SRI VENKATESWARA UNIVERSITY: TIRUPATI

S.V.U. COLLEGE OF SCIENCES

DEPARTMENT OF BIOTECHNOLOGY

Course

M.Sc. BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS)

Eligibility and Credit Requirement for admission in M. Sc. Biotechnology Programme

i. A 3 year B.Sc. Degree with either Biotechnology as Major or Minor discipline with minimum of 120 credits for 2 years M. Sc. Biotechnology Programme.

ii. A student with B.Sc. Degree with either Biotechnology as Major or Minor discipline with 4 year Honours / Honours with Research is eligible for lateral entry into 2nd year M. Sc. Biotechnology Programme (i.e., III Semester) of the M. Sc. Biotechnology Programme, for whom 20% of supernumerary seats shall be sanctioned in 2nd year (i.e., III Semester).

iii. While awarding **M. Sc. Biotechnology** degree for one year **M. Sc. Biotechnology** with lateral entry the Provisional Certificate and the **M. Sc. Biotechnology** Degree shall clearly mention that one year **M. Sc. Biotechnology** degree is awarded after completing 4 year UG Honours / Honours Research Programme.

4. Multiple Entry and Exit Options:

i. If the Student exits after successful completion of all courses of 1st year **M. Sc. Biotechnology**
Programme, in a single attempt, such students may be awarded **M. Sc. Biotechnology Diploma**.

ii. Such students may be permitted to take re-admission and continue the **M. Sc. Biotechnology** programme with in a period of **Three years** from the date of exit.

SRI VENKATESWARA UNIVERSITY

SVU COLLEGE OF SCIENCES, TIRUPATI

M.Sc. Biotechnology Programme (CBCS)NEP-2020 NHEQPas per guidelines of APSCHE

(With effect from the batch admitted in the academic year 2024-25)

SEMESTER - I								
S. No	**Course**	**Code**	**Title of the Course**	**H/W**	**C**	**SEE**	**IA**	**Total Marks**
1	CC	BTE 101	Core course – 1 Cell and Cancer Biology	4	4	70	30	100
2		BTE 102	Core Course – 2(A) Biomolecules, Enzymology and Metabolism	4	3	50	25	75
			Core Course – 2(B) Enzymology and Intermediary Metabolism					
3		BTE 103	Core Course – 3(A) Microbiology and Diseases	4	3	50	25	75
			Core Course – 3(B) General Microbiology					
4	*P	BTE 104	Practical I (related to CC 2 & 3)	6	2	35	15	50
5	SOC	BTE 105	Skill Oriented Course – 1(A) Biophysical and Biochemical Techniques	4	3	50	25	75
			Skill Oriented Course – 1(B) Tools in Biotechnology					
6		BTE 106	Skill Oriented Course – 2(A) Biostatistics and Bioinformatics	4	3	50	25	75
			Skill Oriented Course – 2(B) Biometrics and Computational Biology					
7	*P	BTE 107	Practical II (related to SOC 1 & 2)	6	2	35	15	50
			Total	**36**	**20**	**340**	**160**	**500**
8	Audit Course	BTE 108	Indian Knowledge Systems - 1	4	0	0	100	0

SEMESTER – II								
S. No	**Course**	**Code**	**Title of the Course**	**H/W**	**C**	**SEE**	**IA**	**Total Marks**
1	CC	BTE 201	Core course – 4 Molecular Biology	4	4	70	30	100
2		BTE 202	Core Course – 5(A) Genetic Engineering Core Course – 5(B) Recombinant proteins and Drugs	4	3	50	25	75
3		BTE 203	Core Course – 6(A) Advances in Bioprocess Engineering Core Course – 6(B) Nanobiotechnology	4	3	50	25	75
4	P	BTE 204	Practical III (related to CC 5 & 6)	6	2	35	15	50
5	SOC	BTE 205	Skill Oriented Course – 3(A) Basic and Applied Immunology Skill Oriented Course – 3(B) Molecular diagnostics	4	3	50	25	75
6		BTE 206	Skill Oriented Course – 4(A) Plant Tissue Culture Skill Oriented Course – 4(B) Animal Handling and Preclinical Sciences	4	3	50	25	75
7	P	BTE 207	Practical IV (related to SOC 3 & 4)	6	2	35	15	50
8	OOTC	BTE 208	Open Online Transdisciplinary Course – 1	-	2	-	100	100
			Total	**36**	**22**	**340**	**260**	**600**
9	Audit Course	BTE 209	Indian Knowledge Systems - 2	4	0	0	100	0

S. No	**Course**	**Code**	**Title of the Course**	**H/W**	**C**	**SEE**	**IA**	**Total Marks**

1	CC	BTE 301	Core course – 7 Animal Biotechnology	4	4	70	30	100
2		BTE 302	Core Course – 8(A) Plant and Agriculture Biotechnology	4	3	50	25	75
			Core Course – 8(B) Stem Cell Technology and Regenerative Medicine					
3		BTE 303	Core Course – 9(A) Environmental Biotechnology	4	3	50	25	75
			Core Course – 9(B) Solid Waste Management					
4	P	BTE 304	Practical V (related to CC 8 & 9)	6	2	35	15	50
5	SOC	BTE 305	Skill Oriented Course – 5(A) Food and Industrial Biotechnology	4	3	50	25	75
			Skill Oriented Course – 5(B) Medical Biotechnology and Vaccinology					
6		BTE 306	Skill Oriented Course – 6(A) IPR, Biosafety Bioethics & Bioentrepreneurship	4	3	40	25	75
			Skill Oriented Course – 6(B) Basics of Organic Farming and Bioentrpreneurship					
7	P	BTE 307	Practical VI (related to SOC 5 & 6)	6	2	35	15	50
8	OOTC	BTE 308	Open Online Transdisciplinary Course – 2	-	2	-	100	100
*	Seminar/tutorials/ remedial classes and Quiz as part of internal assessment			4	-	-	-	-
			Total	**36**	**22**	**340**	**260**	**600**

SEMESTER-III

SEMESTER – IV

S. No	Course	Code	Title of the Course	H/W	C	SEE	IA	Total Marks
1	OOSDC	BTE 401	Open Online Skill Development Courses	-	8	-	200	200
2	PW	BTE 402	Project Work - Orientation Classes	24	12	300	0	300
*	Conducting classes for competitive exams, communication skills , UGC/CSIR and NET/ SLET examinations			12	-	-	-	-
			Total	**36**	**20**	**300**	**200**	**500**
Total Semesters				**144**	**84**	**1320**	**880**	**2200**

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE-101
Core - 1 : Cell and Cancer Biology

Semester : I

Course Objectives:

1. The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules.
2. Understanding of various biological processes becomes deeper and inclusive.Further, the course is to build knowledge of basic principles of genetic inheritance at the molecular, cellular and organism levels and genetic interactions.
3. This course helps us to learn the mechanism of cancer biology and
4. Cancer screening and therapy

Course Outcomes:
After the successful completion of the course, students will be able to:

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the Ultra structure of cell and DNA-histone interactions	K1
CO2	Know about Cellular communication and Cell-cell signaling	K3
CO3	Discuss about cancer biology	K5
CO4	Understand the fundamentals of cancer screening and therapy	K6

UNIT – I
Ultra structure of cell and DNA-histone interactions: Ultra structure of cell and Plasma membrane, transport across plasma membrane - cellular energy translocation, active transport, Na+ K+, ATPase pump. Eukaryotic chromosome and organization, DNA-histone interactions - Hetero/Eu chromatin - Histone-H1-significance in regulation of expression. Epigenetics - DNA methylation, acetylation, Histone deacetylases (HDAC).

UNIT – II
Cellular communication and Cell-cell signaling Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation

UNIT – III
Cancer biology: Different types of cancers - types of solid tumors (brain, breast, gastric, colon, lung etc.) and liquid tumors (blood cancers - leukemia, lymphoma), Tumor micro environment - cancer cells, fibroblasts, tumor associated macrophages (TAMS - M1, M2). Immune cells (T, B, Nk and dendritic - cells), extra cellular metrics. Tumor progressive signaling pathways, Tumor suppressive signaling pathways. Cell proliferation, Cell cycle, migration, invasion, angiogenesis, apoptosis, autophagy, senescence and necrosis

UNIT –IV

Cancer screening and therapy - scanning methods (MRI, CT, PET, gastro and colonoscopy), Biochemical - immunohisto and cyto chemistry- blood, semen, Pap smear), molecular tools - PCR. Cancer therapy: chemotherapy, radiotherapy, immunotherapy, targeted therapy, Gene therapy and combination therapies, precision medicine.

Reference Books

1. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson. Molecular Biology of the Cell, Garland publishing, Inc. New York, 1994.
2. E.D.P.De Robertis and E.M.F. De Robertis, Cell and Molecular biology, Jr-8th edition, B.I. Publications Pvt.Ltd.2005.
3. Philip Sheeler and Donald E. Bianchi, Cell and Molecular biology, IIIrd Edition..
4. J. Darnell, H. Lodish and D. Baltimore, Molecular Cell Biology, Scientific American Books, Inc., USA, 1998.
5. Benjamin Lewin, Gene VII, Oxford University Press, U.K., 2000
6. William H Elliott and D C.Elliolt , Biochemistry & Molecular biology, Oxford University press. 2000
7. Watson, Baker, Bell, Gann, Levine, Losick., Molecular biology of Gene,5thedition,Pe4arson Education,2004.
8. SF Gilbert, Developmental Biology, Sinamer Associates Inc, 2004.
9. Gerald Karp, Cell and Molecular Biology, 4th edition, John Wiley & sons, Inc.2004.
10. Thomas D. Pollard, William C. Earnshaw, Cell Biology (Revised Reprint) Saunders, 2004.
11. A text book of Zoology. B.Sc. Second Year by P.A.Kondala Rao, V.Srinivasa Sarma, C.Gopal.
12. Sambamurthy, AVSS. Genetics. 1999. Narosa publ. New Delhi.
13. D.L.G. Hartl , “Basic Genetics” Jones Publ., 1991.
14. M. P. Arora, “Fundamental of Genetics”, Himalaya Publishing House, Mumbai, 2004.
15. C.B. Powar, “Genetics”, Volume 1, Himalaya Publishing House, Mumbai, 2003.
16. Benjamin. A Genetics. A Conceptual Approach Pierce.2006. 2nd Edn. Freeman
17. Theory & problems in Genetics by Stansfield, Schaum out line series McGrahill-2000

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE-102
Core – 2(A) : Biomolecules, Enzymology and Metabolism
Semester : I

Course Objectives:

1.The objective of this course is to build knowledge of Chemistry of carbohydrates
2.To provide an advanced understanding of the Chemistry of Aminoacids core principles and topics of Biochemistry and their experimental basis, with specific emphasis on different metabolic pathways.
3.The course shall make the students aware of Enzyme nomenclature and classification
4. To study about Lipids & Nucleic acid and Genetic errors of metabolism

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the Chemistry of carbohydrates and Metabolism .	K3
CO2	Study about the Chemistry of amino acids and metabolism	K4
CO3	Understand the nomenclature, classification and general properties of Enzymes, Michaelis-Menten equation and Lineweaver-burk plot.	K5
CO4	Discuss about lipids types, classification and their functions.Demonstrate the structure, types and functions of nucleic acids and their metabolism	K6

UNIT – I

Chemistry of carbohydrates – Definition and classification of carbohydrates, Carbohydrate Metabolism: Glycolysis, TCA cycle, Electron Transport chain, Oxidative phosphorylation, Gluconeogenesis, Hexose Monophosphate pathway (HMP shunt).

