St Aloysius College (Autonomous)
Mangaluru

Re-accredited by NAAC with 'A++' Grade – CGPA 3.67/4 (Cycle IV)
Recognised as Centre for Research Capacity Building under UGC-STRIDE Scheme
Recognised under the DBT-BUILDER Scheme, Govt. of India
College with 'STAR STATUS' conferred by DBT, Govt. of India
Recognised by UGC as 'College with Potential for Excellence'

Course structure and syllabus of

B.Sc. BIOTECHNOLOGY (HONOUR'S)NEP SCHEME-2021 0NWARDS

SEMESTER – I

G 511 DC1.1 CELL BIOLOGY AND GENETICS 56 hours

Course Outcomes:

After successful completion of this Course, students will be able to:

CO 1. Acquire a deep insight on the concepts of cell biology and genetics.

CO 2. Describe the ultrastructure of cells, structure and function of organelles, cytosol and cytoskeleton

CO 3. Illustrate the phases of cell cycle, cell division, reductional division in gametes, molecular mechanisms that regulate life and death of a cell including programmed cell death or apoptosis and differentiation in plants

CO 4. Comprehend the organization and structure of chromosomes, banding techniques and Mendelian laws of inheritance, deviations, and exceptions to these laws. CO 5. Describe mutations and its types, genetic or hereditary disorders.

Unit 1. Cell as a basic unit of living systems and cellular organelles: (14 hours)

Concept, Development and Scope of Biotechnology. Historical perspectives. Discovery of cell, the cell theory, Ultra structure of a prokaryotic and eukaryotic cell (Both plant and animal cells), Surface Architecture: Structural organization and functions of plasma membrane and cell wall of eukaryotes. Cellular Organelles: Structure and functions of cell organelles – Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus (Nuclear envelope with nuclear pore complex, Nucleolus, Nucleoplasm and Chromatin). Vacuole, Cytosol and Cytoskeleton structures (Microtubules, Microfilaments, and Intermediate filaments).

Unit II. Chromosomes and cell division (14 hours)

General Introduction, Discovery, Morphology, and structural organization – Centromere, Secondary constriction, Telomere, Chromonema, Euchromatin and Heterochromatin, Chemical composition (molecular organization of chromosome and nucleosome model), Classification of chromosomes based on centromere position and Karyotyping (methods). Giant Chromosomes: Salivary gland and Lamp brush chromosomes.

Cell Division: Cell cycle, phases of cell division, Mitosis and meiosis, regulation of cell cycle, cell cycle checkpoints, and enzymes involved in regulation, Significance of cell

cycle, achromatic apparatus, synaptonemal complex. Cell Senescence and programmed cell death. Cell cycle disruption and Cancer

Unit III. Laws of inheritance and gene interaction (14 hours)

Terminologies in genetics: alleles, gene, genome, Genotype, Phenotype, character, traits, homozygous and heterozygous.

Mendelian theory: Laws of inheritance- dominance, segregation, incomplete dominance, codominance with an example. Law of independent assortment, test cross, back cross. Deviations to Mendelian inheritance, complementary, supplementary and interaction of genes (13:3 ratio).

Maternal Inheritance: Plastid inheritance in Mirabilis, Petite characters in yeast and Kappa particles in paramecium, Sex-linked inheritance (Haemophilia, Colour blindness), Chromosome theory of inheritance. Gene interaction: Supplementary factors: comb pattern in fowls, Complementary genes- Flower colour in sweet peas, Multiple factors–Skin colour in human beings, Epistasis– Plumage colour in poultry, Multiple allelism: Blood groups in Human beings.

Unit IV Human genetics and Sex Determination in Plants and animals: (14 hours)

Linkage and crossing over: Introduction, Coupling and repulsion hypothesis, Linkage in maize and Drosophila, Mechanism of crossing over and its importance, chromosome mapping-linkage map in maize.

Mutations: Types of mutations, Spontaneous and induced, Mutagens: Physical and chemical, Mutations in plants, animals, and microbes for economic benefit of man (one example each).

Sex Determination in Plants and animals: Concept of allosomes and autosomes, XX-XY, XX-XO, ZW-ZZ, ZO-ZZ types.

Human Genetics: A general account of structural and numerical aberrations, inherited disorders – Allosomal (Klinefelter syndrome and Turner's syndrome), Autosomal (Down's syndrome and Cri-Du-Chat Syndrome).

References

1. Alberts, B., Hopkin, K., Johnson, A., Morgan, D., Lewis J., Raff M., Roberts, K., & Walter, P., (2019). Essential Cell Biology, International student edition 5th ed.,WW Norton & Co.
2. Brooker, R.J., (2017). Genetic analysis and principle, 6th ed., Mc Graw Hill.

3. Cooper & Sinauer G.M., (2019). The Cell: A Molecular Approach, International 8th ed., Oxford University Press.
4. Hardin, J. & Bertoni, G P., (2018). Becker's World of The Cell, 9th ed., Pearson Education Ltd, USA.
5. Karp, G., Iwasa, J. & Marshall W., (2016). Cell and Molecular Biology: Concepts and Experiments, 8th ed., Wiley & sons. New York.
6. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K., (2016). Molecular Cell Biology, 8th ed., W.H. Freeman & Co., New York.
7. Gupta ML. and ML. Jangir. (2002) Cell Biology-Fundamentals and Applications. Argosies, Jodhpur, India.
8. Powar C.B(2019). Cell Biology 3rd edition. Himalaya Publishing House, Mumbai.Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.Gupta, P.K. (2019) Genetics, 5th Ed., Rastogi Publication, Meerut, India
9. Krebs, J.E., Goldstein, E.S. & Kilpartick, S.T., (2017). Lewin genes- XII, Jones and Bartlett Publishers.
10. Tamarin, R.., (2017). Principles of Genetics, 7th ed., Mc-Graw – Hill Publication.
11. J. Brooker (2017). Genetics: Analysis and Principles., 6th ed., McGraw-Hill Education

G 511 DC2.1P CELL BIOLOGY AND GENETICS PRACTICAL 56 hours

Course outcome:

After successful completion of this Course, students will be able to:

CO 1. Interpret the different stages of cell division and to calculate the mitotic index.

CO.2.Meaure the size of cells and to count the number of cells using haemocytometer.

CO 3. Demonstrate the handling of Drosophila melanogaster, the model organism for genetic studies.

CO 4. Describe the principles and procedures of genetic techniques in biological experiments.

CO 5. Perform the perform the karyotyping analysis and solve various genetics problems

List of Practical

1. Handling and maintenance of simple and compound microscope
2. Use of Micrometer and calibration, measurement of onion epidermal cells and yeast
3. Cell counting using haemocytometer.
4. Study of divisional stages in mitosis from onion root tips
5. Determination of mitotic index in onion root tips.
6. Effect of osmotic pressure on RBC.
7. Study of divisional stages in meiosis in grasshopper testes/onion or Rheo flower buds.
8. Isolation and staining of Mitochondria
9. Isolation and staining of Chloroplast
10. Mounting of polytene chromosomes
11. Buccal smear – Barr bodies
12. Karyotype analysis – Human – Normal and Abnormal – Down and Turner's syndromes
13. Mounting of the Sex Comb in Drosophila melanogaster
14. Study of mutants in Drosophila melanogaster
15. Separation of eye pigments of Drosophila melanogaster.
16. Genetic problems based on theory

References:

1. Vilas Parmar (2018). Practicals of Cell Biology & Genetics. LAP Lambert Academic Publishing
2. Debarati D. (2017). Essential Practical Handbook of Cell Biology & Genetics, Biometry & Microbiology: A Laboratory Manual. Academic Publishers.
3. Amit Gupta and Bipin Kumar Sati (2019). Practical laboratory manual- Cell Biology. Lambert Academic Publishing
4. Rina M. and Rama S. (2018). Laboratory Manual of Cell Biology. Prestige Publishers

Open Elective Courses SEMESTER – I

G 511 OE1.1 BIOTECHNOLOGY FOR HUMAN WELFARE 42 hours

Course Outcomes:

After successful completion of this Course, students will be able to: CO 1. Apply the biotechnological concepts in the industry

CO 2. Implement the biotechnological techniques in environmental management

CO 3. Describe application of biotechnology to forensic science

CO 4. Comprehend contributions of biotechnology to biomedical fields, such as diagnostics, genomics and therapeutics

Unit I (14 hours)

Environment: Application of biotechnology in environmental aspects: Degradation organic pollutants – chlorinated and non-chlorinated compounds; degradation of hydrocarbons and agricultural wastes, PHB –production and its futuristic applications.

