Shri Rawatpura Sarkar University, Raipur

Faculty of Science

Three Years B.Sc. Programme

Scheme of Teaching and Examination
B.Sc. Fifth Semester Biotechnology
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
(Effective from the Academic Year 2021-2022)

S. No.	Course Code	Th / Pr	Subject	Type of Course	Teaching Hours / Week			TC	Examination Scheme				Total Marks
					L	T	P		Theory		Practical		
									EX	IN	EX	IN	
1	SBS02531T	Th	Biotech IX: Molecular Biology	Core	4	-	-	4	70	30	-	-	100
2	SBS02532T	Th	Biotech X: Bioenergetics & Metabolism	Core	4	-	-	4	70	30	-	-	100
3	SBS02533T	Th	Biotech XI: Genetic Engineering	Core	4	-	-	4	70	30	-	-	100
4	SBS02551T	Th	Chemistry V: Analytical Methods In Chemistry	GE	4	-	-	4	70	30	-	-	100
5	SBS02552T	Th	Bioscience V: Plant Physiology and metabolism	**GE**									
5	SBS02591P	Pr	Lab Course XIII: Biotech IX, X and XI	LAB	-	-	4	2	-	-	35	15	50
7	SBS02592P/SBS02593P	pr	Lab Course XIV: Chemistry V/ Bioscience V Lab	LAB	-	-	4	2	-	-	35	15	50
	Total				**16**		**8**	**22**					**550**

PROGRAM OUTCOMES

[PO.1]. Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational and personal) from different perspectives.

[PO.2]. Effective Communication: Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

[PO.3]. Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

[PO.4]. Effective Citizenship: Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

[PO.5]. Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

[PO.6]. Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

[PO.7]. Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

PROGRAM SPECIFIC OUTCOMES

[PSO.1.] To demonstrate competency in factual content and interpretation of the major biological concept areas of cell and molecular biology, genetics, organismal biology, and evolution and ecology.

[PSO.2.] To demonstrate the ability to identify significant biological research questions, develop research protocols, and properly analyse research questions through the use of the scientific method.

[PSO.3.] Enhance analytical and quantitative skills and demonstrate an understanding of basic computational and statistical techniques in the field of Biotechnology

Course Title	**Biotech IX: Molecular Biology**				
Course Code	**SBS02531T**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Knowledge about Nucleic acids.**				
Course Objectives	To learn basic molecular mechanism of cell.				
Course Contents	**UNIT I:** DNA structure and replication: DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: Pre-primming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication. **UNIT II:** DNA damage and repair: DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photo-reactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. **UNIT III:** Transcription and RNA processing: RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains. 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. **UNIT IV:** Regulation of gene expression: Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Regulation				

	of gene expression in eukaryotes. Genetic code and its characteristics. **UNIT V:** Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Fidelity of translation, Inhibitors of translation.
Course Outcomes (CO)	1. Able to understand DNA structure and its types, mechanism of DNA replication in both prokaryotes and eukaryotes. 2. Able to understand DNA damage and mechanism of DNA repair 3. Able to understand transcription in prokaryotic and eukaryotic cell. 4. Able to understand gene expression regulation in prokaryotes and eukaryoic cells. 5. Able to understand prokaryotic and eukaryotic translation process.
Text and References	1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc. 2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia. 3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco. 4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

Course Title	**Biotech X: Bioenergetics &Metabolism**				
Course Code	**SBS02532T**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Knowledge of macromolecules of cells**				
Course	To understand energy flow and generation of ATP To understand various metabolic pathways.				

Objectives	
Course Contents	**UNIT I** Bioenergetics: Thermodynamics –First law of thermodynamics, second law of thermodynamics, Gibbs free energy, endergonic & exergonic reactions, Standard state free energy changes-DG, DG^0 and DG'^O , Relationship between equilibrium constant and DG'^O. ATPStructure, properties and energy currency of the cell, Electron Transport chain, Oxidative phosphorylation, & production of ATP, Introduction to Metabolism - Catabolism, anabolism, catabolic, anabolic and amphibolic pathways. **UNIT II** Carbohydrate Metabolism: Introduction, Aerobic and anaerobic pathways: Glycolysis and its regulation, Gluconeogenesis and its regulation.TCA cycle, Pentose phosphate pathway (HMP shunt) & its regulation. **UNIT III** Lipid Metabolism: Beta – oxidations of saturated & unsaturated fatty acids. Ketone bodies, production during starving and diabetes Biosynthesis of fatty acids , Regulation of fatty acid biosynthesis. Biosynthesis of triacylglycerols, Biosynthesis of cholesterol, regulation. **UNIT IV** Amino Acid/ Nucleic Acid Metabolism: Biodegradation of amino acids – deamination, transamination, decarboxylation, urea cycle including its regulation. Biosynthesis of amino acids, Disorders of amino acid metabolism (phenylketonuria, alkaptonuria). **UNIT V** Biologically active amines Recycling of Purine and Pyrimidine nucleotides by salvage pathways. Lesch-Nyhan syndrome & Gout.
Course Outcomes (CO)	1. Able to understand transformation of energy by living cell, structure of ATP, process of ATP generation. 2. Able to understand metabolism of carbohydrate. 3. Able to understand metabolism of lipids. 4. Able to understand metabolism of amino acids. 5. Able to understand metabolism of nucleic acids.