UNIT – II

Chemistry of Aminoacids- structure and classification of amino acids, Essential and nonessential Aminoacids. Outline structure of proteins: primary, secondary, tertiary and quaternary structures of protein, Ramachandran plot. Amino acid metabolism - Urea cycle. Catabolism of carbon skeleton of amino acids- glycogenic and ketogenic amino acids.

UNIT – III

Enzyme nomenclature and classification. Factors affecting enzyme activity- Enzyme specificity, Co enzymes, Michaelis-Menten equation - Lineweaver-burk plot. Enzyme inhibition. Applied Enzymology-Immobilized enzymes and applications.

UNIT – IV

Lipids & Nucleic acid - Classification- structure and biological functions - Fatty acids- nomenclature, Phospholipids- Triacylglycerols- Glycolipids- Cholesterol. Catabolism of fatty acids (β- oxidation). Structure and functions of, heterocyclic molecules, porphyrins and vitamins. Nucleic acids: Nucleic acid as genetic material, DNA- structure, properties and functions, RNA- structure and functions. Genetic errors of metabolism- Representative examples - Phenylketonuria, Sickle cell anemia, Thalassemia.

REFERENCE

1. Lehninger AL, Nelson DL and Cox MM, Principles of Biochemistry.Mac Millan Worth Publishers Inc. (CBS Pub. & Distributors, New Delhi) 2002.
2. Martin DW, Jr., Mayer, PA and Rodwell, VW. Harper's Review of Biochemistry 25th Edition, Maruzen Asian Ed: Lange Med. Pub. 2002.
3. Stryer L. Biochemistry, Freeman & Co. 2002.
4. Nelson.D.L, Cox. M. M. Lehninger's Principle of Biochemistry. 4th ed. Freeman. 2004.
5. Murray. R.K, Granner.D.K, Mayes. P. A, Rodwell. V. W. Harper's Biochemistry.27thMcGraw Hill, 2006.
6. Donald Voet, Judith G.Voet and charlotte W.Pratt., Fundamentals of Biochemistry, John Wiley & sons, Inc, 2006.
7. Sawhney & Randhir Singh., Introductory Practical Biochemistry, Narrosa Publishing House PVT LTD, 2005.
8. Nigam. 2007. Lab Manual of Biochemistry
9. Zubay. Biochemistry. 4th ed. William C. Brown Publication, 1998.10.
10. West and Todd., Basic Biochemistry, Oxford and IBH publishing Co. Pvt. Ltd, 2000.

Practical Course books

1. Practical Biochemistry – H. Varley.
2. Methods in Enzymology S.P. Colowick& N.O. Kapalan, Academic Press.
3. Methods in Biochemical analysis.
4. Oser: Hank's Physiological Chemistry.
5. Food analysis – Woodman

Practicals :

1. Quantitative tests for Carbohydrates.
   a. Estimation of glucose by Benedict's method.
   b. Estimation of reducing sugars by DNSA (dinitrosalicylic acid) method.
2. Quantitative tests for Proteins
   a.Estimation of protein by Biuret method.
   b.Estimation of protein by Lowry's method.
3. Assay of urease from Horse-gram.
4. Assay of acid phosphatase from Potato.
5. SDH Enzyme activities.
   a. Determination of optimal conditions for SDH activity
   b. Determination of effect of substrate concentration on SDH activity.
   c. Determination of effect of enzyme concentration on SDH activity.
   d. Determination of effect of temperature on SDH activity.
   e. Determination of effect of pH on SDH activity.
6. Estimation of activity of SGOT.
7. Estimation of activity of SGPT.
8. Estimation of cholesterol by Zak's method.

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE-102
Core - 2(B) : Enzymology and Intermediary Metabolism
Semester : I

Course Objectives:

1. To provide knowledge on classification, nomenclature, isolation, and purification of enzymes
2. To educate them to understand the importance of energy relationships and its transformation in living organisms
3. To explain the metabolic pathways involved in biosynthesis of macromolecules
4. To impart awareness on the types and symptoms of metabolic diseases and their inheritance.

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand Classification and determination of enzymes and their significance	K3
CO2	Understand the bioenergetics and energy transformation cycles in biological systems	K4
CO3	Know the metabolism and regulation of fatty acids	K5
CO4	Understand the metabolism of amino acids, nucleic ancids and inborn errors	K6

UNIT-I

Classification of enzymes and their significance - Isolation and purification of enzymes - assay of enzyme activity. Determination of KM, Vmax and K cat. Enzyme inhibition - competitive, non-competitive, uncompetitive allosteric regulation and irreversible enzyme inhibition. Enzyme action, Active site determination. Isoenzymes - detection, characterization and significance. Ribozymes, Abzymes, multicomplex and multifunctional enzymes.

UNIT-II

Bioenergetics - Free energy change in biological transformations, thermodynamic principles in biology, Redox potential, high energy compounds. Glycolysis - Biochemical steps involved in glycolytic pathway, TCA cycle and their Regulatory mechanisms. Glyoxalatye cycle, gluconeogenesis, HMP shunt, interconversion of hexoses and pentoses, amylogenesis, glycogen metabolism. Brief account of enzymes and co-enzymes involved in biological oxidations, Organization of respiratory electron transport system. Mechanism of oxidative phosphorylation. Biological energy transducers, Chemiosmotic regeneration of ATP.

UNIT-III

Biosynthesis, degradation and regulation of saturated fatty acids. Degradation of lipids from membranes, Oxidation of unsaturated fatty acids and synthesis of UFA by enzymatic (synthesis of prostaglandin and leukotrines) and non-enzymatic (free radicals and lipid peroxidations) mechanisms. Cholesterol and ketone bodies. Metabolism and regulation. Metabolism of triglycerides, phospholipids, glycolipids.

UNIT-IV

Metabolism of amino acids and proteins - Hydrolysis of proteins, proteases, Biosynthesis of essential amino acids and their catabolism (deamination, decarboxylation, and transamination), Coordinated control of metabolism, Formation of ammonia and urea. Nitrogen fixation by bacteria. Metabolism of purines and pyrimidines, Biosynthesis and catabolism of Nucleosides and nucleotides, role of DNases and RNases on nucleic acids. Outlines of biosynthesis of porphyrins (Chlorophyll and Haeme). Inborn errors in metabolism - Phenylketonuria, Alkaptonuria, Sickle cell anaemia, Fructosaemia, galactosuria, Gaucher's and Krabbe's disease.

Reference Books

1. Principles of Biochemistry: White. A, Handler, P., and Smith.
2. Biochemistry, Lehninger A.L.
3. Biochemistry, David E. Metzler.
4. Biochemistry, Lubert Stryer.
5. Review of Physiological Chemistry: Harold A. Harper.
6. Outlines of Biochemistry, Conn and Stummf.
7. Text of Biochemistry, West and Todd.
8. Metabolic Pathways - Greenberg,
9. Biochemistry, 2na Edition, G. Zubay (1988). Practical Course
10. Practical Biochemistry - H. Varley.
11. Methods in Enzymology S.P. Colowick & N.O. Kapalan, Academic Press.
12. Methods in Biochemical analysis.

Practicals:

1. Assay of amylase from Saliva.
2. Assay of urease from Horse-gram.
3. Assay of acid phosphatase from Potato.
4. Determination of optimal conditions for SDH activity.
5. Determination of effect of substrate concentration on SDH activity.
6. Determination of effect of enzyme concentration on SDH activity.
7. Determination of effect of temperature on SDH activity.
8. Determination of effect of P^H on SDH activity.
9. Estimation of activity of SGOT.
10. Estimation of activity of SGPT.

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE-103
Core 3(A) : Microbiology and Diseases
Semester : I

Course Objectives:

- This course intends to provide insights into the scope and significance of commercially important microorganisms.
- To impart knowledge on growth, culture methods, metabolic activities of different types of microbes
- Insight into microbial host interactions
- To provide knowledge on control of microorganisms and antimicrobials.

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Impart knowledge on biotechnological importance of commercially important microorganisms. Understand various modes of nutrition in microbes.	K2
CO2	Understand microbiological techniques like sterilization, isolation, cultivation and maintainance of pure cultures.	K4
CO3	Understand the microbiome and its applications and awareness on microbial diseases.	K5
CO4	Able to know about how to control microorganisms and mode of action of antibiotics.	K6

UNIT – 1

Scope and significance of Microbiology; Structure of Gram positive and Gram-negative bacteria. Microbes of biotechnological importance - bacteria, yeast, algae, fungi and viruses. Nutritional requirements to microorganisms – mode of nutrition – phototrophy, chemotrophy – methylotrophy, organotrophy, mixotrophy, saprophytic, symbiotic and parasitic.

UNIT – II

Microbiological techniques: Methods of sterilization, isolation of pure cultures, cultivation of aerobic and anaerobic organisms, Different types of media used to cultivate microorganisms – natural and Synthetic, Basal, defined, complex, enrichment, selective and differential media. Methods of identification of bacteria, morphological, staining techniques, Biochemical and molecular methods; Preservation and maintenance of cultures.

Microbial growth: Batch and Continuous cultures. Factors influencing the growth (Physical and Chemical). Methods of growth estimation.

UNIT – III

Host-pathogen interaction; Infection and intoxication. Microbial diseases: Airborne infections, food & water borne infections, nosocomial infections and sexually transmitted diseases. Microbial toxins: Exo- and endo toxins – mode of action of toxins. Microbiome and its applications.

UNIT – IV

Control of Microorganisms – Physical – Heat, radiation, osmotic pressure and filters chemical – acids, bases, alcohols, aldehydes, ketones, phenols

Mode of action of antibiotics. Antibacterial, anti-fungal and anti-viral agents. Mechanisms of drug resistance.

REFERENCES

1. Microbiology: concepts and Applications. Michael J. Pelczar, Jr., E.C.S., Chan, Noel R. Krieg, 1993. Mc. Graw Hill, Inc.
2. Introductory Microbiology. 1995, by Trevor Gross.
3. Fundamentals of Microbiology. 4th ed. 1994. I.E. Alcamo. Scientific Publication.
4. Microbiology, 1990. 4thEd.B.D. Davis, R. Dulbeco, H.N. Eisen and H.S. Ginsberg and J.B. Lippincott Company.
5. Fundamental Principles of Bacteriology. 1994. A.J. Sake. Tata McGraw Hill.
6. Laboratory Experiments in Microbiology. 3rd ed. Brief Version. 1992. T.R. Johnson and C.L. Case. Addision Wesley International Publications. PP 350.
7. Microbiological Applications : A Laboratory Manual in General Microbiology. 5th ed. 1990. H.J. Benson. Panima Publications. PP 459.

Practical Course

1. Skerman, N.B.D. A guide to the identification of the Genera of Bacteria.
2. Bergey's Manual of Determinative Bacteriology.