Unit II (14 hours)

Industry: Application of biotechnology in industry: Industrial production of alcoholic beverages (wine), antibiotics (Penicillin), enzymes (lipase). Applications in food, detergent and pharmaceutical industry.

Unit III (14 hours)

Forensic science: Application of biotechnology in forensic science: Solving crimes of murder and rape; solving claims of paternity and theft by using DNA finger printing techniques

Health: Application of biotechnology in health: Genetically engineered insulin, recombinant vaccines, gene therapy, molecular diagnostics using ELISA and PCR. Monoclonal antibodies and their use in cancer. Human genome project.

References:

1. Bhasin M.K. and Nath, S. (2002). Role of Forensic Science in the New Millennium, University of Delhi, Delhi
2. Crueger W. and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd Ed., Panima Publishing Co. New Delhi.
3. Eckert W.G. (1997) Introduction to Forensic Sciences, 2nd Ed., CRC Press, Boca Raton
4. James S.H. and Nordby, J.J. (2005). Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton

5. Joerdening H.-J. and Winter J. (2005). Environmental Biotechnology – Concepts and Applications,
6. Mohapatra, P.K. (2006) Textbook of Environmental Biotechnology, I.K. International Publishing House Pvt. Ltd., New Delhi
7. Nanda B.B. and Tiwari R.K. (2001). Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi
8. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
9. Stanbury P.F, Whitaker A and Hall S.J. (2006). Principles of Fermentation Technology. 2nd Ed., Elsevier Science Ltd.

Skill Enhancement Course SEMESTER – I

BIOTECHNOLOGICAL SKILLS AND ANALYTICAL TECHNIQUES **14 hours**

Course Outcomes:

After successful completion of this Course, students will demonstrate the:

CO 1. Skill enhancement as per National Occupational Standards (NOS) of "Lab Technician/ Assistant" Qualification Pack issued by Life Sciences Sector Skill Development Council – LFS/Q0509, Level 3.

CO 2. Knowledge about major activities of biotech industry, regulations, and compliance, environment, health, and safety (EHS), good laboratory practices (GLP), standard operating procedures (SOP) and GMP as per the industry standards.

CO 3. Soft skills, such as decision making, planning, organizing, problem solving, analytical thinking, critical thinking, and documentation.

1. Insights into biotechnology industry: Biotechnology Industry in Indian and Global context – organization in context of large /medium/ small enterprises, their structure, and benefits.
2. Industry professional skills to be acquired: Planning and organizing skills, decision- making, problem-solving skills, analytical thinking, critical thinking, team management, risk assessment.
3. Interpersonal skills: Writing skills, reading skills, oral communication, conflict-resolution techniques, interpretation of research data, trouble shooting in workplace

4. Digital skills: Basic Computer Skills (MS Office, Excel, Power point, Internet) for Workplace. Professional Email drafting skills and PowerPoint presentation skills

Analytical Skills in laboratory:

Solutions: Molarity, Molality, Normality, Mass percent % (w/w), Percent by volume (% v/v), parts per million (ppm), parts per billion (ppb), Dilution of concentrated solutions. Standard solutions, stock solution, solution of acids. Reagent bottle label reading and precautions

1. Methods and practices of cleaning and management of lab: Learning and Practice of Integrated clean-in-place (CIP) and sterilize-in-place (SIP) as per industry standards, material requirements for cleaning specific area, equipment, ventilation area, personal protective requirements
2. Procedure of cleaning and storage of Labware:
   Methodology for storage area, cleaning procedure and materials to be used for various surfaces. Sign boards, labelling do's & don'ts. Knowledge about standard procedures of cleaning or glass ware, plastic ware. Maintenance of inventory
3. Principles and practices of lab safety:
   Knowledge about safety symbols and hazard signs. Personal safety gears, utility, and disposal. Equipment safety protocols, chemical safety protocols. Documentation of chemical and equipment usage records. Handling hazardous chemicals. MSDS.
4. Best practices of usage and storage of chemicals:
   Knowledge and practice in handling of chemicals, labelling and stock maintenance. SOP and material handling. Procedures to maintain chemicals, labelling, storage, and disposal.
5. Record maintenance as per SOP's
   Labelling of samples and reagents as per SOP's. Recording detail of work done for research experiments. Importance of study of manuals, health, and safety instructions.
6. Usage and maintenance of basic equipment of biotechnology lab: Principles, calibrations, and SOPs of weighing balances, pH meters, autoclaves, laminar flows and biosafety cabinets, basic microscopes, homogenizers, stirrers, colorimeters, UV, and Visible spectrophotometers.
7. Preparation of solutions and standards: Properties and uses of chemicals commonly used in life sciences laboratories. Maintaining safety standards for handling various solutions and chemicals. Preparation of test reagents and buffers, Protocols for proper

mixing of chemicals. Safety precautions while preparation and storage of incompatible chemicals and reagents.

8. Preparation of media: Maintenance and storage of purified water for media (Plant Tissue culture media, Microbiological media, and Animal cell culture media) preparation. Preparation and storage of concentrated stock solutions. Documentation and disposal of expired stocks. Collection of indents of media requirement, preparation, and storage. Media coding, documentation, and purpose of usage.
9. Practical methods for decontamination and disposal: Decontamination methods, Safe disposal practices of decontaminated media or materials.
10. Laboratory record writing: Method of record writing, data collection and recording, reporting of result, discussion of result, summary writing, effective powerpoint presentation taking any experiment as example
11. Industry visits or Analytical laboratory visits

SEMESTER – II

G 511DC1.2 MICROBIOLOGICAL METHODS AND TECHNIQUES 56 hours

Course Outcomes:

After successful completion of this Course, students will be able to: CO 1. Employ the principles of microscopy to study microorganisms CO 2. Apply the analytical techniques in microbiology.

CO 3. Comprehend the importance and methods of sterilization in microbiological work

CO 4. Delineate the formulation of media, culture methods and staining techniques for isolation, characterization of microbes

CO 5. Apply the knowledge of antimicrobial agents in anti- microbial assays.

Unit I (14 hours)

Introduction to microbes and methods to study: Classification of major groups of microorganisms- Bacteria, Fungi, Algae and viruses. binomial nomenclature of microbes, Phylogenetic classification;16S rDNA sequencing.

Microscopy: Principles of Microscopy- Magnification, resolving power, numerical aperture, working principle and applications and limitations of Compound microscope, Dark field microscope, Phase contrast microscope, Fluorescence Microscope, confocal microscope, Electron Microscopes- TEM and SEM.

Analytical techniques: Working principles and applications: Centrifuge, Ultracentrifuge, UV-Vis Spectrophotometer, Chromatography- Paper and TLC.

Unit II **(14 hours)**

Sterilization techniques: Definition of terms-sterilization, disinfectant, antiseptic, sanitizer, germicide, microbicidal agents, microbiostatic agent and antimicrobial agent.

Physical methods of sterilization: Principle, construction, and applications of moist heat sterilization by using autoclave, Pasteurization and Fractional sterilization-Tyndallization. Dry heat sterilization- hot air oven. Incineration. Filter sterilization-membrane filter and HEPA. Radiation- Ionizing radiation-γ rays and non-ionizing radiation- UV rays. Chemical methods: Alcohol, aldehydes, phenols, halogen, metallic salts, Quaternary ammonium compounds and sterilizing gases as antimicrobial agents.

Unit III **(14 hours)**

Culture Media: Nutritional types of bacteria, Components of media, Culture media types (natural and synthetic media, chemically defined media, Complex, synthetic, differential, enrichment and selective media).

Pure culture methods: Serial dilution and plating methods (pour, spread, streak); cultivation, maintenance of aerobic and anaerobic bacteria. Preservation/stocking of pure cultures: Agar Slant Cultures, Agar Slant Culture Covered with Oil (Paraffin Method), Very Low Temperature(glycerol), Freeze Drying (lyophilization). Culture Collection Centers.

Stains and staining techniques: Principles of staining, Types of stains-simple stains, structural stains and differential stains.

Unit IV **(14 hours)**

Antibacterial agents: Antibiotics and mode of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism.

Antibiotic resistance: MDR, XDR, MRSA, NDM-1.

Antibiotic sensitivity testing methods: Kirby-Bauer method, Agar well diffusion techniques, and E-test, MIC.

Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin.

Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine.

