

**S.S. JAIN SUBODH P.G. COLLEGE**  
**(Autonomous)**



**Syllabus**  
**For**

**B.Sc. (Biology/Life Science)**  
**Subject: Biotechnology**  
**Session 2022-23**

**SCHEME OF EXAMINATION AND COURSES OF STUDY**

**FACULTY OF SCIENCE**

**I. Course Overview & Course Objectives**

The main objective of the course is to build a basic foundation for studying Biotechnology.

By the end of the course, a student should be able to:

- a) Understand the importance of having water as a solvent system in cells
- b) Appreciate the importance of bonding and spatial arrangements of molecules for proper functioning and stability.
- c) Establish the concept of how proper conformations are needed for optimum functioning of the molecules and thereby the entire cell
- d) Appreciate how proteins, carbohydrates, lipids and nucleic acids can contribute to the structural integrity of the cell as well as the biochemical reactions.
- e) Appreciate how a change in the structure of the molecules can lead to abnormalities, e.g. A mutated globin results in sickle cell anemia.
- f) Understand both the physical as well as chemical properties of these biomolecules and bionanoparticles as these properties can be used to carry out various studies.
- g) Appreciate experiments carried out by scientists to enable understand the structure of biomolecules, understand their properties, design of experiments to prove the same and analyse the data and give interpretations.

Thus, the knowledge from this course can help in the following:

- a) The students could pursue a career in clinical Biotechnology as maintaining levels of these biomolecules in the body are of utmost importance. The decrease or increase in the amount of some of the biomolecules can have clinical significance. For example, increased blood sugar levels are indicative of a person suffering from diabetes mellitus.
- b) The students can carry out basic research in Biotechnology, which in turn can be of great help in the medical and diagnostic fields.
- h) Students can understand about agriculture, plant tissue culture techniques, animal tissue culture, environment studies, gene cloning and recombinant DNA technology.
- c) Students can also go in for Medical Laboratory Technique Courses, opening opportunities in hospitals and pathological laboratories.
- d) Basic knowledge of Biotechnology is also required for food, Nutrition and Dietetics.
- e) The understanding of proteins, its study, has opened up the field of Proteomics.

- f) Many of the carbohydrates, proteins and lipids discussed have commercial value and thus, find a place in Industrial Biotechnology.
- h) There exist a number of applications of bioinformatics for accelerating research in the area of Biotechnology.

**Semester Structure:** The details of the courses with code, title assigned is as given below.

**Duration:** 6 Semesters (3 Years)

***Semester-I***

**BSBT101: Paper I -Cell Biology**

**BSBT102: Paper II- Concepts of Biotechnology and Bioinformatics.**

**BSBT103: Paper III- Biotechniques.**

**BSBT151: Lab- Practicals Based on Theory Papers**

***Semester -II***

**BSBT201: Paper I- Genetics**

**BSBT202: Paper II- Biochemical Metabolism**

**BSBT203: Paper III- Developmental Biology**

**BSBT251: Lab-: Practicals Based on Theory Papers**

***Semester III***

**BSBT301: Paper I- Molecular Biology**

**BSBT302: Paper II-General Microbiology**

**BSBT304: Paper III- Cellular Biophysics and Biochemistry**

**BSBT351: Lab-Practicals Based on Theory Papers**

***Semester IV***

**BSBT401: Paper I-Recombinant DNA Technology**

**BSBT402: Paper II- Immunology**

**BSBT403: Paper III- Environmental and Agri Biotechnology**

**BSBT451: Lab- Practicals Based on Theory Papers**

***Semester V***

**BSBT501: Paper I- Animal Biotechnology**

**BSBT502: Paper II- Plant Biotechnology**

**BSBT503: Paper III- - Biostatistics and Computer Application**

**BSBT551: Lab- Practicals Based on Theory Papers**

***Semester VI***

**BSBT601: Paper I- Medical Biotechnology**

**BSBT602: Paper II-Industrial Biotechnology**

**BSBT603: Paper III- Biosafety, Bioethics and IPR in Biotechnology.**

**BSBT651: Lab-Practicals Based on Theory Papers**

## B. Sc. Semester I

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

Nomenclature			External Theory	Internal Theory	Total Max. Marks	Total Min. Marks
BSBT101	Paper I	Cell Biology	35	15	50	20
BSBT102	Paper II	Concepts of Biotechnology and Bioinformatics	35	15	50	20
BSBT103	Paper III	Biotechniques	35	15	50	20
					150	
BSBT151	Lab	Practicals based on Theory Paper	45	30	75	30

## B. Sc. Semester II

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

Paper code	Nomenclature		External Theory	Internal Theory	Total Max. Marks	Total Min. Marks
BSBT201	Paper I	Genetics	35	15	50	20
BSBT202	Paper II	Biochemical Metabolism	35	15	50	20
BSBT203	Paper III	Developmental Biology	35	15	50	20
					150	
BSBT251	Lab	Practicals based on Theory Paper	45	30	75	30

## B. Sc. Semester III

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

Paper code	Nomenclature		External Theory	Internal Theory	Total Max. Marks	Total Min. Marks
BSBT301	Paper I	Molecular Biology	35	15	50	20
BSBT302	Paper II	General Microbiology	35	15	50	20
BSBT303	Paper III	Cellular Biophysics and Biochemistry	35	15	50	20
					150	
BSBT351	Lab	Practicals based on Theory Paper	45	30	75	30

#### **B. Sc. Semester IV**

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

Paper code	Nomenclature		External Theory	Internal Theory	Total Max. Marks	Total Min. Marks
BSBT401	Paper I	Recombinant DNA Technology	35	15	50	20
BSBT402	Paper II	Immunology	35	15	50	20
BSBT403	Paper III	Environmental & Agri Biotechnology	35	15	50	20
					150	
BSBT451	Lab	Practicals based on Theory Paper	45	30	75	30