Practicals:

1. General laboratory rules and regulations.
2. Preparation of culture media.
3. Isolation and enumeration of microorganisms from soil by the serial dilution-agar plating method.
4. Methodology for obtaining pure culture of microorganisms.
   a) Streak plate method.
   b) Spread plate method.
   c) Pour plate method.
5. Simple staining.
6. Grams staining.
7. Determination of bacterial growth turbidity measurements (Spectrophotometric method).

8. Antibiotic sensitivity testing by disc diffusion method

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE-103
Core - 3(B) : General Microbiology
Semester : I

Course objectives:

1. To impart the knowledge on discovery and classification of microorganisms
2. To develop understanding on microbial nutrition, cultivation and growth pattern of microorganisms
3. To understand the concept of gene and its transfer mechanism in microbes.
4. To know about viral, bacterial, fungal and protozoan diseases in plants and animals

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classification and characterization nd of major groups of microorganisms. Understand methods of sterilization, isolation and cultivation of of pure cultures,	K2
CO2	Understand the modes of nutrition and growth patterns and determination	K4
CO3	Know transposable elements in prokaryotes and eukaryotes and modes of gene transfer in microbial community	K5
CO4	Understand the pathogenicity of bacterial, viral, fungal and protozoan diseases	K6

UNIT - 1: Introduction to Microbiology

Discovering the microbial world. Classification of microorganisms up to order level - bacteria, algae, fungi, protozoa.
Structure of prokaryotic and eukaryotic microorganisms. General and distinctive characteristics of the major groups of microorganism bacteria, mycoplasma, chalmidae, rickettsias, actinomycetes, fungi, algae, protozoa Prions and viruses.
Isolation, cultivation and enumeration of microorganisms - direct and indirect methods, Maintenance of culture.

Outlines of characterization and identification of common bacteria, fungi, algae and protozoa.

UNIT - II: Microbial nutrition, growth and regulation

Nutritional requirements to microorganisms - Mode of nutrition - phototrophy, chemotrophy - methylotrophy organotrophy, mixotrophy, saprophytic, symbiotic and parasitic, Interaction of microbes. Growth of microorganism (bacteria) - normal and biphasic growth curve, batch and continuous cultures, chemostats, shift up and shift down. Growth determination, Microbial metabolism - energy yielding and energy requiring processes. Control of microorganisms - principles, physical and chemical agents, Assay of antimicrobial action. Batch and continuous sterilization .of media and air. Viruses - nature, cultivation and assay methods, structure, physico-chemical properties, classification, pathogenicity, Replication of viruses. Microbes of biotechnological importance - examples of bacteria, yeast, algae and viruses.

UNIT-III: Microbial Genetics

Chemical nature of gene, Concept of gene, operon, mosaic genes/split genes. Plasmids incompatibility. Classification: copy number, control and its significance. Structure and functions of insertion elements (IS) - transposable elements. Mechanism of transposition. Catabolic transposons and their significance. Horizontal transfer of genome among the microbial community - transformation, conjugation transduction - generalized transduction, specialized transduction - cotransduction. Benzer's classical studies on II locus. Cistron complementation - Elucidation of co-linearity between DNA and protein sequence. Genetics of viruses – bacteriophage, lambda, SV 40, retroviral genome (HIV), replication, lytic and lysogenic cascades.

Unit IV: Diseases caused by microorganisms

Viral diseases: Flu, Dengue fever, Hepatitis, Bacterial diseases: Cholera, tuberculosis, anthrox, Fungal diseases: Athlets foot, Dutch Elm disease, ergotism, Protozoa diseases (Protoctista): Malaria, Sleeping sickness, dysentery and Plant Pathogens: TMV, Rust

REFERENCES:

1. Microbiology: concepts and Applications. Michael J. Pelczar, Jr., E.C.S., Chan, Noel R. Krieg, 1993. Me. Graw Hill, Inc.
2. Introductory Microbiology. 1995, by Trevor Gross.
3. Fundamentals of Microbiology. 4ltled. 1994. I.E.AIcamo. Scientific Publication,
4. Microbiology, 1990. 4th Ed.B.D. Davis, R. Dulbeco, H.N. Eisen and H.S. Ginsberg and J.B. Lippincott Company.
5. Fundamental Principles of Bacteriology. 1994. A.J. Sake. Tata McGraw Hill.
6. Laboratory Experiments in Microbiology. 3rd ed. Brief Version. 1992. T.R. Johnson and C.L. Case. Addision Wesley International Publications. PP 350.
7. Microbiological Applications: A Laboratory Manual in General Microbiology. 5lh ed. 1990. H.J. Benson. Panima Publications. PP 459.
8. Microbes in Action: A Laboratory manual of Microbiology. 4'hed. 1991. H.W. Seeley, Jr. P.I. Van Denmark and J.J. Lee., W.H. Freeman and Co. New York, PP 450.
9. Microbiology: Concepts and Applications. 1988, P.A. Ketchum. Wiley Publication, New York.
10. Manual of Clinical Microbiology. 5lfl ed. 1991. A. Balows. Ed. American Society of Microbiology, PP 1, 364. Practical Course
11. Sherman, N.B.D. A guide to the identification of the Genera of Bacteria.
12. Bergey's Manual of Determinative Bacteriology.

13. Industrial Microbiology by Cassida

Practicals:

9. General laboratory rules and regulations.
10. Preparation of culture media.
11. Isolation and enumeration of microorganisms from soil by the serial dilution-agar plating method.
12. Methodology for obtaining pure culture of microorganisms.
    d) Streak plate method.
    e) Spread plate method.
    f) Pour plate method.
13. Simple staining.
14. Grams staining.
15. Determination of bacterial growth turbidity measurements (Spectrophotometric method).
16. Antibiotic sensitivity testing by disc diffusion method

Programme : M. Sc. Biotechnology
Type of Course : Practical
Course Code : BTE- 104
Practical I : Practical I (related to CC 1 & 2)
Semester : I

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE- 105
Skill Oriented Course 1(A) : Biophysical and Biochemical Techniques
Semester : I

Course objectives:

1. To understand about Principles and applications of Microscopy, centrifugation and Concentration & separation of biomolecules
2. To gain knowledge on Characterization of biomolecules using different Spectroscopic techniques.
3. To know about Principles and applications of different Chromatography and Electrophoresis techniques
4. Acquire knowledge of Radioisotope tracer techniques

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Write about the Principles and applications of Microscopy and Centrifugation, Concentration & separation of biomolecules	K4
CO2	Explain the working principle and applications of UV- Visible, NMR spectrophotometry, X-ray diffraction, ESR Spectroscopy. Surface Plasma Resonance methods and Mass spectrometry.	K5
CO3	Study about the principles, types and applications of Chromatography, Electrophoresis and Blotting techniques.	K2
CO4	Discuss about the Radioisotope tracer techniques and Biological uses of radioisotopes, safety measures in handling radio-	K5

	isotopes.	

UNIT – I

Microscopy: Principles and applications of Light, Phase contrast, Fluorescent, Electron Microscopy (SEM and TEM). Different fixation and Staining techniques for Electron Microscopy. Preparation of specimen for microscopy. Basic Difference of SEM and TEM and its applications.

Centrifugation: Simple theories of preparative and analytical centrifuge, sedimentation coefficient analysis; Types of centrifuge- Microcentrifuge, high speed & ultracentrifuge; Preparative centrifugation; Differential & density gradient centrifugations. Separation of cellular grade organelles, nucleic acids & viruses etc

Concentration & separation of biomolecules: Filtration, salting out with ammonium sulfate precipitation; Dialysis, reverse dialysis their applications.

UNIT – II

Characterization of biomolecules- Spectroscopy – Electromagnetic spectrum of light Beer-Lambert law. UV-visible spectrophotomety fluorescence spectroscopy, Atomic Absorption spectroscopy, NMR spectrophotometry. Mass spectroscopy, MALDI-TOF. Molecular Analysis using light scattering - X-ray diffraction and X-ray crystallography (Molecular Structure Determination). ESR Spectroscopy. Surface Plasma Resonance methods.

UNIT – III

Chromatography – Principles and applications of partition, adsorption chromatography techniques- Paper, Thin layer, Ion exchange, Molecular Sieve and Affinity, Gas-Liquid and HPLC, chromatography techniques.

Electrophoresis: Horizontal and Vertical Gel Electrophoresis. Agarose Gel Electrophoresis. SDS-PAGE Continuous, discontinuous, native, two dimensional, and Isoelectric focusing. DNA protein interactions- (EMSA) electrophoretic mobility shift assay.

Blotting techniques - Southern, Western and Northern

UNIT –IV

Radioisotope tracer techniques – Nature and types of radioactivity, decay units, detection and measurement of different types of radio isotopes used in biology (GM counter, scintillation counter auto radiography). Incorporation of Radioisotopes in Biological Tissues and Cells. Molecular Imaging of Radioactive materials. Biological uses of radioisotopes, safety measures in handling radio-isotopes

References:

1. Biochemical techniques : Theory and Practical. 1987. J.F. Robft and B.J. White, Waveland Press, Inc. Prospect Heights, IL, PP 407.
2. Principles and Techniques of Practical Biochemistry, 1994. 4th ed. Eds. K. Wilson and J. Walker.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology. 2nd ed. David Freifelder. W.H. Freeman and Company, New York.
4. Affinity Chromatography: Bio selective adsorption on insert matrices. 1992. W.H. Scouten, John Wiley & Sons, New York, PP 348.

5. Applications of HPLC in Biochemistry : Laboratory Techniques in Biochemistry and Molecular Biology. 1987. A. Fallon, R.F.G. Booth and L.D. Bell, eds. Elsevier Science Publishers, Amsterdam, the Netherlands. PP 338.
6. Electron microscopy: Principles and Techniques for biologists. 1992. J.J. Bozola and L.D. Rusel, Jones and Bartlett Publishers, Boston, M.A. PP 542.
7. Electrophoresis : Theory, techniques and biochemical applications. 2nd ed. 1986. A.T. Andrews, Oxford University Press, Oxford. PP 452.
8. Flow Cytometry: A practical approach. 1990. M.G. Ormerod. Ed. IRL Press. PP 279.
9. Introduction to Biophysical methods for protein and Nucleic acid research. (1995). J.A. Glasel; and Murray P. Deutscher. Academic Press. PP 505.
10. Special Analytical techniques in Nutritional Biochemistry. 1991. Gopalakrishna and S.K. Ranjhan. Kalyani Publishers.
11. Radioisotopes in Biology : A Practical approach. 1990. R.J. Slater, Ed., IRL Press, PP 307.

Practicals

1. Estimation of DNA by Diphenylamine method.
2. Estimation of RNA by Orcinol method
3. Estimation of DNA and purity determination by UV absorption method.
4. Determination of melting temperature (Tm).
5. Determination of isoelectric point of glycine
6. Separation of amino acids by paper-chromatography.
7. Separation of plant pigments by TLC.
8. Demonstration of Gel Filtration Chromatography.
9. Demonstration of Ion-exchange Chromatography.
10. Electrophoretic separation of DNA (Agarose gel electrophoresis).
11. Electrophoretic separation of Proteins (SDS-PAGE).