References:

1. Black, J. G., & Black, L. J. (2017). Microbiology: Principles and Explorations, 10th ed., United States of America: John Wiley & sons, Inc.
2. Cann, A. J. (2016). Principles of Molecular Virology, 6th ed., London: Academic Press.
3. Dimmock, N. J., Easton, A. J., & Leppard, K. N. (2016). Introduction to Modern Virology, 7th ed., United Kingdom: Wiley-Blackwell.
4. Flint, J., Racaniello, V. R., Rall, G. F., & Skalka, A. M. (2015). Principles of Virology, 4th ed., Washington DC: ASM Press.
5. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2019). Brock Biology of Microorganisms, 15th ed., Harlow, United Kingdom: Pearson.
6. Pommerville, J. C. (2011). Alcamo's Fundamentals of Microbiology, 9th ed., Sudbury, Massachusetts: Jones and Bartlett Publishers.
7. Talaro, K. P. (2009). Foundations in Microbiology: Basic Principles, 7th ed., New York: McGraw-Hill.
8. Tortora, G. J., Funke, B. R., & Case, C. L. (2015). Microbiology: An Introduction, 12th ed., United States of America: Pearson Education Inc.
9. Willey, J. M., Sherwood, L. M., & Woolverton, C. J. (2016). Prescott, Harley, and Klein's microbiology, 10th ed., Americas, New York: McGraw-Hill.
10. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology, 5th Ed., Tata McGraw Hill.
11. Atlas RM. (1997). Principles of Microbiology. 2nd edition. Wm C Brown Publishers.
12. Dubey R. C. and Maheshwari D. K. (2010). A Textbook of Microbiology. S Chand & Company
13. Ananthanarayan R, Jayaram Paniker CK and Reba Kanungo (2020). Textbook of Microbiology.11th Ed. Universities Press (India) Pvt. Ltd.

G 511 DC 2.2P Microbiological methods and techniques Practical

Course Outcomes:

After successful completion of this Course, students will be able to:

CO 1. Handle and use instruments used in Microbiology and Biotechnology laboratories

CO 2. Use analytical techniques for work using microorganisms

CO 3. Experiment with various methods of sterilization in microbiological work

CO 4. Prepare different types of media, perform culture methods and staining techniques for isolation, characterization of microbes

CO 5. Handle and use antimicrobial agents and perform anti-microbial assays

List of Practical:

1. Study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, hot air oven, compound microscope, pH meter) used in the microbiology laboratory.
2. Preparation of culture media for bacteria, fungi and their cultivation.
3. Isolation of bacteria and fungi from soil, water and air
4. Enumeration techniques – direct microscopic, serial dilution and standard plate count technique (Spread plate, pour plate) and study of colony characters of isolated microbes
5. Purification of bacterial and fungal cultures using streak plate technique/mycelial bit transfer
6. Culture preservation techniques – slant and stab culture
7. Study of colony characteristics bacteria from air exposure plate
8. Staining techniques: Bacteria– Gram, Negative, Capsule, Endospore staining. Fungi – Lactophenol / cotton blue staining
9. Study of Rhizopus, Penicillium, Aspergillus using temporary mounts
10. Water analysis – MPN test
11. Biochemical Tests – IMViC, Starch hydrolysis, Catalase test, oxidase and Gelatin hydrolysis
12. Bacterial motility – hanging drop technique
13. Antibiotic sensitivity test by disc diffusion method.

References:

1. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual, 9th Ed., Pearson Education Limited.
2. Saha, Rumpa Das and Shukla (2021). Microbiology Practical Manual, 2nd Ed. CBS.

3. Mukesh Kumar (2018). Practical Manual for Undergraduates Microbiology, Jain Brothers.
4. Maheshwari D.K. and Dubey R.C. (2010). Practical Microbiology, S Chand & Company

SEMESTER – II Open Elective Courses

G 511 OE1.2 APPLICATIONS OF BIOTECHNOLOGY IN AGRICULTURE 42 hours

Course Outcomes:

After successful completion of this Course, students will be able to: CO 1. Employ the biotechnological approaches in agriculture

CO 2. Apply biotechnological methods in plant tissue culture

CO 3. Comprehend the pros and cons of GM crops and their plant products

Unit I (14 hours)

Agricultural Biotechnology: Concepts and scope of biotechnology in Agriculture. Plant tissue culture, micro propagation, entrepreneurship in commercial plant tissue culture. Banana tissue culture – primary and secondary commercial setups, small scale bioenterprises: Mushroom cultivation

Unit II (14 hours)

Transgenic plants: The GM crop debate – safety, ethics, perception and acceptance of GM crops GM crops case study: Bt cotton, Bt brinjal. Plants as biofactories for molecular pharming; edible vaccines, plantibodies, nutraceuticals.

Unit III (14 hours)

BT based pesticides: Baculovirus pesticides (NPV), Mycopesticides (Metarrhizium), Post-harvest Protection: Antisense RNA technology for extending shelf life of fruits and shelf life of flowers. Genetic engineering for quality improvement: Golden rice, Seed storage proteins (LEA), Flavours– capsaicin, vanillin

References:

1. Chrispeels M.J. and Sadava D.E. (1994) Plants, Genes and Crop Biotechnology, 2nd Ed., Jones and Bartlett Publishers, Boston.
2. Gamborg O.L. and Philips G.C. (1998) Plant cell, tissue and organ culture, 2nd Ed., Narosa Publishing House. New Delhi.
3. Gistou, P. and Klu, H. (2004). Handbook of Plant Biotechnology (Vol. I & II). John Publication.

4. Hammond J., McGarvy P. and Yusibov.V. (2000). Plant Biotechnology, Springer Publ.
5. Heldt. H.-W. (1997). Plant Biochemistry and Molecular Biology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
6. Kyte, L., Kleyn, J., Scoggins, H., and Bridgen M. (2003) Plants from test tubes. An introduction to micropropagation, 4th Ed., Timber Press, Portland.
7. Murray D.R. (1996) Advanced methods in plant breeding and biotechnology. Panima Publishing Corporation.
8. Nickoloff, J.A. (1995). Methods in molecular biology, Plant cell electroporation and electrofusion protocols-Humana Press Incorp, USA.
9. Sawahel, W.A. (1997). Plant genetic transformation technology. Daya Publishing House, Delhi.

Semester III

Course code: G511 DC1.3 Biomolecules 56 hours

COURSE OUTCOMES:

After successful completion of this Course, students will be able to:

CO 1. Cognise the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA, glycoproteins and glycolipids and their importance in biological systems.

CO 2. Apprehend the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.

CO 3. Interpret the metabolic pathways such as Glycolysis, Kreb's Cycle, ETC, pentose phosphate pathway, etc. occurring inside living cells.

CO 4. Translate the importance of biological macromolecules and their role in living systems

Unit I: Glycobiology and its metabolism (14hrs)

Carbohydrates: classification of carbohydrates: Monosaccharides: structure of aldoses and ketoses, ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers, structure of biologically important sugar derivatives. Disaccharides: Glycosidic bond, reducing and nonreducing disaccharides, structure and functions of sucrose, lactose and maltose.

Polysaccharides: homo and heteropolysaccharides, structural and storage polysaccharides. structure and functions of starch, glycogen, and chitin. Glycosylation of other biomolecules: glycoproteins and glycolipids.

Metabolism of carbohydrates: Reactions, energetics, and regulation: Glycolysis, Fate of pyruvate under aerobic and anaerobic conditions, citric acid cycle, Pentose phosphate pathway, Gluconeogenesis. Glycogenolysis and glycogen synthesis. Mitochondrial electron transport chain, oxidative Phosphorylation. Energy balance of cellular oxidation of glucose.

Unit II Lipids and its metabolism (14hrs)

Lipids: Structure and functions, Classification of lipids: simple and compound lipids; Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Prostaglandins, Cholesterol. Fatty acids: Classification: short chain, medium chain, and long chain; saturated and unsaturated; essential fatty acids. properties of fatty acids: acid number, Saponification number and iodine number.

Lipid metabolism: Scheme of β-oxidation of fatty acids (stearate and palmitate as examples): role of carnitine. ketone body formation. structure and properties of lipoproteins- HDL, LDL, VLDL.

Unit III Amino acids and its metabolism (14hrs)

Amino acids & Proteins: Structure and properties of Amino acids, classification of proteins: fibrous proteins, globular proteins, conjugated proteins. Forces stabilizing protein structure and shape. Different Level of structural organization of proteins: primary, secondary, tertiary, and quaternary structure of proteins, Denaturation, and renaturation of proteins. Introduction to Proteomics.