#### **B. Sc. Semester V**

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

<b>Paper code</b>	<b>Nomenclature</b>		<b>External Theory</b>	<b>Internal Theory</b>	<b>Total Max. Marks</b>	<b>Total Min. Marks</b>
BSBT501	Paper I	Animal Biotechnology	35	15	50	20
BSBT502	Paper II	Plant Biotechnology	35	15	50	20
BSBT503	Paper III	Biostatistics & Computer Applications	35	15	50	20
					150	
BSBT551	Lab	Practicals based on Theory Paper	45	30	75	30

**B. Sc. Semester VI**

**Max. Marks (Theory): 150**

**(Practical):75**

**Teaching Hours per week for every paper: 2**

<b>Paper code</b>	<b>Nomenclature</b>		<b>External Theory</b>	<b>Internal Theory</b>	<b>Total Max. Marks</b>	<b>Total Min. Marks</b>
BSBT601	Paper I	Medical Biotechnology	35	15	50	20
BSBT602	Paper II	Industrial Biotechnology	35	15	50	20
BSBT603	Paper III	Biosafety, Bioethics and IPR in Biotechnology	35	15	50	20
					150	
BSBT651	Lab	Practicals based on Theory Paper	45	30	75	30

## B.Sc. Biotechnology

### Semester -I

#### PAPER I - CELL BIOLOGY

##### Unit -I

**Cell as a Basic unit of Living Systems:** Discovery of cell, the cell theory. General characteristics of cell. Ultra-structure of prokaryotic and eukaryotic cell (both plant and animal cells). **Surface Architecture:** Structural organization and functions of plasma membrane and cell wall of eukaryotes and cell wall of prokaryotes.

##### Unit -II

**Cellular Organelles:** Structure and functions of cell organelles – Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus (Nuclear envelope with nuclear pore complex, Nucleolus, Nucleoplasm and Chromatin). Vacuole, Cytosol and Cytoskeleton structures (Microtubules, Microfilaments and Intermediate filaments).

##### Unit -III

**Chromosomes:** Discovery, Morphology and structural organization – Centromere, Secondary constriction, Telomere, Chromonema, Euchromatin and Heterochromatin, Chemical composition and Karyotype. Ultrastructure: Single-stranded and multi-stranded hypothesis, folded- fibre and nucleosome models. Special type of chromosomes: Salivary gland and Lampbrush chromosomes.

##### Unit -IV

**Cell cycle:** An overview of cell cycle; Components of cell cycle control system; Intracellular and Extra-cellular control of cell division. Elementary idea about Programmed cell death (Apoptosis) and Senescence. AIDS and Organ transplantation.

#### Suggested Readings:

1. Chouhan R. (2018). Molecular Biology and Biotechnology. Second edition. CBH Publication, Jaipur.
2. Cooper, G. M. and Hausman, R. E. (2009). The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
3. De Robertis, E. D. P. and De Robertis, E. M. F. (2006). Cell and Molecular Biology. 8<sup>th</sup> edition. Lippincott Williams and Wilkins, Philadelphia.
4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.



## Semester -I

### Paper II- CONCEPTS OF BIOTECHNOLOGY AND BIOINFORMATICS

#### Unit -I

**Introduction:** Historical development of Biotechnology. Basic concepts of Biotechnology, Definition and descriptions of some important terminology in Biotechnology.

**Branches and Applications of Biotechnology:** Practice of Biotechnology in medicine, industry, agriculture, livestock improvement and environment and Future perspectives. Whittaker's five kingdom classification

#### Unit -II

**Biotechnology and Other Disciplines:** Biotechnology- an interdisciplinary pursuit, types of biotechnology and a three component central core. Product safety. Sterilization- Physical, chemical and radiation method. Microscopic techniques- Organization and working of optical microscopes: Dissecting and Compound microscope. Stains and staining techniques – Principle of staining, types (simple, structural and differential stains) and micrometry.

#### Unit -III

**Elementary Idea about Nano-biotechnology**– concepts, definitions, prospects; nanoparticles – size, shape, properties. Bionanoparticles – nanostarch, nanocomposites–dendrimers. Hot–Dotnanoparticles. Applications of nanobiotechnology in medicine, drug designing and cancer treatment.

#### Unit -IV

**Elementary idea about Bioinformatics** - Definition, introduction, application and scopes. Databanks – Gen Bank, DataBanks – PubMed. BLAST, FASTA, and NCBI. Applications of Bioinformatics in relation to Biotechnology.

#### Suggested Readings:

1. Brown, T.A (1996). Gene cloning and DNA analysis Blackwell science, Osney Mead, Oxford.
2. Chouhan R. (2018). Molecular Biology and Biotechnology. Second edition.CBH Publication, Jaipur
3. Dubey, R. C. (2007). A textbook of Biotechnology, S.Chand & Company Ltd. New Delhi.
4. Gupta P.K: (2004). Biotechnology and Genomics, Rastogi publication, Meerut
5. Satyanarayana. U, (2008),.Biotechnology, Books and Allied (p) Ltd
6. Singh, B. D (2004). Biotechnology, Kalyani Publishers, New Delhi.

## Semester –I

### PAPER III- BIOTECHNIQUES

#### Unit -I

**Microscopy-** Principles Applications of Bright field and Dark-field Microscopy and fluorescent Microscopy, Phase contrast Microscopy, Confocal Microscopy. Electron Microscope-Principles and Applications of Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Sample preparation for Electron Microscopy.

#### Unit- II

**Centrifugation:** Basic principles of sedimentation. Types of centrifuges: Preparative, analytical, high speed, low speed, ultracentrifuge, differential and density gradient.  
Determination of molecular weight: sedimentation velocity and sedimentation equilibrium.

**Chromatography:** General principle of chromatographic separation. Principle, instrumentation and applications of Partition Chromatography, Adsorption Chromatography, Paper Chromatography, TLC, HPTLC, Ion Exchange Chromatography, Gel permeation Chromatography, Affinity Chromatography, and HPLC.