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE- 105
Skill Oriented Course 1(B) : Tools in Biotechnology
Semester : I

Course Objectives:

1. To improve understanding on replication initiation point mapping.
2. To gain knowledge on use of DNA microarrays to analyze origin activation patterns
3. To build knowledge on Electron microscopic methods for identifying DNA replication intermediates.
4. To give insight on replication dynamics of gene

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)

CO1	Understand the genome replication intermediates and mapping points	K4
CO2	Know the chip based micro arrays and detection of comparative genomes and recombination assays	K5
CO3	Study the *invivo* DNA replication intermediates and DNA fragmentation assays.	K2
CO4	Understand the replication check point assays and determine the DNA content by flow cytometry	K5

UNIT-I

Replication initiation point mapping: Approach and implications, purification of restriction fragments containing replication intermediates, Topological analysis of plasmid DNA replication intermediates, Analysis of telomeric DNA replication using neutral alkaline 2D gel electrophoresis, chromatin immunoprecipitation of replication factors moving with replication fork, density transfer as a method to analyze the progression of DNA replication fork, High resolution mapping of points of site specific replication, DNA replication in nucleus

UNIT-II

Chip-chip to analyze the binding of replication proteins to chromatin using oligonucleotides DNA microarrays, analyzing origin activation patterns by changing experiments. Detection of replication origins using comparative genomics and recombination ARS assay. Isolation of restriction fragments containing origin of replication from complex genomes. Application of alkaline sucrose degradation and analysis of DNA replication after DNA damage.

UNIT-III

Isolation of recombinant DNA elongation proteins *In vitro* assays for studying helicase activities, the use of two amino fluorescence to study DNA polymerase function, Single molecule observation of prokaryotic DNA replication, The FAST-HALO assay for the assessment of DNA damage for the single cell level. Electron microscopic methods for studying In vivo DNA replication intermediates.

UNIT-IV

Visualization of DNA replication sites in mammalian nuclei, measuring of DNA content by flow cytometry in Fission Yeast. Assays used to study replication check point in Fission Yeast. Use of DNA combining to study SNA replication in genus and in human cell free systems. Determining the replication dynamics of specific gene loci by single molecule analysis of replicated DNA.

Reference Books

1. DNA replication methods and protocols in Methods in Molecular Biology Edited by John N walker coedited by Soniya and Jacob Gelgard 2009. Humana press, New York.
2. General biochemistry and biophysics methods books.

Practicals:

1. 2D- gel electrophoresis
2. Flow cytometry
3. DNA microarray
4. FAST-HALO assay

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 106
Skill Oriented Course 2(A) : Biostatistics and Bioinformatics
Semester : I

Course Objectives:

Student will be able to

1. Gain the basic knowledge on Frequency distribution
2. Understand the Biological Sequence & Structure Databases and Sequence analysis Algorithms
3. Impart the knowledge on data Mining Data Mining, nucleic acid and protein sequencing analysis
4. Know about Molecular modeling, Drug designing &Docking systems

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the measures of central tendency and methods of sampling	K1
CO2	Study the importance of databases and identify their domains	K2
CO3	Identify various sequence alignments methods and distinguish between Homology, Phylogeny and evolutionary tree	K5
CO4	Explain the computer analysis of nucleic acid structure, Handling of available software on enzyme kinetics and protein sequencing analysis Know the concept of molecular modeling of drugs with target validation by docking studies	K6

UNIT – I

Frequency distribution- Measures of central tendency: mean, median, mode, Measures of dispersion: Standard deviation and Quartile deviation. Coefficient of Dispersion and coefficient of variation. Hypothesis testing. Methods of sampling and tests of significance - t, f and structure chi-square tests, correlation and regression, concept of analysis of variance.

UNIT – II

Biological Sequence & Structure Data bases: Classification of biological databases, Primary and Secondary Databases: EMBL; EBI outstations, NCBI, Gene bank, DDBJ, NLM, NIH, NRDB, OWL; UniPROT, Structural databases.

Sequence analysis Algorithms: Similarity searching: BLAST, FASTA. Multiple Sequence alignment, Advances in bioinformatics, Clustal-W (or) Clustal-X, Phylogenetic tree evolution (PHYLIP). Methods of analysis (Distance method, Neighbour joining method),

UNIT – III

Data Mining, Computer analysis of nucleic acid structure, Handling of available software on enzyme kinetics and protein sequencing analysis. Molecular biology software packages – DNASIS, DNSTAR, CLONE MANAGER, CD-ROM.

UNIT-IV

Molecular modeling, Drug designing &Docking systems: Introduction to the concepts of molecular modeling. Drug discovery, Structure based drug design. Automated docking, de novo technique. Docking programs, evaluation of docking prediction, QSAR.

REFERENCES

1. Computing supplement to Models in Biology: Mathematics, Statistics and Computing. 1994. B. Brown and P. Rothery. Sciential Publication.
2. Meical informatics: Computer applications in Health care. 1990. E. H. Shortliffe, L.E. Pereault, G. Wiederhold and L.M. Fagan. Addision-Wesly International Publications. PP 714.
3. Computing for Biologists. 1985. A Fielding Addison-Wesley Publishers.
4. Microcomputers in Biology: A Practical approach. 1985. C. R. Ireland and S.P. Long. IRL Press.
5. Subhas Mehta, "Dos made simple", Golgotia Publications, New Delhi.
6. Taxali R.K., "Wordstat 4.0", Tata Mc. Graw-Hill Publishing Company Ltd., New Delhi.
7. Statistical methods in Agriculture and Experimental biology. 2nd ed. 1993. R. Mead, R.N. Curnow, A.H. Hasted, Panima Publication, PP 415.
8. Introduction to Biostatistics. 1995. R.N. Forthafter and E.S. Lee. Academic Press. PP 656.
9. Statistics with application to the biological and health sciences. 1985. R.D. Remington and M.A. Schork, Prentice-Hall.
10. Biostatistics an introductory text, Goldstein, Avrom, New York, The Mac Millian Company, 1971.

Practicals

1. Mean
2. Median
3. Mode
4. Standard Deviation
5. t-test
6. f-test
7. ANOVA
8. BLAST
9. FASTA
10. Multiple Sequence alignment
11. Clustal-W
12. Phylogenetic trees

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 106
Skill Oriented Course 2(B) : Biometrics and Computational Biology
Semester : I

Course Objectives

1. For better integration of the concepts at the intercepts of mathematical methods and biological codes, sequences, structures, networks, and systems biology.

2. Understand and apply statistical techniques that are essential to process and interpret biological data
3. To provide students with the basic knowledge of biosimilar, computational biology and their advances of synthetic biology.
4. To facilitate the students to attain skills in basic computational biology, sequence matching and its various biomedical applications.

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the analysis of variance, SAS and PRISM tools	K1
CO2	Study the measures of central tendency and types and methods of correlation and regression	K2
CO3	Understand the computational measures	K5
CO4	Understand the sequence alignmetnts and know the phylogenetic relation among biological systems	K6

Unit-I

Biostatistics: Application of statistics to biology, sample size and power analysis, hypothesis testing, confidence intervals, regression, ANOVA, Computer software package for statistical analysis including R, SAS, and PRISM packages. R programming for Biostatistics: Basic statistics in R, correlation and covariance, T-test, ANOVA and probability distributions.

Unit -II

Correlation and Regression: Types of Correlation, Methods of studying Correlation: Scatter diagram, Karl Pearson's Coefficient of Correlation, Spearman's Rank Correlation. Types of numerical data, Tables and Graphs. Measures of central tendency: Arithmetic Mean, Weighted arithmetic mean, Median and Mode - Geometric mean and Harmonic mean. Measures of dispersion: Range, Inter-quartile range, Average deviation, Standard deviation and Coefficient of variation, Lorenz curve. Theory of Sampling: The purpose of sampling, Principles of sampling, Methods of samplings, Techniques of non-probability sampling, Size of Sample, Sampling and Non-Sampling errors.

Unit -III

Introduction to Computational Biology: Nature and scope of Computational Biology, Alignment definition, Pairwise sequence alignment, biological interpretation of the alignment problem, scoring alignment, Global alignment, local alignment, overlap alignment, banded alignment, normalized local alignment, maximizing Vs minimizing score, similarity and distance measures, PAM matrices, BLOSUM matrices, comparison between PAM and BLOSUM matrices, Application of substitution matrices.

Unit-IV

Pairwise sequence matching analysis: Sequence matching method- Dot plot visualization method, Dynamic programming method, Word method, Bayesian method, progressive method, Markov chain model, Hidden Markov Models and Kernal methods. Computational Sequences and Maps: General ideas of sequence alignment, multiple sequence alignment, Restriction map-Graph, Interval graphs and Measuring fragment sizes. Multiple maps-double design problems, reflection, overlap equivalence, overlap size equivalence, restriction map and border block graph, Cassettle transformation of restriction map.

Reference Books:

Aluru, S. (2005). Handbook of computational molecular biology. Chapman and Hall/CRC.
Gutka, H. J., Yang, H., & Kakar, S. (Eds.). (2018). Biosimilars: Regulatory, Clinical, and Biopharmaceutical Development (Vol. 34). Springer.
Haubold, B., & Wiehe, T. (2006). Introduction to computational biology: an evolutionary approach. Springer Science & Business Media.
Najarian, K., Najarian, S., Gharibzadeh, S., & Eichelberger, C. N. (2009). Systems biology and bioinformatics: a computational approach. CRC Press.
Andrew, R. L. (2001). Molecular modeling principles and applications. Prentice Hall, London.
Dastmalchi, S., Hamzeh-Mivehroud, M., & Sokouti, B. (2018). Quantitative structure–activity relationship: a practical approach. CRC Press
Hey-Hawkins, E., & Teixidor, C. V. (Eds.). (2018). Boron-Based Compounds: Potential and Emerging Applications in Medicine. John Wiley & Sons.
Schlick, T. (2010). Molecular modeling and simulation: an interdisciplinary guide: an interdisciplinary guide (Vol. 21). Springer Science & Business Media.
Sehgal, S. A., Mirza, A. H., Tahir, R. A., & Mir, A. (2018). Quick Guideline for Computational Drug Design. Bentham Science Publishers.

Practicals:

1. Mean
2. Median
3. Mode
4. Standard Deviation
5. ANOVA
6. BLAST
7. FASTA

Programme : **M. Sc. Biotechnology**
Type of Course : **Practical**
Course Code : **BTE- 107**
Practical II : Practical II (related to SOC 1 & SOC 2)
Semester : **I**

Programme : **M. Sc. Biotechnology**
Type of Course : **Audit Course**
Course Code : **BTE 108**
Indian Knowledge Systems (1) : **Health and Well Being**
Semester : **I**

Course Objectives:

The course introduces about the fundamental principles of Indian health systems such as yoga which are useful in maintaining the health of a healthy person. Practical implementation of health principles to correct the intake of our food, air, water and sunlight to achieve perfect health. Understanding traditional way of cleansing the body regularly, strengthening body with Yogic exercises, maintaining the internal balance to prevent diseases. This course is meant to enhance their professional development as they work to becoming practicing health and wellbeing specialists.

Learning Outcomes:

The student will be able to

- Understanding the influence of external environment on internal health and ways to synchronise our body and mind with nature to ensure smooth functioning of all organ systems of our body.
- Understanding mind and its dynamics through knowledge of Yoga
- Use the knowledge to maintain harmony between body and mind to achieve perfect mental well being.

