Course structure

First Year

Semester	Paper no	Title of the Course	Theory/ Practical	Marks	Lecture/ Practical
I	I	Diversity and classification of the plant*/animal# kingdom	theory	75	45 theory
		Diversity and classification of the plant*/animal# kingdom	practical	25	13 practical
	II	Basic Microbiology	theory	75	45 theory
		Basic Microbiology	practical	25	13 practical
II	III	Plant */animal# physiology	theory	75	45 theory
		Plant* /animal# physiology	practical	25	13 practical
	IV	Essential Physics for Biologists	theory	75	45 theory
		Essential Physics for Biologists	practical	25	13 practical

*for **Chemistry- Zoology-Biotechnology subject combinations.**

#for **Chemistry-Botany-Biotechnology subject combinations.**

Second Year

Semester	Paper no	Title of the Course	Theory/ Practical	Marks	Lecture/ Practical
III	V	Biochemistry	theory	75	45 theory
		Biochemistry	practical	25	13 practical
	VI	Biostatistics and Bioinformatics	theory	75	45 theory
		Biostatistics and Bioinformatics	practical	25	13 practical
IV	VII	Essential Mathematics for Biologists	theory	75	45 theory
		Essential Mathematics for Biologists - Problem solving	practical	25	13 practice sessions
	VIII	Immunology	theory	75	45 theory
		Immunology	practical	25	13 practical

Third year

Semester	Paper no	Title of the Course	Theory/ Practical	Marks	Lecture/ Practical
V	IX	Molecular Biology	theory	100	50 theory
	X	Plant Biotechnology	theory	100	50 theory
	XI	Industrial Biotechnology	theory	100	50 theory
	XII	Techniques in biotechnology	theory	100	50 theory
	Lab Course I	Molecular Biology & Plant Biotechnology	practical	100	15 practical
	Lab Course II	Industrial Biotechnology & Techniques in Biotechnology	practical	100	15 practical
VI	XIII	Concepts in Genetic Engineering	theory	100	50 theory
	XIV	Animal Cell Culture	theory	100	50 theory
	XV	Environmental Biotechnology	theory	100	50 theory
	XVI	Food Biotechnology	theory	100	50 theory
	Lab Course III	Genetic Engineering & Animal Cell Culture	practical	100	15 practical
	Lab Course IV	Environmental & Food Biotechnology	practical	100	15 practical
		Project work		100	

Paper I	Diversity and Classification of the Plant Kingdom	45 Hours

Course Objectives

1. To state the classification of each plant group.
2. To understand the economic importance of the different types of plant groups.
3. To understand and explain the general characters, and elaborate on the life cycle of different plant groups.

THEORY

Plant kingdom Classification of kingdoms and the criteria Three domain classification (Prokaryotes and Eukaryotes), life span, nutrition and ecological status. Origin, evolution and phylogeny of land plants	**(6 Lectures)**
Algae General characters, Classification (Bold and Wynne), range of thalli and reproductive structures, types of life cycles with minimum one example each. Ecological, economic and biotechnological significance	**(7 Lectures)**
Fungi General characters, nutritional modes, classification (G.C. Ainsworth), range of vegetative and reproductive structures,, important features of Mastigomycotina - Pythium,; Zygomycotina -Mucor; Ascomycotina Saccharomyces; Basidiomycotina - Agaricus; Deuteromycotina- Cercospora General account of Lichens and Mycorrhizae; Ecological, economic and biotechnological significance of fungi.	**(7 Lectures)**
Bryophytes General characters, classification (G.M.Smith), study of morphology, anatomy, reproduction of Hepaticae, Anthocerotae and Musci; Ecological and economic importance of bryophytes	**(7 Lectures)**
Pteridophytes Salient features of primary vascular plants; classification(Foster & Gifford), Comparative study of morphology, anatomy, reproduction of Psilopsida, Lycopsida, Sphenopsida and Pteropsida	**(7 Lectures)**
Gymnosperms Classification (Coulter and Chamberlain) and salient features Comparative general study of morphology, anatomy and reproduction of Cycadales, Coniferales and Gnetales; Economic importance	**(6 Lectures)**
Angiosperms Unique features of angiosperms; nomenclature (asperICBN)and Classification; general account of morphology, anatomy, flower structure, reproduction and seed development.	**(5 Lectures)**

Learning Outcomes

1. State the three domain classification.
2. List the general characters, morphology, anatomy and reproduction of each division of the plant kingdom
3. State the classification of algae, fungi, bryophytes, Pteridophytes, Gymnosperms and Angiosperms
4. Discuss the economic importance of various plants.

Paper II	Basic Microbiology.	45 Hours

Course Objectives

- To describe classification by Linneaus, Haeckel, Whittaker, and viral classification by Baltimore and understand the cryptogram
- To understand bacterial identification by Bergey's Manual of Systematic/Determinative Bacteriology and rDNA sequencing.
- To study Organization and Ultrastructure of a Bacterial cell
- To understand structure and chemical composition in gram positive and gram negative bacteria.
- To study structure, composition and function of flagella pili, slime and capsule.
- To study nature and function of cell membrane and nuclear material and reserve materials present in cells.
- To understand endospore structure, sporulation and germination:
- To understand viral structure and replication and describe assays of infectivity (plaques, pocks)
- To study about reproduction in bacteria, cell growth, growth rate, generation time.
- To draw and interpret a normal and diauxic bacterial growth curve.
- To define autotrophs, heterotrophs, phototrophs and chemotrophs and obligate parasites.
- To study different types of culture media: synthetic, complex, enriched, enrichment, selective, differential, dehydrated solid and liquid.
- To learn the basic principles of preservation and methods such as periodic transfer, overlaying with mineral oil, preservation in liquid nitrogen, lyophilisation.
- To define Thermophiles, barophiles, halophiles, acidophilesand alkaliphiles
- To study the causative agent, Spread, Pathogenesis, Symptoms, Microbiological diagnosis, Prevention and control of: (i) Tuberculosis, (ii) Plague, (iii) Bacterial meningitis (iv) Herpes
- To define phosphate solubilization, nitrification denitrification, Symbiotic /non symbiotic nitrogen fixing bacteria.
- To define mutualism, commensalism, competition, antagonism, parasitism ectosymbiosis and endosymbiosis.

THEORY

Classification of microorganisms. Brief description of classification schemes proposed by Linneaus, Haeckel, Whittaker, Woese. Classification of viruses by Baltimore,Cryptogram	**(4 Periods)**
Bacterial identification Bergey's Manual of Systematic/Determinative Bacteriology and rDNA sequencing_	**(2 Periods)**
Organization and Ultrastructure of a Bacterial cell Cell wall: structure and chemical composition in gram positive and gram negative bacteria. Flagella and pili. Cell membrane: structure and function. Slime and capsule: composition & function. Nuclear material: nature and function. Endospore: structure, sporulation and germination. Reserve materials: glycogen,	**(6 Periods)**

lipid granules, gas vesicles, polyhydroxyalkanoate, volutin, sulphur inclusions. cyanophycin, carboxysomes,	
Viruses Structure Viral replication, Assays of infectivity (plaques, pocks)	**(3Periods)**
Reproduction in bacteria Binary fission Definitions: cell growth, growth rate, generation time. 3 Bacterial growth curve, characteristics of growth phases; diauxic growth curve.	**(3 Periods)**
Nutritional types of bacteria Autotrophs, Heterotrophs, Phototrophs and Chemotrophs and obligate parasite with examples of each type.	**(3 Periods)**
Cultivation of microorganisms Types of culture media: synthetic, complex, enriched, enrichment, selective, differential, dehydrated solid and liquid.	**(3 Periods)**
Preservation and Maintenance of microbial cultures Basic principles of preservation Methods-periodic transfer, overlaying with mineral oil, preservation in liquid nitrogen, lyophilisation	**(3 Periods)**
Microbial diversity Thermophiles, barophiles, halophiles, acidophiles and alkaliphiles	**(4 Periods)**
Medical microbiology Causative agent, Spread, Pathogenesis, Symptoms, Microbiological diagnosis, Prevention and control: (i) Tuberculosis, (ii) Plague, (iii) Bacterial meningitis (iv) Herpes	**(4 Periods)**
Soil microbiology Phosphate solubilization, Nitrification, Denitrification, Symbiotic /non symbiotic nitrogen fixing bacteria.	**(4 Periods)**
Microbial interactions Basic concepts: mutualism, commensalism, competition, antagonism, parasitism Ectosymbiosis and Endosymbiosis. Examples of each.	**(6 Periods)**
Classification of microorganisms. Brief description of classification schemes proposed by Linneaus, Haeckel, Whittaker, Woese. Classification of viruses by Baltimore, Cryptogram	**(4 Periods)**
Bacterial identification Bergey's Manual of Systematic/Determinative Bacteriology and rDNA sequencing	**(2 Periods)**
Learning Outcomes **The student will be able to :-**	

- Classify microorganisms by Linneaus, Haeckel, Whittaker, Baltimore systems of classification. Cryptogram
- Identify bacteria by Bergey's Manual of Systematic/Determinative Bacteriology and rDNA sequencing.
- Explain organization and ultrastructure of a Bacterial cell (Gram positive and Gram negative)
- Explain structure, composition and function of flagella pili, slime and capsulecell membrane and nuclear material, endospore structure, sporulation and germination:
- List and explain reserve materials present in bacteria.
- Describe viral structure and replication.
- Summarize assays of infectivity (plaques, pocks)
- Explain reproduction in bacteria.
- Define cell growth, growth rate, generation time.
- Define autotrophs, heterotrophs, phototrophs and chemotrophs and obligate parasites.
- Describe different types of culture media.
- Express the basic principles of preservation and methods.
- Define thermophiles, barophiles, halophiles, acidophiles and alkaliphiles.
- Explain the causative agent, Spread, Pathogenesis, Symptoms, Microbiological diagnosis, Prevention and control of: (i) Tuberculosis, (ii) Plague, (iii) Bacterial meningitis (iv) Herpes
- Illustrate phosphate solubilization, nitrification denitrification, symbiotic /non symbiotic nitrogen fixing bacteria.
- Define mutualism, commensalism, competition, antagonism, parasitism ectosymbiosis and endosymbiosis.