Overview of amino acid metabolism, general reactions of amino acid metabolism: transamination, mechanism, and role of pyridoxal phosphate in transamination, deamination (oxidative and non-oxidative). Disorders of amino acids metabolism, phenylketonuria, alkaptonuria,

Unit IV Nucleic acid and its metabolism (14hrs)

Nucleic acids: structure of purines and pyrimidines, ribose and deoxy ribose, nucleoside and nucleotides, Chargaff's rule, Physical & chemical properties of Nucleic acids: denaturation, renaturation, melting temperature, hyperchromicity, cot curve. RNA: types of RNA (t-RNA, r-RNA, m-RNA & micro-RNAs). Introduction to nucleic acid sequencing.

Nucleotide metabolism: Overview of *de novo* and salvage pathway of nucleotide synthesis, Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism: Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

References

1. Agarwal, G. R., & Agarwal, O. P. (2007). Text book of Biochemistry. Krishna Prakashan Media.
2. Campbell, M. K., Farrell, S. O., & McDougal, O. M. (2016). Biochemistry. Cengage Learning.
3. Champe, P. C., Harvey, R. A., & Ferrier, D. R. (2005). Biochemistry. Lippincott Williams & Wilkins.
4. Cox, M. M., Nelson, D. L., Lehninger, A. L. (2008). Lehninger principles of biochemistry. United Kingdom: W. H. Freeman.
5. Hames, D., & Hooper, N. (2006). *Instant notes biochemistry*. Taylor & Francis.
6. Jain, J.L, Sunjay, J. & & Nithin, J.(2012). Fundamentals of Biochemistry. (6 th ed.) S. Chand & Company.
7. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.
8. Satyanarayana, U. (2017). Biochemistry - E-book. India: Elsevier Health Sciences.
9. Rodwell, V. W., Bender, D. A., Botham, K. M., Kennelly, P. J., & Weil, P. A. (2018). Harper's illustrated biochemistry (pp. 661-686). New York, NY, USA:: McGraw-Hill Education.
10. Voet, D., Voet, J. G., & Pratt, C. W. (2016). Fundamentals of biochemistry: life at the molecular level. John Wiley & Sons.

Course code: G511 DC2.3P Biomolecules Practical

Course outcome:

After successful completion of this Course, students will be able to:

CO 1. Exposure to basic reactions of biomolecules.

CO 2. Determine presence of biomolecules like carbohydrates, proteins, lipids, etc. in known and unknown samples.

CO 3. Determine the extent of adulteration in samples containing biomolecules

CO 4. Construct the standard curve, analyse the data and interpret the results.

CO 5. Apply knowledge of biochemistry and metabolism in various cellular functions, and the application of research involved in various biochemical processes.

List of Practical:

1. Preparation of buffers.
2. Verification of Beer's law- determination of absorbance maxima of proteins
3. Separation of carbohydrates by paper chromatography.
4. Separation of Amino acids by Thin layered chromatography.
5. Qualitative tests for Carbohydrates
6. Qualitative tests for lipids
7. Qualitative tests for amino acids and proteins
8. Estimation of reducing sugar by DNS method.
9. Estimation of Proteins by Biuret method
10. Estimation of Proteins by Lowry's method

References:

1. Dhiman, P., Rajendiran, S., Dhiman, P., Rajendiran, S. (2019). Biochemistry Practical Manual - E-Book. India: Elsevier Health Sciences.
2. Plummer, D. T., Plummer, D. T. (2001). Introduction to Practical Biochemistry. India: Tata McGraw Hill Publishing Company.
3. Vasudevan, D., Das, K. S., Vasudevan, D., Das, K. S. (2019). Practical Textbook of Biochemistry for Medical Students. India: Jaypee Brothers Medical Publishers Pvt. Limited.
4. Wilson, K., & Walker, J. (Eds.). (2010). Principles and techniques of biochemistry and molecular biology. Cambridge university press.

Semester III Open elective

Course code: G511 OE1.3 IPR, Biosafety & Bioethics in Biotechnology 42 hours

After successful completion of this Course, students will be able to:

CO.1 Know the importance of bioethics, biosafety and IPR

CO.2 Elucidate different types of intellectual property rights in general and protection of products derived from biotechnology research

CO.3 Follow environment, health and safety (EHS),GMP and GLP norms at work in the life sciences facility/ laboratory

CO. 4 Evaluate multiple perspectives concerning bioethical issues and recognize that different value systems may lead to different ethical decisions.

CO.5 Follow the regulatory framework in their future venture to ensure product safety and benefit the society

Unit 1 IPR (14 hours)

Introduction to Intellectual Property Rights, Types of IP: Patents, Trademarks, Trade secrets, Copyright, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of Plant Varieties, Registration of new plant variety. IP as a factor in R&D; relevance of IPs to Biotechnology and few Case Studies (Neem Patent Case & Turmeric Patent Case).

Unit 2. Biosafety (14 hours)

Introduction to biosafety, Biological Risk Assessment, health hazards related to Biotechnology, Primary Containment for Biohazards, Introduction to Biological Safety Cabinets, Biosafety Levels. Biosafety During Industrial Production, introduction to Good manufacturing practice (GMP) and OECED guidelines of Good lab practices (GLP). The Cartagena Protocol on Biosafety.

Unit 3. Bioethics (14 hours)

Bioethics: Ethical implications of biotechnological products and techniques. Bioethics in Biodiversity and resources management. Social and ethical implications of biological weapons. bioterrorism and Biological Weapons Convention (BWC).

Reference:

1. Ashok, K. M. & Mohd, I. A. (2008). Intellectual property rights. 1st ed. Serials Publications New Delhi.
2. Acharya, N.K. (2014). Textbook of intellectual property rights. 7th Ed. Asia Law House, Hyderabad.
3. Chadwick, R. F., Schüklenk, U., Chadwick, R. F., Schüklenk, U. (2020). This is Bioethics: An Introduction. United Kingdom: Wiley.
4. Cooper B. N., (2017), Good Manufacturing Practices for Pharmaceuticals-GMP in Practice. Create Space Independent Publishing Platform.
5. Dawn P. Wooley, Karen B. B. (2020). Biological Safety: Principles and Practices. United States: Wiley.

6. Fleming D.A., Hunt D. (2000) Biological safety Principles and practices 3rd. Ed.ASM Press
7. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
8. Kuhse, H. (2010). Bioethics: An anthology. Malden, MA: Blackwell.
9. Pace, T. N., Pace, T. N. (2010). Bioethics: Issues and Dilemmas. United States: Nova Science Publishers.
10. Talbot, M., Talbot, M. (2012). Bioethics: An Introduction. United Kingdom: Cambridge University Press.

Semester IV

Course code: G511 DC1.4 MOLECULAR BIOLOGY 56 hours

Course Outcomes:

After successful completion of this Course, students will be able to:

CO 1. Acquire a deep insight on the concepts of central dogma in Molecular biology.

CO 2. Describe the fine structure of DNA and the mechanism of replication in prokaryotes and eukaryotes.

CO 3. Comprehend the causes of DNA damage and various mechanism of DNA repair.

CO 4. Illustrate the fundamental principles of gene expression and regulation in cells

CO 5. Select appropriate model systems for studying different molecular biological processes

UNIT I: DNA structure and replication (14 Hours)

DNA as genetic material: Experiments of Griffith, Avery and Hershey & Chase. Structure of DNA, Types of DNA (A, B & Z), Organelle DNA: cpDNA and mtDNA. Chromatin and the Nucleosome, Histones and Non-Histones. Central dogma in molecular biology. Replication of DNA in prokaryotes: Semiconservative nature of DNA replication, replicon, origin of replication, enzymes in DNA replication. Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

UNIT II: DNA damage, repair, and homologous recombination (14 Hours)

DNA damage: causes (physical and chemical) and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch

repair, recombinational repair, SoS repair, nonhomologous end joining. Homologous recombination- Holliday model.

UNIT III: Transcription and RNA processing (14 Hours)

RNA structure and types of RNA, transcriptome, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation, and termination of RNA synthesis. Polycistronic mRNA.

Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation. RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing of mRNA: spliceosome. RNA editing and role of guide RNA. Inhibitors of transcription: Rifampicin, α- amanitin.

UNIT IV Translation & Regulation of gene expression: (14hrs)

Genetic code and its characteristics. Translation in Prokaryotes and Eukaryotes: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Post translational modifications of proteins.