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the concept of body & mind and establishing the communication as well the language of body.	K1
CO2	Study the relation between health and well being.	K2

UNIT I

Understanding human body

Introduction to the Knowledge of Life.. Influence of Pancha maha bhuta on Internal environment of Human being, Understanding composition of Human body through the concept of Dosha Dhatu Mala. The Mind – Body Constitution. Establishing communication between body and mind by understanding the language of body.

Understanding the concept of Agni, Koshta, Sara and Ojas and their relevance in enhancing our immunity to protect from various infections.

UNIT-II

Relation between health & Well-being

Concept and facets of wellbeing. The relation between health and well-being. Well-being and metal health, Relation between Mental health and physical health

Benefits of physical activity for physical and mental health. Exercise prescription and behavior change strategies

References:

1. The Charaka Samhita
2. The Susruta Samhita
3. Teh Ashtanga Hridaya
4. Dr Deepak Chopra, Perfect Health--Revised and Updated: The Complete Mind Body Guide, Harmony publication, 2001

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 201
Core - 4 : Molecular Biology
Semester : II

Course Objectives:

The main objective of the study is

- To Study about replication of Prokaryotes and Eukaryotes
- To introduce about transcription in Prokaryotes & Eukaryotes.
- To gain insight into Prokaryotic and Eukaryotic translation.
- To know about regulation of gene expression in prokaryotes and eukaryotes

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand about Study about replication of Prokaryotes and Eukaryotes. Discuss DNA damage and repair mechanism	K1
CO2	Know about transcription in Prokaryotes & Eukaryotes and explain the Post transcriptional modifications in Prokaryotes and Eukaryotes	K5
CO3	Know about Prokaryotic and Eukaryotic translation	K4
CO4	Understand Regulation of gene expression in prokaryotes and eukaryotes	K3

UNIT – I

DNA replication - Enzymes involved in DNA replication. Mechanism of formation of oriC. Replication initiation – elongation - Okazaki fragments synthesis and processing, Termination . Mode of DNA replication Messelson and Stahl experiments. Replication of single stranded DNA -ØX174. bacteriophage lambda DNA (rolling circle), closed covalent circular DNA (θ model of DNA replication). DNA damage and repair.

UNIT – II

Transcription - Prokaryotic RNA polymerase - σ factors: -σ^{70}, σ^{32}, σ^{54} , σ^{28} promoter elements- Promotor polymerase interaction - Foot printing assays - Gene structure, Upstream activating sequences and their role in regulation of transcription. Transcription elongation and termination.
Eukaryotic RNA polymerases - Transcription factors – Structure and functions of RNA pol I, II and III dependent promoters. Enhancer sequences. Post transcriptional modification of RNA and its regulation, Mechanism of tissue specific transcription.

UNIT – III

Translation-Prokaryotic and Eukaryotic translation, Genetic Code, Codon degeneracy. Mechanism of initiation, elongation and termination of protein synthesis. Inhibitors of Protein synthesis. Post translational modifications of proteins.

UNIT – IV

Regulation of gene expression: Regulation of catabolic gene expression Eg: lac operon, ara operon and gal operon. Regulation of anabolic gene expression Eg: Trp and His operons. Hormones and environmental factors affecting gene expression.

DNA-Protein interaction, House Keeping genes, Constitutive genes and motifs of regulatory proteins- Zinc finger motif, leucine Zipper, Helix turn helix, Helix loop helix

Reference Books

1. J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner, Molecular Biology of the Gene, 5th edition, The Benjamin/Cummings Publ., Inc., California, 2004..
2. J. Darnell, H. Lodish and D. Baltimore, Molecular Cell Biology ,Scientific American Books, Inc., USA, 1998.
3. Benjamin Lewin, Gene VII , Oxford University Press, U.K., 2000
4. William H Elliott and D C.Elliolt , Biochemistry & Molecular biology, Oxford University press. 2000.
5. David freifelder and G.M.Malacinik, Essentials of molecular biology 1996.
6. T.A. Brown (Ed. Molecular Biology LabFAx), Bios Scientific Publishers Ltd., Oxford, 1981
7. B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts, and J.D. Watson Molecular Biology of the Cell (2nd Edition), Garland publishing, Inc.New York, 1994.
8. J. Sambrook, E.F. Fritsch and T. Maniatis, Molecular Cloning: a Laboratory Manual, Cold Spring Harbor Laboratory Press, New York, 2002.
9. R.A. Meyers (Ed.), Molecular Biology and Biotechnology A comprehensive desk reference, VCH Publishers, Inc., New York, 1995.
10. E.D.P.De Robertis and E.M.F. De Robertis, Cell and Molecular biology, Jr-8th edition, B.I. Publications Pvt.Ltd.2005.

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 202
Core -5 (A) : Genetic Engineering
Semester : II

Course objectives:

1. To impart knowledge about major events in the development of rDNA technology
2. To acquire skills on techniques of construction of recombinant DNA - Cloning vectors and isolation of gene of interest.
3. To familiarize with the concepts of constructing genomic DNA library and cDNA library
4. To understand the principles and applications of Polymerase Chain Reaction (PCR).

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Familiar with the tools and techniques for isolation and purification of genes	K3
CO2	Acquire knowledge on vectors for construction of genomic libraries and cDNA libraries	K4
CO3	Understand the mechanism of cDNA synthesis	K5
CO4	Know the techniques for transfer and expression of cloned gene and applications of genetic engineering in biological research	K6

UNIT-I

Requirements and steps involved in gene cloning, Isolation of gene/DNA fragments. Purification of genes. Enzymes used in gene cloning: Restriction endonucleases – types, nomenclature and properties. DNA polymerases-I, polynucleotide kinase, DNA ligases, terminal nucleotide transferases, Reverse transcriptase, alkaline phosphatases, S1 nucleases. Production of DNA fragments with cohesive ends and blunt ends and their significance, vectors and hosts.

UNIT-II

Vectors for construction of genomic libraries - cosmids, bacterial artificial chromosomes (BACs), yeast artificial chromosomes (YACs) - vectors for construction of cDNA libraries - lamda ZAP. Multipurpose vectors - pUC 18/19, Blue script vectors - multiple cloning site - Strategies for unidirectional deletion of cloned DNA fragments - Generation of sequence of cloned DNA fragments. Site directed mutagenesis.
Expression vectors – structure - promoters used in expression vectors - *lac, tac, λpL*, T7 promoters and their significance in constructing expression vectors. Promoter-probe vectors – Structure promoter probe vector - Reporter genes (*lacZ*, *gf*p, gus, luciferase) and strategies used to assay promoter activity. Vectors used for cloning in to mammalian cells - SV40. Vectors - Cloning in plants by Ti and Ri vectors.

UNIT-III

cDNA synthesis - Mechanism of cDNA synthesis, Strategies used to obtain full length cDNA. 5' and 3' RACE. Chemical synthesis - solid phase synthesis of oligonulceotides - Designing of gene from amino acid sequences, *In vitro* synthesis of gene. Ligation of foreign DNA to vectors – cohesive and blunt ends methods –linkers, homopolymer tailing and adaptors. Genome Editing Technologies: Principles and applications of CRISPR technology; Gene silencing techniques: Principle and application of RNAi miRNA and siRNA

UNIT-IV

Cloning stratergies – cloned gene transfer techniques – transformation, transfection, electroporation, lipofection, microinjection and biolistics. Screening of cloned genes and their expression – nucleic acid probes, colony and fluorescent in-situ hybridization, DNA micro array technology. PCR – concept and technology – types (real time, inverse and multiplex) and its significance. Analysis of DNA polymorphism: RFLP, RAPD, AFLP techniques. Applications of genetic engineering.

Reference Books

1. DNA replication, 2nd ed. 1991. A. Kornberg and T.A. baker. W.H. Freeman and Company, New York. Ny. PP931.
2. Gene transfer and expression protocols: Methods in Molecular Biology, Vol.7,1991. E.J. Murray Ed. Human Press, Clifton, NJ. PP 439.
3. Genes IV, 1990. B. Lewin. Oxford University Press. PP 857.
4. Microbial genetics. 1994. Freifelder, D. Springer.
5. Gene regulation, 2nd ed. 1994. D, latchman. Sciential Publication.
6. Bacterial and Bacteriophage genetics. 1994. E.A. Birge. Springerscan Publication.
7. Genetics: A molecular approach. 2nd ed. 1992. T.B. Brown. Panima Publications. PP 496.
8. Principles of Gene Manipulation. 1991. R.W. Old and S.B. Prim-Rose. 2nd ed. Blackwell Scientific.

Practicals

1. Plasmid Isolation
2. Restriction digestion of DNA.
3. Elution of DNA from Agarose gel.
4. Ligation of DNA into linearized plasmid.
5. Preparation of competent Cells
6. Transformation
7. Isolation of RNA from yeast.
8. Polymerase chain reaction (PCR)
9. RFLP
10. RAPD

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 202
Core - 5(B) : Recombinant Proteins and Drugs
Semester : II

Course objectives:

The main objective of the course is to make the student

- To understand how recombinant proteins are used in medical, pharmaceutical, industrial, and scientific research applications
- To learn about Expression vectors and Yeast expression system and Yeast expression system
- To know about Animal cell expression systems
- To study Downstream processing

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the significance, problems and prospects in recombinant protein drugs.	K1
CO2	Demonstrate the cloning and expression strategies to produce recombinant protein drugs with C / N terminal affinity tags. Write about the Yeast expression system and Recombinant human growth hormone.	K5
CO3	Discuss about Animal cell expression systems and cloning transduction strategies	K2
CO4	Illustrate the Downstream processing- purification of recombinant protein- removal of affinity tags and Clinical trials-Marketing strategies.	K6

UNIT – I

Protein drugs- Introduction, significance, problems and prospects in recombinant protein drug industry. Introduction to expression system – bacterial –*E.coli, Pseudomonas fluorescens*, *Bacillus subtilis.*

UNIT-II

Expression vectors – cloning and expression strategies to produce recombinant protein drugs with C / N terminal affinity tags. Downstream processing, large scale purification, protein drug formulations – production of insulin in *E.coli*.

Yeast expression system: Brief introduction to pichia pectoris, methanol indusible promoter vectors, Clinical applications of recombinant technology; Erythropoietin; Insulin analogs and its role in diabetes; Recombinant human growth hormone; Streptokinase and urokinase in thrombosis; Recombinant coagulation factors.

UNIT – III

Animal cell expression systems: vectors, promoters and cloning transduction strategies and large scale production of recombinant protein drugs using cell culture based fermentation technologies – Erythropoietin.

UNIT – IV

Downstream processing- purification of recombinant protein- removal of affinity tags Clinical trials- marketing regulatory science, marketing strategies.