Books

1.MadiganM., Martinko., Parker J. Brock's Biology of microorganisms. (2007). Pearson Prentice Hall.

2.J.L. Ingraham., Ingraham C. A., Introduction to microbiology. 2000. Brooks/Cole pacific groove.

3. Dubey R.C., Maheshwari D.K., A textbook ofMicrobiology, 2005. S. Chand and 4.Company Ltd,New Delhi.

4. Pelczar M.J., Chan E.C.S., KriegN.R., Microbiology, 1986, Fong and sons printerspvt.

5. Prescott, Harley, Klein, Microbiology. 2008. McGraw-Hill Higher Education.

6. Stanier R.Y. General Microbiology. 1993.Cambridge University.

7. Martin Frobisher. Fundamentals of Microbiology: An Introduction to the Microorganisms with Special Reference to the Procaryons. (8th edition, reprint) 1937, Saunders.

SEMESTER II

Paper III	**Plant Physiology**	**45 Hours**

Course Objectives

1. To explain the different process of transport
2. To understand and explain the role of different minerals important for the nutrition for plant
3. To understand and explain the different cycles in nitrogen fixation
4. To explain the physiological role and mechanism of action of the phytohormones
5. To understand the role of cell membrane, ion pumps and carriers.

THEORY

Plant-water Relations Water transport processes; diffusion and osmosis; water potential and chemical potential; absorption of water, water transport through tracheids and xylem (ascent of sap); transpiration and its significance Factors affecting transpiration; mechanism of stomatal movement, root pressure, guttation, imbibition, mass flow, anti-transpirant.	**(12 Lectures)**
Mineral nutrition Criteria of essentiality of elements; macro- and micronutrients. Role of essential elements, mineral deficiency symptoms and plant disorders. Nutrient uptake and transport mechanisms. Role of cell membrane, ion pumps and carriers.	**(12 Lectures)**
Photosynthesis Structure of photosynthetic apparatus. Photosyntheticpigments. Accessory pigments, reaction center complexes, photochemicalreactions. Electron transport pathways in chloroplast membranes, photophosphorylation, the Calvin cycle, the C4 carbon cycle, crassulacean acid metabolism. Photorespiration.	**(10 Lectures)**
Nitrogen metabolism Biological nitrogen fixation, reduction ofN2 into ammonia, nifgenes. Regulation of nitrate reductase and nitrogenase, nitrate and ammonium assimilation, pyridoxal phosphate	**(6 Lectures)**
Growth Regulators Physiological role and mechanism of action of the phytohormones -auxins, cytokinins, gibberellins, abscisic acid and ethylene.	**(6 Lectures)**

Learning Outcomes

The students will be able to :-

Explain the water transport processes.

Describe the absorption of water and transport of water through tracheids.

Discuss transpiration and the factors affecting it.

Discuss the role of essential elements, mineral deficiency symptoms and plant disorders.

Draw the structure of the photosynthetic apparatus and explain the process of photosynthesis.

Describe biological nitrogen fixation and reduction ofN2 into ammonia

Explain the physiological role and mechanism of action of the phytohormones.

Books

1. Galston A.W. 1989. Life Processes in Plants. Scientific American Library, Springer Verlag., NewYork, USA.

2. HooykaasP.J.J.,HallM.A. and LibbengaK.R. (eds) 1999. Biochemistry and Molecular Biology of Plant Hormones. Elsevier, Amsterdam, The Netherlands.

3. Hopkins W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc.,New York, USA.

4. Moore T.C. 1989. Biochemistry and Physiology of Plant Hormones (2'd edition). Springer-Verlag, New York, USA. Salisbury, F.B. and Ross, C.W. 1992. Plant Physiology(4hedition).Wadsworth PublishingCo., California, USA.

5. Taiz L. and Zeiger E. 1998. Plant Physiology (Td edition). Sinauer Associates, Inc., Publishers, Massachusetts USA.

Paper IV	Essential Physics for Biologists	45 Hours

Course Objectives

1. To describe the different units used to measure temperature and electricity.
2. To review Newton's Laws, Friction, Drag, elasticity, surface tension and capillarity, fluid dynamics and viscosity and to understand its applications in life sciences.
3. To understand and explain the different concepts in fluid dynamics.
4. To understand and explain different laws of electricity
5. To understand the optical properties of lenses, thin lenses & thick lenses Cardinal points of an optical system, aberrations and methods to minimize Spherical & Chromatic Aberrations.
6. To describe the motion of a charged particle in a uniform constant electric field and magnetic field(crossed)in mutually perpendicular directions.

THEORY

Measurement of Physical quantities, standards and units. Length: radius of proton to size to astronomical distances. Mass: atomic mass unit to mass of earth. Time: time for fast elementary particle to pass through nucleus to age of earth. Units in electricity: volts, Amperes, ohms. Units of Temperature: Celsius scale, Kelvin scale. International systems and units: Units used to measure physical quantities and the inter-conversion.	**(2 Lectures)**
Mechanics and introduction to Properties of matter Review of Newton's Laws, Friction, Drag, elasticity, surface tension and capillarity, fluid dynamics and viscosity, Applications to life sciences	**(6 Lectures)**
Fluid Statics and fluid dynamics Fluids: Definition, Pressure and Density. The variation of pressure in a fluid at rest. Pascal's Principle. Measurement of pressure. Various units of pressure and the inter-conversion Reynolds number and its physical significance. Concept of pressure energy. Bernoulli's theorem and its applications-Venturimeter and Pitot's tube. Viscosity estimation by Oswald's viscometer. Relevance to life sciences	**(6 Lectures)**
Acoustics Sound as a longitudinal wave. Intensity level:Be land Decibel. Production and detection of Ultrasonic waves and its applications. Doppler effect. Calculation of apparent frequency, (Normal incidence only), application to life sciences.	**(3 Lectures)**
Electrostatics and Electricity Basics of Electrostatics: Electric charge. Coulomb's law. Applications of electrostatics in life sciences. Basics of electricity: Current, voltage and resistance and their units, Ohm's law, Conductor, Semiconductor and Insulator, Transducers (sensors): basics, classification of transuders-electrical, mechanical, optical. Applications in biological instruments	**(5 Lectures)**
The magnetic field The definition of B. magnetic dipoles. Units of magnetism. Magnetism of earth. Molecular fields: Diamagnetism, Paramagnetism and Ferromagnetism	**(5 Lectures)**

Nuclearmagnetism Motion of a charged particle in Electro-magnetic field. (only qualitative approach):Motion of a charged particle in a uniform constant (1)electric field,(2) magnetic field. Motion of a charged particle in a uniform constant electric field and magnetic field(crossed)in mutually perpendicular directions. Lorentz force.	
Optics and Lasers Intensity of light: Luminous intensity and its units. Lenses: Introduction to Lenses optical properties of lenses, thin lenses & thick lenses, Cardinal points of an optical system, Aberrations; Spherical & Chromatic aberrations in lenses(only conceptual), methods of minimizing Spherical & Chromatic Aberrations, Properties of light: Reflection, refraction, dispersion Interference: Interference by division of wave front & division of amplitude. One example of each kind with demonstration in Physics Laboratory. Diffraction: Concept of Diffraction, Fresnel and Fraunhoffer class of Diffraction. Fresnel diffraction: thickness of symmetric obstacles Fraunhoffer Diffraction: Width of diffraction maxima of Fraunhoffer diffraction, Application of Fraunhoffer diffraction to resolving power of optical instruments, Raleygh's criterian for resolution, Resolving power of telescope and microscope, Polarization: Concept of polarization, Plane of polarization, Polarization by reflection, Brewster's law, Polarization by refraction, Double refraction. Nicol prism, simple polarimeter. Lasers: Laser theory (qualitative),different kinds of laser, Applications of lasers in Medicine, and Science. Optical fibers: Basic principle and applications in medical field.	**(18 Lectures)**
Learning Outcomes ***At the end of the course students will be able to*** Describe the different units used to measure temperature and electricity Derive the equation for Bernoulli's theorem and its applications-Venturimeter and Pitot's tube. Describe the Production and detection of Ultrasonic waves and its applications Explain Doppler effect. Explain Conductor, Semiconductor and Insulator Classify the transducers into electrical, mechanical, optical entities Explain Diamagnetism, Paramagnetism and Ferromagnetism Distinguish between Fresnel and Fraunhoffer class of Diffraction Discuss the different types of lasers and its application in medicine and science	
Books 1.H.C.Verma, Concepts of Physics Volume I and II,2006,Bharati bhawan Publishers, Patna. 2.Haliday and Robert Resnik, Physics Volume I and II 3.D. S.Mathur,Elements of Properties of Matter, S.Chand&Co. 4.D. R.Khannaand R.S.Bedi, Textbook of Sound. AtmaRam, NewDelhi(1994). 5.ArthurBeiser, Introductions to Modem physics	