Regulation of gene expression in prokaryotes: Operon concept, Lac operon-fine structure, repressor, and the catabolite activator in regulation of lactose operon. Transcriptional control by attenuation in tryptophan operon. Gene regulation in eukaryotes: galactose operon in yeast.

References:

1. Alberts B., Hopkin K., Johnson A., Morgan D., Lewis J., Raff M., Roberts K. and Walter P., (2019), Essential Cell Biology, International student edition 5th ed.,WW Norton & Co.
2. Brown T. A., (2017), Genomes 4, 4th ed., Garland Science, Taylor and Francis group, New York.
3. Cooper & Sinauer G.M., (2019), The Cell: A Molecular Approach, International 8th ed., Oxford University Press
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2017). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
5. Karp G., Iwasa J. & Marshall W., (2016), Cell and Molecular Biology: Concepts and Experiments, 8th ed., Wiley & sons. New York.

6. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A. & Martin, K., (2016), Molecular Cell Biology, 8th ed., W.H. Freeman & Co., New York
7. P.S. Verma, D. V. A. (2009). Molecular Biology. S. Chand Limited., India
8. Tropp B.E., (2020), Molecular Biology: Genes to Proteins, 5th ed., Jones & Bartlett Learning.
9. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2014) Molecular Biology of the Gene (VII Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.
10. Wilson and Walker (2018). Principles and Techniques of Biochemistry and Molecular Biology. United Kingdom: Cambridge University Press.

Course code: G511 DC2.3P Molecular Biology Practical

Course Outcomes:

After successful completion of this Course, students will be able to:

CO 1. Independently execute laboratory experiments using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

CO 2. Independently use various instruments such as centrifuges, colorimeters, UV-transilluminator, Gel Doc, UV- Vis spectrophotometer in laboratory work.

List of Practical:

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from yeast / bacterial cells
3. Isolation of genomic DNA from animal tissues/ plant tissues
4. Characterization of purity of DNA by UV spectrophotometry
5. Estimation of DNA by diphenylamine method
6. Isolation of RNA from coconut endosperm/ yeast
7. Estimation of RNA by orcinol method
8. Isolation of Plasmid DNA by alkaline lysis method
9. Agarose gel electrophoresis of genomic DNA & plasmid DNA
10. Separation of proteins and Molecular weight determination by SDS-PAGE.

References:

1. Chaitanya, K. V. (2013). Cell and Molecular Biology: A Lab Manual. PHI Learning., India.
2. Fernandez, T. G., Pattison, S. (2015). Biochemistry Laboratory Manual For Undergraduates: An Inquiry-Based Approach. De Gruyter., Germany.
3. Gakhar, S. K., Miglani, M., Kumar, A. (2013). Molecular Biology: A Laboratory Manual. I.K. International Publishing House Pvt. Limited.,India.
4. Lone, S. M., Rasool, R. S., Masoodi, K. Z. (2020). Advanced Methods in Molecular Biology and Biotechnology: A Practical Lab Manual. Elsevier Science., Netherlands.
5. Miller, H. B., Carson, S., Witherow, D. S., Carson, S. (2012). Molecular Biology Techniques: A Classroom Laboratory Manual.: Elsevier Science., Netherlands.
6. Ravi, I., Baunthiyal, M., Saxena, J. (2015). Laboratory Manual of Microbiology, Biochemistry and Molecular Biology. Scientific Publishers., India.
7. Thompson, D. (2011). Cell and Molecular Biology Lab Manual. CreateSpace Independent Publishing Platform.

SEMESTER – IV

OPEN ELECTIVE COURSE

Course Title	**INTELLECTUAL PROPERTY RIGHTS**		
Course Code	**G511 OE1.4**		
Number of credits	**3**	**Contact Hours**	**42**

Course Outcomes:

CO 1. Elucidate different types of intellectual property rights in general and protection of products derived from biotechnology research.

CO 2. Acquire knowledge about filing patents, process, and infringement.

CO 3. Evaluate multiple perspectives about trademarks, industrial designs, and copyright.

Unit 1. Introduction to Intellectual property rights (IPR) (14 hours)

Genesis and scope. Types of Intellectual property rights - Patent, Trademarks, Copyright, Design, Trade secret, Geographical indicators, Plant variety protection. National and International agencies – WIPO, World Trade Organization (WTO), Trade-Related Aspects of Intellectual Property Rights (TRIPS), General Agreement on Tariffs and Trade (GATT).

Unit II. Patenting, process, and infringement (14 hours)

Basics of patents - Types of patents; Patentable and Non-Patentable inventions, Process and Product patent. Indian Patent Act 1970; Recent amendments; Patent Cooperation Treaty (PCT) and implications. Process of patenting. Types of patent applications: Provisional and complete specifications; Concept of "prior art", patent databases (USPTO, EPO, India). Financial assistance, schemes, and grants for patenting. Patent infringement- Case studies on patents (Basmati rice, Turmeric, Neem).

Unit III. Trademarks, Copy right, industrial Designs (14 hours)

Trademarks- types, Purpose and function of trademarks, trademark registration, Protection of trademark. Copy right- Fundamentals of copyright law, Originality of material, rights of reproduction, industrial Designs: Protection, Kind of protection provided by industrial design.

References

1. Ashok, K. M. & Mohd, I. A. (2008). Intellectual property rights. 1st Ed. Serials Publications New Delhi.
2. Acharya, N.K. (2014). Textbook of intellectual property rights. 7th Ed. Asia Law House, Hyderabad.
3. Fleming D.A., Hunt D. (2000) Biological safety Principles and practices 3rd Ed. ASM Press.
4. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. New Delhi: Tata McGraw-Hill Pub.
5. Manish Arora. (2007). Universal's Guide to Patents Law 4th Ed. Universal Law Publishing House.

6. Kalyan C. Kankanala. 2012. Fundamentals of Intellectual Property. Asia Law House
7. World trade organization - http://www.wto.org
8. World Intellectual Property organization – www.wipo.intOffice of the controller general of Patents, Design & Trademarks - www.ipindia.nic.in.

SEMESTER – V

Discipline Specific Course.1

Course Title GENETIC ENGINEERING

Course Code G511 DC1.5

Number of credits 4 Contact Hours 60

Course Outcome:

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

CO 1. Describe the principles, role of various DNA modifying enzymes used in genetic engineering.

CO 2. Implement a range of methodologies for genetic manipulation, encompassing diverse practices and genome editing techniques.

CO 3. Utilise various genetic engineering practices such as PCR, Hybridisation methods for diagnosis and various advanced development.

CO 4. Explore the multifaceted applications of genetic engineering in the biotechnology industry, employ computational tools in genetic manipulation, and critically examine the ethical implications associated with the manipulation of genetic material and its societal impact.

Unit I. Fundamentals of Genetic Engineering (15 hours)

Introduction to rDNA technology. Isolation and purification of DNA (genomic and plasmid) and plant and animal DNA. Methods for quantification and characterization of DNA samples.

Restriction-modification systems: Restriction enzymes-types, isoschizomers and neoschizomers. double digests, Restriction enzymes – function, classification (Based on recognition and restriction sequence: -type I, II and III; based on pattern of restriction: sticky and blunt end cutters, Restriction mapping. DNA modifying enzymes and its functions (DNA Polymerases, Klenow fragment, DNA Ligase, S1 Nuclease, Alkaline Phosphatase, Terminal Transferase, Polynucleotide kinases, Polynucleotide phosphorylase, RNase A, RNase H, DNase 1, DNase II, Exonuclease III, Reverse Transcriptase).

Essential features of cloning and expression vectors. Selectable markers and reporter genes. Plasmid vectors: pUC19, pBR322. M-13 vectors and Cosmid vectors. Artificial chromosome vectors (YAC, BAC). Animal vectors: SV40 vectors and Adeno-associated

virus (AAV) vectors, baculoviruses as vectors. Plant vectors: Agrobacterium plasmid biology: organization of Ti plasmid and T-DNA transfer, cointegrate and binary vectors.

Unit II. Practices in Genetic Engineering (15 hours)

Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymer tailing. Construction of libraries: genomic library; Isolation of mRNA and methods of cDNA synthesis and construction of cDNA library. Gene knockout techniques in bacterial and eukaryotic organisms.

Physical and chemical methods of gene transfer: Biolistic, Microinjection, electroporation, Calcium phosphate co precipitation, Liposome mediated transformation, PEG, DEAE dextran.

Identifying the right clones: Insertional inactivation of marker gene, visual screening-Blue-white selection, colony and plaque hybridization, Immunological techniques.