#### Unit- III

##### Electrophoresis

Basic principle and types of electrophoresis. Electrophoretic mobility. Factors affecting electrophoretic migration, Technique and uses of agarose gel electrophoresis, PAGE, SDS-PAGE, Two-dimensional electrophoresis and Isoelectric focussing.

#### Unit -IV

**Spectroscopy-**Beer-Lambert law and its limitations. Light absorption and transmission. Extinction coefficient. Basic design of photoelectric colorimeter and spectrophotometer. Applications of UV-visible spectroscopic techniques. Flame Photometry. Atomic absorption spectrophotometry, Circular Dichroism and Rotatory Dispersion, Principle and application of NMR and ESR techniques.

**Crystallography-**Principle, instrumentation and applications of X-Ray Crystallography – X-ray diffraction.

#### Suggested Readings:

1. Boyer, R.F. (2000). Modern Experimental Biochemistry, 3rd Edition, Prentice Edition. Wiley-Inter science, USA.
2. Friefelder, D.M. (1983). Physical Biochemistry: Applications to Biochemistry Hall publishers, USA.
3. Hammes, G. G. (2007). Physical Chemistry for the Biological Sciences, 1st Techniques. 4th Edition, MKU, Madurai.
4. P.Asokan. (2003). Analytical Biochemistry. 2nd Edition. China publications.
5. P.Palanivelu and M.Salih. (2009). Analytical Biochemistry and Separation and Molecular Biology. 2nd Revised edition. W. H. Freeman, USA.
6. Pavia, D.L., Lampman, G.M., Kriz , G.S. (2000). Introduction to Spectroscopy. 3rd Revised edition. Brooks Cole Publishing Company, USA.

7. Upadhyay and Upadhyay Nath. (2009). Biophysical Chemistry, Principles and Techniques. Himalaya Publishing House.
8. Wilson and Walkar. (2000). A Biologist Guide to Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, UK.
9. Work and Work (2009). Laboratory Techniques in Biochemistry and Molecular Biology. Elsevier Science.

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### **Semester I**

### **Lab: Practicals Based on Theory Papers**

1. Safety measures in Biotechnology laboratory
2. Cleaning and sterilization of glass wares
3. Organization and working of optical microscopes: Dissecting and Compound Microscope
4. Principle and experimentation of tissue fixation, staining and micrometry
5. Study of the structure of Prokaryotic and Eukaryotic cell.
6. To prepare the permanent slide using given material like plant stem, root and leaf.
7. To make an inventory study the principle and applications of important instruments used in the Biotechnology laboratory.
8. Demonstrate the BLAST and FASTA
9. Preparation of polytene chromosomes from *Drosophila* salivary gland.
10. Study of mitochondria in Buccal Epithelium.
11. Demonstration of Beer-Lambert law.
12. Separation of amino acids by paper chromatography.
13. Separation of amino acids by thin layer chromatography.
14. Demonstrate the basic principle of centrifugation

### **B. Sc. Biotechnology**

## Semester II

### PAPER I- GENETICS

#### Unit -I

**History of Classical and Modern Genetics:** Concept and organization of Genetic material in Bacteria, Plant and Animal (*E.coli*, *Arabidopsis thaliana*, *Coenorhabditis elegans*). Structure, types, forms and functions of DNA and RNA.

#### Unit- II

**Concept of gene:** Allele, multiple alleles, pseudo alleles and complement test.

**Cytogenetics:** Human karyotype, Banding techniques, Human genetic diseases. Pedigree analysis.

#### Unit- III

**Mendelian principles and laws of inheritance:** Law of dominance, segregation, independent assortment, co-dominance and incomplete dominance and pleiotrophy. Back cross and Test cross.

#### Unit -IV

**Structural and numerical alterations of chromosome:** Deletion, Inversion, Duplication, Translocation. Ploidy and their genetic implications.

**Mutation:** (Spontaneous and Induced) Mutagens. Biochemical basis of mutation.

#### Suggested Readings:

1. Alberts. (2002). Molecular Biology of the Cell –. Garland publication, Fourth Edition.
2. Gardener E. J., Simmons M. J and Snustad, D. P. (2005). Principles of Genetics – John Wiley & Sons Publications.
3. Paul A. (2011). Text Book of Genetics- from Genes to Genomes- Books and Allied (P) Ltd, Kolkata. Third Edition.
4. Robertis *et. al.*, (1995) Eighth Edition. Cell and Molecular Biology –Waverly publication.
5. Strickberger, M. W., (1997). Fourth Edition. Genetics. Printice Hall.

## Semester-II

## PAPER II- BIOCHEMICAL METABOLISM

### Unit- I

**Bioenergetics:** Oxidation–reduction and energy and Carbon source utilization. Metabolism - Catabolism, anabolism, plant and animal metabolism and fermentation (alcoholic, lactic, propionic acid and butanol fermentation)

### Unit- II

**Cellular respiration:** definition, types and mechanism (Glycolysis and Krebs cycle) with detailed account and regulation.

Electron Transport Chain: Components of the chain, sites of ATP synthesis, chemo-osmotic theory of oxidative phosphorylation.

### Unit -III

**Lipid Metabolism:** Beta oxidations of saturated & unsaturated fatty acids. Ketone bodies, production during starving and diabetes Biosynthesis of fatty acids – Acetyl-CoA carboxylase reaction, Fatty acid synthase complex, biosynthesis of palmitate, energetics, Regulation of fatty acid biosynthesis. Biosynthesis of triacylglycerols, Biosynthesis of cholesterol, regulation.

### Unit -IV

**Metabolism of Nitrogenous Compounds:** 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, biologically active amines, Recycling of Purine and Pyrimidine nucleotides by salvage pathways. Lesch-Nyhan syndrome & Gout. Biosynthesis of purines and pyrimidines: Salvage pathways.