SEMESTER III

Paper V	**Biochemistry**	**45 Hours**
Course Objectives 1. To understand the concept of Urey-Miller experiment and various interactions between molecules. 2. To understand and describe the structure and function of different biomolecules and nucleic acids. 3. To understand the different concepts of working of enzymes and factors affecting the working, 4. To understand the different metabolic cycles involved in carbohydrate, protein, lipid and other components.		
THEORY		
Topic 1: Urey –Millers experiment Urey -Millers experiment		**(3 periods)**
Topic 2: Molecular interactions Covalent, hydrogen, ionic, hydrophobic and Vander waal's interactions. Water structure and unique properties		
Topic 3: Bio-molecules Definition, structure function, Biological Significance Classification of-Carbohydrate :Monosaccharide, Disaccharide (Lactose, Sucrose and Maltose), Reducing and non-reducing sugars, Polysaccharides: (Structural and storage) Lipids: Fatty acids (saturated & unsaturated), Simple Lipids: Fats, oils, waxes, Compound Lipids: Phospholipids, glycolipids, Derived Lipids: Steroids Amino Acids: Structure and nomenclature, General properties, Zwitter ions Proteins: Structural Levels of protein, peptide bond formation Ramchandran plot Nucleic acids: Structural components of nucleic acid, Nucleotides &nucleosides. Structure of DNA & Types of DNA (A, B, C, D, E, Z) & RNAand its types, Differences between DNA and RNA, Forces stabilizing the structure of DNA. Vitamins: Deficiencies symptoms. Co-enzymes (Thiamine, riboflavin, niacin, PLP, Lipoic acid, Pantothenate, Folic acid, Cyanocobalamine.)		**(21 periods)**
Topic 4: Enzymology Basic concepts: Classification of enzymes, Mechanism of enzyme action ,Lock &key theory &Induced fit Theory, Factors affecting enzymes activity (time, enzyme conc., substrate concentration, pH, temperature), Enzyme Inhibition and its types, MM equation, Lineweaver-Burk plot, Ribozymes &Isoenzymes		**(10 periods)**
Topic 5: Metabolism (Outlines of pathway and structures of intermediates, name of the enzymes and their regulatory aspects). Definition of metabolism; energy relationship between catabolic and anabolic pathways. ATP as the energy currency of the cell. Generalized concept of Carbohydrate metabolism: Glycolysis, tricarboxylic acid cycle, pentose-		**(11 periods)**

phosphate pathway, gluconeogenesis, glycogen synthesis and breakdown Oxidative degradation of proteins: Urea cycle. Lipid metabolism: Synthesis and degradation of fatty acids. Nucleic-acid metabolism: de novo and salvage pathways.	

Learning Outcomes

At the end of the course students will be able to

- Explain Urey-Miller's experiment
- Discuss unique properties of water
- Describe different types of molecular interactions
- Explain the structure, function and properties of monosaccharaides, disaccharides and polysaccharides
- Define and discuss the Classification of Carbohydrates and Lipids
- To describe the structure and biological significance of carbohydrates, lipids, proteins and amino acids
- Draw the Structure Amino acids and enlist their general properties
- Explain the Structural levels of protein
- Discuss the significance of Ramachandran Plot.
- Describe the structure of DNA & Types of DNA (A, B, C, D, E, Z) & RNA and its types,
- Distinguish between DNA and RNA
- Enlist the symptoms of different types of Vitamin deficiencies:
- Enumerate the biological functions of various Co-enzymes (Thiamine, riboflavin, niacin, PLP, Lipoic acid, Pantothenate, Folic acid, Cyanocobalamine)
- Differentiate between reducing and non-reducing sugar.
- Describe the structures and properties of lipids and nucleic acid
- Explain the effect of substrate concentration, temperature and pH on an enzyme catalyzed reaction
- Compare the "lock and key" model and induced fit model of enzyme specificity.
- Explain the significance of the regulation of various metabolic pathways.
- Discuss gluconeogenesis, glycolysis, glycogenesis and glycogenolysis with respect to the steps involved in the pathway, their energetics and their regulation.
- Discuss the Urea Cycle.
- Describe the de novo and salvage pathway for Nucleic acid metabolism

Books

1. Nelson D.L. and Cox M.M. 2000. Lehninger Principles of Biochemistry (3d Edition). Worth Publishers, New York, USA.
2. Stryer L. 1995. Biochemistry. W.H. Freeman and Co.,New York, USA.
3. Zubay G. 1993. Biochemistry (3d Edition). WCB Publishers, Iowa, USA.
4. Gupta P.K. 1999. A Text-book of Cell and Molecular Biology. Rastogi Publcations, Meerut, India

Paper VI	Biostatistics and Bioinformatics	45 Hours

Course Objectives

1. To recognize Scope of Statistics and understand the types of biological data and explain the terms Population, Sample and types of sampling.
2. To study the different types graphical forms of representing data.
3. To understand the concept of central tendency of statistical data and find the Mean, Median, Mode, Range, Standard deviation of the given data.
4. To understand the concept of Permutations and Combinations, the rules for calculating Probability and compute Binominal distribution and Poisson distribution.
5. To estimate the variation among and between groups of data
6. To understand concept of the positive and negative Correlation and Regression equations.
7. To understand concept of goodness of fit, and measure differences in observed and expected frequencies in the given data.
8. To explain the scope of Bioinformatics and discuss the concept of biological databases.
9. To explain the EMBL,NCBI database
10. To describe the different features of RNA, Protein, literature, structure and other database systems for searching

THEORY

Introduction: Population and sample Introduction to statistics, scope Types of biological data. Population, sample Types of sampling	**(3 Lectures)**
Graphical presentation of data Histogram, frequency curve. Frequency polygon, ogive curves	**(3 Lectures)**
Measures of central tendency and dispersion Concept of central tendency of statistical data Mean (ungrouped and grouped data) Mode, Median. (ungrouped and grouped data) Concept of dispersion. Range Standard deviation	**(5 Lectures)**
Probability and probability distribution Permutations Combinations Rules for calculating Probability, Binominal distribution Poisson distribution.	**(5 Lectures)**
Analysis of variance ANOVA	**(2 Lectures)**
Regression and correlation Simple regression and Correlation	**(3 Lectures)**
Chi-square test Chi-square goodness of fit	**(2 Lectures)**
Introduction to Bioinformatics Definition and scope of Bioinformatics.	**(1 Lecture)**
Biological Databases and data banks Types of data Biological databases	**(2 Lecture)**
Major sequence repositories EMBL, NCBI	**(2 Lecture)**
RNA databases Rfam, RNAbase	**(2 Lectures)**

Protein databases Primary: Swiss-Prot, PIR Composite: OWL, PROSIT	**(5 Lectures)**
Structure databases PDBCATHSCOP	**(3 Lectures)**
Literature databases Pubmed, MedlineOMIM	**(3 Lectures)**
Database system for searching SRS, Entrez	**(2 Lectures)**
Tools for similarity search and sequence alignment Introduction to BLAST and FASTA	**(2 Lectures)**

Learning Outcomes

At the end of the course students will be able to

- Understand the types of biological data,
- Explain and apply types of sampling in biological studies.
- Plot histogram, frequency curve, frequency polygon, ogive curves
- Read and interpret histogram, frequency curve, frequency polygon, ogive curves
- Solve problems to find the Mean, Median, Mode of given data.
- Find the Range, Standard deviation of the given data.
- Calculate Permutations and Combinations.
- Calculate Probability of possible outcomes in a trial.
- Compute Binominal distribution and Poisson distribution of a given data.
- Frame a null hypothesis.
- Calculate the degrees of freedom and level of significance of the proposed hypothesis.
- Estimate the variation among and between groups of data.
- Explain positive and negative Correlation.
- Calculate the degree of correlation of the given data
- Derive the regression equation for the given data.
- Measure differences in observed and expected frequencies in the given data.
- Define a biological database and explain the different types of data
- Describe the different types of biological databases- literature, RNA, protein and structure databases.
- Explain the working and salient features of BLAST and FASTA

Books

1) Rastogi S.C., Mendiratta N. &Rastogi P., Bioinformatics: Concepts, Skills and Applications.2004, C B Spublishers.
2) David W. Mount, Bioinformatics - sequence and Genome analysis; (2004), CBS Publishers and Distributers.
3) IgnacimuthuS., Basic Bioinformatics.2005. Narosa Publishing House, New Delhi.
4) Chikhale N.J., Gomase V.S., Bioinformatics: Theory and Practice, 2007, Himalaya Publishing House, New Delhi.
5) Xiong,Jin, EssentialBioinformatics,2006,CambridgeUniversityPress

SEMESTER IV

Paper VII	**Essential Mathematics for Biologists**	**45 Hours**

Course Objectives

1. To define sets and perform the various operations on sets and solve problems on Venn diagrams.
2. To calculate the solution for linear equations using substitution, elimination and cross multiplication methods and solve the solutions for Quadratic equations.
3. To find the solutions for matrices of the order 2 and 3 and perform various operations on matrices.
4. To understand the definition of Arithmetic& Geometric Progression
5. To state the binomial theorem and express using different examples
6. To understand the different concepts in Plane Analytical Geometry.
7. To understand the concept of calculus and solve problems on integration and calculate the limit of algebraic and Exponential functions
8. To solve word problems on linear programming and determine using graphical solutions

THEORY

Set Theory Definition, Operations on Sets, Venn diagram	**(5 Lectures)**
Theory of Equations Solution of Linear, Quadratic equations	**(4 Lectures)**
Matrices and Determinants Order 2& 3 Algebra of matrices(addition, Sub-fraction, scalar multiplication, multiplication, transpose) Determinants by expansion solution of linear simultaneous equations (Cramer's Rule).	**(6 Lectures)**
Progressions Arithmetic & Geometric, Sum to 'n' terms of an A.P. and G.P.	**(3 Lectures)**
Binomial theorem Expansion for positive integral index(statement only)	**(2 Lectures)**
Plane Analytical Geometry Rectangular Cartesian coordinates Length of a line segment, section formulae, slope, equations of straight lines, circle (standard forms only)	**(6 Lectures)**
Calculus Variables, constants, functions, graph of functions, limit of algebraic, Exponential functions, continuity, Derivatives (algebraic, exponential & logarithmic functions only). Rules of differentiation (without proof),Integration (by substitution& by parts) using (ax+b)n , e ax+b , log (ax+b), Definite integral and integral as an area.	**(15 Lectures)**
Linear Formulations and graphical solutions. Programming problems Formulations, graphical solutions	**(4 Lectures)**

Learning Outcomes

At the end of the course students will be able to

Define sets and perform various operations.