References

1. Old and Primrose Principles of Gene Manipulation: An introduction to genetic engineering..6th ed.. Blackwell Scientific Publ. 2001
2. SB. Primrose and R.W. Twyman. Principles of genome analysis and genomics. 3rd edition. Blackwell Science. 2003.
3. Glick and Pasternak, Molecular Biotechnology, Panima Publ.2003
4. J. Sambrook, E.F. Fritsch and T. Maniatis. Molecular Cloning: a Laboratory Manual, Cold Spring Harbor Laboratory Press, New York, 2000.
5. M.R. Walker and R. Rapley. Route Maps in Gene Technology, Blackwell Science Ltd., Oxford, 1997
6. M. Kingsman and A.J. Kingsman Genetic Engineering. An Introduction to gene analysis and exploitation in eukaryotes, S, Balckwell Scientific Publications, Oxford, 1998
7. S.P Hunt and R. Liveey. Functional Genomics:A practical Approach. Oxford University Press, 2000.
8. H. Kreuzer and A. Massey. Recombinant DNA and Biotechnology: A guide for Teachers: (2nd ed.) ASM Press, 2001.
9. H. Kreuzer and A. Massey. Recombinant DNA and Biotechnology: A guide for students: 2nd ed. ASM Press, 2001.

Practicals

1. Immobilization of yeast cells
2. Invertase assay
3. Isolation of beta amylase from sweet potato
4. Estimation of aspirin
5. Estimation of urease enzyme from horse gram
6. Estimation of streptomycin by oxidized sodium nitroprusside method
7. Isolation of streptomycin resistant mutants by replica plating method
8. Prediction of secondary structure of protein using SOPMA
9. Prediction of protein protein interaction by using STRING

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 203
Core - 6(A) : Advances in Bioprocess Engineering
Semester : II

Course Objectives:

1.To prepare students to acquire basic knowledge for successful career in industry and Food and research institutes.
2. To know about fermentation and its types .
3.To enable students to learn about recovery and purification of fermentation products
4.To lear about fermentation technology

Course Outcomes

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Demonstrate the Isolation, screening, Preservation and maintenance of industrially important microorganisms.	K3
CO2	Explain the basic principles, construction of Fermentation and Bioprocess control measurements.	K2
CO3	Illustrate various Methods for Downstream Processing and product recovery.	K5
CO4	Know microbial Production of Alcohols & Beverages: Wine, beer, ethanol & acetone-butanol.	K6

UNIT – I

Introduction to Bioprocess Engineering: Historical development of bioprocessing technology, processing and production of recombinant products.

Selection of Microorganisms: Isolation, screening, Preservation and maintenance of industrially important microorganisms. Media formulation; Air and Media Sterilization. Strain improvement methods – Conventional and rDNA methods.

UNIT – II

Fermentation and its Types- Solid state and submerged fermentations. Analysis of batch, fed-batch and continuous fermentations and Scaleup. The oxygen requirements of industrial fermentation: Determination of KLa Value. Bioprocess control measurements: Physical and chemical measurements and control of bioprocess parameters. Methods for off-line and on-line monitoring of bioreactors.

UNIT – III

Recovery and purification of fermentation products: Liquid-liquid extraction, cell disruption and isolation of non- secreted products, Lyophilization and Spray drying. Membrane based affinity separations; two-phase affinity partitioning; use of reverse micelles in protein separation; chiral separations; molecular imprinting.

UNIT – IV

Fermentation Technology:

Case studies on production of lactic acid, glutamic acid, penicillin, microbial lipase and protease, recombinant insulin. Case studies should deal with strain improvement,medium designs, and process optimization.

REFERENCES

1. Biochemical Engineering fundamentals" by J E Bailey and D F Ollis, 2nd ed, McGraw-Hill .
2. "Principles of fermentation technology" by P F Stanbury and A Whitaker, Pergamon press.
3. "Principles of Cell Energetics" : BIOTOL series, Butterworth - Heinemann.
4. "Bioprocess Technology - Kinetics & Reactors" by A Moser, Springer-Verlag.
5. "Biotechnology" Vol.4 Meanning Modeling and Control Ed. K.Schugerl, VCH (1991).
6 "Biotechnology" Vol.3 Bioprocessing Ed.G. Stephanopoulos, VCH (1991).
7. "Biochemical Engineering and Biotechnology Handbook" by B.Atkinson&F.Mavituna, 2nd Ed. Stockton Press (1991).
7. Specific journals and published references.

Practical Course books

1. Manual of Industrial microbiology and biotechnology. 1986. Edited by Arnold L. Demain and Nadine. A.Solomon. PP 466.
2. Vanderzant, C., and D. Splittstoesser. : Compendium of Methods for the Microbiological Examination of Foods, American Public Health Association, Washington, D.C. 1992.

Practicals

1. Isolation & screening of industrially important microorganisms from soil.
2. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer.
3. Batch growth kinetics of bacteria
4. Effect of substrate concentration on Growth of *E.coli*
5. Effect of temperature on Growth of *E.coli*
6. Effect of pH on Growth of *E.coli*

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 203
Core - 6(B) : Nanobiotechnology
Semester : II

Course Objectives:

To understand the application of nanotechnology in the field of research, industry and developmental domains.

- To study basics in Nano- biotechnology and Nanoparticular carrier systems
- To provide the professional services to industry, research organization, institutes.
- To Study professional consultancy and research support for the relevant organization in the domain of super specialization.
- To provide, value based and ethical leadership in the professional and social life

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Know about nanobiotechnology, Nanomaterials and synthesis of Nanomaterials	K1
CO2	Study about the Characterization Techniques of nanoparticles	K2
CO3	Explain about applications of Nanomaterials for diagnostics, drug delivery	K5
CO4	Understand about the application of nanobiotechnology in food industries. Describe Environmental, ecological and health hazards of nanoparticles	K4

UNIT- I

Introduction to Nanobiotechnology: Nanomaterials –Classification of Nanomaterials (0D, 1D, 2D and 3D); Bio-inspired nanomaterials - Interaction Between Biomolecules and Nanoparticle Surfaces - Strategies for synthesis of Nanomaterials by top-down and bottom-up approaches; Bottom-up Approaches: Chemical Methods of Synthesis – Sol-Gel process, Green Synthesis of nanoparticle, Top-down approaches–Hydrothermal method, Solvothermal method.

UNIT-II

Preparation and Characterization of nanoparticles : Principle, instrumentation and applications of UV–visible Spectrophotometer – Fourier Transform Infrared Spectrophotometry –X-ray diffraction, particle size analyzer, microscopy viz., electron microscopy, atomic force microscopy etc

UNIT-III

Applications of Nanomaterials: Nanomaterials for diagnostics, drug delivery, optimization of nanoparticle properties for suitability of administration through various routes of delivery, Drug loading; Drug release characteristics, surface properties - protein adsorption, characterization methods, surface modification (PEG, PEO coated) – Nanoparticles for effective drug delivery to the CNS.

UNIT-IV

Nanotechnology in Food industry: Nanomaterials as food additives and ingredients, mprovement of texture, appearance, taste and nutritional values, food processing, food packaging and preservation,

Nano-toxicity: Introduction to safety of nanomaterials, Adverse effects of engineered nanomaterials, Nanotoxicity assessment; Environmental and health hazards of nanoparticles

REFERENCES

1. Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers and Architects - M.F.Ashby, P.J.Ferreira, D.L.Schodek, Elsevier (2009).
2. Text book of Nanoscience and Nanotechnology - B S Murthy, P Shankar, Baldev Raj, B BRath and James Murday, Universities Press (2012).
3. NANO: The Essentials – T.Pradeep, TATA McGraw Hill (2007).
4. Nanostructured Materials and Nanotechnology– Edited by Hari Singh Nalwa, Concise Edition, Academic Press (2002).
5. Nanoscale Materials– Edited by L.M. Liz-Marzan, P.V.Kamat; Kuluwar Academic Publishers (2004).
6. Nanostructures &Nanomaterials: Synthesis, Properties & Applications, GuozhongGao,
Imperial College Press (2004).
7. Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press (2005).
8. Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, BurkhardRaguse, Overseas Press (2005).
9. BK Sharma, Spectroscopy, Goel Publishers House, Meerut (2007)

Suggested Readings:

1. Nalwa, H. S. 2005. Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology. American Scientific Publications.
2. Niemeyer CM &Mirkin CA. Eds (2005). Nanobiotechnology: Concepts Applications and Perspectives, Wiley Inter-science publications.
1. Cao, G., and Wang, Y., (2004) Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press.

Practicals

1. Synthesis of gold nanoparticles by sol-gel method
2. Chemical synthesis of metal (silver/gold) nanoparticles,
3. Green synthesis of silver nanoparticles
4. Green Synthesis of gold nanoparticles
5. Green synthesis of magnesium oxide nanoparticles
6. Green synthesis of zinc oxide nanoparticles
7. Antimicrobial activity of silver and gold nanoparticles
8. Optical and structural characterization of metal / metal oxide nanoparticles

Demonstrations

a. Evaluation of surface morphology using SEM/TEM
b. Determination of particle size from XRD spectrum (using Scherrer’s formula)

Programme : M. Sc. Biotechnology
Type of Course : Practical
Course Code : BTE- 204
Practical III : Practical III (related to CC 4 & 5)
Semester : II

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 205
Skill Oriented Course - 3(A) : Basic and Applied Immunology
Semester : II

Course Objectives:

Students will be able to synthesize key concepts in

- immunity and cells of the immune system.
- properties of antigens and formation of antibody
- complement cascade pathway and major histocompatability complex
- autoimmune diseases

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Study about the Types of immunity and cells of the immune system	K1
CO2	Study about the definition and properties of antigens & Explain about the nature and formation of antibody	K2
CO3	complement cascade pathway and major histocompatability complex	K5
CO4	Explain about immune therapy	K2

UNIT – I

Immunity – natural and acquired; specific and non-specific; Primary and Secondary organ of immune system – thymus, spleen, lymph nodes, bursa fabricus, other types of lymphoid tissue. Cells of the immune system; B and T lymphocytes, neutrophils, macrophages, plasma cells, eosinophils and basophils. Blood groups and cytokines, interferons and interleukins

UNIT–II

Antigen – definition, properties, specificity, cross reactivity, immunogenicity, antigenic determinants and haptens. Antibody: nature and formation, classification of immunoglobulings and types, valency and avidity. production of polyclonal antibodies, Hybridoma technology
Infection, Inflammation and Immunity: Introduction, Inflammation, Chemotaxis, Cytokines, Inflammatory Diseases, Vascular modifications, Healing and Fibrosis

UNIT – III

Complement –definition, complement cascade pathway, complement fixation. Hyper sensitivity and its types. The major histocompatability complex. Transplantation and G.V.H. reactions. Immuno pathology – Autoimmune diseases (Multiple sclerosis, Myasthenia gravis, systemic lupus, erythematous, rheumatoid arthritis, Type I Diabetes),immune complex diseases; immunodeficiency diseases.

UNIT – IV

Modern Immunotherapy Technologies: Introduction, types of immune therapies and target diseases, Hybridoma technology, Bi-specific antibodies, Tumor immunotherapy techniques, CAR-T cell therapy, Immune check points(PD1, PDL 1, CTL-4, TIM -3,LaG-3& TIGIT) and their inhibitors (anti-PD1, anti-PDL 1, anti-CTL-4, anti-TIM -3, anti-LaG-3& anti-TIGIT).

REFERENCE

1. Immunology edition Janis kuby 2000
2. Immunology 5th edition, Indian Roitt et al 2000
3. Serology & Immunology-a clinical approach, William D. Stansfield 1981.
4. Immunology 2nd edition, Richad M. Hydel 1992
5. Medical microbiology & immunology 4th edition, WarresLeminson, Ernest Jawetz.
6. Serology & Immunology carpenter
7. Immunology-An introduction 4theiditonTizard 1996
8. Janeway-Biology of Immune system.