### Suggested Readings:

1. Van Holde K. E. And Johnson W. C. (2003). Principles of Physical Biochemistry”, Prentice Hall.
2. Stryer L. (2002) “Biochemistry”, W. H. Freeman and Company. New York
3. Lehninger A. L., Nelson D. L, and Cox M. M. (2017). “Principles of Biochemistry”, Worth Publishing. Wisconsin.
4. Mathews C. K., Van Holde K. E., and Ahern K. G. (2020) “Biochemistry”, 3<sup>rd</sup> Edition, Benjamin/Cummings Publishing Company.
5. Robert K., Murray M. D. Granner D. K., Mayes P. A. And Rodwell V. I, (2017) Harper’s Biochemistry”, McGraw-Hill/Appleton and Lange.
6. Segal. I. H. (2001) “Biochemical Calculations”, John Wiley and Sons.
7. Wilson K. and Goulding, K. H. (1993) “A Biologist’s Guide to Principles and Techniques of Practical Biochemistry”, Print India.
8. Work and Work (2009). Laboratory Techniques in Biochemistry and Molecular Biology. Elsevier Science.

### Semester-II

## PAPER III-DEVELOPMENTAL BIOLOGY

### Unit -I

**Gametogenesis:** Sex gametes, spermatogenesis and oogenesis in mammals, fertilization (activation of sperm and egg– interaction of sperm and egg – Sequence of events in sperm entry – Egg surface changes.) Post–fertilization changes.

### Unit –II

**Embryo development:** Cell cleavage, pattern of cleavage, blastulation and gastrulation, germ cell migration and axis specification in vertebrate. Fate of ectoderm, mesoderm and endoderm.

### Unit –III

**Plant development:** Development of Microsporangium and Megasporangium, Pollination, Embryo - Embryo sac development and double fertilization in plants, seed formation and germination. Organization of shoot and root apical meristem and their development.

### Unit -IV

**Unicellular models:** Sporulation in *Bacillus subtilis*, mating type switching in Yeast and aggregation and culmination in *Dictyostelium discoideum*.

### Suggested Readings:

1. Balinsky, B. I., (1981).. An Introduction to Embryology, 5 edition W. B. Saunders Co., Philadelphia
2. Berril, N. T., Karp, G., (1988). Development. Tata McGraw Hill Co., New York
3. Bruce M Carlson (2006). Patten's Foundation of Embryology,. Tata McGraw Hill Co.
4. Chattopadhyay, S. (2016). An Introduction to Developmental Biology, Books and Allied (P) Ltd, Kolkata. First Edition.
5. Gilbert, Scott's. (2014). Developmental biology. 10 edition Sinauer Association, Inc., Publishers.
6. Verma , P. S., Agarwal, V. K., and Tyagi., (1995). Chordate embryology, S. Chand & Co., New Delhi.

### Semester-II

### Lab- Practicals Based on Theory Papers

1. Mendel's law of genetics - Mono and Dihybrid crosses.
2. Rearing morphology of *Drosophila* (mutant eye identification)
3. Observation of Genetic model organisms (*Arabidopsis thaliana* and *Coenorhabditis elegans*)-  
By Permanent slides
4. Identification of Barr body (blood cells)
5. Estimation of blood glucose by glucose oxidase method.
6. To identify lipids in given sample by thin layered chromatography.
7. Principles of Colorimetry:
  - a) To study relation between absorbance and % transmission.
8. DNA isolation by spooling from cheek cells/ fruits.
9. Study the permanent slide embryonic developmental stages of frog (Egg, cleavage , morula, blastula and gastrula).
10. Study of permanent slides of plant part section (root, stem and leaf)
11. Dissection of flower to study its various parts.

### Semester-III



## **PAPER I- MOLECULAR BIOLOGY**

### **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-priming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

### **Unit -II**

DNA damage, repair and homologous recombination. DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Homologous recombination: models and mechanism.

### **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, rRNA and tRNA splicing.

### **Unit- IV**

**Regulation of gene expression and translation:** Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Posttranslational modifications of proteins.

### **Suggested Readings:**

1. Chouhan R. (2018). Molecular Biology and Biotechnology. Second edition. CBH Publication, Jaipur.
2. Glick, B.R and Pasternak J.J (1998). Molecular biotechnology, Principles and application of recombinant DNA, Washington D.C. ASM press.
3. Howe. C. (1995). Gene cloning and manipulation, Cambridge University Press, USA
4. Karp. G (2002). Cell & Molecular Biology, 3rd Edition, John Wiley & Sons; I
5. Lewin, B., (1997). Gene VII New York, Oxford University Press.
6. Rigby, P.W.J. (1987) Genetic Engineering Academic Press Inc. Florida, USA.
7. Sambrook et al (2000) Molecular cloning Volumes I, II & III, Cold spring Harbor Laboratory Press New York, USA
8. Walker J. M. and Ging old, E.B. (1983). Molecular Biology & Biotechnology (Indian Edition) Royal Society of Chemistry U.K.

### **Semester-III**

## PAPER II- GENERAL MICROBIOLOGY

### Unit - I

**Fundamentals, History and Evolution of Microbiology:** Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria.

**Microbial Diversity:** Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms e.g. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

### Unit- II

**Cultivation and Maintenance of microorganisms:** Different nutritional categories of microorganisms, different methods of isolation (Streak plate, pour plate spread plate method), Purification and preservation of Micro-organisms.

### Unit -III

**Microbial growth:** Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

**Microbial Metabolism:** Metabolic pathways, amphi-catabolic and biosynthetic pathways.

**Bacterial Reproduction:** Transformation, Transduction and Conjugation. Endospore and sporulation in bacteria.

### Unit -IV

**Control of Microorganisms:** By physical, chemical and chemotherapeutic Agents.

**Water Microbiology:** Bacterial pollutants of water, coliforms and non-coliforms. Sewage composition and its disposal.

**Food Microbiology:** Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food-borne infections and intoxications, preservation of various types of foods. Fermented Foods.