DNA sequencing- Sanger's, Next Generation Sequencing. RNA sequencing and its types. Genome editing technology: Principles and applications of genome editing techniques, CRISPER/Cas 9, site-directed mutagenesis, and other genome editing methods.

Unit III. Applications of Genetic Engineering

(15 hours)

Analysis of gene expression: Southern blot, Northern blot and western blot. In situ hybridization: FISH & GISH. Recombinant Protein Expression and Purification, affinity tags in protein purification.

PCR: Basic principle and amplification of DNA, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR.

DNA fingerprinting and its applications in forensics. Molecular diagnostic techniques and their role in disease diagnosis. Use of genetic engineering in the development of therapeutics and vaccines. Production of biopharmaceuticals using recombinant DNA technology. Genomics: methods and applications.

Unit IV. Advances in Genetic Engineering (15 hours)

Industrial applications of genetic engineering, such as enzyme production, biofuel production, and bioremediation. Introduction to synthetic biology and its integration with genetic engineering. Design and construction of artificial biological systems. Bioinformatics and Computational Tools: Introduction to bioinformatics and its role in genetic engineering. Use of computational tools for sequence analysis, gene prediction, and protein structure analysis.

Ethical and Regulatory Considerations - Discussion of ethical implications associated with genetic engineering. Introduction to regulatory guidelines and safety considerations for genetic engineering research and applications

SEMESTER – V

Discipline Specific Course.2

Course Title GENETIC ENGINEERING PRACTICAL

Course Code G 511DC1.5 P **Number of hours /weeks- 4**

Number of credits 2 **Contact Hours** 60

Course Outcome:

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

CO 1. Utilize essential genetic engineering tools and techniques effectively for conducting practical experiments.

CO.2 Design experiments for isolation, purification and amplification of DNA for genetic engineering work.

CO 3. Analyse and interpret genetic data using bioinformatics tools for understanding of gene function and evolutionary relationships.

List of Practical:

1. Isolation of nucleic acids from different sources.
2. Quantification of DNA by UV-Vis spectroscopy
3. Restriction enzyme digestion of DNA and calculation of molecular weight of the digested DNA
4. Isolation of Plasmids-electrophoretic identification of linear, circular and supercoiled DNA
5. DNA ligation
6. DNA amplification by PCR.
7. Preparation of competent cells in *E. coli.*
8. Calcium chloride mediated transformation of *E. coli* & selection of transformants
9. Demonstration experiments: Southern Blotting.
10. Restriction mapping
11. Bioinformatics for Genetic Engineering

Introduction to bioinformatics databases and tools

Sequence analysis (e.g., BLAST, multiple sequence alignment) Prediction of protein structure and function.

12. Gel Electrophoresis and DNA Analysis

Agarose gel electrophoresis for DNA fragment separation and analysis DNA size determination using molecular weight markers. DNA band visualization techniques (e.g., ethidium bromide staining, DNA intercalating dyes).

References

1. Abdelmigid, H. (2013). Genetic Engineering: Laboratory Manual. (n.p.): CreateSpace Independent Publishing Platform.
2. Masoodi, K. Z., Lone, S. M., Rasool, R. S. (2020). Advanced Methods in Molecular Biology and Biotechnology: A Practical Lab Manual. Netherlands: Elsevier Science.
3. Noble. (2023). A Complete Lab Manual for Biotechnology. (n.p.): Notion Press.
4. Kurnaz, I. A. (2015). Techniques in Genetic Engineering. United Kingdom: CRC Press.

SEMESTER – V

Discipline Specific Course. 3

PLANT AND ANIMAL BIOTECHNOLOGY

G 511 DC2.5

4 Contact Hours 60

Course Outcome:

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

CO 1. Analyze the fundamental concept of cellular totipotency and adeptly apply this understanding to proficiently execute micropropagation techniques, including bud culture, meristem culture, and organogenesis.

CO 2. Evaluate the applications of transgenic plants and analyze their safety and ethical concerns.

CO 3. Apply the basic techniques of mammalian cell culture, including parameters for measuring cell growth, viability, and cytotoxicity.

CO 4. Analyze the concepts of gene therapy and cloning, evaluate applications of transgenic animals, and consider their ethical implications.

Unit I. Plant Tissue culture (15 hours)

Introduction to plant tissue culture, history, definition, Concept of cellular totipotency, cytodifferentiation - xylogenesis, Commercial PTC laboratory organization; Brief overview of nutrient requirements, culture media (MS media), role of growth regulators, and factors influencing the growth. Basic steps involved in plant tissue culture selection of mother plant, explant, surface sterilisation of explant. Callus. Differentiation: Organogenesis and somatic embryogenesis, synthetic seeds. Micropropagation, bud culture and meristem culture. Haploid Production: anther culture, pollen culture, ovary culture, ovule culture. Embryo culture, Meristem culture and production of virus free plants.

Secondary metabolites, *in vitro* secondary metabolite production, Cell suspension cultures, growth vs secondary metabolite production, bioreactors and scaling up of secondary metabolite production, limitations, and applications.

Unit II. Transgenic Plants and biosafety (15 hours)

Overview of transgenic plants and their significance in agriculture. Applications of Transgenic Plants - Improved crop traits through genetic engineering: pest resistance (Bt gene- case study of Bt -cotton), herbicide tolerance, disease resistance: bacteria and fungi (pathogenesis related proteins, anti-microbial proteins, phytoalexins), and virus (coat protein mediated cross protection,), and abiotic stress tolerance. Case study of golden rice and Flavr Savr tomato.

Biosafety assessment of transgenic plants: potential risks and benefits. International/

national regulatory frameworks for releasing and commercializing genetically modified organisms (GMOs). Ethical and socio-economic impacts of transgenic crops. Intellectual property rights and access to transgenic technologies.

Unit III. Animal Cell culture methods (15 hours)

History and laboratory organisation (Equipment and materials for animal cell culture), Media components and types. Cell types and culture characters. Pluripotency, Multipotency, Differentiation, Trans differentiation, Reprogramming.

Biology and characterization of cultured cells- cell adhesion, proliferation, differentiation, morphology of cells, and identification. The basic technique of mammalian cell culture *in vitro*, Measuring parameters of growth in cultured cells, cell viability, and cytotoxicity. Large-scale culture of cell lines- monolayer, suspension, and immobilized cultures.

Organ and histotypic culture: Technique, advantages, limitations, applications. Stem cells: types (embryonic, adult, induced pluripotent), isolation, identification, expansion, differentiation and uses, stem cell engineering.

Unit IV. Gene therapy and transgenic animals. (15 hours)

Gene therapy: Somatic therapy and germline therapy with examples – SCID, CF. Tissue engineering and applications (e.g. artificial skin).

Reproductive cloning (nuclear transplantation- Cloning of Dolly) and therapeutic cloning (xenotransplantation).

Biopharming: concept, mammary glands of farm animals as bioreactors for production of regulatory proteins [α- anti trypsin (AAT), human tissue plasminogen activator], Silkworms as bioreactors for production of heterologous proteins. Transgenic animals and applications (e.g. transgenic cattle, sheep and fish). CPCSEA guidelines.

References

1. Chawla, H. S. (2000). Introduction to Plant Biotechnology. Enfield, NH: Science.
2. Razdan, M. K. (2003). Introduction to Plant Tissue Culture. Enfield, NH: Science.
3. Slater, A., Scott, N. W., & Fowler, M. R. (2008). Plant Biotechnology: an Introduction to Genetic Engineering. Oxford University Press.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants. John Wiley & Sons.
5. Glick, B.R., and Pasternak, J.J. (2018). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 5th edition. Washington, DC: ASM Press.
6. Satyanarayana, B.N. & Varghese, D.B.(2007). Plant tissue culture practices and new experimental protocols, IK International Publications.

7. Razdan, M. (2016). Introduction to Plant Tissue Culture 3rd edition. Oxford University Press.
8. Neal Stewart Jr. (2016). Plant Biotechnology and Genetics: Principles, Techniques and Applications. Wiley and Sons, New York.
9. Taiz, L., and Zeiger, E. (2014). Plant Physiology. 5th edition. Sunderland, MA: Sinauer Associates.
10. Freshney, I. (2016). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (8th ed.). Wiley-Blackwell.
11. Pörtner, R. (Ed.). (2007). Animal Cell Biotechnology: Methods and Protocols. Humana Press.
12. Singh, B., & Gautam, S.K. (2013). Textbook of Animal Biotechnology. The Energy and Resources Institute (TERI).
13. Gupta, P.K. (2018). Animal Biotechnology. Rastogi Publications.
14. Mather, J.P., & Barnes, D. (Eds.). (Year N/A). Animal Cell Culture Methods. In Methods in Cell Biology, Vol. 57. Academic Press.
15. Singh, B.D. (2006). Biotechnology: Expanding Horizons (3rd ed.). Kalyani Publishers.
16. Srivastava A.K. Animal Biotechnology. (2018). Oxford & IBH Publishing Co Pvt.Ltd.