Practical Course books

1. Serological methods for detection and identification of viral and bacterial plant pathogens. 1990. R. Hampton, E. Ball and S.De.Boer (eds.) American Phytopathological Society.
2. Practical immunology. 1989. 3rd ed. Hudson and F.C. Horp. Blackwell Scientific Publication.

Antibodies : A Laboratory Manual. 1988. E. Harlow and D

Practicals:

1. Determination of A, B, O and Rh blood groups in human beings.
2. Ouchterloney double diffusion.
3. Radial immunodiffusion.
4. Rocket Immunoelectrophoresis.
5. Diagnostic test for typhoid fever by Widal test.
6. Pregnancy tests.
7. VDRL

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 205
Skill Oriented Course-3(B) : Molecular diagnostics
Semester : II

Course Objectives:

Students will be able to synthesize key concepts in

1. Analytical Methods for QC of Bio-samples
2. Immuno-diagnostics
3. Molecular diagnostics
4. Molecular Pathology and Cell Based Screening

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Learn about Analytical Methods for QC of Bio-samples	K1
CO2	Study about the definition and properties of antigens & Explain about the nature and formation of antibody	K2
CO3	complement cascade pathway and major histocompatability complex	K5
CO4	Explain about Molecular Pathology and Cell Based Screening	K2
CO4	Understand the role of enzymes in food and their applications in industries	

UNIT – I

Analytical Methods for QC of Bio-samples:

Protein impurities, contaminants, electrophoretic analysis, HPLC based analysis, Spectrophotometric Analysis, DNA and RNA content analysis, immunological assays for impurities, combined immunological and electrophoretic methods.

UNIT – II

Immuno-diagnostics: Principles and methods of some clinically used diagnostic immunoassays, e.g., homogeneous immunoassays, fluorescence, chemiluminescence and bioluminescence enzyme immunoassays, immunoblot, immunoaffinity, immunoprecipitation, biotinylation, immunosensors. Multiplexing ELISA.

UNIT – III

Molecular diagnostics: DNA probe-based diagnostics, sample preparation, hybridization, separation, detection, PCR-RFLP in paternity and forensic cases SNP detection MALDI and DHPLC. PCR and its application for clinical diagnostics. Real Time PCR and Multiplexing.

UNIT – IV

Molecular Pathology: Basic pathological assays for routine diagnostics using H&E (infectious diseases, cancer), Disease specific pathological markers using Immunohistochemistry and In Situ Hubridization. Multiplex Immuno Florescence

Cell Based Screening: Functional cell-based assay – Reporter gene assay. Automated Cell Based Assays for drug discoveries, Application of Microfluidic Technologies for single cell assay. Application of Flow cytometry in research and clinic.

Reference Books

1. David Wild. The Immunoassay Handbook. 4th Edition - 2013. ISBN: 9780080970370.
2. Lela Buckingham. Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications. 3rd Edition. ISBN-13: 978-0803668294.
3. Joshua A Bittker, Nathan T Ross. High Throughput Screening Methods: Evolution and Refinement. 2017. ISBN- 978-1-78262-471-4.
4. Frank H. Stephenson. Calculations for Molecular Biology and Biotechnology. 3rd Edition. 2016. ISBN - 978-0-12-802211-5.
5. Taosheng Chen. A Practical Guide to Assay Development and High-Throughput Screening in Drug Discovery. 2010. ISBN-9780367384708.

Practicals:

1. Spectrophotometric Analysis of DNA and RNA
2. Determination of A, B, O and Rh blood groups in human beings. Reagents preparations and protocols for histology staining
3. Tissue handling for histology.
4. Identification and interpretation of tissue samples under the microscope.
5. Special tissue preparations for immunohistochemistry.
6. Multi staining immunohistochemistry.
7. Diagnostic test for typhoid fever by Widal test.
8. Pregnancy tests.
9. VDRL

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 206
Skill Oriented Course 4(A) : Plant Tissue Culture
Semester : II

Course Objectives:

1. To impart knowledge about the organization of Plant Tissue Culture Lab.
2. To give insight of nutrient requirements and factors influencing plant tissue culture.
3. To develop skill on micropropagation of forest trees, medicinal plants and endangered plants.
4. To educate the student to learn methods to *in vitro* germplasm conservation and production of secondary metabolites through cell culture.

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Learn important milestones in the plant tissue culture and understand the concepts and principles of Plant tissue culture	K1
CO2	Learn different pathways of plant regeneration under in vitro conditions – organogenesis, somatic embryogenesis, synthetic seeds and applications.	K2
CO3	Understand techniques of establishing cell suspension culture, techniques of virus elimination by meristem and shoot tip culture.	K5
CO4	Acquire skill of propagation of elite medicinal and economically important plants and establish micropropagation unit for commercialization.	K4

UNIT-I

Introduction to plant tissue culture: Preparatory techniques - cleaning, sterilization, sterile handling tissue culture lab requirements. Media - Composition, preparation and sterilization. Genetic manipulation through tissue culture techniques - Concepts of differentiation and dedifferentiation. Callus - growth pattern/characteristics, Organogenesis and plant regeneration.

UNIT-II

Somatic embryogenesis. Anther, endosperm and pollen cultures, Significance and advantages of haploid plants. Production of virus-free plants by meristem tip and other tissue culture techniques.

UNIT-III

Cell culture techniques for micropropagation of elite plants - Food and fruit crops, forest trees, fiber crops, ornamental plants, medicinal plants and endangered plants. Cell culture techniques for production of useful compounds - Hairy root cultures - transformed roots using Agro bacterium rhizogenesis - Production of secondary metabolites of commercial importance - Elicitors - factors affecting their yield, immobilized cell systems, bioreactors.

UNIT-IV

Selection of clones for nutritional, disease resistance, salt and drought resistance. Germplasm preservation by tissue technology, artificial synthetic seeds. Protoplast culture -isolation of protoplasts, culture and fusion methods, Somatic hybrids and cybrids.

Reference Books

1. Plant tissue culture – theory and practice by Bhojwani S.S.
2. Plant cell culture – A practical approach by Dixion R.A.
3. Plant Cell, Tissue and Organ Culture, By Reinert, J. and YPS Bajaj (Springer – Verlag).
4. Plant tissue and cell culture, by Street, HE (Blackwell).
5. Introduction to Plant Biotechnology, Chawla, H. S. (2000), Enfield, NH: Science.
6. Introduction to Plant Tissue Culture, Razdan, M. K. (2003), Enfield, NH: Science.
7. Plant Biotechnology: an Introduction to Genetic Engineering, Slater, A., Scott, N. W., & Fowler, M. R. (2008), Oxford: Oxford University Press.
8. Biochemistry & Molecular Biology of Plants, Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015), Chichester, West Sussex: John Wiley & Sons.

PRACTICALS: PLANT TISSUE CULTURE

1. Organizing Plant tissue culture Laboratory.
2. Preparation of Tissue Culture Media.
3. Callus Induction.
4. Shoot tip culture.
5. Organogenesis.
6. Cell suspension culture.
7. Anther and Pollen cultures.

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 206
Skill Oriented Course 4(B) : Animal Handling and Preclinical Sciences
Semester : II

Course Objectives:
Students will be able to understand

- Concepts of physiology, nutrition, herd-health, and physiological parameters relevant to preclinical research
- The ethology and behaviour
- Techniques in managing animal behaviour
- Imaging Techniques in Preclinical Research

Course Outcomes:
After the successful completion of the course, students will be able to:

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Tell the importance of animal welfare in research and Ethical considerations & regulations in animal handling.	K1
CO2	Study about the animal behaviour and animal nutrition.	K2
CO3	Explain about the principles of experimental design and hypothesis testing in preclinical research	K5
CO4	Understand the imaging techniques in preclinical research. Describe the principles of pharmacokinetics and pharmacodynamics	K6

UNIT-I
Introduction to Animal Handling and Welfare
Overview of the importance of animal welfare in research. Ethical considerations and regulations in animal handling. Principles of human treatment and care. **Animal Physiology** Basic principles of animal physiology. Comparative anatomy and physiology of common laboratory animals. Physiological parameters relevant to preclinical research
UNIT-II
Animal Behavior
Introduction to ethology and behavior analysis. Understanding stress and its impact on animal behavior. Techniques for assessing and managing animal behavior in research settings.
Animal Nutrition and Husbandry Nutritional requirements of laboratory animals. Housing and environmental enrichment strategies. Management of common health issues in laboratory animals
UNIT-III
Experimental Design in Preclinical Research Principles of experimental design and hypothesis testing Good laboratory practices and data management Introduction to laboratory equipment and instrumentation. Techniques for sample collection, processing, and analysis. Quality control and assurance in preclinical research

UNIT-IV
Imaging Techniques in Preclinical Research Principles of in vivo imaging modalities (e.g., MRI, CT, PET) Image acquisition, analysis, and interpretation Applications of imaging in preclinical disease models. **Preclinical Pharmacology and Toxicology** Principles of pharmacokinetics and pharmacodynamics. Preclinical drug development process. Safety assessment and regulatory requirements in preclinical toxicology

Practicals

1. Handling Common Laboratory Species
2. Techniques: Procedures And Equipment Required For the Safe handling and restraint For Common Husbandry
3. Sexing Common Laboratory Animals
4. Health Checks Healthy Animal: Recognition of the normal behaviour and appearance Of the named Species
5. Health Checking: Observation at Rest and in Movement,
6. Detailed Examination Procedure, Clinical Signs, Recording and Reporting,
7. Protocol for Safety disposal of animal wastes.

References

- Handbook on Laboratory Animals- PV Desai and P Saravanan
- Animal Handling Techniques and Protocol Development Strategies- Bhushan P Hatwar, Arunabha Mallik, UK Jain, Satish Nayak.
- Concise Textbook of Large Animal Handling, A Practical Handbook-C.B.Chastain.

Programme : M. Sc. Biotechnology
Type of Course : Practical
Course Code : BTE- 207
Practical IV : Practical IV (related to SOC 3 & SOC 4)
Semester : II

Programme : M. Sc. Biotechnology
Type of Course : Open Online Trans-disciplinary Course (1) MOOCS / SWAYAM
Course Code : BTE 208
Semester : II

Programme : M. Sc. Biotechnology
Type of Cou : Audit Course
Course Code : BTE 209
Audit Course : Indian Knowledge Systems (II) – Herbal Heritage and Clinical Systems
Semester : II

Course Objectives:
It teaches you to recognize health conditions and the herbs and foods that address them. Further, creates an awareness among biology students about herbal remedies and clinical practice.