Text and References	Lehninger, Nelson and Cox, Principles of Biochemistry, 4 Edition, W.H.Freeman & Company, 2004. 2. Voet & Voet, Fundamentals of Biochemistry, Upgrade Edition, Wiley, 2002. 3. Lubert Stryer, Biochemistry, 4th Edition, W.H.Freeman and Company, 1995

Course Title	**Biotech XI:Genetic Engineering**				
Course Code	**SBS02533T**				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Knowledge of enzymes, proteins, nucleic acids.**				
Course Objectives	To discuss the gene cloning methods and the tools and techniques involved in gene cloning and genome analysis and genomics.				
Course Contents	**UNIT 1** Molecular tools for gene cloning- Nucleases: Exonucleases and Endonucleases, Restriction Enzymes (Type I, Type II, Type III, Type IV & Type V) Methylases: CpG Methylase , Dam Methylase, Dcm Methylase, Polymerases: DNA Pol I; Reverse Transcriptase; Ligases: T4 DNA Ligase, E.coli DNA Ligase ;Topoisomerases: Type I(A, B) & Type II(A,B). **UNIT 2** Vectors and gene cloning- Introduction to cloning vectors -- Desirable properties of vectors – Prokaryotic & Eukaryotic Expression Systems (Constitutive & Inducible) Plasmid Vectors; Phage Vectors; Cosmids; Phagemids ; BACs; Yeast Vectors – YACs.				

	UNIT 3 Advanced techniques in molecular biology- Polymerase Chain Reaction -- Quantitative Real Time PCR -- Gel Electrophoresis: AGE & PAGE -- Blotting Techniques: Southern, Western & Northern Methods of gene transfer in Plants and Animals: Chemical, Physical & Viral mediated DNA transfer **UNIT 4** Construction of Genomic & cDNA Libraries -- DNA Sequencing – Protein Engineering: Site Directed Mutagenesis -- Reporter Gene Assays -- DNA Protein Interactions: EMSA, DNA Footprinting -- Protein Protein Interactions. **UNIT 5** Recent trends in molecular biology research Targeted Genome Editing: ZFNs, TALENs, CRISPRs , Gene Targeting: Knock-ins & Knock-outs , DNA Finger Printing.
Course Outcomes (CO)	1. Able to understand molecular tools for gene cloning. 2. Able to understand about vectors for gene cloning. 3. Able to understand advanced techniques in molecular biology. 4. Able to understand construction of genomic DNA library, DNA-protein interaction, protein-protein interactions. 5. Able to understand recent trends in molecular biology research.
Text and References	Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press

Course Title	Generic Elective III: Analytical Methods in Chemistry				
Course Code	SBS02551T				
Course Credits	**L**	**T**	**P**	**Details**	
	4			**4**	
Prerequisites	Physical, Organic and Inorganic Chemistry				
Course objectives	Understand the basic knowledge of analytical methods in chemistry				
Course Contents	**UNIT-I** **Qualitative and quantitative aspects of analysis** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals. Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. **UV-Visible Spectrometry:**Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; *Basic principles of quantitative analysis:* estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method. Wood ward fieser rule. **UNIT-II** **Infrared Spectrometry:**Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution. **Flame Atomic Absorption and Emission Spectrometry:**Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples. **UNIT-III** **NMR and Mass spectrometry** **NMR**:Principle of nuclear magnetic resonance - Basic instrumentation - Block diagram. Shielding mechanism - Chemical shift and number of signals - splitting of signals - coupling constants - Applications of NMR to simple				