Find the solutions for problems using the venn diagram
Calculate the solutions for linear and quadratic equations
Solve the matrices and evaluate the determinant, finding the solutions of the precautions using Cramer's rule
Find the sum of n terms in A.P and G,P
Expand the binomial theorem
Write the equation of straight line and circle
Differentiate and integrate the data provided.
Find the solution for the equations using linear programming

Books

1. Dr.JoshiN,ChitaleS.G.,2012,AnewApproachtoMathematicalTechniques,Seth Publishers.
2. ZameevuddinQ.,KhannaV.K.;BhambriS.K.,2009,BusinessMathematics,Vikas PublishinghousePvt.Limited.
3. SanchetiD.C.,KapoorV.K.,2007,BusinessMathematics,SultanChand& Sons.

Paper VIII	**Immunology**	**45 Hours**

Course Objectives

1. To explain various concepts of immune system, its working mechanism, types and process of vaccination.
2. To explain the origin, features and functions of different cells of immune system.
3. To understand and explain types and functions of antigens.
4. To understand the different types, structure and properties and functions of antibodies.
5. To understand various concepts of immune responses, and learn different immuno-assays.
6. To understand and explain the formation, maturation and functions of T-cells and B-cells.
7. To explain the functions and components of complement system and discuss the different steps and players involved in activation pathways (classical, alternate and lectin).
8. To explain Immune response to bacterial and viral infections.
9. To understand and learn about different immune-deficiencies.
10. To understand and explain the concept of Polyclonal and monoclonal Antibodies and Hybridoma technology.
11. To explain the immune cells, molecules and steps involved in the process of type I, II, III and IV Hypersensitivity

THEORY

Topic 1: Immune system Historical perspective, Innate and acquired immunity, active and passive immunity, Vaccination.	**(5 periods)**
Topic 2: Cells and organs of the immune system Myeloid and Lymphoid lineage: Myeloid and Lymphoid lineage	**(4 periods)**
Topic 3: Antigens Antigenicity, Haptens and Adjuvants	**(2 periods)**
Topic 4: Antibodies Structure, classes, Properties and variants	**(4 periods)**
Topic 5:Antigens- Antibodies interactions Primary and secondary response, affinity, avidity, cross-reaction and	**(4 periods)**

precipitation, assays used in immune-cytochemistry	
Topic 6: B-cells Maturation and Activation	**(3 periods)**
Topic 7: T-cells Maturation and Activation	**(3 periods)**
Topic 8: The complement system Functions and Components, Activation pathways (classical, alternate and lectin)	**(3 periods)**
Topic 9: Immune response Immune response to bacterial and infections	**(5 periods)**
Topic10: Immunodeficiency Types, AIDS	**(5 periods)**
Topic11: Polyclonal and monoclonal Ab Polyclonal and monoclonal Ab (Hybridoma technology)	**(2 periods)**
Topic12: Hypersensitivity Type I to IV	**(5 periods)**

Learning Outcomes

At the end of the course students will be able to

- Define Plasma and Serum
- Describe innate immunity, acquired immunity, active immunization and passive immunization
- Elaborate on different types of vaccines
- Enlist different types of cells (neutrophils, basophils, eosinophils, mast cells, monocytes and macrophages) of the immune system and Compare their properties and roles in the immune system
- Discuss the biological functions of antibodies
- Illustrate the structure of antibody
- Define and give examples Antigen, Hapten and Adjuvant
- Explain the effects adjuvants the immune response
- Differentiate between primary and secondary immune response.
- Define Affinity,Avidity and cross-reactivity
- Describe Coombs test, Immunofluorescence, RIA and ELISA
- Explain the steps involved in maturation and activation of B cells and T cells
- Differentiate between plasma cells and memory cells
- Elaborate on Humoral immunity
- To differentiate between antigen dependent T cells and antigen independent T cells
- Discuss the characteristic features of different pathways for the activation of complement system
- Describe the immune response against bacterial and viral infections
- Discuss the structural features of Human Immunodeficiency Virus with the help of a diagram
- To define monoclonal and polyclonal antibodies
- To differentiate between monoclonal and polyclonal antibodies
- Enlist the types of immune cells and chemicals involved in different types of Hypersensitivity
- Describe the steps involved in the process of Hypersensitivity

Books

1. Roitt and Roitt, Essential Immunology. 1994. Blackwell science, Oxford Blackwell Scientific Publications.
2. Kuby J., Immunology, 5th Edition, 2005. W.H. Freemanand Company, New York.
3. Rastogi V.B., Genetics. 2000. S. Chand Publishers, New Delhi.
4. Weir D.M.,1986. Handbook of Experimental Immunology-Vol I & II.

SEMESTER V

Paper IX	**Molecular Biology**	**45 Hours**

Course Objectives

1. To explain about Mendel's experiment in detail and state the Mendel's laws of inheritance.
2. To define the terms Multiple alleles and Iso-alleles, Multiple genes and explain genetic basis of presence of different blood groups in human beings.
3. To describe inheritance pattern Brown Eyes, Polydactyly, Diabetes insipidus, Phenylketonuria, Sickle cell Anemia.
4. To understand and discuss the importance of Genetic Counseling.
5. To understand and describe the hereditary defects such as Klinefelter, Turner, Cri-du-chat and Down's syndromes.
6. To understand the concept of Genetic Equilibrium and derive the Hardy Weinberg Law.
7. To describe the theories of DNA replication.
8. To describe the Structure of eukaryotic chromosomes.
9. To discuss the Characteristics of genetic code**.**
10. To understand and describe the types and agents of genetic mutations.
11. To discuss about the process of DNA replication, transcription and translation in prokaryotic and eukaryotic system.
12. To explain the Role of enhancers/promoters and silencers in modulating Transcription
13. To describe Post transcriptional regulation-capping, splicing, polyadenylation and to state the importance of it.
14. To state and explain the concept of Transformation in bacteria.
15. To understand and describe various concepts of mobile DNA elements like transposons.

THEORY

Mendel's laws of Inheritance: Mendel's Experiment. Mendel's Laws of Inheritance, test cross, back cross, incomplete dominance and co-dominance.	**(3 hours)**
Multiple alleles and multiple genes: Multiple alleles and Isoalleles, blood groups in human beings, Multiple genes	**(3 hours)**
Inheritance of Human traits: Brown Eyes, Polydactyly, Diabetes insipidus, Phenylketonuria, Sickle cell Anemia, Genetic Counselling.	**(3 hours)**
Structure and numerical aberrations involving chromosomes: Hereditary defects-Klinefelter, Turner, Cri-du-chat and Down syndromes.	**(2 hours)**
Population Genetics: Population, Gene pool, Gene frequency and genotype frequency, Genetic	**(3 hours)**

Equilibrium and Hardy Weinberg Law	
Introduction to molecular biology: Semi-conservative replication of DNA Meselson-Stahl experiment	**(2 hours)**
Chromosomes: Structure of eukaryotic chromosomes. Giant chromosomes-Polytene and Lampbrush	**(2 hours)**
Genetic code : Characteristics of genetic code.	**(2 hours)**
DNA Mutation: Spontaneous and Induced mutation, (ethidiumbromide, alkylating agents, base analogs) and physical Mutagens.DNA repair systems: Mismatch, photo-reactivation repair, Excision repair.	**(4 hours)**
DNA replication: DNA replication in prokaryotic and eukaryotic system.	**(3 hours)**
Transcription: Transcription in Prokaryotes and Eukaryotes, RNA- rRNA, m-RNA, t-RNA Promoters and transcriptional factors, RNA polymerases, Initiation-Elongation-Termination.	**(5 hours)**
Translation : Protein synthesis in prokaryotes and eukaryotes: Initiation, elongation and termination. Protein factors involved in translation.	**(5 hours)**
Regulation of gene expression: Prokaryotes-: Operon concept-lac and trp Eukaryotes:-Role of enhancers / promoters and silencers in modulating Transcription.-Post transcriptional regulation-capping, Splicing, polyadenylation.	**(5 hours)**
Recombination in Prokaryotes: Conjugation, Transduction-specialized and generalized. Transformation-concept.	**(4 hours)**
Mobile DNA elements: Transposons, History, IS sequences, Composite transposons, replicative transposons	**(4 hours)**

Learning Outcomes

At the end of the course students will be able to:

1. Explain the process and role of various proteins involved in DNA replication, transcription, translation and DNA repair.
2. Explain various processes of recombination in prokaryotes
3. Define various terms involved in Genetics and Molecular Biology
4. Differentiate between various concepts such as incomplete and co-dominance, test cross and Back cross
5. State Mendel's laws of inheritance, characteristics of genetic code
6. Justify various statements and concepts from the syllabus
7. Describe the structure of chromosomes with proper diagrams

Books

1.Lewin B. Genes XI. 2007. Jones and Bartlett Publishers

2.Nelson D.L. and Cox M. M. 2000. Lehninger Principles of Biochemistry (3rd Edition).Worth Publishers, New York, USA.

