and pteridophytes in general. Global applications of cryptogams in industry.

References:

1. V. Singh, P.C. Pande and D.K. Jain. Diversity of Microbes and Cryptogams, 5th Revised Edition, Rastogi Publication, Meerut, India. 2012.
2. N. S. Parihar. Biology and Morphology of Pteridophytes, Central Book Depot., Allahabad, 2002.
3. S. K Bassi, Diversity of Microbes and Cryptogams. S. Chand Publications, New Delhi, India, 2007.
4. B. R. Vashishta, A. K. Sinha and V. P. Singh. Botany for Degree Students: Algae, S. Chand Publications, New Delhi, India. 2014.
5. G. M. Smith. Cryptogamic Botany: Bryophytes and Pteridophytes, Tata McGraw Hill Publishing Co., New Delhi, 2008.
6. E. Karl. Cryptogams: Cyanobacteria, Algae, Fungi, Lichens. Cambridge University Press. 1982.

BIO1102: FUNDAMENTALS OF BIOTECHNOLOGY [2 1 0 3]

Biotechnology: Introduction and history. Basic concepts, definition and descriptions of some important terminology in biotechnology. Study of various branches of Biotechnology including plant, animal, medical, industrial, environmental, marine biotechnology, bioinformatics. Introduction of Techniques: Genetic engineering, plant and animal tissue culture, fermentation technology, immobilized enzymes, monoclonal antibodies and hybridoma technology, embryo transfer technology, introduction to gene and genomes, proteins and proteome, recombinant DNA technology, DNA fingerprinting and forensic analysis. Avenues of Biotechnology: Current status of biotechnology and future of biotechnology in developing world, role of biotechnology in Indian industry, new trends in biotechnology. Practice of biotechnology: Medicine, industry, agriculture, livestock improvement and environment.

References:

1. S. C. Bhatia, Textbook of Biotechnology. Atlantic Publisher and Distributor, New Delhi. 2012.
2. A. K. Chakravarty. Introduction to Biotechnology. Oxford University Press, New Delhi, 2013.
3. J. William, M. Thieman and A. Palladino. Introduction to Biotechnology. Benjamin Cummings. 2013.
4. R.W. Old and S.B. Primrose. Principles of Gene Manipulation. Blackwell Scientific Publications, U.K. 2006.

BIO1103: CELL BIOLOGY: STRUCTURE & FUNCTIONS [2 1 0 3]

History and Introduction of Cell: Cell theory, eukaryotic and prokaryotic cells, different models of cell membrane and structure of cell wall, active & passive transport. Cell organelles: Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplasts, Ribosome, Peroxisomes, Nucleus, lysosomes, Vacuole, Cytosol and Cytoskeleton (Microtubules, Microfilaments and Intermediate filaments). Discovery, morphology and structural organization of chromosome- chemical composition and karyotype. Cell Division: Amitosis, Mitosis & meiosis, cell cycle. Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways. Cellular communication: Cell adhesion and roles of different adhesion molecules. Cell Senescence and Programmed Cell Death (PCD).

References:

1. S. C. Rastogi. Cell Biology, Tata Mc Graw Hill Pub. Co. New Delhi, 2017.
2. P. K. Gupta. A Textbook of Cell and Molecular Biology, Rastogi Publications, Meerut, 2012.
3. B. Alberts, D. Bray, J. Lewis, M. Raff and J.D. Watson. Molecular Biology of the Cell, Garland Publishing Inc. New York, 2017.
4. D. Robertis, Cell and Molecular Biology, Waverly International, New York, 2011.
5. H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, and J. Darnell, Molecular Cell Biology, WH Freeman & Co., New York, 2013.

BIO1130: BOTANY LABORATORY-I [0 0 2 1]

To make students aware about the major contributors in the field of microbiology- Louis Pasteur, Leeuwenhoek, Koch, Metchnikoff, Paul Ehrlich, Flemming. To study morphology of bacteria using Gram's staining. Microscopic preparation and study of the following algae: *Volvox, Chara, Vaucheria, Polysiphonia*. Study of external morphology and microscopic preparation of *Marchantia* (VTS of thallus, gemma cup, HLS of antheridiophore, archegoniophore), *Anthoceros* (Thallus, rhizoids, Sporogonium), *Sphagnum (*external structure of thallus). External study and microscopic double stained preparation of reproductive parts of *Lycopodium, Selaginella, Equisetum* and *Marsilea*. Study of specimens and permanent slides of sporophyte of all the above Pteridophytes.

BIO1131: BIOTECHNOLOGY LABORATORY-I 0 0 4 2]

Laboratory: Introduction to lab and lab environment, Good Laboratory Practices (GLP), Identification of different cells, mito sis in onion root tip. Study of electron micrographs of cell organelles- cell ultrastructure, specialized chromosomes, nucleus, Golgi body and endoplasmic reticulum. Study of different stages of mitosis in onion root tip. Study of different stages of meiosis in anthers of *Datura innoxia*. Study of Permanent slides of different cell organelles and specimens in the above-mentioned class work material.

CAP1170 FUNDAMENTALS OF COMPUTERS [1 1 0 2]

Computer Fundamentals, Definition and Purpose, Data, Information and Knowledge, Characteristics of Computers, Classification of Computers, Generations of Computer, Basic organization of Computer, System Software and Application Software. Operating Systems and Multimedia, Types of Operating System, Windows v/s Linux, Mobile based OS, Multimedia, Definition and Types , Multimedia Software, Computer Networks, Applications of Networking, Network Topologies- Mesh, Bus, Star, Ring, Types of Network (LAN, MAN, WAN), Network Cables- Optical Fiber, Twisted, Co-axial, Network Devices- Hubs, Switch, Router, Network Interface Card, Ethernet, Internet, Introduction and Usage of Internet, Internet Connectivity Options (Wired and Wireless), IP Addressing and DNS, Website, URL, HTML, Web Browser and Search Engines, Operational Guideline of Computer Usage, Do's and Don'ts of Computer, E-mails, Email Etiquettes, Cyber Security, Internet Frauds, Secure Password Formation , Computer Security, Malware, Virus, Ransomware, Social Media and its Impact.

References:

1. R. Thareja, Fundamental of Computer, (1e) Oxford Publications, 2014.
2. K. Atul, Information Technology, (3e) Tata McGraw Hill Publication, 2008.

CAP1175 FUNDAMENTALS OF COMPUTERS LAB [0 0 2 1]

Computer Peripheral and Windows operations, MS WORD- Creating and formatting of a document, Introduction of cut, copy and paste operations, to explore various page layout and printing options, creating. Formatting, editing Table in MS word, Introduction of Graphics and print options in MS word, Introduce the student with mail merge option. MS EXCEL- creation of spreadsheet and usage of excel, Formatting and editing in worksheet, Sorting, searching in Excel sheets, using formula and filter in MS excel, printing and additional features of worksheet, maintaining multiple worksheet and creating graphics chart. MS POWER POINT – creation of presentation, Power point views, creating slides and other operations, using design, animation, and transition in slides, Internet Tools, Using Email and Outlook facilities, Google Drive, Google Forms, Google Spreadsheet, Google groups.

References:

1. R. Thareja, Fundamental of Computer, (1e) Oxford Publications, 2014.
2. K. Atul, Information Technology, (3e) Tata McGraw Hill Publication, 2008.

CHY1003: ENVIRONMENTAL SCIENCE [3 0 0 3]

Introduction: Multidisciplinary nature, scope and importance, sustainability and sustainable development. Ecosystems: Concept, structure and function, energy flow, food chain, food webs and ecological succession, examples. Natural Resources (Renewable and Non-renewable Resources): Land resources and land use change, Land degradation, soil erosion and desertification, deforestation. Water: Use and over-exploitation, floods, droughts, conflicts. Energy resources: Renewable and non- renewable energy sources, alternate energy sources, growing energy needs, case studies. Biodiversity and Conservation: Levels, biogeographic zones, biodiversity patterns and hot spots, India as a mega-biodiversity nation; Endangered and endemic species, threats, conservation, biodiversity services. Environmental Pollution: Type, causes, effects, and controls of Air, Water, Soil and Noise pollution, nuclear hazards and human health risks, fireworks, solid waste management, case studies. Environmental Policies and Practices: Climate change, global warming, ozone layer depletion, acid rain, environment laws, environmental protection acts, international agreements, nature reserves, tribal populations and rights, human wildlife conflicts in Indian context. Human Communities and the Environment: Human population growth, human health and welfare, resettlement and rehabilitation, case studies, disaster management, environmental ethics, environmental communication and public awareness, case studies. Field Work and visit.