SEMESTER – V

Discipline Specific Course.4

Course Title **PLANT AND ANIMAL BIOTECHNOLOGY PRACTICAL**

Course Code **G 511 DC2.5P**

Number of credits **2** **Contact Hours** **60**

Course Outcome:

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

CO 1. Demonstrate skills in plant and animal tissue culture techniques.

CO 2. Apply knowledge of cell and tissue culture techniques and PCR for both research and commercial purposes.

CO 3. Plan and conduct experiments with the use of specific methods applied to *in vitro* culture of animal cell .

List of Practical:

1. Preparation of MS media for plant tissue culture.
2. Seed culture
3. Callus culture form *Daucus carota*
4. Preparation of synthetic seeds- sodium alginate-$CaCl_2$ method.
5. Explant preparation – Leaf, bud, rhizome, and meristem
6. Micropropagation in Bougainvillea plant
7. Anther culture
8. Acclimatization and hardening techniques
9. Preparation of cell culture media: Preparation of basic cell culture media, such as Dulbecco's Modified Eagle Medium (DMEM), supplemented with fetal bovine serum (FBS), antibiotics, and other required additives.
10. Filter sterilization: Practice filter sterilization for sensitive media ingredients
11. Primary explant culture using liver cells / kidney / spleen cells.
12. Disaggregation of liver tissue by Warm Trypsin method.
13. Estimation of cell viability for the trypsinized liver cells by dye exclusion method
14. Assessing cell viability using the MTT assay.

References:

1. Santosh Nagar, Madhavi Adhav (2009). Practical Biotechnology and Plant Tissue Culture. S. Chand Limited.

2. Chawla. H.S. (2004). Plant Biotechnology: Laboratory Manual for Plant Biotechnology. Oxford & IBH Publishing Company Pvt. Limited.
3. Reinert J., Yeoman M.M. (2012). Plant Cell and Tissue Culture, A Laboratory Manual. Springer Berlin Heidelberg
4. Park, S. (2021). Plant Tissue Culture: Techniques and Experiments. Netherlands: Elsevier Science.
5. John Davis. (2011). Animal Cell Culture: Essential Methods. United Kingdom: Wiley.
6. Capes-Davis, A., Freshney, R. I. (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. United Kingdom: Wiley.
7. Freshney, R. I. (2015). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Germany: Wiley.

SEMESTER – VI
Discipline Specific Course. 1

IMMUNOLOGY
G 511 DC1.6
4 Contact Hours 60
Course Outcome:

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

CO 1. Explain the distinction between innate and acquired immunity and recognize the roles of B and T-lymphocytes in both humoral and cell-mediated immune responses.

CO 2. Understand major histocompatibility complexes, antigen processing pathways, complement pathways, cytokines, and types of hypersensitivity reactions.

CO 3. Apply knowledge of immunodiffusion reactions, agglutination reactions, ELISA, RIA, immunocytochemistry, and fluorescent techniques in diagnosis.

CO 4. Apply the domain-specific knowledge and skills acquired in immunology for innovative therapies and Immuno-technologies.

Unit I. Cells and Organs of the Immune System (15 hours)

Introduction to the Immune System: History of Immunology, Types of Immunity: first and second line of defense, innate and acquired/adaptive immunity, specificity, diversity.

Cells of the immune system: Antigen-presenting cells (APCs), Role of B and T-lymphocytes in Humoral immunity and cell-mediated immunity, primary and secondary immune response, Immunization, memory. Organs of the Immune system: Thymus, bone marrow, spleen, Lymph Node, peripheral lymphoid organs.

Unit II. Molecules of the Immune System (15 hours)

Antigens and haptens: Properties (foreignness, molecular size, heterogeneity). Adjuvants. Antigenicity and Immunogenicity. Affinity and Avidity. B and T cell epitopes, superantigens Immunoglobulins: Classification, structure, and function. Antibody diversity (Neutralising and Non neutralising antibodies) , Monoclonal and polyclonal antibodies.

Major histocompatibility complexes: Classification, structure, and function. Antigen processing pathways – Cytosolic and Endocytic, Complement Pathways, Cytokines: Classification and function, Hypersensitivity: Reactions – Types I, II, and III. Delayed Type Hypersensitive Response.

Unit III. Immunotechniques and vaccines (15 hours)

Structure and properties of antigens- iso- and allo-antigens, antigen specificity, Cross-reactivity, Precipitation, Immunodiffusion reactions: Radial immunodiffusion, Ouchterlony double diffusion, Immuno electrophoresis. Agglutination: Agglutination

reactions. Use of antibody conjugates in bioassays: ELISA, RIA, Immunocytochemistry. Vaccines: Conventional (killed or attenuated vaccines), peptide vaccines, subunit, DNA vaccines, mRNA vaccines. Toxoids, antisera, edible vaccines, plantibodies, and Cancer vaccines.

Unit IV. Immunology of diseases (15 hours)

Transplantation immunology: Phases in graft rejection and immuno-suppressors. Autoimmune Disorders: Systemic and Organ-specific Autoimmune disorders with examples. Immunodeficiencies: Primary and secondary immunodeficiencies; acquired immunodeficiency syndrome.

Cancer and the immune system – immune surveillance, immunological escape, cancer antigens, cancer immunotherapy.

Microbial diseases in humans: Mode of infection, symptoms, epidemiology and control measures of diseases caused by Viruses (Hepatits-B), Bacteria (Typhoid), Fungi (Aspergillosis), Protozoa (Malaria).

References

1. Abbas A., Lichtman, A. H. & Pillai, S., (2017), Cellular and Molecular Immunology, 9th ed., Elsevier.
2. Coico, R. & Sunshine, G., (2015), Immunology: A Short Course, 7th ed.,Wiley-Blackwell.
3. Delves, P.J., Martin, S.J., Burton, D. R. & Roitt, I. M., (2017), Roitt's Essential Immunology, 13th ed., Wiley- Blackwell.
4. Kindt, T. J., Goldsby, R. A., Osborne, B. A. &Kuby, J., (2007),Kuby Immunology, 7th ed. 2007. W.H. Freeman.
5. Lippincott W.E., (2014), Fundamental Immunology,7th ed. Paul, Williams and Wilkins
6. Male, D., Brostoff, J., Roth, D. B. &Roitt, I. V., (2012), Elsevier Immunology, 8th ed.
7. Murphy,K. & Weaver , C., (2016), Janeway's Immunobiology, 9th ed., Garland Science.
8. Owen J., Jenni Punt J. & Stranford S., (2018), Kuby Immunology, 8th ed., Jones P. W. H. Freeman.
9. Playfair, J. H. L. & Chain, B. M., (2012), Immunology at a Glance, 10th ed.,Wiley-Blackwell.
10. Tizard, I. R., (2000), Immunology: an Introduction, 4th ed.,Ceneage Learning India.

Ananthanarayan, R., Paniker, C. J. (2006). Ananthanarayan and Paniker's Textbook of Microbiology. India: Orient Longman Private Limited.`

SEMESTER – VI

Discipline Specific Course. 2

Course Title **Immunology Practical**

Course Code **G 511 DC1.6P**

Number of credits **2** **Contact Hours** **60**

Course Outcome:

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

CO 1. Execute immune cell differential counting and whole count of white blood cells accurately.

CO 2. Successfully perform immunoassay techniques such as radial immunodiffusion and Ouchterlony double diffusion, dot ELISA, serum immune-electrophoresis, and Western blotting.

CO 4. Demonstrate proficiency in analyzing and interpreting experimental results.

List of Practical:

1. Hemagglutination of ABO Blood groups
2. Determination of Rh factor
3. Whole Count of WBC using Hemocytometer
4. Cells of the Immune System- Differential counting by Giemsa/Leishman stain.
5. Radial immunodiffusion
6. Ouchterlony double diffusion
7. Testing for Typhoid antigens by Widal test
8. Dot ELISA
9. Serum Immunoelectrophoresis.
10. Western Blotting
11. Cell culture techniques-Chinese Hamster Ovary (CHO) Cells
12. Estimation of viability and enumeration of the CHO cells.