	organic compounds – ethanol, ethyl acetate – Benzyl alcohol.larmer precision, NMR active and non active element, peak ratio, ^{1} HNMR, ^{13}CNMR and its application. **Mass spectrometry** Basic principles of mass spectroscopy - molecular peak - base peak - isotopic peak - metastable peak and their uses – Fragmentation - Nitrogen rule. Instrumentation - Block diagram - Mass spectrum of simple organic compounds – Alkanes - Mc Lafferty rearrangement. **UNIT-IV** **Thermal methods of analysis:** Theory of thermogravimetry (TG), basic principle of instrumentationTechniques for quantitative estimation of Ca and Mg from their mixture. **Electroanalytical methods:** Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pK_a values. **UNIT-V** **Separation techniques:** **Solvent extraction:** Classification, principle and efficiency of the technique. Technique of extraction: batch, continuous and counter current extractions.Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media. **Chromatography:** Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GC, TLC and HPLC. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition and chiral separation. Role of computers in instrumental methods of analysis.
Course outcomes	On the completion of this course successfully, student will be able to

	understand the analysis and separation of organic molecules.
Text books	1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989. 2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988. 3. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004. 4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
Reference books	1. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009. 2. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed. 3. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

Course Title	**PLANT PHYSIOLOGY AND METABOLISM**				
Course Code	SBS02552T				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Knowledge of basic plant physiology and metabolism**				
Course Objectives	• To help students acquire a comprehension of plant physiology from the subcellular to the organismal level. • The course explores various topics in plant physiology and biochemistry including primary and secondary metabolism,				
Course Contents	**UNIT I:** **Plant-water relations:** Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation. **UNIT II:** **Mineral nutrition:** Essential elements, macro and micronutrients; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps. **Translocation:** Composition of phloem				

	sap, Pressure flow model; Phloem loading and unloading. **UNIT III:** **Photosynthesis:** Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration. **UNIT IV:** **Respiration:** Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway. **UNIT V:** **Plant growth regulators:** Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene; Photoperiodism, Phytochrome (discovery and structure) red and far red light responses on photomorphogenesis; Vernalization.
Course Outcomes	1. The students are able understand the relationship between structure and function as it relates to plant macromolecules, cells, and tissues 2. Understand the interaction between the environment and plant growth and development 3. Gain an appreciation of the metabolic and physiological processes unique to plants
Text Books	1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition. 2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
Reference Books	1. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi

Course Title	**Lab Course XIIV: Generic Elective Chemistry**				
Course Code	**SBS05592P**				
Course Credits	**L**	**T**	**P**	**Total**	
			4	**2**	
Prerequisites	Practical knowledge of analytical methods in chemistry				

Course objectives	Understand the practical knowledge of analytical methods in chemistry
Course Contents	**Perform Any Ten Experiments** 1. Chromatography: (a) Separation of mixtures (i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, andCr^{3+}. (ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the $R_f$values. (b) Chromatographicseparationoftheactiveingredients ofplants,flowersandjuices by TLC 2. To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and extracting the Ni^{2+}- DMG complex in chloroform, and determine its concentration by spectrophotometry. 3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps. 4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques. 5. Analysis of soil: (i) Determination of pH of soil. (ii)Total soluble salt (iii) Estimation of calcium, magnesium, phosphate,nitrate 6. Ionexchange: (i) Determination of exchange capacity of cation exchange resins and anion exchange resins. (ii) Separation of metal ions from their binarymixture 7. Determination of Hardness of water sample 8. Determination of total alkalinity and acidity of a water sample. 9. Detection of Iron and Manganese in water 10. Determination of dissolved oxygen in water. 11. Determination of Na / K in water sample by Flame photometry. 12. Determination of Biological oxygen demand (BOD) 13. Determination of Nitrate and Nitrite in water by UV-Visible spectrometry.
Course outcomes	On the completion of this course successfully, student will be able to understand the analysis and separation of organic molecules.
Text books	1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989. 2. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988. 3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004. 4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H.