References:

1. R. Rajagopalan, Environmental Studies: From Crisis to Cure, Oxford University Press, 2016.
2. A. K. De, Environmental Studies, New Age International Publishers, New Delhi, 2007.
3. E. Bharucha, Textbook of Environmental Studies for undergraduate courses, Universities Press, Hyderabad, 2013.
4. R. Carson, Silent Spring, Houghton Mifflin Harcourt, 2002.
5. M. Gadgil & R. Guha, This Fissured Land: An Ecological History of India, University of California Press, 1993.
6. M. J. Groom, K. Meffe Gary and C. R. Carroll, Principles of Conservation Biology, OUP, USA, 2005.

LLC1106: COMMUNICATIVE ENGLISH [2 0 0 2]

Communication- Definition, Process, Types, Flow, Modes, Barriers; Types of Sentences; Modal Auxiliaries; Tenses and its Usage; Voice; Reported Speech; Articles; Subject-Verb Agreement; Spotting Errors; Synonyms and Antonyms; One Word Substitution; Reading Comprehension; Précis Writing; Essay Writing; Formal Letter Writing; Email Etiquettes; Résumé & Curriculum Vitae; Statement of Purpose; Presentations

References:

1. Collins English Usage. Harpers Collins, 2012.
2. Hobson, Archie Ed. The Oxford Dictionary of Difficult Words. Oxford, 2004.
3. Jones, Daniel. English Pronouncing Dictionary. ELBS, 2011.

4. N. Krishnaswamy, Modern English: A Book of Grammar Usage and Composition, Macmillan India, 2015.
5. Longman Dictionary of Contemporary English. Pearson, 2008.
6. M. McCarthy, English Idioms in Use. Cambridge UP, 2002.
7. S. Mishra, C. Muralikrishna. Communication Skills for Engineers. Pearson, 2004.
8. Oxford Dictionary of English. Oxford UP, 2012.
9. N. D. Turton, J.B. Heaton. Longman Dictionary of Common Errors. Pearson, 2004.

SECOND SEMESTER

BIO1201: MYCOLOGY AND PLANT PATHOLOGY [2 1 0 3]

Fungi: Occurrence, general characteristics, structure, classification (Alexopoulos and Mims, 1979), recent developments in fungal taxonomy, reproduction, parasexual cycle, heterothallism, mushroom cultivation, economic and ecological importance, Study of life cycle of the following genera: *Albugo, Puccinia.* Plant diseases and their control measures: history, classification, symptoms, defense mechanism, mechanism of host parasite interaction, transmission and dissemination of diseases. Causal organisms of disease cycle of the following: green ear disease of Bajra, rust of Crucifers, rusts and smuts of Wheat. Disease Management: prophylaxis-quarantine measures, biological control and integrated pest management. Association of Algae and Fungi: General characteristics, structure, types, reproduction and ecological importance.

References:

1. H.C. Dube. An Introduction to Fungi, Vikas Publishing House Pvt., Ltd. Delhi, 2013.
2. V. N. Pathak, N.K. Khatri and M. Pathak, Fundamentals of Plant Pathology, Agrobios, Jodhpur, 2012.
3. B. R. Vashishta, A. K. Sinha and A. Kumar. Botany for Degree Students: Fungi. S. Chand & Company Pvt. Ltd, New Delhi, 2016
4. C. J. Alexopoulos, C.W. Mims, and M. Blackwel, Introductory Mycology, John Wiley & Sons Inc, New Delhi, 2012.
5. R.S. Singh, An Introduction to Principles of Plant Pathology, Oxford and IBH Publishing Co. Pvt. Ltd., Nw Delhi, 2011.

BIO1202: ELEMENTS OF BIOCHEMISTRY [2 1 0 3]

Introduction to Biochemistry: Structure and properties of important biomolecules: Carbohydrates: Classification of carbohydrates, chemical structure and properties of monosaccharide, disaccharides, oligosaccharides and polysaccharides- Starch, cellulose and glycogen. Lipids: Saturated and unsaturated fatty acids. Protein: Structure and classification of amino acids. Primary, secondary and tertiary structure of protein. Ramachandran Plot. Membrane proteins, Hydropathy plots, Significance of membrane proteins. Vitamins: Structure and functions. Principles of thermodynamics: First and Second law of thermodynamics, concept of free energy. Enzymes: classification, nomenclature, holoenzyme, co-enzyme and cofactors, isozymes and ribozymes. Features of enzyme catalysis, Enzyme kinetics: Michaelis-Menten equation, Lineweaver-Burk plot, Eadie-Hofstee and Hanes plot. K_m and V_{max}, K_{cat} and turnover number. Enzyme inhibition, regulation of enzyme activity. Purine and Pyrimidine: structure and properties, nucleotid e biosynthesis, Conformation of nucleic acids [helix (A, B, Z), t-RNA, micro-RNA].

References:

1. H.S**.** Srivastav. Elements of Biochemistry**,** Rastogi Publication, Meerut, 2005.
2. J. L. Jain. Fundamentals of Biochemistry. S. Chand & Co. Pvt. Ltd. New Delhi, 2016.
3. J. Jayaraman. Laboratory Manual in Biochemistry, New Age Publishers, New Delhi, 2011.
4. A. J. Ninfa, D.P. Ballou and M.B. Parsons. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Wiley Inter Science, 2009.
5. D. Voet and J. G. Voet. Biochemistry, John Wiley & Sons Inc., New Delhi, India, 1995.
6. A. Lehninger, D. L. Nelson and M. M. Cox. Principles of Biochemistry, Freeman Publishers, New York, 2017.
7. M. Holtzhauer. Basic Methods for the Biochemical Lab, Springer, USA, 2006
8. S. O. Farrell and L.E. Taylor. Experiments in Biochemistry: A Hands-on Approach, Cengage Learning, USA, 2005.

BIO1211: CELL BIOLOGY OF MICROORGANISMS [2 1 0 3]

An Overview of Microbial Cell: Comparative study of archaebacteria, eubacteria and eukaryotic cells. Cell organization: Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili, cell-wall, cell membrane, cytoplasm, ribosomes, chromosome and plasmids, endospore. Reproduction in Bacteria: Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate. Bacterial Systematics: Concept of species, taxa, strain, conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota: Methanogens (*Methanobacterium*, *Methanocaldococcus*). Eubacteria: Morphology, metabolism, ecological significance and economic importance of Gram Negative: Non proteobacteria, Alpha proteobacteria, Beta proteobacteria, Gamma proteobacteria, Delta proteobacteria, Epsilon proteobacteria, Zeta proteobacteria, Gram Positive: Low G+ C (Firmicutes), High G+C (Actinobacteria). Cyanobacteria.

References:

1. S.C. Rastogi. Cell Biology, Tata McGraw Hill Pub. Co. New Delhi, 2010.
2. P. K. Gupta. A Textbook of Cell and Molecular Biology, Rastogi Publications, Meerut, 2019.
3. J. Willey, L. Sherwood and C. J. Woolverton. Prescott's Microbiology, Tata McGraw Hill Publishing, 10th Edition, 2017.

4. B. Alberts, D. Bray, J. Lewis, M. Raff and J.D. Watson. Molecular Biology of the Cell, Garland Publishing Inc. New York, 2017.
5. D. Robertis, Cell and Molecular Biology, Waverly International, New York, 2011.
6. H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, and J. Darnell, Molecular Cell Biology, WH Freeman & Co., New York, 2013.

BIO1212: MICROBIAL NUTRITION AND GROWTH [2 1 0 3]

Microbial Nutritional Types and Requirements: Carbon, Oxygen, Hydrogen, Nitrogen, Phosphorus, Sulphur and Growth factors. Nutrient uptake mechanisms. Types of culture media. Isolation, pure culture and preservation techniques of microorganisms and pure culture techniques of microorganisms. Microbial Growth: Definition of growth, growth curve and kinetics, cultivation of anaerobic bacteria. Measurement of Growth: Direct Microscopic count-Petroff-Hausser counting chamber, hemocytometer, spread plate and pour plate techniques, membrane filtration, cell mass and turbidity measurement. Synchronous growth, Continuous growth (chemostat and turbidostat), Diauxic growth and Growth Yield. Influence of environmental factors on growth. Viable non-culturable organisms. Control of Microorganisms: Pattern/Rate of Microbial Death.

References:

1. M.J. Pelczar, E.C.S. Chan and N.R. Krieg. Microbiology. 5thedition. McGraw Hill Book Company, 1993.
2. S. Srivastava and P.S. Srivastava. Understanding Bacteria. Kluwer Academic Publishers, Dordrecht, 2003.
3. J. Willey, L. Sherwood and C. J. Woolverton. Prescott's Microbiology, Tata McGraw Hill Publishing, 10th Edition, 2017.
4. R.Y. Stanier, J.L. Ingraham, M.L. Wheelis, and P.R. Painter. General Microbiology. 5thedition. McMillan, 2005.
5. G.J. Tortora, B.R. Funke, and C.L. Case. Microbiology: An Introduction. 9th edition Pearson Education, 2008.
6. M.T. Madigen, J.M. Martinko, K.S. Bender, D.H. Buckley, D. A. Stahl and T. Brock. Brock Biology of Microorganisms. 15th edition, Benjamin Cunnings-Pearson, 2018.