3.Gerald Karp, Harris D. Cell and Molecular Biology-Concepts and Experiments. 2008. John

Wiley & Sons Inc, New York.
4.Robertis E.D.P., Robertis E.M.F., Cell Biology and Molecular Biology, 8th edition, 1998. Sauder College.
5.Watson J.D., Hopkins N.H.et.al. Molecular Biology of the Gene.(2008). Garland Publishing (Taylor & Francis Group), New York & London.
6.Avinash and Kakoli Upadhyay, Basic molecular Biology.2005. Himalaya Publishing House, Mumbai.

Paper X	**Plant Biotechnology**	**50 Hours**

Course Objectives:

1. To understand the concept and findings of the scientists in the field of Plant Tissue culture
2. To describe the different components in a PTC media and its preparation and sterilization, the different media used for culturing.
3. To recognize the different parts of the plant used as an explant and the different surface sterilizing agents.
4. To outline the structure and environmental conditions of the green house.
5. To know the characteristics of callus tissue. To understand soma clonal variations and its applications in plants
6. To describe root, shoot tip, anther and embryo culture.

Theory	
UNIT-1- History Concept and history of plant tissue culture	**(1 Period)**
UNIT 2 - Plant tissue culture laboratory Design, equipment and sterilization	**(1 Period)**
UNIT 3- Plant tissue culture media Types, preparation and sterilization	**(2 Period)**
UNIT 4 – Explants Types and surface sterilization	**(1 Period)**
UNIT 5- Establishment of in vitro cultures Ideal condition for incubation, subculture, regeneration of plantlets, hardening, green house	**(3 Period)**
UNIT 6- Totipotency Meristems soma clonal variations Totipotency and its importance, Meristems-types and role, Characteristics of callus tissue, soma clonal variations and its application	**(4 Period)**
UNIT 7 Organogenesis and somatic embryogenesis Organogenesis Somatic embryogenesis; artificial seeds	**(3 Periods)**
UNIT 8 - Organ culture and its application Root, Shoot tip, Anther, Embryo culture	**(5 Periods)**
UNIT 9 - Cell suspension culture (applications): Principle, isolation, growth patterns, concept of batch and continuous culture, viability testing	**(3 Periods)**
UNIT 10- Somatic hybridization/protoplast culture: Principle enzymes used in protoplast isolation; isolation of protoplasts (mechanical and enzymatic); checking viability; protoplast fusion (spontaneous and induced); selection of hybrid protoplasts; methods of culture; Applications of somatic hybridization.	**(6 Periods)**
UNIT 11 - Applications of tissue culture in plant sciences: Micro propagation, Gene conservation banks, Forestry	**(3 Periods)**
UNIT 12 - Production of secondary metabolites in culture Callus culture, cell suspension culture, hairy root culture (*A. rhizogenes*), Immobilized cell systems.	**(3 Periods)**
UNIT 13 - Plant transformation Using *Agrobacterium tumefaciens*, Selection of transformants.	**(3 Periods)**
UNIT 14- Gene transfer in plants Gene transfer in plants: Agrobacterium based vectors, direct gene transfer	**(6 Periods)**
UNIT 15 - Applications of transgenic plants: Insect resistance (BT toxin), drought and salt tolerance, herbicide resistance, increasing shelf life of fruits, improvement of vitamin content (golden rice) edible vaccines	**(6 Periods)**

Learning Outcomes: ***At the end of the course students will be able to:***

1. Explain the concept of Plant Tissue culture and also outline the research findings in the field. And design the PTC laboratory and choose the appropriate method of sterilization to be used for different equipment and formulate the PTC media. Also, to select the explants and choose the appropriate surface sterilizing agent and know about the ideal conditions of incubation and regeneration of cultures and give details of the structure and environmental conditions of the green house.
2. Summarize the concept of totipotency, soma clonal variation, somatic hybridization classifies the meristem based on their position and origin and to distinguish the callus tissue on the basis of color, texture, microscopic examination along with organogenesis and somatic embryogenesis, the various factors affecting it and its importance and to explain the steps involved in the preparation of artificial seeds and its advantages and also the principle and importance of the root, shoot tip, anther and embryo culture.
3. Generalize the concept of cell suspension culture, the protocol and the different methods used for establishment of batch and continuous culture in addition to be able to identify the best method for protoplast isolation, the different enzymes used to isolate the protoplast, evaluate protoplast viability, explain the different methods for protoplast fusion, hybrid selection and culturing methods.
4. Explain the three stages of micropropagation, how tissue culture can be used in making gene banks and its importance in forestry and also classify the secondary metabolites produced in plants and compare the different methods of culture used for secondary metabolite production along with knowing about the structure of Ti plasmid and the virulence region and also explain the process of gene transfer and further elaborate on the methods used for the selection of transformants.
5. Draw the structure of the Cointegrate and binary vector and discuss the direct gene transfer methods like Microinjection, Particle gun method, Electroporation and Chemical methods and outline the application of transgenic plants.

Books 1. Kalyan Kumar De: Plant Tissue Culture; 1992. New Central Book Agency (P)Ltd., Calcutta.

2. Narayanswamy S; Plant Cell and Tissue Culture; 1994. Tata McGraw- Hill Publishing Company Ltd. New Delhi.

3. S. P. Misra: Plant Tissue Culture; 2009. Ane Books Pvt. Ltd., New Delhi.

4. Chawla H.S.; Introduction to Plant Biotechnology; 2002. Science Publishers Inc. USA.

5. K. G. Ramawat: Plant Biotechnology; S. Chand & Company Ltd., New Delhi, 2004.

6. Jha & Ghosh: Plant Tissue Culture; Universities Press Pvt. Ltd., Hyderabad, 2005.

7. Prakash and Arora: Cell and Tissue Culture;5th ed 2005 Anmol Publications Pvt. Ltd., New Delhi.

8. Kumar U; Methods in Plant Tissue Culture. 2011. Agro-Bios.India

9. S. S. Purohit, Practical PlantBiotechnology,7th ed,2009. Student Edition.

Paper XI	Industrial Biotechnology	50 Hours

Course Objectives:

1. To understand fermentation equipment and design and its working along with the parts, components of a bioreactor and fermenter.
2. To learn the techniques of primary and secondary screening and the microbial storage methods.
3. To study the aims of preservation of cultures and define working and primary stock cultures and to study the characteristics, working and applications of different types of fermentation processes.
4. To understand the importance of good lab practices, good manufacturing practices and quality control and ISO standards with respect to manufacturing of fermentation products.
5. To understand the different types of downstream processes that involve separation, disintegration, enrichment, purification and drying downstream processes and to study the industrial production of wine, alcohol, streptomycin and penicillin.

Theory

1. Fermentation equipment and its use. A) definition of fermenter/bioreactors 10 b) structure of ideal fermenter c) definition and uses of impellers and their types, spargers and their types, baffles, headspace d) controls and sensors (temperature, pH, antifoam, dissolved oxygen and carbon dioxide sensor) e) types of reactors (definition, description, diagram and uses) stirred tank reactors, bubble columns, airlift bioreactors (internal and external loop), fluidized bed, packed bed column, photobioreactors, tray bioreactors.	
2. Screening and selection of microorganisms a) primary screening-definition and techniques crowded plate, auxanography, enrichment, indicator dye B) secondary screening- definition and features	
3. Stock cultures a) aims of preservation of cultures b) definition of working and primary stock c c) techniques of preservation • serial subculture, sterile soil, water, silica gel, sterile mineral oil, lyophilization, cryogenic preservation.	
4. Types of fermentation processes • submerged, surface/solid state, batch, fed batch, continuous.	
5. Fermentation media. A) characteristics of an ideal production media fermentation media. B) media composition: crude, synthetic. C) media sterilization • heat, radiation, chemical methods and filtration. • batch and continuous sterilization	

d) sterilization of air. E) inoculum preparation	
6. Detection and assay of fermentation products A). Physical or chemical assay. I). Titration and gravimetric assay. Ii). Turbidity analysis and cell determination. Iii). Spectrophotometric assay. Iv) chromatographic partition assay. B). Biological assay-concept benefits and drawbacks. I) diffusion assay. Ii) turbidimetric and growth assay. Iii) endpoint assay. Iv) metabolic response assay. V) enzymatic assay.	
7. Scale up of fermentations and increasing product yields. A) significance of scale up. B) pilot fermenters c) increasing product yields by mutagens-physical and chemical mutagens/strain improvement.	
8. Quality control Good manufacturing practices, factors affecting gmp, lal assay	
9. Downstream processing 1. Biomass a) separation of cells (flocculation, floatation, filter aids and filtration (surface, depth), centrifugation) a) batch centrifuge eg. Tubular bowl centrifuge b) continuous centrifuge eg. Basket centrifuge. B) disintegration in brief • mechanical eg ultrasonication, homogenizers and use of ballotini • non mechanical eg. Thermal lysis • chemical: eg. Detergent solubilisation, organic solvents • enzymatic methods eg. Lysozyme 2. Broth a) enrichment: evaporation, membrane filtration, liquid-liquid, extraction, precipitation, adsorption. B) purification: crystallization and chromatography. C) drying: convection drying eg. Spray dryers. Freeze drying	
10. Industrial production Organisms, fermentation media and conditions, downstream, processing and uses (penicillin, streptomycin, wine, alcohol)	
Learning Outcomes: ***At the end of the course students will be able to:*** 1. Explain the stages of a bacterial growth curve and classify organisms by cell structure also to state the principle, working, key features and applications of screening technique of microorganisms. 2. List and describe the various methods of preservation of microbes and distinguish between stock and working cultures and their significance. 3. Describe batch, fed batch, continuous and solid-state fermentations and to list the various fermentation media, their components of, sources of carbon, nitrogen and vitamins and explain their significance. 4. Perform the lal assay and state the significance of iso certification and learn the good lab practices and their significance and explain the types and working of various types of downstream processes and their significance. 5. Describe the production of industrial fermentation of wine, alcohol,	

streptomycin and penicillin.	