### Suggested Readings:

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12<sup>th</sup> edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5<sup>th</sup> edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.

### Semester-III

## Paper III- BIOPHYSICS AND BIOCHEMISTRY

### Unit -I

**Biophysics:** Introduction, Application and scopes.

**Bioenergetics:** Entropy, Biochemical equilibria, Dissociation and association constants, pH and buffers.

**Chemical bonding:** Ionic bond, covalent bond, hydrogen bond, peptide bond, Vander walls forces, Principles of thermodynamics.

**Interactions in biological systems:** Intra and intermolecular forces, Electrostatic and hydrogen bonds, Disulfide bridges, Hydrophobic and hydrophilic molecules and forces, Water and weak interactions, Debye-Huckel theory.

### Unit -II

**Amino acids:** Classification and properties due to intra, centre and side-chain and functions.

**Proteins:** Classification based on structure and functions, structural organization of proteins (Primary, secondary, tertiary and quaternary structure).

### Unit - III

**Carbohydrates:** Structure, properties and classification with examples, Carbohydrates as a source of Energy.

**Lipids:** Definition, Structure, properties and classification and functions.

### Unit- IV

**Enzymes:** Introduction, classification, enzyme kinetics, factors influencing enzyme activity, co-Enzymes and co-factors.

**Vitamins:** Introduction, types, water soluble and fat-soluble vitamins, Dietary source and functions.

**Hormones:** Introduction, Classification and their Functions (Steroid hormones, & Glucocorticoid hormones)

### Suggested Readings:

1. Narayanan, P (2000) Essentials of Biophysics, New Age Int. Pub. New Delhi.
2. Bliss, C. J. K. (1967) Statistics in Biology, Vol. I McGraw hill. New York.
3. Campbell R. C. (1974) Statistics for Biologists, Cambridge University, Press, Cambridge
4. Daniel (1999) Biostatistics (3rd edition) Panima Publishing, Computation
5. D. L. Lehninger (2017). Principles of Biochemistry (seventh edition) Macmillan Publishers
6. L. Upret. Stryer (2018). Biochemistry- Freeman International Edition.
7. Deb A. C. (2001). Fundamental of Biochemistry, Publisher: New Central Book Agency, Kolkata
8. Soni P. L. (2017) Textbook of Organic Chemistry (A Modern approach), Sultan Chand and Sons, Publishers.
9. Roger L.P. Adams, John T. Knowler and David P. Leader (1992). The Biochemistry of Nucleic acid-tenth Edition- Chapman and Hall Publications.

### Semester-III

### **Lab- Practicals Based on Theory Papers**

1. Introduction to basic laboratory instruments and equipments- Autoclave, Centrifuge, pH meter, Micropipettes, Digital balance, Homogenizer, Electrophoresis.
2. Demonstration of Bacterial growth curve.
3. Demonstration of TDP and TDT.
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Staining methods: simple staining, Gram staining, spore staining, negative staining, capsule staining, acid fast staining
6. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources (Air, water and soil)
7. Qualitative tests of Sugars, amino acids and lipids
8. Separation of amino acids by paper chromatography,

**B. Sc. Biotechnology**  
**Semester- IV**

**PAPER I- RECOMBINANT DNA TECHNOLOGY**

**Unit –I**

**Recombinant DNA Tool:** Enzymes used in genetic engineering: Exonucleases, endonucleases - S1 nuclease, restriction endonucleases; ligases, polymerases, reverse transcriptase, terminal deoxy nucleotidyl transferases, kinases, alkaline phosphatase. PCR technique and its application.

**Unit –II**

**Gene transfer Strategy and biology of cloning vectors:** Plasmids, lambda bacteriophage, cosmids, M13 bacteriophage, phagemid, *Agrobacterium tumefaciens*: binary and cointegration vector strategy. Cloning host: bacteria, fungi and Plant.

**Unit -III**

**Principles of recombinant DNA technology:** Construction of recombinant DNA, rDNA expression, genomic and complimentary DNA (c-DNA) libraries, detecting expression of foreign genes. Application of r-DNA technology: Medicine, industry, agriculture, livestock, improvement, environmental protection.

**Unit- IV**

**Transposons:** Definition, types and classification with mechanism. **Strategies for production of recombinant molecules:** Design the vector for the over expression of recombinant proteins, Selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, purification tags and Plasmid copy number.

**Suggested Readings:**

1. Brown T. A., (2008). Genomes. 3rd Edition. New York: Garland Publishing Co. New York: Garland Science.
2. Dubey. R. C. A (2018) Text Book of Biotechnology. S. Chand & Co Ltd, New Delhi.
3. Primrose, S. B. and Twyman, R. M., (2006). Principles of Gene Manipulation and Genomics - 7<sup>th</sup> Edition. Blackwell Publishing Company.
4. Satyanarayana, U. (2008). Biotechnology, Books and Allied (P) Ltd .Kolkata
5. Tvan, R. S. (1997). Recombinant gene expression protocols. Human Press Inc., Tokiwa
6. Work and Work (2009). Laboratory Techniques in Biochemistry and Molecular Biology. Elsevier Science.
7. Aneja. K. R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.

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Semester-IV**

**PAPER II- IMMUNOLOGY**

**Unit -I**

**Immune system, Organs and cells of immune system:** Historical perspective and terminologies, Innate immune response and its role in protection, Adaptive immune response - Humoral and cellular component of immune response, complement system, cytokines, interferons; Innate v/s Adaptive immune response, hematopoiesis, Cells and organs of the immune system (primary and secondary lymphoid organ).

**Unit -II**

**Antigen and Antibody structure and classes:** Characteristics of antigen, antigen and immunogen, Epitopes, Haptens, adjuvants, Structure, Function and classification of immunoglobulins. Antigen-antibody reactions, agglutination and precipitation, complement fixing test, ELISA, RIA and hybridoma technology.