BIO2134: MICROBIOLOGY LABORATORY - III [0 0 4 2]

Introduction to Laboratory Safety and Biosafety Levels Protocol, Collection and Isolation of Viruses Cultivation of virus into cells lines, Isolation of viral genetic material (DNA/RNA). Detection of viral antigens or antibodies in the culture supernatant by ELISA, Collection and Isolation of bacteriophages. Identification and characterization of isolated bacteriophages via plaque assay. Isolation and purification of DNA from microbial cells (Bacteria). Elution of DNA from agarose gel. Determination of plasmid in given bacterial strain Isolation and purification of DNA from microbial cells (Bacteria). Agarose gel electrophoresis of isolated DNA. Elution of DNA from agarose gel. Determination of plasmid in given bacterial strain. Isolation of bacteriophage, demonstration of bacteriophage specificity. Bacteriophage Enumeration (PFU) and detection. One step multiplication curve.

THIRD SEMESTER

BIO2101: FUNDAMENTALS OF BIOINFORMATICS [2 1 0 3]

Introduction to Bioinformatics: Background, scope and application of bioinformatics. Genome organization: Genomes, transcriptome and proteomes, Evolution of genomes, Sequencing projects (Homo sapiens and E. coli), Biological databases: Gene, protein, and structural databases. Sequence alignment and phylogenetic trees: Similarity, identity, and homology ((BLAST). Alignment – local and global alignment, pairwise and multiple sequence alignments (CLUSTALW), alignment algorithms, amino acid substitution matrices (PAM and BLOSUM), Construction of phylogenetic tree, dendrograms. Structural bioinformatics and drug discovery: Protein structure prediction methods, drug discovery and development.

References:

1. T. K. Attwood, and P. Smith. Introduction to Bioinformatics, Pearson Education, New Delhi, 2004.
2. S. C. Rastogi, N. Mendairatta and P. Rastogi. Bioinformatics: Methods and Applications (Genomics, proteomics and drug discovery,) Printice Hall India Pvt. Ltd. New Delhi, 2008.
3. C. Subramanian. A textbook of Bioinformatics. Dominat Publishers. New Delhi. 2015.
4. S. Pennigton and M.J. Dunn. Proteomics: From protein sequences to function, Viva Books Publishers, New Delhi, 2002.
5. D. H. Mount. Bioinformatics, CBS Publishers, New Delhi, 2005.

BIO2111: MICROBIAL GENETICS [3 1 0 4]

Basic concepts of microbial genetics. Nucleic acids transfer genetic information: DNA as the carrier of genetic information, Central Dogma, DNA Double helix, genetic code. Bacterial Genetics and its Analysis: Importance and tools. The Origin of Mutations: Fluctuation test, Newcombe test and Replica plating. Genetic exchange in bacteria and its evolutionary role. Competence in the Gram+ B. subtilis. Plasmids: General properties, replication and partitioning. Conjugation: Transfer mechanism of self- transmissible plasmids; F plasmid, Hfr strains, Prime factors. History and mechanism of transformation. Introduction to Viral Genetics: Lytic bacteriophages: developmental cycle, replication, genetic analysis. Genetic experiments with the rII genes of T4 and the discovery of the genetic code. Transduction. Lysogenic phages, Lambda & Genetic analysis of Lambda mutants. Bacterial defense systems. CRISPR. Toxin-Antitoxin systems. Microbial DNA replication, recombination, transcription and regulation of gene expression. DNA mutation and repair. Cell division in bacteria and archaea. Rolling circle replication and theta model. Genome segregation. Developmental Genetics.

References:

1. L. Snyder, W. Champness. Molecular Genetics of Bacteria, 3rd edition ASM Press, 2011.
2. E. A. Birge. Fundamentals of bacterial and bacteriophage genetics, Springer, 2000.
3. N. J. Dimmock, A.J. Easton, K.N. Leppard. Introduction to modern virology, 6th edition, Blackwell publishers. 2014.
4. B. A. Pierce. Genetics: A conceptual Approach. MacMillan Publishers, UK, 6th edition, 2017.
5. M. T. Madigen, J.M. Martinko, K.S. Bender, D.H. Buckley, D. A. Stahl and T. Brock. Brock Biology of Microorganisms. 15th edition, Benjamin Cunnings-Pearson, 2018.
6. W. S. Klug, M.R. Cummings, C.A. Spencer. Concepts of Genetics. 11th edition, Benjamin Cummings, 2009.
7. A. J. F. Griffiths, S.R. Wessler, R. C. Lewontin and S.B. Carroll. Introduction to Genetic Analysis, 9th edition, W. H. Freeman & Co., 2010.

BIO2112: VIROLOGY [3 1 0 4]

Nature and Properties of Viruses: Discovery of viruses, concept of viroids, virusoids, satellite viruses and Prions, theories of viral origin, Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses. Bacteriophages: Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage). Modes of viral transmission: Persistent, non-persistent, vertical and horizontal, unusual bases (TMV,T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picorna virus), capping and tailing (TMV). Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna), Assembly, maturation and release of virions, Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes. Prevention & control of viral diseases: Antiviral compounds and their mode of action, interferon and their mode of action, general principles of viral vaccination. Applications of Virology: Use of viral vectors in cloning and expression, Gene therapy and Phage display.

References:

1. E.A. Birge. Fundamentals of bacterial and bacteriophage genetics, Springer, 2000.
2. N.J. Dimmock, A.J. Easton, K.N. Leppard. Introduction to modern virology, 6th edition, Blackwell publishers. 2014.
3. R.Y. Stanier, J.L. Ingraham, M.L. Wheelis, and P.R. Painter. General Microbiology. 5th edition. McMillan publishers, 2005.
4. J Willey, L. Sherwood and J Woolverton. Prescott's Microbiology. McGwaw Hill Education, USA, 2017.

BIO2133: BIOLOGY LABORATORY-III [0 0 4 2]

Analysis of protein structure by PyMol, PDB, NCBI and EMBL (Accession of information), BLAST and FASTA search, Alignments – pair wise and multiple sequence alignment – CLUSTALW and X. Primary sequence analyses (Protparam). • Secondary structure prediction (GOR, nnPredict). Tertiary structure prediction (SWISSMODEL). • Protein structure evaluation - Ramachandran map (PROCHECK).

References:

1. T. K. Attwood, and P. Smith. Introduction to Bioinformatics, Pearson Education, New Delhi, 2004.
2. S. C. Rastogi, N. Mendairatta and P. Rastogi. Bioinformatics: Methods and Applications (Genomics, proteomics and drug discovery,) Printice Hall India Pvt. Ltd. New Delhi, 2008.
3. C. Subramanian. A textbook of Bioinformatics. Dominat Publishers. New Delhi. 2015.
4. S. Pennigton and M.J. Dunn. Proteomics: From protein sequences to function, Viva Books Publishers, New Delhi, 2002.
5. D. H. Mount. Bioinformatics, CBS Publishers, New Delhi, 2005.

FOURTH SEMESTER

BIO2201: INTRODUCTION TO BIOTECHNIQUES [2 1 0 3]

Microscopy: Light microscope, resolution and visibility, types, applications of microscopes. pH meter: Calibration and standardization of pH meter. Colorimeter: Calibration of colorimeter, calibration curve, principle, description and application of colorimeter. Electrophoresis: Principle, types, horizontal, vertical and two-dimensional gel electrophoresis. Spectroscopy: Principle and law of absorption- Beer -Lambert's law, UV-visible spectroscopy. Chromatography: Principle, types - paper, thin layer, adsorption, ion-exchange, affinity, gel filtration, gas and HPLC, ion exchange chromatography. Centrifugation: Principle of sedimentation, types and uses, different types of rotors and autoradiography.

References:

1. K. Ghatak. Techniques and Methods in Biology, PHI Learning Pvt. Ltd., New Delhi, 2015.
2. S. V. S. Rana. Biotechniques: Theory and Practice, Rastogi Publications, Meerut, 2007.
3. H. Willard and H. Merrit. Instrumental Methods of Analysis, Prentice Hall India Publications, New Delhi, 2008.
4. D. Skoog. Instrumental Methods of Analysis, International Thomson Computer Press, UK, 2007.
5. A. Hoffmanna and S. Clokie. Wilson and Walker's, Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, UK. 2018.

BIO2202: FUNDAMENTALS OF IMMUNOLOGY [2 1 0 3]

Immunology: History, types of immunology (Innate and acquired), active and passive, humoral and cell mediated immunology. Types of Immune Cells: Myeloid and Lymphoid Lineages. Cells of Immunology: B & T cells. Antigen and Immunogens: Characteristic of antigen, adjuvants, haptens. Antibody: Types and structure, antigen and antibody interactions. Interferon: Introduction, immunodeficiency and HIV, prions and diseases. Blood Groups: Blood cell components, ABO blood groups, Rh typing.