Books

1) Wulf Cruger and Anneliese Cruger, A Text book of Industrial Microbiology. 2007. Sinauer associates pub.
2) Prave P., Faust U., Sitting W., Sukatsch D.A., Fundamentals of Biotechnology. 2004. VCH publishers.
3) Casida L.E., Industrial Microbiology. 2009. Wiley.
4) Prescott and Dunn, Industrial Microbiology. 4th ed, 1982. AVI Pub Co.
5) Sivasankar B., Bioseparations: Principles and techniques. 2005. Prentice hall of India pvt ltd New Delhi.
6) CollinRatlege, Basic Biotechnology. 2006. Cambrige university press.
7) Patel A.H., Industrial Microbiology, 2012, MacMillan Publishers India Ltd.
8) Srivastava M.L., Microbial Biochemistry, 2008, Narosa Publishing House, New Delhi.

Paper XII	Techniques in Biotechnology	50 Hours

Course Objective:

1. To explain the General safety measures, Safety signs and different types of Hazards-chemical, physical, biological and to explain methods to handle Spillage and waste disposal.
2. To elucidate the principles of centrifugation (centrifugal force and sedimentation rate) and the principle and working of Preparative ultracentrifuges, Analytical ultracentrifuges, Differential centrifugation, Density gradient centrifugation, Rate Zonal centrifugation, Isopycnic centrifugation and their applications in field of science.
3. To explain the working principle, methodology and applications of Chromatographic techniques like Paper Chromatography, TLC, Gel filtration chromatography, Ion Exchange chromatography, Affinity chromatography, HPLC, GLC, Agarose gel electrophoresis, PAGE-SDS, PAGE-Native, Isoelectric focusing and 2D-PAGE.
4. To describe hybridization probes, radioactive probes, non-radioactive probes and to explain the principle, procedure and applications of FISH Southern Blotting Northern Blotting Western Blotting.
5. To discuss the principle, procedure and applications of ELISA, RIA, Chemiluminescent immunoassay, Immunofluorescence, Flow cytometry, RAPD, RFLP, Microarray, DNA Finger printing, PCR: Real time, PCR: Reverse transcriptase, Nested PCR, Overlap extension.

Theory

Safety in laboratories General safety measures, Safety signs, Hazards-chemical, physical, biological, Spillage and waste disposal	**(5 periods)**
Centrifugation Principles of centrifugation-centrifugal force and sedimentation rate, Preparative and Analytical ultracentrifuges, Differential and Density gradient centrifugation	**(5 periods)**
Chromatography Chromatographic techniques: Principle, Paper Chromatography, TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography, HPLC, GLC	**(8 periods)**
Electrophoresis Gel electrophoresis-Agarose and PAGE (SDS and native), Isoelectric Focusing and 2D PAGE	**(6 periods)**
Probes and Hybridization Introduction to Hybridization probes, Radioactive and non-radioactive probes. FISH, Southern, Northern, Western blotting and hybridization.	**(8 periods)**
Immunological Diagnostics ELISA, RIA, Chemiluminescent immunoassay, Immunofluorescence. Flow cytometry	**(8 periods)**
Techniques in Genetic engineering and its applications RAPD, RFLP, Microarray, DNA Finger printing, PCR, types: Real time, reverse transcriptase, nested, overlap extension.	**(10 periods)**

Learning Outcomes: At the end of the course students will be able to:

1. State the types of radiations encountered in a biological lab and the precautions to be taken while dealing with radioactivity: the ways to deal with spillage and disposal of bio-hazardous wastes; and the potential physical hazards in lab.
2. State the principle of Centrifugation and explain the factors that affect the process of centrifugation and state the principle of separation by different types of chromatography techniques**.**
3. Explain the instrumentation and working of GLC and HPLC and explain separation of nucleic acids using agarose gel electrophoresis and separation of proteins by SDS-PAGE, Native-PAGE and Isoelectric focusing and perform SDS-PAGE.
4. State the applications of PAGE, agarose gel electrophoresis, Isoelectric focusing and 2D-PAGE.
5. Discuss the methods employed to obtain DNA probes and mention the method of labelling non-radioactive probes and radioactive probes.
6. Perform Western Blotting, Southern Blotting and Northern Blotting and the different types of ELISA, RIA and other immunoassay-based techniques.
7. Explain the principle and applications of RAPD, RFLP, DNA fingerprinting, microarray and different types of PCR techniques.

Books

Reference books:

1. Purohit S.S., Biotechnology: Fundamentals and applications (2004), Kalyani Publishers.
2. Singh B.D., Biotechnology: Expanding horizons (2004), Kalyani publishers
3. Satynarayan U., Biotechnology, 2009, Books and AlliedP ltd, Calcutta.
4. Primrose S.B. and Twyman R.M., Principles of Gene Manipulation and Genomics, 2009, Blackwell Publishing.

Paper XIII	Concepts in Genetic Engineering	50 Hours

Course Objective:

1. To introduce genetic engineering and the basic steps of Gene cloning
2. To explain the properties and applications of endonucleases, DNA ligases, Reverse transcriptases, Polynucleotide kinases, alkaline phosphatases and Nucleotidyl transferases and the differences between DNA ligases from *E.coli* and T4 phage
3. To explain the classification of restriction enzymes and discuss the properties and classification of plasmids, ideal cloning vector, pBR322, pUC18, Lambda gt10, M13, Mp8/9, YAC, YEP, Shuttle vectors, Cosmids and Pagemids and to define Ligation and to discuss the use of linkers and adapters in gene cloning
4. To explain the steps involved in Homopolymer tailing and describe the techniques of electroporation, Liposome mediated DNA transfer and $CaCl_2$ method and to discuss the applications of electroporation, Liposome mediated DNA transfer and $CaCl_2$ method.
5. To Explain in vitro packaging of DNA of lambda phage and to learn the principle and procedure of plasmid isolation and (spectrophotometric and agarose gel) used for analysis of DNA yields and to discuss the principle, working and applications of Agarose gel electrophoresis.
6. To explain the preparation of genomic library and cDNA libraries and describe different approaches like Antibiotic resistance (amp, tet resistance), Lac selection, Colony hybridization and cI selection used for screening of gene libraries and to understand the different methods used for DNA sequencing (Maxam Gilbert's method, Sanger's method and Automatic DNA sequencer)
7. To discuss the advantages of automatic DNA sequencer and to explain the different levels of Physical containment (BSL-1, BSL-2, BSL-3 and BSL-4). To explain the different levels of Biological containment.

Theory

Topic 1: Introduction Genetic Engineering: Introduction to gene cloning, Basic steps of Gene cloning.	**(2 periods)**
Topic 2: DNA manipulative/modifying enzymes Nucleases- Endonucleases (Restriction enzymes, recognition sequences, cleavage pattern). Exonucleases, DNA ligases, Reverse Transcriptase, Polynucleotide kinases, Alkaline phosphatases, Nucleotidyl transferases.	**(8 periods)**
Topic 3: Vectors for gene cloning Plasmids-Properties, Classification, Vectors-properties of Ideal cloning vectors, Vector for Prokaryotes-pBR322, pUC 18, Bacteriophages as cloning vectors - lambda gtlO, Ml3, mp8/9, YAC and YEP vectors, Vehicles for Gene cloning Shuttle vectors-any one example Phagemids, Cosmids-any one example.	**(14 periods)**
Topic 4: DNA Insertion into Vector Ligation-definition, Use of linkers and Adaptors, Homopolymer tailing.	**(4 periods)**
Topic 5: DNA Transfer methods Artificial transformation**,** Electroporation, Liposome mediated transfer, CaCl2 method ln-vitro packaging.	**(7 periods)**
Topic 6: DNA isolation methods and analysis Principle of Plasmid Isolation, Analysis of DNA yields, Agarose gel electrophoresis, Spectrophotometric analysis.	**(5 periods)**

Topic 7: Genomic/cDNA libraries Preparation of genomic library, cDNA library, Screening of Libraries.	**(3 periods)**
Topic 8: Identification of Recombinants Antibiotic resistance (amp, tet resistance) lac selection, Identification of Recombinants, Colony hybridization, cl selection	**(3 periods)**
Topic 9: DNA Sequencing Maxam Gilbert's method, Sanger's method, Automatic DNA sequencer.	**(4 periods)**
Topic 10: Biosafety levels Levels of Physical and Biological Containment.	**(3 periods)**

Learning Outcomes: ***At the end of the course students will be able to:***

1. Outline the Basic steps of Gene cloning and state the properties and applications of endonucleases, DNA ligases, Reverse transcriptases, Polynucleotide kinases, alkaline phosphatases and Nucleotidyl transferases.
2. Classify restriction enzymes based on recognition sequences and nature of cuts and differentiate between *E.coli* and T4 ligase and list the properties of ideal Vectors and discuss the structure and properties of PBR322 Vectors, pUC18, Lambda gt10, M13, Mp8/9
3. Describe Bacteriophages and M13 as cloning vectors, cosmids, phagemids, YAC and YEP vectors and the techniques of electroporation, liposome mediated DNA transfer and $CaCl_2$ method and state the applications of electroporation, liposome mediated DNA transfer and $CaCl_2$ method.
4. Describe in vitro packaging of DNA of lambda phage and state the principle, requirements and procedure for plasmid isolation by boiling method and alkaline lysis method and also the working and applications of Agarose gel electrophoresis.
5. Elucidate different methods used for preparation and screening of Genomic libraries and compare the Maxam Gilbert's method and Sanger's method for DNA sequencing and discuss the advantages of automatic DNA sequencer over Maxam Gilbert's method and Sanger's method for DNA sequencing and finally highlight features of different levels of physical containment and Biological containment.