**Unit -III**

**Antigen processing and Presentation:** Major Histocompatibility Complex, Structure, types and function of MHC, Immune cells: T-cell maturation, activation and differentiation, B-cell maturation, activation and differentiation.

**Unit -IV**

**Diseases related to immune system:** Immunodeficiency diseases (AIDS), autoimmune diseases: Organ specific disease (e.g. Myasthenia gravis), and systemic autoimmune diseases (e.g. Rheumatism), hypersensitive reactions, Transplantation immunology: Graft rejection, Evidences and mechanism, prevention of graft rejection and Immunosuppressive drugs.

**Suggested Readings:**

1. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne, (2006). "Immunology" 6th Edition, Freeman.
2. Janeway *et al.*, (2012) "Immunobiology" 4th Edition, Current Biology Publications.
3. Paul, (2012) "Fundamental of Immunology, 4th edition", Lippencott Raven
4. Roitt I. (2017). Essential Immunology. Wiley Blackwell, London U.K.
5. S.C. Rastogi (1996). "Immunodiagnosics" New Age, Rastogi Publication. Meerut,
6. Pelczar, M. J., Chan, E. C. S. Kreig and NR (2001). "Microbiology" McGraw Hill Education; 5 edition. Noida, Uttar Pradesh, India
7. Satyanarayana, U. (2008). Biotechnology, Books and Allied (p) Ltd, Kolkata

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## Semester-IV

### PAPER III-ENVIRONMENTAL AND AGRI BIOTECHNOLOGY

#### Unit -I

**Introduction to environmental biotechnology:** Importance of biotechnology in environmental protection. Biodiversity, ecosystem and population diversity. Environmental hazards. Global environment issues: Ozone depletion, greenhouse effect, acid rain, sea level rise, global warming.

#### Unit -II

**Xenobiotics. Biomass utilization:** Bioremediation, bioleaching, biodegradation, biostimulation, bioaccumulation, bioaugmentation and biomagnifications. Sewage water treatment and soil waste management.

#### Unit –III

**Biotechnological methods of pollution detection:** Bioassay, biosensors and biological indicators. Assessment of water and wastewater quality: COD, DO and BOD. Indication of faecal pollution and MPN and MF technique for coliform bacteria.

#### Unit- IV

Introduction and applications of GM Crops: (Bt- Cotton; and golden rice), Global area of biotech crops. Introduction to organic farming, green manure production, soil fertility and management. Role of earthworms in soil structure, and productivity, Cost-benefit analysis of vermi-composting. *In-vitro* propagation and Conservation of forest and medicinal plants

#### Suggested Readings:

1. Chatterji A. K. (2011). Environmental Biotechnology. Third edition. PHI Learning Pvt Ltd. New Delhi.
2. Singh. B. D. (2018). Text book of Biotechnology.
3. Dubey. R. C. (1993). A Text Book of Biotechnology. S. Chand & Co Ltd, New Delhi.
4. Das H. K. (2004). Text book of Biotechnology .Wiley Publication..Wiley India Pvt. Limited.
5. Casida. L.E. (1968). Industrial Bitechology. New Age International Pub. (P) Limited.
6. Satya and Das. (2010). Essential Biotechnology PeePee Publishers and Distributors Pvt. Limited, India
7. Satyanarayana U. (2008). Biotechnology, Books and Allied (p)Ltd Kolkata

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**IV Semester**

**Lab- Practicals based on theory Papers**

1. Isolation of plasmid DNA and size analysis
2. Isolation of chromosomal DNA from bacterial cells.
3. Transformations of recombinants in *E.coli* (Preparation of competent cells).
4. Selection & screening of r-DNA antibiotic resistance, blue – white colony.
5. Study different organs of immune system.
6. Determine the blood group types and Rh factor of a blood sample.
7. Study the immunodiffusion technique by Single Radial Immunodiffusion.
8. Study the reaction pattern of an antigen with a set of antibodies by Ouchterlony Double Diffusion method.
9. To learn the technique of Immunoelectrophoresis.
10. To learn the technique of Dot ELISA for the detection of an antigen.
11. Study of Soil Microbes
12. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
13. MPN test for coliform bacteria in water.
14. Water analysis: estimation BOD.

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## Semester-V

### PAPER I- ANIMAL BIOTECHNOLOGY

#### Unit-I

**Introduction to animal biotechnology:** Definition, history, importance and scope of animal biotechnology. Applications of animal biotechnology. Various techniques of animal cell and tissue culture, culture media, growth factors and laboratory facilities.

#### Unit- II

**Gene manipulation of animals:** Animal viral genome, animal cloning vectors. Gene transfer methods in eukaryotic systems - retroviral vector method, DNA microinjection method, engineered embryonic stem cell method. Selection of clones by using different methods.

#### Unit- III

**Characteristics of cells in culture:** Contact inhibition, anchorage dependence, cell-cell communication. Primary culture, immortal cells, cell lines. Maintenance of cell lines in the laboratory. Tissue engineering.

#### Unit -IV

**Transgenic animals:** Introduction, method and application of transgenic animals. Production of transgenic mice, rabbits, fish, sheep. Transgenic animals as bioreactors- recombinant proteins produced by animal bioreactors. Transgenic animals as models of human diseases. Xenotransplantation. Embryo transfer technologies in cattle and its application.

#### Essential Readings:

1. Dubey R. C., (2018). A Text Book of Biotechnology. S. Chand & Co Ltd, New Delhi.
2. Gangal S., (2010). Animal Tissue culture. Second edition. University Press (India) PvtLtd. Hyderabad.
3. Ranga, M. (2006). Animal Biotechnology, Studam publishers.
4. Sasidhara, R. (2006). Animal Biotechnology, MJP Publishers.
5. Satya and Das (2005). Essential Biotechnology for students. Pee Pee Publishers. New Delhi
6. Shivangi Mathur (2012). Animal cell and tissue culture. Agrobios Publisher, India
7. Sverdrup H.U.,(1942). Oceans & their Physics, Chemistry & Biology –Johns & R. H. Fleming, Prentice Hall Inc.
8. Satyanarayana, U. (2008). Biotechnology, Books and Allied (p) Ltd, Kolkata.