References:

1. P. M. Rajasekara and S. B. Kumar. Immunology and ImmunoTechnology, Panima Publishing Corporation, New Delhi, 2007.
2. J. Kuby. Immunology, Freeman and Company, New York, 2013.
3. A. Nigam and A. Ayyangari. Lab Manual in Biochemistry, Immunology and Biotechnology, McGraw-Hill Education, India, 2008.
4. A. Sharma. Immunology: Concepts and Techniques, Indiana University Press, USA, 2007.
5. T. A. Springer. Hybridoma Technology in the Biosciences and Medicine, Plenum Press, New York, 2004.

BIO2203: **RECOMBINANT DNA TECHNOLOGY AND FORENSICS [3 1 0 4]**

Basics of Genetic Engineering Technology: Milestones in genetic engineering and biotechnology. Tools of recombinant DNA technology. Restriction modification systems: Types I, II and III, mode of action, nomenclature, application of Type II restriction enzymes in genetic engineering. DNA modifying enzymes and their applications. Cloning Vectors: Plasmid, cosmids, phage vectors, BAC, YAC and shuttle vectors, linkers and adaptors. Transformation of DNA by chemical and physical methods. Methods of gene delivery in plants and animals: Microinjection, biolistic method (gene gun), liposome and viral-mediated delivery. Introduction to GM crops. Amplification of nucleic acids: Polymerase chain reaction- enzymes used, primer design. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. RNAi technology. Forensic Science: Definition, introduction, basic principles & significance, history & development of forensic science in India and World, organizational structure of Forensic Science laboratory, different divisions and their field of work and units of Forensic Science Laboratory, organiz ational Structure of forensic science teaching institution.

References:

1. P.K. Gupta. A Textbook of Cell and Molecular Biology, Rastogi Publications, Meerut, 2012.
2. B.D. Singh. Molecular Biology and Genetic Engineering. Kalyani Publishers, New Delhi, India. 2005.
3. B.B. Nanda, and R.K. Tewari R.K. Forensic Science in India: A vision for the twenty first century. Select Publisher, New Delhi. 2001.
4. R.W. Old and S.B. Primrose. Principles of Gene Manipulation: An Introduction to Genetic Engineering, Blackwell Science Publications, New Delhi, 2003.
5. B. Lewin. Genes XII, Oxford University Press, Oxford, New York. 2013.

BIO2211: FOOD AND DAIRY MICROBIOLOGY [3 1 0 4]

Food as a Substrate for Microorganisms: Intrinsic and extrinsic factors that affect growth and survival of microbes in foods and source of contamination of food, Microbial spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods. Food Preservation: principles, Physical Methods of Food Preservation Temperature: Irradiation, microwave processing and aseptic packaging, chemical methods of food preservation. Fermented Foods: Dairy starter cultures fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, Dahi cheese and other fermented foods. Food Borne Diseases: Causative agents, symptoms and preventive measures. Food Intoxication: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins. Food Infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*. Food Sanitation and Control: HACCP, Indices of food sanitary quality and sanitizers; important institutions of dairy technology in India.

References:

1. J.M. Jay, M.J. Loessner and D.A. Golden. Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India, 2005.
2. J.M. Banwart. Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India, 1987.
3. H.A. Modi. Fermentation Technology Vol 1 & 2, Pointer Publications, India, 2009.
4. H.J. Peppler, D. Perlman. Microbial Technology Vol 1 & 2, Academic Press, 2014.
5. W.C. Frazier and D.C. Westhoff. Food Microbiology. 3rd edition. Tata McGraw-Hill Publishers, New Delhi, 1992.
6. P.M. Davidson PM and A.L. Brannen AL. Antimicrobials in Foods. Marcel Dekker, New York, 1993.
7. J. Willey, L. Sherwood and C. J. Woolverton. Prescott's Microbiology, Tata McGraw Hill Publishing, 10th Edition, 2017.

BIO2212: MEDICAL MICROBIOLOGY [2 1 0 3]

Host microbe interaction, Mechanism of pathogenicity. Laboratory strategies in diagnosis of infective syndrome. Pathogen, Pathogenicity, Virulence, Disease, Determinants of infectious diseases-transmissibility, Attachment and colonization, Entry, growth and multiplication, Toxigenicity- Exotoxins and endotoxins. Developmental Processes in Bacteria: Quorum sensing, Biofilm formation and persistence. Skin Infections: Frunucle, Chicken pox, Measles and Herpes simplex. Respiratory Infections: Diphtheria, Pneumonia, Tuberculosis, Influenza and Rheumatic fever. Alimentary Infections: Dental plaque, Cholera, Typhoid fever, Giardiasis and Amoebiasis. Nervous System Infections: Leprosy, poliomyelitis, Rabies and meningitis. Sexually Transmitted Diseases (STDs). Parameters of blood and urine examination.

References:

1. P. Chakraborty. A Textbook of Microbiology. 2nd Edition, Published by New Central Book Agency (P) Ltd., Kolkata. 2013.
2. S. Rajan. Medical Microbiology. Neha Publishers & Distributors., New Delhi, 2005
3. Anathanarayana and Paniker, Textbook of Microbiology. Orient and Longman, New Delhi, 2005.
4. P.R. Murray, K.S. Rosenthal, M.A. Pfaller. Medical Microbiology, 7th edition, Jaypee Medical, 2012.
5. M.J. Pelczar, E.C.S Chan and N.R Krieg. Microbiology. McGraw Hill Book Company, New York, 2001.
6. M.H. Jawetz, A.D. Brooks, Butel and Orston, Medical Microbiology, Prentice Hail Inc. London, 2005.

BIO2232: BIOLOGY LABORATORY -IV [0 0 4 2]

Working principles of various available laboratory instruments: Laminar air flow cabinet, centrifuge, spectrophotometer, oven, incubator, BOD incubator, autoclave. Study of UV absorption spectra of macromolecules (protein and nucleic acid).

Determination of protein and nucleic acid concentration by spectrophotometric method. To identify blood group of the given human blood sample; To perform total and differential leukocyte count of the given blood sample; To perform immune double diffusion by Ouchterlony method, To perform DOT ELISA using the given antigen-antibody samples, Blood film preparation and identification of cells, to perform preparation of antigens, to study the separation of lymphocytes from peripheral blood sample from Rat, To perform Immuno-electrophoresis using the given antigen-antibody samples. To perform digestion of DNA using restriction enzymes, separation and analysis by agarose gel electrophoresis, To perform ligation of DNA fragments using ligase enzyme, to perform competent cell preparation.

BIO2233: MICROBIOLOGY LABORATORY-IV [0 0 4 2]

To perform MBRT of milk samples and their standard plate count, To perform alkaline phosphatase test to check the efficiency of pasteurization of milk, Isolation of bacteria from food and food-products, Isolation of spoilage microorganisms from spoiled vegetables/fruits, Isolation of spoilage microorganisms from bread, Preparation of Yogurt/Dahi, Determination of potability and faecal contamination of water samples by presumptive test/MPN test, confirmed and completed tests, To study different preservation techniques: temperature, irradiation, microwave processing and aseptic packaging, chemical methods of food preservation. Tests for the detection of enteric pathogens. To identify bacteria (E. coli, Pseudomonas) based on cultural, morphological and biochemical characteristics. Cultural characteristics on nutrient agar and in nutrient broth, Gram characteristic, motility, presence of endospore and capsule, IMViC, TSI, sugar fermentation, nitrate reduction, urease production, oxidase and catalase tests, To study composition of important differential media for identification of pathogenic bacteria EMB agar, McConkey agar. To study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV, AIDS, dermatomycoses.

FIFTH SEMESTER

BIO3111: INDUSTRIAL MICROBIOLOGY [2 1 0 3]

Introduction to Industrial Microbiology: Brief history and developments in industrial microbiology. Fermentation processes: Solid-state and liquid-state (stationary and submerged) fermentations, Batch, and continuous fermentations. Bioreactors/Fermenters: Components of a typical bioreactor, stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. Measurement and Control of Fermentation Parameters: pH, temperature, dissolved oxygen, foaming and aeration, isolation, development, preservation and maintenance of industrially important microbial strains. Media and Ingredients for Industrial Fermentations: crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract. Down-Stream Processing: Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying. Microbial Production of Industrial Products (micro-organisms involved, media, fermentation conditions, downstream processing and uses): Ethanol, wine, beer, penicillin, riboflavin, amylase, glucose oxidase, cellulose.

References:

1. G. Reed. Prescott and Dunn's, Industrial Microbiology, 4th Edition, McMillan Publishers, 2004.
2. A.H. Patel, Industrial Microbiology, Macmillan Publishers India Limited, 2011.
3. L.E. Casida Industrial Microbiology. New Age Publishers, 2016.
4. A.L. Demain, N.A. Solomon. Manual of Industrial Microbiology and Biotechnology. ASM Press, 1986.