	Freeman, 2001.
Reference books	1. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009. 2. Skoog, D.A. Holler F.J. &Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed. 3. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979. 4. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

Course Title	**LAB COURSE: PLANT PHYSIOLOGY AND METABOLISM**				
Course Code	SBS02593P				
Course Credits	**L**	**T**	**P**	**TC**	
	-	**-**	**4**	**2**	
Prerequisites	**Theoretical knowledge of Plant physiology and metabolism**				
Course Objectives	• To enable students the concepts of Plant physiology, Practically and understand the fundamentals of metabolism in plants and its importance.				
Course Contents	1. Demonstration of the Effect of Auxins on Rooting. 2. Demonstration of Root Respiration 3. To Determine the Osmotic Potential of Plant Cell Sap byPlasmolytic Method 4. To Study the Effect of Two Environmental Factors (Light and Wind Velocity) on Transpiration by an Excised 5. To Demonstrate Hill Reaction 6. To Demonstrate the Activity of Catalase and Study the Effect ofpH and Enzyme Concentration 7. To Study the Effect of Light Intensity and Bicarbonate Concentration on O2 Evolution in Photosynthesis 8. To Compare the Rate of Respiration in any Two Parts of a Plant 9. To Separate Amino Acids by Paper Chromatograph 10. To Determine the Stomatal Index and Stomatal Frequency in a Mesophyte and Xerophyte				

Course Outcome	• After the practical course, students will be able to understand the cells of various metabolic activities of Plants and their Physiology and Metabolism • Students will be able to observe and correctly identify different Plant physiological process and their importance for plant life.
Text Books	1. Ashok K Bendre, Botany practical vol I,1988 2. Ashok K Bendre, Botany practical vol I,1989 3. N.B. SinghUnified Practical book Botany, 1992

Course Title	**Lab Course : Combining Biotech IX, X and XI**				
Course Code	SBS02591P				
Course Credits	**L**	**T**	**P**	**TC**	
	4	**-**	**-**	**4**	
Prerequisites	**Knowledge of molecular biology, macromolecules, genetic engineering**				
Course Objectives	To understand basic molecular biology techniques To understand basic biochemistry analysis. To understand basic genetic engineering techniques.				
Course Contents	1. Isolation of chromosomal DNA from plant cells 2. Isolation of chromosomal DNA from E.coli 3. Qualitative and quantitative analysis of DNA using spectrophotometer 4. Plasmid DNA isolation 5. Restriction digestion of DNA 6. Preparation of solutions for Molecular Biology experiments. 7. Isolation of chromosomal DNA from bacterial cells. 8. Isolation of Plasmid DNA by alkaline lysis method 9. Agarose gel electrophoresis of genomic DNA & plasmid DNA 10. Estimation of blood glucose by glucose oxidase method. 11. Principles of Colorimetry: (i) Verification of Beer's law, estimation of protein. (ii) To study relation between absorbance and % transmission. 12. Preparation of buffers. 13. Separation of Amino acids by paper chromatography. 14. Qualitative tests for Carbohydrates, lipids and proteins				

Course Outcomes (CO)	1. Able to understand basic molecular biology techniques 2. Able to understand basic biochemistry analysis. 3. Able to understand basic genetic engineering techniques.
Text and References	1. Principles and techniques of practical biochemistry and molecular biology (Ebook PDF) by Keith Wilson and John Walker | 18 June 2021

Course Title	**Lab Course XIIV: Generic Elective Bioscience**				
Course Code	**SBS05592P**				
Course Credits	**L**	**T**	**P**	**Total**	
			4	**2**	
Prerequisites	Theoretical knowledge of plant ecology				
Course objectives	To Understand the practical knowledge of Plant tissue culture.				
Course Contents	1. (a) Preparation of MS medium. (b) Demonstration of in vitro sterilization methods and inoculation methods using leaf and nodal explants of Tobacco/ Datura/ Brassica etc. 2. Study of embryo and culture, micro propagation of Banana, somatic embryogenesis, artificial seeds through photographs. 3. Construction of restriction map of circular and linear DNA from the data provided. 4. Study of methods of gene transfer through photographs: Agrobacterium-mediated, direct gene transfer by electroporation, microinjection, and micro projectile bombardment. 5. Different steps involved in genetic engineering for production of Bt. cotton, Golden rice, Flavr Savr tomato through photographs. 6. Isolation of plasmid DNA.				

	7. Restriction digestion and gel electrophoresis of plasmid DNA (optional) 8. Field visit to a lab involved in tissue culture 9. Study project under supervision of lecturer – tissue culture/ genetic engineering .
Course outcomes	**CO:** Ability to prepare artificial nutrient media, preparing independently, applying various sterilization procedures for media, glassware and biological materials, in vitro propagation of Banana callus, morphogenesis--s, clonal propagation methods, isolation of plasmid DNA individually and as a group.
Text books	1. Pullaiah. T. and M.V.Subba Rao. 2009. Plant Tissue culture. Scientific Publishers, New Delhi. 2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.