Books

Reference books:

1. Primrose S.B. and Twyman R.M., Principles of Gene Manipulation and Genomics, 2009, Blackwell Publishing.
2. Brown T.A., Gene Cloning and DNA Analysis: An Introduction. Fifth Edition. 2006. Wiley-Blackwell.
3. Jogdand S.N., Gene biotechnology. 2nd edition, 2008. Himalaya Publishing House, Mumbai.
4. Purohit S.S., Biotechnology: Fundamentals and Applications, 2009, Student Edition.
5. Singh B.D. Biotechnology Expanding Horizons. 2008. Kalyani publishers.
6. Glick BT, JJ Pasternak. Molecular Biotechnology. Principles and applications of Recombinant DNA. 3rd edition, 2003. Washington DC ASMPress.
7. Karp G, Cell and Molecular Biology. 3rd Edition, 1999, John Wiley and Sons.
8. Robertis E.D.P., Robertis E.M.F., Cell Biology and Molecular Biology. 8th edition, 1998. Sauder College.

Paper XIV:	Animal Cell Culture	50 Hours

Course Objective:

1. To learn the History and Scope of animal tissue culture, and list requirements for animal cell culture washing room, media preparation and sterilization room, inoculation and culture room, equipment's, culture vessels for tissue culture and their use also to understand the effect of Physico-chemical properties of culture media on growth of cells and to differentiate between Natural media and Complex natural media, Artificial media and list their advantages & disadvantages.
2. To describe Serum containing media, Serum- free media, Chemically defined media, Protein- free media, Basal salt solution (BSS), Other constituents of basal media, Vitamins, Amino acids, Trace elements, Inorganic ions and to study the Growth factors-promoting proliferation of animal cells and Special secondary metabolites / products and to understand the role of Serum as complex supplement, Influence of culture condition & media on protein expression.
3. To list types of culture: organ culture, whole embryo culture, histotypic culture, explants cultures, and to understand Primary and Established cell line cultures. Characteristics & maintenance of continuous cell lines their establishment and methods and to study characteristics of normal and transformed cells and to learn maintenance of stock cultures, Antibiotic free stock cultures, properties of transformed cells also to understand physical methods of cell separation, separation based on cell size, cell density, cell surface charge, cell affinity, Separation by cytofluorometry
4. To understand the concept of Cytogenetics, Karyotyping, Isoenzymes, immunological tests and to study direct method and indirect method of cell measurements, to study the Eukaryotic cell cycle and the methods of Cell Synchronization: Gi, Gj/S, selective detachment synchronization.
5. To understand Apoptosis in cultured cells and reasons for cell suicide and to understand the concept of tissue engineering: Artificial skin, Artificial cartilage, Stem cell culture, cell culture-based vaccine and to know the valuable products available from cell cultures.

Theory	**No. of lectures**
1. Introduction to ACC History and Scope of Animal Tissue Culture.	**1**
2. Requirement for animal cell culture: Washing room, Media preparation and sterilization room, Inoculation and culture room, equipment, culture vessels for tissue culture	**3**
3. Growth media Physico-chemical properties of culture media. pH, C02, 02, Temperature. Natural media: advantages & disadvantages Clots biological fluids tissue extracts Complex natural media. Artificial media: advantages & disadvantages. Serum containing media, Serum- free media, Chemically defined media, Protein- free media) d) Basal salt solution (BSS), Other constituents of basal media, Vitamins, Amino acids, Trace elements Inorganic ions. Growth factors-promoting proliferation of animal cells EGF, FGF, PDGF, IL-I, II-2, NGE, Erythropoietin. Special secondary metabolites / products (insulin, growth hormone, interferon, t-plasminogen activator, factor VIII etc. Serum as complex supplement, Influence of culture condition & media on protein expression.	**10**

4.Culturing of Cells Basic techniques of mammalian cell cultures, Material source, isolation of cells, Mechanical disaggregation Enzymatic disaggregation. Types of culture: organ culture Whole embryo culture Histotypic culture Explants cultures, Primary and Established cell line cultures. Characteristics & maintenance of Established/ continuous cell lines, Establishment of continuous cell lines: spontaneous transformation chemical transformation viral transformation non- chemical methods. Characteristics of normal and transformed cells. Maintenance of stock cultures, Antibiotic free stock cultures, Properties of Transformed cells	**8**
5. Cell separation methods. • Physical method of cell separation, separation based on cell size, cell density, cell surface charge, cell affinity, Separation by cytofluorometry	**6**
6. General consideration of animal cell culture scale up Large scale culture of cell lines: monolayer culture, suspension culture, immobilized culture.	**5**
7. **Characterization and growth measurements of cultured cells:** Cytogenetics, Karyotyping, Isoenzymes, immunological tests Direct method: Particle counter, dye exclusion test, cytotoxicity assay Indirect method: MTT assay	**5**
8. **Cell growth** Eukaryotic cell cycle Cell Synchronization: Gi, Gj/S, selective detachment synchronization Phases of cell growth, population doubling level in cultured cells Apoptosis in cultured cells Reasons for cell suicide	**2**
9.**Applications of cell culture:** Concept of tissue engineering: Artificial skin, Artificial cartilage, Stem cell culture, cell culture based vaccine, valuable products from cell cultures	**6**

Learning Outcomes: ***At the end of the course students will be able to:***

1. List major historical contributors and their contributions and give significance of washing room, media prep, sterilization room, inoculation and culture room, equipment, culture vessels for cell culture.
2. Describe basic techniques of cell culture, cell lines and maintenance, types of culture, transformed and normal cells, and cell growth (cell cycle, synchronization, apoptosis). Explain the effect of Physico-chemical properties of culture media on growth of cells.
3. Differentiate between Natural media and Complex natural media, Artificial media and list their advantages & disadvantages and describe Serum containing media, Serum- free media, Chemically defined media, Protein- free media, Basal salt solution (BSS), Other constituents of basal media, Vitamins, Amino acids, Trace elements, Inorganic ions and their use.
4. Explain the role of growth factors-promoting proliferation of animal cells and Special secondary metabolites / products, Serum as complex supplement, Influence of culture condition & media on protein expression and to list and explain types of culture: organ culture, whole embryo culture, histotypic culture, explants cultures,
5. Distinguish between Primary and Established cell line cultures and their Characteristics &

methods of maintenance and to describe characteristics of normal and transformed cells.

6. Know how to maintain stock cultures, Antibiotic free stock cultures, properties of transformed cells and to explain physical methods of cell separation, separation based on cell size, cell density, cell surface charge, cell affinity, Separation by cytofluorometry and to explain the concept of Cytogenetics, Karyotyping, Isoenzymes, immunological tests to study direct method and indirect method of cell measurements.

Books

1. Mathur shivangi, Animal cell & tissue culture, (2009),, Agrobios (India),
2. Masters john, Animal cell culture -A practical approach. 2000. OUP oxford publishers
3. Butterworth- Heinemann, invitro cultivation of animal cells, 2007,
4. Das H.K., Textbook of Biotechnology, 2007. WileyTndia, New Delhi
5. Sudha gangal, Principles and practicle of animal tissue culture. 2007. Orient BlackSwan.
6. Freshney Ian, Animal Cell Biotechnology (5th Edition) 2005. Wiley,John & sons
7. Gupta P.K., Elements of Biotechnology - (1st Edition -2000). Rastogi Publications

Paper XV	Environmental Biotechnology	**50 Hours**

Course Objective:

1. To describe the scope of environmental Biotechnology and to explain the Structure of biotic and abiotic components, Food chain and food webs, Ecological pyramids: pyramids of numbers and energy so also to discuss 10% law of eco-energetics and describe Environmental Impact Assessment and Environmental Management Plan and discuss the Major air pollutants and their sources. -Impacts of air pollution on human health, animals, plants and climate and about Air pollution standards: SO_2, NOx, CO, SPM
2. To explain direct and indirect mechanisms of Microbial desulphurization of coal and discuss the Principal forms of water pollutants and their sources. Concepts of total solid/suspended solid, BOD, COD and Impacts of water pollution. Also, explain the Concept of soil pollution and their sources: Industrial waste effluents and heavy metals, soil acidity/alkalinity, soil salinity and to discuss Treatment of solid wastes using Composting and vermitechnology with reactions taking place during the process.
3. To explain the concept Bioindicators with examples and to discuss various tests for pollution monitoring such as Visual rating, Genotoxicity, Metabolic rating, assessing Genetic damage: Ames test, Cyto-genetic assay, Membrane damage and describe the plant and animal test systems, reporter gene, biosensors along with the applications of reporter gene and biosensors and define the terms such as Bioremediation, Microbial bioremediation, Phytoremediation, in situ and ex-situ remediation, xenobiotic and recalcitrant compounds
4. To explain the Concept of use of mixed microbial populations and genetically engineered microorganisms and describe reactions involved in Biodegradation of benzene and alkane, principle and mechanism of Biosorption, merits of bioenergy against conventional fuels, Process and organisms involved in Biogas, Bioethanol, Biohydrogen and Biodiesel production, Ethanol recovery during Bioethanol production, merits of Biofertilisers against chemical fertilizers and to describe free living and symbiotic organisms as biofertilizers and Aquatic Green Manure and explain the Concept of integrated pest management.
5. To discuss the merits of Biopesticides against chemical pesticides and describe *Bacillus thuringensis,* Entomopathogenic fungi and plant alkaloids and discuss the Merits of Bioplastics against synthetic plastics and to describe about Biopol and biolac, merits and applications of Microbial Ore leaching and explain the process of Desulphurization of Coal**.**