BIO3113: ENVIRONMENTAL MICROBIOLOGY [3 1 0 4]

Soil Microbiology: Formation and composition of soil, estimation of soil microflora, soil management, rhizosphere- positive and negative interactions among soil microflorae. Water Microbiology: Microbiology of water and water bodies, water purification, eutrophication. Waste Water Treatment: Primary treatment, secondary treatment, advanced and final treatment. Air Microbiology: Composition and analysis of air, aero microflora of different habitats, aeroallergens. Biogeochemical Cycles: Role of microbes in Nitrogen and Carbon cycles. Water Potability: Treatment and safety of drinking (potable) water, methods to detect potability of water samples. Role of biotechnology in pollution detection and control. Biosensors for the detection of pollutants. Bioremediation: Use of microbes, plants, bio-surfactant and bio emulsifiers in biodegradation and biotransformation, biodegradation of agricultural chemicals.

References:

1. R.E. Campbell. Microbial Ecology. Blackwell Scientific Publication, Oxford, England, 1983.
2. N.S. Subba Rao. Soil Microbiology. Oxford & IBH Publishing Co. New Delhi, 2017.
3. D.J. Bagyaraj and G. Rangaswamy. Agricultural Microbiology. Prentice Hall Publishers Pvt. Ltd. India, 2005.
4. R.M. Maier, I.L. Pepper and C.P. Gerba. Environmental Microbiology. 2nd edition, Academic Press, 2009.
5. A. Martin. An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons, 1977.

BIO3114: MOLECULAR GENETICS [2 1 0 3]

An introduction to Molecular Genetics: Basis of life, central dogma, identification of the genetic material: classical experiments of Hershey Chase, F Griffith, Avery McLeod etc. Organization of genome: interaction with histones at its different levels, molecular structure of nucleic acids, DNA packaging, DNA replication and its requirements, transcription, and translation. Fine structure of genes: The concept of promoter, regulator, enhancer, operator, structural genes, coding sequence and non-coding sequences, gene expression and regulation, inducible and repressible gene expressions, operon concept- lac operon.

References:

1. B.D. Singh. Biotechnology. Kalyani Publishers, New Delhi, India. 2021.

2. P. K. Gupta. Textbook of Cell and Molecular Biology, Rastogi Publications, Meerut, 2022.
3. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. Molecular Biology of the Cell, Garland Publishing Inc., New York, 2021.
4. G. Karp. Cell and Molecular Biology: Concepts and Experiments, John Wiley & Sons, New Delhi, 2008.
5. H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore and J. Darnell. Molecular Cell Biology, WH Freeman & Co. New York, 2013.

BIO3132: MICROBIOLOGY LABORATORY-V [0 0 4 2]

Agarose gel electrophoresis, Isolation of genomic DNA. Determination of plasmid in given bacterial strain. Perform Southern Blot Hybridization. Perform Western Blot. Demonstration of DNA amplification by PCR. Media formulations using crude and synthetic components; Analysis of microbial fermentation process involving breakdown of carbon substances; Analysis of nitrogen utilized in microbial fermentation process; Estimation of nitrates and phosphates occurring in the microbial media via fermentation process; Isolation of microorganisms from samples; Isolation of microbes from rhizosphere of soil. Determination of the parameters viz. electrical conductivity, total dissolved solids and alkalinity of given water samples; Determination of mineral ions viz. calcium, magnesium, fluorides in drinking water as per BIS standards.

SIXTH SEMESTER

BIO3201: PHYSIOLOGY OF LIVING SYSTEMS [2 1 0 3]

Plant Physiology: Plant cell-water relations, water and mineral absorption. Transpiration, guttation, mineral nutrition- essential micro and macro nutrients, deficiency of minerals, nitrogen metabolism. Photosynthesis: Photosystems, photophosphorylation, Calvin cycle, C_4 pathway, CAM, photorespiration. Respiration: RQ, ATP- the biological energy currency, glycolysis, Kreb's cycle, Electron transport mechanism, oxidative phosphorylation, pentose phosphate pathway. Animal Physiology: Blood and Circulation: Blood corpuscles, Hemopoiesis and formed elements, Plasma function, Hemostasis. Cardiovascular System: Comparative anatomy of heart structure, Myogenic heart, Specialized tissue, Cardiac cycle, Blood pressure. Respiratory System: Transport and exchange of gases. Nervous System: Central and peripheral nervous system, Neural control of muscle tone and posture.

References:

1. S.K. Verma. Plant Physiology and Biochemistry, S. Chand & Sons, New Delhi, 2012.
2. R.M. Devlin. Plant Physiology, East-West Press Pvt. Ltd. New Delhi, 1997.
3. W.G. Hopkins. Introduction to Plant Physiology, John Wiley & Sons Inc. New York, USA, 1995.
4. L. Taiz and E. Zieger. Plant Physiology, Sinauer Associates, Inc., Publishers, Massachusetts, USA, 2010.
5. P.B. Reddy. Textb o o k on animal physiology. Ratna Prasad Multidisciplinary Research & Educational Society, Ibrahimpatnam, Krishna, A.P., India. 2015.

BIO3211: BIOPROCESS TECHNOLOGY [2 1 0 3]

The microbial-derived products of white biotechnology: Definition of scope and product classes. Process flow diagrams for representative products. Over-production of primary and secondary metabolites: Classical mutagenesis and directed selection strategies in the context of the microbial control of metabolite production. Control of anabolic and catabolic metabolism in microbes: feedback inhibition and repression, attenuation, induction and repression control of enzyme synthesis. Catabolite repression. Choice of cell factory for bioprocesses: Factors influencing the choice of in vitro cell production platforms for industrial processes: comparison of bacteria, yeasts, filamentous fungi, insect and mammalian cells. Transgenic animals and plants as 'bioreactors'. Human health biopharmaceutical production: A technical and market review of the different classes of biologicals, encompassing an upstream bioprocess design perspective, therapeutic monoclonal antibodies, cytokines, growth factors, hormones, blood products, enzymes and vaccines. Biopharmaceutical process characterization case studies: (i) Production of recombinant coagulation Factor IX; (ii) Production of a monoclonal antibody, Infliximab. Downstream processing: introduction, principles and characteristics. Cell disruption for product release: mechanical, enzymatic and chemical methods. Isolation: adsorption, liquid-liquid extraction, aqueous two-phase extraction, membrane separation – ultrafiltration and reverse osmosis, dialysis and precipitation. Pretreatment and stabilization of bioproducts.

References:

1. P. A. Belter. E. L. Cussler and W. Houhu, Bio Separations: Downstream Processing for Biotechnology, Wiley Interscience Publications, New Delhi, 2003.
2. B. Sivasankar. Bioseparations: Principles and Techniques. PHI Learning Pvt. Ltd. New Delhi, 2007.
3. R. K. Scopes. Protein Purification: Principles and Practice, Narosa Publication, New Delhi, 1994.
4. G. Roger, Harrison, P. Todd, R. Rudge and D. P. Petrides. Bioseperation Science and Engineering, Oxford University Press, New York, 2003.

BIO3203: APPLIED PLANT BIOLOGY [2 1 0 3]

Horticulture: Fundamentals, techniques of plant propagation, a brief account of pomology, olericulture, floriculture and ornamental horticulture, viticulture, applications of plant tissue culture in horticulture. Development of garden and nursery : Fundamentals of landscape design, principles and styles of landscape design, propagation and conservation of plants. Management of gardens. Industrial Botany: Organic farming, biofuels and biodiesel, applications of plants in cosmetic industry, aroma therapy, pharmaceutical industry, phytoremediation. Center of origin of crop plants (wheat, rice and maize).

References:

1. K. L. Chadha. Handbook of Horticulture, ICAR Publication, New Delhi, 2008.
2. P. D. Sharma. Ecology and Environment, Rastogi Publication, New Delhi, 2012.
3. S.L. Kocchar. Economic Botany in Tropics, McMillan India Ltd., 2nd Edition, New Delhi, 2010.
4. H. T. Hartman and D. E. Kester. Plant propagation principles and practices, Prenice Hall of India, New Delhi, 1989.
5. E.P. Odum. Fundamentals of Ecology, Saunders, Philadelphia, New York, 1996.
6. J.L. Chapman and M.J. Reiss. Ecology: Principles and Applications, Cambridge University Press, Cambridge, U.K. 2006.

BIO3232: BIOLOGY LABORATORY–VI [0 0 4 2]

Plant Tissue Culture - micropropagation, Cell, tissue and organ culture, somatic embryogenesis, anther culture for production of haploids, Protoplast culture, Genetic transformation using *Agrobacterium*, determination of clonal fidelity using PCR based molecular markers (RAPD, ISSR). To perform competent cell preparation, to study the transformation of competent cells and selection of transformed cells, to analyze expression of recombinant proteins using Southern blotting, SDS page/western blotting.