## Semester -V

## PAPER II- PLANT BIOTECHNOLOGY

### Unit -I

**Introduction to Plant Biotechnology:** Definition. History and development of plant biotechnology. Modern trends in plant biotechnology. Various techniques of plant cell and tissue culture, culture media, growth factors and laboratory facilities.

### Unit –II

**Callus and suspension culture:** initiation and maintenance and signal cell clone. Tissue and micropropagation, callus formation, regeneration, production of haploids, protoplast culture and somatic hybridization.

### Unit- III

**Gene transfer in plants using Agrobacterium:** Ti plasmids, transfer of T-DNA, Direct gene transfer in plants: Physical (Particle gun delivery, electroporation, microinjection, macroinjection, electroinjection, fiber mediated DNA delivery, Laser induced DNA uptake, Sonication) and Chemical methods of gene transfer (Poly ethylene glycol, Poly vinyl alcohol, Calcium phosphate). Bt. Cotton.

### Unit -IV

Production of transgenic plants and their applications: Improving agronomic traits – genetic manipulation of plants for salt resistance, herbicide resistance, fungi and virus resistance, insect and other pest resistance. Modification of production traits - delayed fruit ripening, improving seed storage proteins.

### Suggested Readings:

1. Chawla, (2003). Introduction to Plant Biotechnology (2 edn) Oxford and IBH Publishers
2. Chrispeel M.J, Sadava D.E, (1994). Revised edition, Plants, Genes and Agriculture, Jones and Barlett Publication, Boston.
3. R. Keshava Chandran and K.V. Peter. (2008).Plant Biotechnology. First edition. University Press (India) Pvt. Ltd, Hyderabad.
4. R.C. Dubey, (2006). A Text Book of Biotechnology. S.Chand & Co Ltd, New Delhi.
5. Ramawat K.G , (2003). Plant Biotechnology, S. Chand and Co, Edition 2
6. Satyanarayana . U, (2008). Biotechnology, Books and Allied (p) Ltd.
7. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.

### Semester -V

## **Paper III- Biostatistics and Computer Application**

### **Unit –I**

**Introduction to Basic Statistics:** Types of data, primary and secondary, Collection and Classification of Data, tabulation, Types of Numerical Data, Frequency Distribution, Population and Sampling, Representation of Data. Line chart, Bar diagram, Pie chart, Histograms, Frequency Polygons.

### **Unit- II**

**Measures of Central Tendencies:** Mean, median, mode, Measures of Dispersion, Standard Deviation, Coefficient of Variation, Probability. Concept of t-test hypothesis. Application of t-test statistics to biological problems/ data.

### **Unit- III**

**Basic Computers Introduction:** Characteristics of Computers, Classification of Computers, Binary Number System .Computer Software, Computer languages, Concept of assembler, interpreter, linker and compiler. Uses of MS DOS commands: Basic Concept of internal & external Commands, File commands, copying, erasing, renaming and displaying files.

### **Unit -IV**

**Microsoft Word:** Concept of the toolbar, Character, paragraph & document formatting, drawing tool- bar, Header footer, document editing, page setup, short cut keys, text and graphics.

**Data Communications and Computer Networks:** Basic Elements of a Communication System, **The Internet:** Brief History, Its basic Services, WWW & browsers, internet search engines, introduction to internet. Microsoft power point: slide presentation. Slide layout & design, custom animation and slide transition.

### **Suggested Readings:**

1. Anita Goel, (2010). Fundamentals of Computers; Forthcoming title in Pearson-Education.1st edition
2. Campbell R C (1989). Statistics for Biologist, Cambridge University Press,.
3. Khan (1999). Fundamentals of Biostatistics, , Publishing Corporation,
4. Swardlaw A. C. (1985). Practical statistics for Experimental Biologists, , John Wiley and Sons Inc.,
5. V Rajaraman,(2014). Fundamentals of Computers, Fourth Edition, PHI.
6. W W. Daniel, (1995). Biostatistics: A Foundation for Analysis in Health Sciences, (6th edition), John Wiley and Sons Inc.,

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Semester-V**

**Lab: Practicals Based on Theory Papers**

1. Preparation of animal cell culture media.
2. Preparation & sterilization of balanced salt solution and DBSS.
3. Disaggregation of tissues by enzymatic and mechanical method.
4. Viability test and cell counting.
5. Isolation of genetic DNA from animal and plant tissue.
6. Preparation of MS media.
7. Establishment of shoot tip culture using MS medium
8. Isolation of protoplasts using enzymatic method.
9. Establishment and maintenance of somatic embryogenesis (Demo).
10. Preparation of synthetic seeds (Entrapment method).
11. Extraction & Separation of Chlorophyll A & B using Column Chromatography.
12. Representation of Statistical data by
  - a. Histograms , b) Pie diagrams
13. Determination of Statistical averages/ central tendencies.
  - a) Arithmetic mean, b) Median, c) Mode
14. Determination of measures of Dispersion a) Mean deviation, b) Standard deviation and coefficient of variation, c) Quartile deviation.
15. Applications of computers in biology using MS-Office.
  - A] MS-Word B] Excel C] PowerPoint
16. Creating an e-mail account, sending and receiving mails. Search engines, websites, browsing and Downloading. Searching research articles in Medline and Pubmed.

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## Semester- VI

### PAPER I- MEDICAL BIOTECHNOLOGY

#### Unit -I

**Characteristics of Infectious diseases:** Herd Immunity. Disease cycle (sources of disease, reservoir and carrier). Transmission of Pathogens (Air born, contact transmission and vector transmission). General account of fungal disease- Mycosis, Subcutaneous and deep.