Theory

1. Introduction: The scope of environmental Biotechnology	**(1 hour)**
2. Basic Ecological Concepts and Principles: - Structure (biotic and abiotic components) -Food chain and food webs -Ecological pyramids: pyramids of numbers and energy -Productivity and eco-energetics (10% law) -Environmental Impact Assessment (EIA)	**(4 hours)**

-Environmental Management Plan (EMP)	
3. Anthropogenic activities, its effects and control: Air pollution - Major air pollutants and their sources. -Impacts of air pollution onhuman health, animals, plants and climate. - Removal of gaseous contaminants and odour: bioscrubbers, biotrickling filters and biofilters/biobeds; - Microbial desulphurization of coal (direct and indirect mechanisms). - Air pollution standards: S02,NOx, CO, SPM Water pollution -Principal forms of water pollutants and their,sources. -Wastewater monitoring: Concepts of total solid/suspended solid, BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), -Impacts of water pollution -Wastewater treatment: Aerobic processes (Activated sludge process, rotating biological discs, oxidation ponds, trickling filters) Soil pollution -Concept of soil pollution and their sources: Industrial waste effluents and heavy metals, soil acidity/alkalinity, soil salinity. -Treatment of solid wastes: Composting and vermitechnology (mention of Recovery of energy from solid waste, dealt in detail under section -biogas).	**(15 hours)**
4. Pollution Monitoring: -Bioindicators: Concept and examples (Coliforms and *E.coli*, clostridia as indicators of water quality; Lichens as air pollution indictors). -Choice of criteria: Visual rating, Genotoxicity, Metabolic rating -Applications (two each), using plant test systems and animal Test Systems. -Tests for assessing Genetic damage: Ames Test, Cyto-genetic assay, Membrane damage. -Concept and applications of molecular biology in environmental monitoring: reporter gene. -Concept and applications of biosensors in pollution detection	**(7 hours)**
5. Pollution abatement: Bioremediation and biodegradation: Bioremediation -Definition -Microbial bioremediation -Phytoremediation -Bioremediation of contaminated site (two examples) Biodegradation -Introduction to xenobiotic and recalcitrant compounds -Basis of biodegradation: Concepts of use of mixed microbial populations. - Biodegradation of two xenobiotics: Aromatic hydrocarbon (benzene) and alkane. Biosorption –Principle, -Use of Fungi and Algae (2 Examples each). Genetically engineered microorganisms -Super Bug	**(9 hours)**

6. Biofuels: -Merits of bioenergy against conventional fuels -Process and organisms involved in: -Biogas (Biomethanisation) production: Dome shaped biogas plant -Fuel alcohol (Ethanol) production: including ethanol recovery by distillation -Bio hydrogen production: anaerobic bacteria and photolysis photosynthetic algae -Biodiesel production: Biodiesel from lipids and hydrocarbons	**(5 hours)**
7. Ecofriendly bioproducts: Biofertilisers: -Merits against chemical fertilizers - Free living (Azospirillum,) and symbiotic association (Rhizobia-Legume and mycorrhizal fungi) -Aquatic Green Manure Biopesticides -Concept of integrated pest management. -Merits against chemical pesticides -Bacillus thuringensis, Entomopathogenic fungi and plant alkaloids Bioplastics -Merits against synthetic plastics -Biopol and biolac_	**(7 hours)**
8. Mining and Metal biotechnology: Microbial Ore leaching: merits, applications, removal of copper. - Desulphurization of Coal**.**	**(2 hours)**
Learning Outcomes: ***At the end of the course students will be able to:*** 1. State applications of various techniques studied for pollution control. 2. Define various terms involved in environmental Biotechnology 3. Explain various bioremediation techniques taught in the syllabus. 4. Justify various statements and concepts from the syllabus 5. Describe various water pollution, air pollution and soil pollution control measures. 6. Describe about the production of various bioproducts.	
Books 1) Chatterji A.K., Introduction to Environmental Biotechnology. 2nd ed, 2009. Prentice Hall ofIndia Pvt. Ltd.New Delhi 110 001, 2. Jogdand B.N.,Environmental Biotechnology (Industrial Pollution Management). 2008. Himalaya Publishing House, Mumbai. 3) Agarwal S.K., Environmental Biotechnology. 2009. APH Publishing Corporation New Delhi. 4). Indu Shekar Thakur, Environmental Biotechnology: Basic concepts and applications. 2006. 1.K.International Pvt. Ltd.New Delhi. 5). Singh B.D., Biotechnology. 3rd edition, 2008. Kalyani Publishers. 6). Murugesan A;G., Rajakumari C., Environmental science and Biotechnology: theory and techniques. 2006. MJP publishers, Chennai. 7). Santra S.C., Environmental Science.2001.New central book agency (P) ltd.Calcutta. 8). Anjaneyula Y.,Introduction to environmental Science.2005. BS publications.	

Paper XVI	Food Biotechnology	50 Hours

Course Objective:

1. To understand the role and significance of microorganisms in foods and explain the intrinsic and extrinsic factors responsible for food spoilage.
2. To discuss the microorganisms involved in spoilage of fruits, vegetables, meat, eggs and bread and study the food poisoning caused by bacterial and fungal toxins Also, to indicate the causative agent symptoms, diagnosis and treatment for food borne Infections such as Gastroenteritis and Salmonellosis
3. To explain the sources of contamination in milk and the different microorganisms involved in spoilage with reference to the causative agent symptoms, diagnosis and treatment for milk borne diseases such as Listeriosis and Scarlet fever
4. To elaborate the principle and determine the quality of the milk using dye reduction test – MBRT and Resazurin and to explain the principle of SPC, Breeds smear and also selective and differential media for identification of spoilage organisms and describe the use of gene probes, RDT and Bioluminescence and to explain the principle of Preservation by Drying, High temperature and low temperature also, to outline the concept of TDP and TDT and describe the Pasteurization process and state the principle of phosphatase test, canning, Hurdle technology.
5. To summarize the use of additives and radiation for preservation of food and understand the process, microbiology involved and changes during fermentation of sauerkraut and yogurt so also to explain the Nutritive value and use of Mushroom and *Spirulina* and to outline the HACCP System to food protection and finally to outline the Pros and Cons of GM foods Egs: Golden rice, Flavr Savr tomato and Bt Brinjal.

Theory

UNIT 1- Microbiology of food History of microorganisms in food Role and significance of microorganisms in foods.	**(3 Lectures)**
UNIT 2- Food Technology and Diseases Intrinsic and extrinsic factors responsible for food spoilage Microorganisms involved in food spoilage: fruits, vegetables, meat, eggs, bread Food Borne diseases. Food poisoning: (Bacterial Toxin Botulism and Staphylococcal toxin) Fungal Toxins: Aflatoxin. Food borne Infections: Gastroenteritis and Salmonellosis	**(10 Lectures)**
UNIT 3- Milk technology and Diseases Sources of contamination Different microorganisms implicated in spoilage Milk borne diseases: Listeriosis and Scarlet fever Grading of milk by dye reduction test – MBRT and Resazurin,	**(5 Lectures)**
UNIT 4 - Detection of food spoilage Methods of detection of food spoilage: Traditional approaches: SCP, Breeds smear, Identification of specific organisms by using selective and differential media. New approaches: use of gene probes, RDT Bioluminescence	**(7 Lectures)**

UNIT 5 - Food preservation Preservation by Drying: Solar drying, mechanical drying, salting, smoking). Preservation at High temperature: Concept of TDP and TDT. Pasteurization (LTHT, HTST, UHT processes; Efficiency of pasteurization – phosphatase test, canning, Hurdle technology. Preservation at low temperature: Freezing, Preservation by use of additives: Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants. Preservation by radiation: UV, ionizing radiations, gamma and cathode rays, microwave processing. Other methods: Hydrostatic pressure-cooking modified atmosphere.	**(12 Lectures)**
UNIT 6 - Fermentation technology Fermented Food: Process, microbiology involved and changes during fermentation of Fermented food: sourkraut Milk products: yogurt	**(3 Lectures)**
UNIT 7 - Microorganisms as source of food and enzymes Nutritive value and use of Mushroom (production done in industrial) Nutritive value and use of SCP eg. Spirulllina Enzymes and its application in food industry	**(3 Lectures)**
UNIT 8 - Food quality assurance Food safety: HACCP System to food protection, Responsibility for food safety.	**(2 Lectures)**
UNIT 9 - GM foods Pros and Cons of GM foods Egs: Golden rice, Flavr Savr tomato and Bt Brinjal	**(5 Lectures)**

Learning Outcomes: ***At the end of the course students will be able to:***

Explain the role of various microorganisms in food.

Describe the causative agent symptoms, diagnosis and treatment for various food borne Infections and diseases.

Discuss the use of various approaches to identify food spoilage organisms.

Explain the various food preservation methods.

Outline the HACCP system for food protection

Books:

1. Jay, James M., Loessner, Martin J., Golden, David A. Modern Food Microbiology, 2005
2. M. R. Adams, M. O. Moss, Food Microbiology, Royal Society of Chemistry, 2008 –
3. Frazier, Food Microbiology, Tata McGraw-Hill Education, 1950
4. Bibek Ray, Arun Bhunia, Fundamental Food Microbiology, Fifth Edition
5. **Banwart,** George, Basic Food Microbiology, (1989).