BIO3233: MICROBIOLOGY LABORATORY-VI [0 0 4 2]

Introduction to Bioprocess Technology: Overview of industrial bioprocesses and applications, Laboratory safety, aseptic techniques, and sterilization methods (e.g., autoclaving, filtration). Microbial Cultivation Techniques: Media Preparation: Formulating growth media for microbial cultures (bacteria, yeast). Inoculation and Culturing: Techniques for inoculating and maintaining cultures under aseptic conditions. Growth Kinetics: Monitoring microbial growth (OD measurements, dry weight, CFU). Thermal Death analysis: Concepts of Thermal Death: Thermal Death Time (TDT): Determining the time required to kill a population of microorganisms at a specific temperature Immobilization of Yeast Cell: Immobilization yeast using sodium alginate and calcium chloride for use in fermentation or enzymatic processes. Experiments on Effect of Temperature, pH, and Substrate Concentratio n on Microbial Growth Curve

DISCIPLINE SPECIFIC ELECTIVES (DSE)

DSE – I

BIO2240: ETHICAL ISSUES AND IPR IN BIOTECHNOLOGY [2 1 0 3]

Intellectual property rights: Classification and importance of IPRs in the fields of science and technology. Patents and copyright: Concepts and principles of patenting and copyrights, patentable subject matter. Procedure of obtaining patents: Rights of patents, infringement of patent rights, remedies for infringement of patent rights: process validation, regulation of biotechnology. Gene patents and Ethical issues, plant breeder's rights, criticism of intellectual property, plagiarism. Ethical issues: Society and public perception towards biotechnology. Release of genetically modified organisms. International and Indian Scenario. Designing of manufacturing area: GMP, FAO requirements. Biosafety: Good lab practices, biosafety for human health and environment, biological warfare.

References:

1. D.O. Fleming, and D.L. Hunt. Biological Safety: Principles and Practices, American Society for Microbiology, USA, 2006.
2. T.A. Shannon. An Introduction to Bioethics, Paulist Press, USA, 2009.
3. H.B. Rockman. Intellectual Property Law for Engineers and Scientists. Wiley-IEEE Press, USA, 2004.
4. L. Vaughn. Bioethics: Principles, Issues, and Cases, Oxford University Press, UK, 2009.
5. WHO. Laboratory Biosafety Manual, World Health Organization, 2005.

BIO2241: CELL BASED ASSAYS [2 1 0 3]

Understanding principals of an assay: Cell proliferation assay and cell cycle assay, Cell viability assay, Cytotoxicity assay, Reporter gene, Luciferase reporter assay. Apoptosis: Introduction to apoptosis mechanisms, Apoptosis marker and detection method, Autophagy, Introduction to autophagy mechanisms, Autophagy marker and detection method. Introduction to Reactive Oxygen Species: Measurement of ROS in Cells, Cell and organelle Labelling, cell culture, Specialized cell culture, Stem cell culture, Sphere formation assay, Microscopy: Phase contrast microscopy, Endocytosis, TMR-dextran labelling, Lysosome labelling, Mitochondrial labelling, Nucleus labelling, confocal microscopy, Cell metabolism, ATP measurement in cell, Glycolysis, TCA cycle. Telomere detection: FISH, Chromatin immunoprecipitation (ChIP), Flow cytometry: Method and principal, Cell analysis and quantitation by FACS, Role of cell-based assay in cancer research.

References:

1. P.K. Gupta. A Textbook of Cell and Molecular Biology, Rastogi Publications, Meerut, 2012.
2. B.D. Singh. Molecular Biology and Genetic Engineering. Kalyani Publishers, New Delhi, India. 2005
3. H. Lodish and D. Baltimore. Molecular Cell Biology, WH Freeman and company, USA, 2012.
4. B. Alberts, A. Jahusan, J. Levis, M. Raff, K Roberts and P Walter. Molecular Biology of Cell, Garland Science, USA, 2002.

DSE – III (A)

BIO3140: ENTREPRENEURSHIP DEVELOPMENT [2 1 0 3]

Entrepreneurship: Starting, Managing, and Leading Biotech. Companies, entrepreneurship practices and strategies: biological

entrepreneurship and general characteristics, Difference between general and biological entrepreneurship, driving forces for decision, strategies to prevent failure, characteristics of successful biotechnology leaders. Marketing: labeling requirements, Biotechnology clusters, Building, managing and motivating teams, potential investors, term sheet, contract and balance sheet, biotechnology product sector, biotechnology business models and managing risk.

References:

1. C. Shimasaki. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Elsevier Inc. USA, 2014.
2. M. Lall and Shikha Sahai. Entrepreneurship, Excel Books, New Delhi, 2008.
3. D. Hine and J. Kapeleris. Innovation and Entrepreneurship in Biotechnology, an International Perspective: Concepts,Theories and Cases. Edward Elgar Publishing Limited, England 2006.
4. T. K. Ghose and P. Ghosh. Biotechnology in India, Springer-Verlag, USA, 2003.

BIO3141: ORGANIC FARMING [2 1 0 3]

Organic Farming: Historical development of Organic Farming in India, definition and scope, detrimental effects of chemical dependent farming and pesticide contamination. Types of Farming: Pure Organic Farming, Integrated Farming system, Concept of different cropping systems in relation to Organic Farming. Developing organic farms: Important steps. Sources of nutrients for Organic Agriculture: Organic Manure – FYM/Rural compost, City compost, Oil cakes, Animal wastes, Vermi composts; Bio-fertilizers: recycling of organic matter in organic agriculture, preparation of compost, preparation of vermin compost, quali ty improvement of finished vermin compost; Status of organic farming and Government policies in India.

References:

1. J.M. Fortier, M. Bilodeau. The Market Gardener: A Successful Grower's Handbook for Small-scale Organic Farming. New Society Publishers, Gabriola Island, Canada, 2014.
2. B. Rateaver. Organic method primer update: A practical explanation: the how and why for the beginner and the experience (Conservation gardening and farming). The Rateavers; Special Edition. Western Australia, 1993.

DSE – III (B)

BIO3142: BIOPHYSICS [2 1 0 3]

Introduction: General Biophysical methods and scope; Radiobiology: Radioactive labeling & counting, Nuclear Biology; Structural Biophysics: Biomolecular structure analysis; CD spectroscopy, X-ray crystallography, Cryo-Electron Microscopy; Optical tweezers; Membrane Biophysics: membrane transport, action potential, ion channels Bioenergetics: Glycolysis, TCA cycle; Oxidative phosphorylation; Coupled and group transfer reactions; Bio-molecular Interaction: Surface Plasma Resonance (SPR) and fluorescence methods to study biological systems

References:

1. V. Pattabhi and N. Gautham. Biophysics, Narosa Publishing house, New Delhi 2002.
2. P. Narayanan. Essential of Biophysics, New Age International Publishers, New Delhi, 2000.
3. R. Cotterill. Biophysics: An Introduction, John Wiley and Sons, England, 2002.
4. W. S. Bialek. Biophysics: Searching for Principles, Princeton University Press, USA, 2012.

BIO3143: PROBIOTICS [2 1 0 3]

Introduction and history of Probiotics, Probiotic microorganisms, Safety of probiotic microorganisms, Segal status of probiot ics. Characteristics of Probiotics for Selection: Tolerance to additives, Stability during storage, Stability during passage to intestinal sites, Minimum effective dose, Maintenance of probiotic microorganisms. Role of Probiotics in Health and Disease: Prevention and treatment of gastrointestinal bacterial infection, Treatment and prevention of constipations, Treatment of hepatic encephalopathy, Chronic urinary tract infection, Antitumor and antihypertensive, Cholesterol level. Mechanism of Probiotics: Complete exclusion, Production of antimicrobial substances, Modulation of immune system, Alteration of intestinal bacterial metabolite action, Alteration of microecology of healthy humans and patients. Probiotics in various foods: fermented milk products, non-milk products etc. Quality Assurance of probiotics and safety. Prebiotics: Concept, definition, criteria, types and sources of prebiotics, Prebiotics and gut microflora. Prebiotics and Health Benefits: Mineral absorption, Immune response, Cancer prevention, IBD, Elderly health and infant health, Prebiotics in foods.

References:

1. Y. K. Lee, Salminen S. Handbook of Probiotics and Prebiotics. A John Willey and Sons Inc. Publication. 2009.
2. T. M. Sandholm, Saarela, M. Functional Dairy Products. CRC Woodhead Publishing Ltd. 2003.
3. S. Salminen, Wright, A. V. Lactic Acid Bacteria, Marcel Dekker, 1998.
4. R. G. Glenn, R. Marcel Handbook of Prebiotics. CRC press, 2008.

DSE – IV (A)

BIO3240: PLANT BREEDING [2 1 0 3]

History, introduction and scope of plant breeding: Centers of origin of cultivated and food plants, germplasm conservation, p lant introduction, Methods of plant breeding in self- and cross-pollinated crops: selection, pedigree analysis, acclimatization, hybridization, heterosis and inbreeding depression. The Hardy-Weinberg Law and its applications in plant breeding. Brief account of mass selection: Pure line and clonal selection, mutation and polyploidy breeding. Molecular marker systems: identification, utilization and integration in plant breeding programs. Renowned Indian and international plant breeders. Contributions ofnational

and international institutes of plant breeding and centers for plant breeding. Green revolution. Horticulture, organic farming, biofuels and phytoremediation.