References:

1. Sam-Yellowe, T. Y. (2021). Immunology: Overview and Laboratory Manual. Germany: Springer International Publishing.
2. Speshock, J. (2019). Immunology Lab Manual. (n.p.): Kendall Hunt Publishing Company.
3. Arora, B., Arora, D. R. (2020). Practical Microbiology. India: CBS Publishers & Distributors.
4. Maheshwari D.K. (2002). Practical Microbiology. India: S. Chand Limited.

SEMESTER – VI

Discipline Specific Course. 3

Course Title **Bioprocess and Environmental Biotechnology**
Course Code **G 511 DC2.6**
Number of credits **4** **Contact Hours** **56**
Course Outcome:

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

CO 1. Describe the principles of upstream processing and calculate growth rates and biomass yields within diverse culture modes.

CO 2. Compare and contrast various bioreactor designs and describe the principles and applications of various downstream processing techniques.

CO 3. Propose biotechnological solutions to address specific environmental pollution challenges.

CO 4. Design a bioremediation strategy for a specific contaminant and propose methods for effective wastewater treatment and solid waste management.

Unit I. Introduction to bioprocess technology (14 hours)

Basic principle components of fermentation technology. Strain improvement of industrially important microorganisms (membrane permeability, metabolic engineering, auxotrophic mutants, analogue resistant mutants, Use of recombination systems). Types of microbial culture and its growth kinetics– Batch, Fed-batch, and Continuous culture. Principles of upstream processing – Design of fermentation media (Carbon and nitrogen sources, precursors and metabolic regulators, Anti-foams), Inocula development, and sterilization -thermal death kinetics. sterilization of medium (batch and continuous).

Unit II. Bioreactors and downstream processing (14 hours)

Bioreactors- Design of a bioreactor, Significance of Impeller, Baffles, Sparger; Specialized bioreactors- design and their functions: airlift bioreactor, tubular bioreactors, membrane bioreactors, tower bioreactors, fluidized bed reactor, packed bed reactors.

Downstream processing- cell disruption, precipitation methods, solid-liquid separation, liquid-liquid extraction, filtration (Rotary vacuum filters, membrane filtration- micro filtration, reverse osmosis and ultrafiltration), centrifugation (principle, Basket and tubular bowl), chromatography (GPC, IEC, Affinity), drying devices (Lyophilization and spray dry technology), crystallization, biosensors-construction and applications, Microbial production of ethanol, Penicillin, and Single Cell Proteins.

Unit III. Fundamentals of Environmental Biotechnology-Air, water and soil microbiology (14 hours)

Introduction to Environmental Biotechnology- soil microorganisms-Interaction among microorganisms in Soil: Positive and Negative interactions: Neutralism, Commensalisms, Synergism (proto-cooperation), Mutualism (symbiotic), Competition,

Amensalism, Parasitism and Predation.

Microbial composition of air, Sampling Techniques for trapping of indoor and air borne microbes in brief: agar plate, Gravity slide. Anderson, Burkard.

Air borne diseases in brief (Tuberculosis, Corona, SARS, MERS) and allergens (Hay fever, Rhinitis).

Analysis of Water –sampling, qualitative (Presumptive, Confirmed and completed coliform test) and quantitative -Membrane filter technique. Standards of water quality for drinking and industry.

Water borne Diseases: Water borne pathogens and diseases- Bacterial (Cholera, Shigella) **and Protozoal (Amoebiasis, Giardiasis).**

Role of Biotechnology in Environmental Conservation. Biotechnological Methods in Pollution detection and Abatement. Reduction of CO_2 emission using biotechnological approaches. Application of cell immobilization techniques in pollution abatement.

Unit IV. Biofertilizers, Biopesticides, Bioremediation and Waste Management **(14 hours)**

Introduction to biofertilizers, Production of biofertilizers and utilization of organisms- for Biological Nitrogen fixation. Ex: *Rhizobia*, cyanobacteria, *Azotobacter, Azospirillum,* Phosphate solubilizing organisms, mycorrhiza- ectomycorrhiza and endomycorrhiza, sea weeds for soil enrichment

Introduction to biopesticides, properties, organisms- bacteria (*Bacillus thuringiensis, Bacillus papillae, Bacillus sphaericus),* Fungi (*Beauveria bassiana*) virus (*Baculovirus*), protozoans and plant products as biopesticides. Limitations of biopesticides.

Importance of bioremediation in environmental cleanup. Types (Phyto and microbial bioremediation) and microorganisms used in bioremediation. *In-situ and ex-situ* Bioremediation Methods. Microbial degradation of Xenobiotics (pesticides, hydrocarbons and detergents) and bio- mining.

Wastewater Management- Primary (screening and sedimentation), secondary (trickling filters, activated sludge process, oxidation ponds, rotating biological contactors, fluidized bed reactor), tertiary, advanced treatment of wastewater. Anaerobic Digestion and Biogas Production. Solid Waste Management- Vermi composting, organic waste treatment using black soldier fly.

References

1. Stanburry, P.F. & Whitaker, (2005). 2nd ed., Principles of Fermentation Technology, Pergamon Press, Butterworth Heinemann-Elsevier.

2. Stanbury, P. F., Whitaker, A., Hall, S. J. (2016). Principles of Fermentation Technology. Netherlands: Elsevier Science.
3. Arindam, K., Vinay, S. (2018). Principles and Applications of Fermentation Technology. United States: Wiley.
4. Das, D., Pandit, S. (2021). Industrial Biotechnology. United States: CRC Press.
5. Okafor, N., Okeke, B. C. (2017). Modern Industrial Microbiology and Biotechnology. United Kingdom: CRC Press.
6. Kalaichelvan, P.T., Arul, P. (2019). Bioprocess Technology. (n.p.): MJP Publisher.
7. Shuler M.L. & Kargi F. (2002). Bioprocess Engineering Basic Concepts 2nd ed., Prentice Hall of India pvt. Ltd.
8. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
9. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (2014). Environmental engineering. McGraw-Hill Education.
10. Banerjee, S., & Santhosh, C. (2019). Environmental biotechnology: Concepts and applications. CRC Press.
11. Mishra, A. K. (2016). Environmental biotechnology: Basic concepts and applications. CRC Press.
12. Mohapatra, P. K. (2013). Textbook of Environmental Biotechnology. India: I.K. International Publishing House Pvt. Limited.

SEMESTER – VI

Discipline Specific Course. 3

Course Title **Bioprocess and Environmental Biotechnology Practical**

Course Code **G 511 DC2.6P**

Number of credits **2** **Contact Hours** **56**

Course Outcome:

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

CO 1. Utilize crowding plate method to isolate industrially important microorganisms from natural resources.

CO 2 Apply various techniques to estimate key water quality parameters including sulphates, phosphates, chlorides, biological oxygen demand and microbial analysis of water.

CO 3. Produce amylase, ethanol, lactic acid, and wine through fermentation processes.

CO 4. Gain hands-on experience in essential techniques such as ammonium sulphate precipitation, dialysis, and total solids (TS) determination.

List of Practical:

1. Isolation of industrially important microorganisms from natural resources. (Crowed plate and screening for amylase production)
2. Submerged fermentation and analysis of amylase
3. Ammonium sulphate precipitation
4. Dialysis
5. Study of fermentor- Demonstration.
6. Production of wine
7. Estimation of the percentage of alcohol, total acidity & volatile acidity in wine.
8. Production and analysis of ethanol.
9. Production and analysis of lactic acid.
10. Mushroom cultivation-demo.
11. Determination of TS and TDS
12. Microbial analysis of water-MPN, Confirmed and Completed test.
13. Estimation of Sulphates
14. Estimation of Phosphates
15. Determination of DO and BOD in water.
16. Estimation of chlorides.

References:

1. Patra, J. K., Das, G., Das, S. K., Thatoi, H. (2020). A Practical Guide to Environmental Biotechnology. Germany: Springer Nature Singapore.
2. Kulandaivel, S., Janarthanan, S. (2012). Practical Manual on Fermentation Technology. India: I.K. International Publishing House Pvt. Limited.
3. Chellapandi, P. (2007). Laboratory Manual in Industrial Biotechnology. India: Pointer Publishers.
4. Mamta, B., Indu, R., Jyoti S. (2019). Comprehensive Laboratory Manual of Life Sciences. (n.p.): Scientific Publishers.