#### Unit -II

**Bacterial and Viral Diseases-** Epidemiology, Pathogenicity, laboratory diagnosis, prevention and control of the following disease. Anthrax, Tuberculosis, Typhoid, Whooping cough, tetanus, leprosy AIDS, Chickenpox and SARS. COVID 19.

#### Unit -III

**Mitochondrial diseases:** LHON, MERRF . Cancer – types, molecular basis of colon cancer and breast cancer. Gene therapy – ex-vivo and *in-vivo* gene therapy; somatic and germline gene therapy; Strategies of gene therapy: gene augmentation – ADA deficiency; Prodrug therapy/ suicide gene-glioma

#### Unit -IV

**Stem cells:** Potency definitions; embryonic and adult stem cells; applications of stem cells – cell based therapies and regenerative medicine. Encapsulation technology and therapeutics-Diabetes DNA based vaccines, subunit vaccines – Herpes Simplex Virus, Recombinant attenuated vaccines– Cholera

#### Suggested Readings:

1. Jones & Bartlett, (1993). Human Genetics Molecular Evolution, Mc Conkey, Boston
2. Strachan, T; Read, Andrew P, (1939). Human Molecular Genetics, Tom Strachen and A P Read, Bios Scientific Publishers, New York.
3. Jack J. Pasternak (2005). Introduction to Human Molecular Genetics – J.J Pasternak, John Wiley Publishers, Wiley.
4. Pratibha Nallari, V. Venugopal Rao (2010). Medical Biotechnology. Publisher Oxford Press
5. Glick and Pasternak (2010). Molecular Biotechnology. ASM Press, USA
6. Rimoin D. et. al., (2013). Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery
7. Work and Work (2009). Laboratory Techniques in Biochemistry and Molecular Biology. Elsevier Science.

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Semester-VI**

**PAPER II- INDUSTRIAL BIOTECHNOLOGY**

**Unit- I**

**Industrial Practices:** Culture and media for fermentation, criteria for selection of industrial organisms, screening from natural habitat and strain improvement. Inoculum development for bacteria, yeast and fungi. Raw material: Molasses Hydrocarbons, antifoams and agriculture waste. Sterilization: Bioreactor, media, air exhaust and waste.

**Unit -II**

**Fermentative production of Microbial biomass:** Culture medium, process and recovery of fermentative products (Edible mushroom, Bakers yeast and SCP. **Fermentative production of Primary metabolites:** Citric acid, Alcohol, acetone- butanol and vitamin B12.

**Unit –III**

**Fermentative production of Primary metabolites:** Secondary metabolism and its control. Product survey. Overproduction of Antibiotics by Strain improvement program, Polyketide biosynthesis pathway. Application of biotechnology in pharmaceutical.

**Unit- IV**

**Quality control and quality assurance in food and pharmaceutical industries,** concept of good manufacturing practices in pharmaceutical industry, role of biotechnology to improve food quality food production and assessment of microbiological quality of various foods Fermentation, cultures of microorganisms, solid or semisolid cultures, batch culture, continuous culture, fed batch culture.

**Suggested Readings:**

1. Patel, A. H. (2005). Industrial Microbiology –MacMillan Publishers
2. Alexendar N. Glazer & Hiroshi Nikaido Microbial Biotechnology (Fundamental of Applied Microbiology)
3. El –Mans, E.M.T., and Bryce, C.F.A. (2002) Fermentation Microbiology and Biotechnology. Taylor.
4. Huffnagle GB & Wernick S. (2007). The Probiotics Revolution: The Definitive Guide to Safe, Natural Health. Bantam Books.
5. Kun LY. (2006). Microbial Biotechnology. World Scientific.
6. Ponmurugan, P., Ramasubramanian, N., and Fredimosos. (2012). Experimental Procedures in Bioprocess technology and Downstream processing. Anjana Book House, Chennai.
7. Primrose SB. (2001). Molecular Biotechnology. Panima.
8. Satyanarayana. U, 2008. Biotechnology, Books and Allied (p) Ltd. Kolkata.

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## Semester-VI

### PAPER III- BIOSAFETY, BIOETHICS AND IPR IN BIOTECHNOLOGY

#### Unit -I

The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national and international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, regulatory bodies in biotechnology, biosafety committee.

#### Unit- II

Ethical issues, moral values on experimental animals, ethical implications of biotechnological products and techniques. Intellectual property rights, WTO, TRIPS, International conventions, patents and copy rights, patent claims, methods of applications of patents.

#### Unit- III

**Entrepreneurship:** Starting an enterprise, stage in setting up an enterprise, business idea, Setting a business plan. Management team, Marketing, market research, market strategies (4p strategies) financial planning, Balance sheet, profit and loose statement.

#### Unit -IV

Legal implications, biodiversity and farmers right. Beneficial application and development of research focus to the need of the poor, identification of directions for yield effect in agriculture, aquaculture etc.

#### Suggested Readings:

1. Aneja. K.R. (2007). Laboratory Manual of Microbiology and Biotechnology, New Age International Publisher.
2. Goel And Parashar (2013). IPR, Biosafety and Bioethics. Pearson Education India
3. Nambisan, P. (2017). An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology, Academic Press.
4. Joshi R. (2007). Biosafety and Bioethics. Isha Book Publisher.
5. Sateesh M.K. (2010). Bioethics and Biosafety, I. K. International Pvt Ltd.
6. Sree Krishna V. (2007). Bioethics and Biosafety in Biotechnology, New Age international publishers.

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Semester-VI**

**Lab- Practicals based on theory papers**

1. Sauerkraut production.
2. Demonstration of typhoid test.
3. Production of grapes wine.
4. Production of ginger wine.
5. Strain improvement.
6. Production of citric acid using *Aspergillus* in batch culture
7. Effect of pH on citric acid production
8. Effect of temperature on citric acid production
9. Proxy filing of Indian Product patent
10. Planning of establishing a hypothetical biotechnology industry in India
11. A case study on clinical trials of drugs in India with emphasis on ethical issues.