References:

1. B. D. Singh. Plant Breeding, Kalyani Publishers, New Delhi, 2021.
2. P. K. Gupta. Genetics and Plant Breeding, Rastogi Publications, Meerut, 2022.
3. R.A. Allard. Principles of Plant Breeding, John Wiley & Sons, New York, 2010.
4. G. Acquaah. Principles of Plant Genetics and Breeding, Wiley Blackwell, New York, 2012

BIO3244: MICROBES IN SUSTAINABLE DEVELOPMENT [2 1 0 3]

Soil Microbiology: Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil. Mineralization of Organic & Inorganic Matter in Soil: Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium. Microbial Activity in Soil and Green House Gases: Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control. Microbial Control of Soil Borne Plant Pathogens: Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant pathogens, Insects, Weeds. Biofertilization, Phytostimulatio n. Bioinsecticides: Plant growth promoting bateria, biofertilizers – symbiotic (Bradyrhizobium, Rhizobium, Frankia), Non Symbiotic (Azospirillum, Azotobacter, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs. Secondary Agriculture Biotechnology: Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters. Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

References:

1. G. N. Agrios, Plant Pathology. 5th edition. Academic press, San Diego, 2006.
2. R. S. Singh, Plant Diseases Management. 7th edition. Oxford & IBH, New Delhi, 1998
3. S.M. Reddy, Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers, 2002.
4. B. R. Glick, J. J. Pasternak, C. L. Patten, Molecular Biotechnology 4th edition, ASM Press, 2010.
5. L. L. Barton, D. E. Northup DE, Microbial Ecology, 1st edition, Wiley Blackwell, USA, 2011.

DSE – IV (B)

BIO3243: EXPRESSION PURIFICATION OF THERAPEUTIC PROTEINS [2 1 0 3]

Purification and characterization of a proteins and peptides: Native or heterologously expressed proteins from a complex mixture (involving the following methods/techniques. Exercises: Preparation of the sample. Ion-exchange chromatography. Gel filtration chromatography. Affinity chromatography. Electrophoresis. Principle ad instrumentation of High Performance Liquid Chromatography (HPLC): Demonstration of various protein and peptide purification columns, scaling up strategy. Principle and instrumentation of UV-visible spectroscopy: Determination of concentration of a protein solution by Lowry/BCA method. Downstream processes: Dialysis; salting in and salting out of proteins; analysis of oligomeric behavior, activity.

References:

1. H.S. Srivastav. Elements of Biochemistry, Rastogi Publication, Meerut, 2005.
2. J.L. Jain. Fundamentals of Biochemistry. S. Chand& Co. Pvt. Ltd. New Delhi, 2016.
3. J. Jayaraman. Laboratory Manual in Biochemistry, New Age Publishers, New Delhi, 2011
4. A.J. Ninfa, D.P. Ballou and M.B. Parsons. Fundamental Laboratory Approaches for Biochemistry and Biotechnology. Wiley Inter Science, 2009.
5. S.N. Gupta. Concepts of Biochemistry. Rastogi Publications, Meerut, 2017.
6. D. Voet and J. G. Voet. Biochemistry, John Wiley & Sons Inc., New Delhi, India, 1995.
7. A. Lehninger, D. L. Nelson and M. M. Cox. Principles of Biochemistry, Freeman Publishers, New York, 2017.
8. M. Holtzhauer. Basic Methods for the Biochemical Lab, Springer, USA, 2006.
9. S.O. Farrell and L.E. Taylor. Experiments in Biochemistry: A Hands-on Approach, Cengage Learning, USA, 2005.

BIO3245: NUTRACEUTICALS [2 1 0 3]

Introduction to Nutraceutical: Organizational elements, Classification of nutraceuticals, Dietary supplements, Fortified foods, Functional foods and phytonutracuticals. Scope involved in the industry, Indian and global scenario. Concept, Biochemistry of Nutrition and Dietetics: Classification of food components based on nutritional value, recommended dietary intake, Acceptable dietary intake, Nitrogen balance, Protein efficiency ratio, Net protein utilization. Basics of energy balance - Basal Metabolic Rate (BMR), Body Mass Index (BMI) and Standard Dynamic Action (SDA) with special reference to nutraceutical industry. Nutrition related diseases and disorders: Role of nutraceuticals with special reference to diabetes mellitus, Hypertension, Hypercholesterolemia, Cancer, Glands in the prevention and treatment, Role of nutraceuticals and functional foods in pediatrics, Geriatrics, Sports, Pregnancy and Lactation. Nutraceuticals of plant and animal origin: Sources, examples and applications, Concept of cosmoceuticals and aquaceuticals. Biotechnology in Phytonutraceuticals: Role of medicinal and aromatic plants in nutraceutical industry.

References:

1. F. Shahidi, D.K. Weerasinghe (Ed.). Nutraceutical beverages Chemistry, Nutrition and health Effects. American Chemical Society, 2004
2. R. Neeser, J. Bruce German. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals. Jean, Marcel Dekker, Inc, 2004.
3. I. Goldberg (Ed.) Functional foods, designer foods, pharma foods, nutraceuticals. Aspen publishers Inc., USA, 1999.
4. L. Rapport, B. Lockwood. Nutraceuticals, 2nd Edition, Pharmaceutical Press. 2002.

BIO3246: PLANT AND ANIMAL TISSUE CULTURE [2 1 0 3]

Introduction to Techniques: Introductory history, Laboratory organization, Media, Aseptic manipulation. Basic Concepts in Cell Culture: Cell culture, Cellular Totipotency, Somatic Embryogenesis. In Vitro Culture: approaches & methodologies, preparation steps for tissue culture, surface sterilization of plant tissue material, basic procedure for aseptic tissue transfer, incubation of culture. Tissue Nutrition: Growth Hormones, Plant cells (Composition of culture media, Growth hormones, Vitamins, Unidentified supplements, selection of media), Animal cells (substrate on which cells grow, Feeder layer on substrate, gas phase for tissue culture, media and supplements). Tissue Culture Methodologies: Plant cells (Callus Culture, Cell Suspension Culture, Organ Micro-culture, plant micro-propagation, Somatic Embryogenesis), Animal cells (Source of tissue, primary culture, differentiation of cells, growth kinetics, animal cell lines and their origin and characterization). Cloning & Selection of Specific Cell Types: cloning, somatic cell fusion and HAT selection, medium suspension fusion, selection of Hybrid clone, production of monoclonal antibodies. Organ Culture: Culture of embryonic organs, whole embryo culture, culture of adult organs.

References:

1. M.K. Razdan, An introduction of Plant Tissue Culture, Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi. 2005.
2. S.S. Bhojwani, M.K. Razdan, Plant Tissue Culture theory and practice a Revised edition, Elsevier Science Publishers, New York, USA, 2011.
3. P. Ramadass, R. S. Meera. Textbook of Animal Biotechnology, Akshara Printers, New Delhi, 1997.
4. S. Mathur. Animal Cell and Tissue Culture, Agrobios, India, New Delhi, 2009.
5. O.L. Gamborg and G.C. Phillips. Plant Cell Tissue and Organ Culture. Narosa Publishing House, New Delhi. 1998.
6. M. Butler. Animal Cell Culture and Technology, Bios Scientific Publishers Ltd. U.K., 2008.

BIO3247: SANITATION AND SLUDGE MANAGEMENT [2 1 0 3]

Definition, Global situation, Onsite and Offsite sanitation, Sanitation value chain, Characterization of faecal sludge, Pathogens in faecal sludge. Physical, chemical and biological treatment mechanisms, Collection and Transport practices; Treatment technologies: Co-composting, Co-treatment, Anaerobic digestion, Vermicomposting, Black soldier flies, Unplanted and planted drying beds, End use of treatment products: Use as soil conditioner and resource recovery.

References:

1. Strande, L., & Brdjanovic, D. (Eds.). *Faecal sludge management: Systems approach for implementation and operation*. IWA publishing, 2014
2. Velkushanova, K., Brdjanovic, D., Koottatep, T., Strande, L., Buckley, C., & Ronteltap, M. *Methods for faecal sludge analysis*. IWA Publishing, 2021

GENERIC ELECTIVES (GE)

GE – I & LAB

CHY1160: GENERAL CHEMISTRY-I [2 1 0 3]

Introduction to stereochemistry; Conformational analysis of open chain systems; Conformational analysis of cyclic systems; Symmetry elements, Point group analysis; Stereochemical conventions; Stereogenicity, Topicity; Stereochemical reactions; Reactions involving stereo centres; Aromaticity, Aromatic stabilization energy, Hückel MO, Polycyclic aromatic hydrocarbon (PAH), Polyacenes, Annulene; Aromatic Electrophilic substitutions; Aromatic Nucleophilic substitutions; Reaction dynamics, Hammond postulate; Linear free energy relationship, Hammett equation; Carbocation: Generation, Structure and Geometry, Stabilization of carbocation, Reactions of Carbocation; Carbanions: pKa and its significance; Hard and Soft Acid and Base principle; Structure, Formation, Stability, Reactivity; Free radical: Formation, Structure, Stability, Reactivity; Carbene, Nitrene: Generation, Structure, Reactivity.

References:

1. G. W. Solomon and B. F. Craig, Organic Chemistry, John Wiley & Sons, Inc., 2010.
2. P. Sykes, A Guidebook to Mechanism in Organic Chemistry, Pearson India, 2003.

CHY1138: ORGANIC CHEMISTRY LABORATORY [0 0 2 1]

Basics: Distillation, crystallization, decolorization and crystallization using charcoal, sublimation. Qualitative Analysis: Identification, functional group analysis, melting point, preparation of derivatives.

Reference:

1. A. K. Nad, B. Mahapatra, & A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency, 2011.

GE – II (A) & LAB

CHY1260: GENERAL CHEMISTRY-II [2 1 0 3]

Basics in Inorganic Chemistry; Purification of elements; Coordination chemistry; 18 electron rule; Valence bond theory; Crystal field theory; Term symbols; Spectroscopy of complexes; Jahn-Teller distortion; Spinels; Magnetism; Bio-inorganic chemistry, Enzymes; Hemoglobin and Myoglobin; Toxicity; Medicinal inorganic compounds

References:

1. J. D. Lee, Concise Inorganic Chemistry, Blackwell Science, 2008.
2. J. E. Huheey, E. A. Keiter & R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, Pearson India, 2008.

CHY1238: INORGANIC CHEMISTRY LABORATORY [0 0 2 1]

Inorganic: Qualitative analysis of inorganic salts, volumetric analysis of inorganic mixtures, synthesis of transition metal complexes.

Reference:

1. A. K. Nad, B. Mahapatra, & A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency, 2011

GE – II (B) & LAB

CHY1261: GENERAL CHEMISTRY-III [2 1 0 3]

Thermodynamics everywhere; historical development of thermodynamics; Zeroth Law of Thermodynamics and concept of temperature; Discussion on internal energy heat and work; First Law of Thermodynamics; State function and path function; calculation of p-V work; Heat capacities; Joule & Joule-Thomson expansion; Some practice problems; thermochemistry; Second Law of thermodynamics (various statements and their equivalence); Carnot cycle; definition of entropy; Heat engines and their efficiencies; practice problems on the classical second law; Statistical Formulation of the Second Law (probability overview; Boltzmann formula, distribution of energy); Statistical formulation of the Second Law continued (the most probable distributi on, Boltzmann distribution); Calculation of entropy for various processes using Boltzmann entropy formula; Fundamental equation and entropy postulates; introduction to free energies; Maxwell Relations and conversion of thermodynamic derivatives; Applications of free energy

References:

1. A. Bahl, S. S. Bahl, G. D. Tuli, Essentials of Physical Chemistry, S. Chand, 2016.
2. P. Atkins and J. de Paula, Atkins's Physical Chemistry, Oxford University Press, NY, 2010.

CHY1239: PHYSICAL CHEMISTRY LABORATORY [0 0 2 1]

Physical: Determination of rate constants, conductometric titrations, thermochemistry, phase diagrams.

Reference:

1. A. K. Nad, B. Mahapatra, & A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency, 2011.

GE – III (A) & LAB

CHY2160: ANALYTICAL CHEMISTRY [2 1 0 3]

Basic Concepts: Introduction to analytical chemistry. Measurement Basics: Introduction, electrical components and circuits, operational amplifiers in chemical instrumentation. Atomic spectroscopy: Introduction to spectrometric methods, components of optical instruments, atomic absorption and atomic fluorescence spectrometry, atomic emission spectrometry, atomic mass spectrometry, atomic X-ray spectrometry. Molecular Spectroscopy: UV-Vis, IR, NMR, mass, Raman, fluorescence spectroscopy, instrumentations and applications. Electroanalytical Chemistry: Introduction to electroanalytical chemistry, potentiometry, coulometry, voltammetry, instrumentation and application. Separation Methods: An introduction to chromatographic separations, gas chromatography, high-performance liquid chromatography, capillary electrophoresis and capillary electrochromatography, components of instruments and applications. Miscellaneous Methods: Thermal methods for analytical chemistry, instrumentation and applications.

References:

1. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, Saunders College Publishing, 2013.
2. H. H. Willard, L. L. Merritt Jr., J. A. Dean, F. A. Settle, Instrumental Methods of Analysis, CBS Publishing Company, 2012.
3. G.D. Christian, Analytical Chemistry, John Wiley, 2004.
4. D.A. Skoog, D.M. West, F.J. Holler, S.R. Crouch, Fundamentals of Analytical chemistry, Brooks/Cole, 2004.

CHY2138: ANALYTICAL CHEMISTRY LABORATORY [0 0 2 1]

Analytical: TLC, paper chromatography, determination of Rf values, separation techniques.

Reference:

1. A. K. Nad, B. Mahapatra, & A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency, 2011.

GE – III (B) & LAB

MAS2146: FUNDAMENTALS OF BIOSTATISTICS [2 1 0 3]

Introduction: Definition, scope, functions, limitations, uses, types of data, types of variables, classification, tabulation, graphical representation of biological data; Measures of Central Tendency: Mean, mode, median; Measures of Dispersion: Range, standard deviation, mean deviation, co-efficient of variation, their applications, merits and demerits; Probability: Definitions of probability , additive rule, multiplicative rule, conditional probability, Bayes theorem; Random Variable and Probability Distribution, types of random variable, functions of probability distribution of random variables, expected value and variance of random variables, Binomial distribution, Poisson distribution, Normal Distribution; Correlation and Regression: Introduction, Karl Pearson's, Spearman's coefficient of correlation, regression equations, regression lines, regression coefficients, similarities and dissimilarities of correlation and regression; Testing of Hypothesis: Large sample tests, student 't'-test, chi square test, run test, sign test and median test.

References:

1. A.K. Sharma. Textbook of Biostatistics I. Discovery Publishing House, New Delhi, 2005.
2. B.K. Mahajan. Methods in Biostatistics. Jaypee Brothers Publishers, New Delhi. 2002.
3. B. L. Agarwal. Basic Statistics. New Age International, New Delhi, 2006.
4. M. Pandey. Biostatistics: Basic and Advanced, MV learning, 2015.
5. A.K. Irfan. A. Khanum, S. Khan. Fundamentals of Biostatistics, 5th Edition, 2018.
6. G. K. Kanji, 100 Statistical Tests, SAGE Publication, 3rd Edition, 2006.

MA2134: LAB ON FUNDAMENTALS OF BIOSTATISTICS [0 0 2 1]

The following practical will be performed using statistical software**:** graphical representation of biological data, mean, mode, median, range, standard deviation, mean deviation, co-efficient of variations, correlation, regression, large sample tests, student 't'-test, chi square test, run test sign test and median test.

GE – IV & LAB

CHY3260: BIOPHYSICAL CHEMISTRY [2 1 0 3]

Basic Concepts: Introduction to Physical Chemistry. General Biophysical Principles: Laws of biophysics, hydrogen bonding, van der Waals and hydrophobic interactions, disulphide bridges, role of water and weak interactions, energies, forces & bonds, kinetics of biological processes, electron transport & oxidative phosphorylation. Methods in Biophysics: Analytical ultracentrifugation, micro calorimetry, x-ray diffraction, spectroscopy – UV, IR, NMR, mass fluorescence, circular dichroism, microscopy, separation techniques. Molecular Biophysics: Principles of protein structure & confirmation, proteins structure and stability, structure of nucleic acids. Protein Engineering: Micro sequencing methods for proteins & engineering proteins for purification chemical approach to protein engineering & protein engineering for thermostability. Membrane Biophysics: Membrane structure & models, physical properties of membrane, membrane transport, molecular dynamics of membranes, Membrane potential and lipid membrane technology.

References:

1. D. L. Nelson, M. M. Cox, Lehninger's Principles of Biochemistry, W. H. Freeman, 2015.
2. Satyanarayana, Biochemistry, Elsevier, 2017.
3. J. M. Berg, J. L. Tymoczko, L. Stryer, Biochemistry, W. H. Freeman, 2011.

CHY3238: APPLIED CHEMISTRY LABORATORY [0 0 2 1]

Applied chemistry: Water analysis, effluent analysis, pH-metric and conductometric titrations. Computational: Scientific software, data handling.

Reference:

1. A. K. Nad, B. Mahapatra, & A. Ghoshal, An Advanced Course in Practical Chemistry, New Central Book Agency, 2011.