Learning Outcomes:
By the end of the programme the student will be able to:

- Describe the principles of herbalism
- Describe processes plant morphology and taxonomy.
- Explain terms used in herbs.
- Discuss the phytochemistry of medicinal plants
- Explain the Integrative approaches to healthcare incorporating herbal medicine
- Understand Herbal treatment protocols for specific diseases and conditions
- Understand the Clinical case studies and patient management

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Tell about the basic principles of herbalism and traditional knowledge systems.	K1
CO2	Study about the Integrative approaches to healthcare incorporating herbal medicine.	K2

UNIT-I

Introduction to Herbal Medicine

- Historical perspectives on herbal medicine
- Basic principles of herbalism and traditional knowledge systems
- Current status and trends in herbal medicine research and practice

Pharmacology of Medicinal Plants

- Introduction to phytochemistry and pharmacodynamics
- Mechanisms of action of bioactive compounds in medicinal plants
- Pharmacokinetics and metabolism of herbal products
- Quality assessment and standardization of herbal medicines

UNIT-II

Clinical Herbal Medicine

- Integrative approaches to healthcare incorporating herbal medicine
- Herbal treatment for specific diseases and conditions
- Clinical case studies and patient management
- Emerging trends and advancements in herbal medicine research
- Therapeutic potential of specific herbal compounds or plant families
- Innovative applications of herbal medicine in healthcare

Herbal Product Development and Regulation

- Process of herbal product development from bench to market
- Regulatory frameworks for herbal medicines in different countries
  Good manufacturing practices (GMP) and quality control in herbal industry

SEMESTER – III								
S. No	**Course**	**Code**	**Title of the Course**	**H/W**	**C**	**SEE**	**IA**	**Total Marks**
1	CC	BTE 301	Core course – 7 Animal Biotechnology	4	4	70	30	100
2		BTE 302	Core Course – 8(A) Plant and Agriculture Biotechnology	4	3	50	25	75
			Core Course – 8(B) Stem Cell Technology and Regenerative Medicine					
3		BTE 303	Core Course – 9(A) Environmental Biotechnology	4	3	50	25	75
			Core Course – 9(B) Solid Waste Management					
4	P	BTE 304	Practical V (related to CC 8 & 9)	6	2	35	15	50
5		BTE 305	Skill Oriented Course – 5(A) Food and Industrial Biotechnology	4	3	50	25	75

	SOC		Skill Oriented Course – 5(B) Medical Biotechnology and Vaccinology					
6		BTE 306	Skill Oriented Course – 6(A) IPR, Biosafety Bioethics & Bioentrepreneurship	4	3	40	25	75
			Skill Oriented Course – 6(B) Basics of Organic Farming and Bioentrpreneurship					
7	P	BTE 307	Practical VI (related to SOC 5 & 6)	6	2	35	15	50
8	OOTC	BTE 308	Open Online Transdisciplinary Course – 2	-	2	-	100	100
*	Seminar/tutorials/ remedial classes and Quiz as part of internal assessment			4	-	-	-	-
			Total	**36**	**22**	**340**	**260**	**600**

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 301
Core - 7 : Animal Biotechnology
Semester : III

Course objectives:

1. These objectives will provide knowledge animal cell culture and its applications
2. These objectives will provide students able to understand the nature of stem cell biology, its applications in stem cell therapy and regenerative medicine.
3. These objectives will provide students with a thorough understanding of reproductive biology, IVF technology, reproductive health and fertility treatment.
4. These objectives will provide students with a comprehensive understanding the production of transgenic animals and its applications in biomedical research.

Course Outcomes:
After the successful completion of the course, students will be able to learn about:

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	animal cell culture and discuss its applications	K2
CO2	stem cell culture and discuss about Clinical applications of stem cell therapy	K4
CO3	Reproductive Biology and IVF	K5
CO4	Transgenic technology -Development of transgenic mice and other animal models	K5

UNIT-I
Animal cell culture: cell culture media and reagents; culture of mammalian cells, tissues and organs; primary culture, secondary culture, continuous cell lines, suspension cultures.
Application of animal cell culture for virus isolation and in vitro testing of drugs, environmental pollutants, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT-II
Stem cell culture -The biology of stem cells – Different types of stem cells – embryonic stem cells, fetal tissue stem cells, adult stem cells - stem cell differentiation, stem cell plasticity. Isolation and propagation of embryonic stem cells.
Clinical applications of stem cell therapy - neurodegenerative diseases (Parkinson's disease, Alzeimer's, spinal cord injury, other brain syndromes), tissue systems failures (diabetes, cardiomyopathy, kidney failure, liver failure), haemophilia, lymphoma and leukaemia.

UNIT-III
Reproductive Biology and IVF -Structure and function of male reproductive system - Hormonal regulation of spermatogenesis; Structure and function of female reproductive system - influence of hormones on development of ovarian follicles and oogenesis; Reproductive cycles - menstrual cycle; Ovulation, atresia and corpus luteum formation; Implantation and placentation. Pregnancy and lactation; *in vitro* fertilization (IVF), Embryo transfer - ICSI and preservation of

endangered species.

UNIT – IV

Transgenic technology -Development of transgenic mice and other animal models (fish and sheep) by injection of foreign DNA/gene into zygote; optimization of construct for *in vivo* expression. Potential application of transgenic animals: Models for various diseases/disorders (knock out mice), Production of peptides and proteins of biopharmaceutical interest (molecular pharming)

.

REFERENCE

1. R. Ian Freshney, "Culture of animal cells – A manual of basic techniques" 4th edition, John Wiley & Sons, Inc, publication, New York. 2000
2. Daniel R. Marshak, Richard L.Gardner, David Gottllieb "Stem cell Biology" edited by Daniel Cold Spring Harbour Laboratory press, New York. 2001
3. M.M. Ranga, Animal Biotechnology; Agrobios (India) ,2006.
4. Butterworth " Invitro cultivation of Animal Cells"– Heinemann publishers – Open Universities. Nederland, 1994.
5. J. Kruzer , "Recombinant DNA & Biotechnology for Teachers", 2nd Edition, Adrianne Massey, A. Massey & Association.
6. John R.W. Master "Animal Cell culture", University College London, Oxford University press, 2000.
7. ANN A. KIESSLING, SCOTT ANDERSON, Human Embryonic Stem Cells, Jones & Bartlett Publishers, Sudbury, Massachusetts, Boston, Toronto, London, 2003.
8. A.J. Thomson, Gene Targeting & embryonic Stem Cells, Bios Scientific Publishers, Taylor & Francis Group London & New york.
9. B.D.Singh, Biotechnology, Kalyani Publishers, udhiana, New Dehli, Noida (U.P) 2003
10. P.K.Gupta, Biotechnology and Genomics, Rostogi Publications, Shivaji Road Meerut, India. 2005

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 302
Core - 8 (A) : Plant & Agriculture Biotechnology
Semester : III

Course Objectives:

Students will be able to

- Gain fundamental knowledge in plant biotechnology and their applications.
- Understand the application of plants as bioreactors for the production of secondary metabolites, enzymes, food and food additives.
- Gain knowledge about Algae as a source of food, feed, single cell proteins, biofertilizers.
- Understand the application of phytodiagnostics based on immunological and molecular techniques

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Know about Application of genetic engineering technology for crop improvement	K2
CO2	Discuss about Plant secondary metabolites and their pathways	K3
CO3	Study about Algal technology	K4
CO4	Explain the concept of phytodiagnostics based on immunological and molecular techniques	K6

UNIT – I

Gene Transfer in Plants - Plant genome organization (nuclear, chloroplast, mitochondrial) and expression, Gene cloning, tools of genetic engineering, Vectors and Plant viral vectors (Ti plasmid & Ri Plasmid vectors), Selectable markers, Reporter genes and Promoters used in plant vectors. Mechanism of T-DNA transfer mechanism, Agrobacterium mediated DNA transformation. Direct transformation of plants by physical methods, status and expression of transferred genes.

UNIT – II

Application of genetic engineering technology for crop improvement - production of transgenic plants resistant to herbicides, pathogens, pests and abiotic stresses (drought, salt, frosts); production of transgenic plants with improved yields and nutritional quality; transgenic plants for production of viral antigens. Breeding strategies for enhancing the active principles in plants.

UNIT – III

Algae as a source of food, feed, single cell proteins, biofertilizers, industrial uses of algae. Mass cultivation of commercially valuable marine microalgae for agar agar, alginates and other products of commerce and their uses. Mass cultivation of macroalgae as a source of protein and feed. Indoor and outdoor cultivation of economic important algae – Use of algae in waste water treatment.

UNIT – IV

Nutrient film culture techniques - plant diseases – Physiology of infection in plants – disease resistance in plants - phytodiagnostics based on immunological and molecular techniques. Biological control of pests and diseases of crop plants and weeds - biopesticides - predators, parasites, insect viruses, antagonistic fungi and bacteria, antifeedants, and insecticidal activities of the compounds of Botanicals.

References

1. Ray V. Herren, Introduction to Biotechnology an Agricultural Revolution Thomson Delmar Learning, 2005.
2. Maarten J. Chrispeels & David E. Sadava, Plants, Genes and Crop Biotechnology, Jones and Bartlett Publishers, 2003.
3. Adrian Stator, Nigel Scott and Mark Fowler (Eds) : Plant Biotechnology – The Genetic Manipulation of Plants, Oxford University Press, 2003.
4. H.S.Chawla : Biotechnology in Crop improvement, International Book Distributing Company, 1998.
5. P.K. Gupta **:** Biotechnology & Genomics, Rastogi Publishers Co. Meerut, 2004.
6. Metabolic Engineering of Plant Secondary Metabolism ; R. Verpoorte & A.W. Alfermann ; Kluwer Academic Publishers, 2000.
7. Plant Biochemistry & Molecular Biology, 2nd Ed., Edited by P.J.Lea & R.C. Leegood, 1999; John Wiley & Sons Ltd.,
8. J. *Hammond, P. MCGarvey and V. Yusibov (Eds.): Plant Biotechnology. Springer Verlag, 2000.*
9. *T-J. Fu, G. Singh, and W.R. Curtis (Eds.): Plant Cell and Tissue Culture for the Production of Food Ingredients. Kluwer Academic/Plenum Press. 1999.*

Practicals

1. Preparation of media.
2. Surface sterilization.
3. Induction of Callus and Establishment of cell suspension cultures.

4. Production of secondary metabolites in cell suspension culture
5. Agro bacterium culture, selection of putative transformants

Programme : M. Sc. Biotechnology
Type of Course : Core
Course Code : BTE 302
Core – 8 (B) : Stem Cell Technology and Regenerative Medicine
Semester : III

Course Objectives:
Students will be able to

- Understand the properties, proliferation, culture of stem cells and medical applications of stem cells.
- Learn about about Stem Cell biology and therapy, types embryonic stem cell.
- Know about about the Gene Therapy: Introduction, History and evolution of Gene therapy, optimal disease targets
- Increasing awareness of professional, ethical and social responsibilities with relationship to Stem cell and Regenerative Medicine.

Course Outcomes:
After the successful completion of the course, students will be able to:

COs	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Define the properties, proliferation, culture of stem cells and medical applications of stem cells.	K1
CO2	learn about Therapeutic applications of stem cells	K2
CO3	Explain about the Gene Therapy: Introduction, History and evolution of Gene therapy, optimal disease targets.	K5
CO4	Discuss about the Ethical Issues associated with stem cell-based regenerative medicine field. Demonstrate the stem cell Therapy (SCT) for degenerative neuronal diseases.	K2

UNIT – I
Introduction to stem cells: Definition, properties, proliferation, culture of stem cells, medical applications of stem cells, ethical and legal issues in use of stem cells.

UNIT – II
Types of stem cells: Stem Cell biology and therapy, types embryonic stem cell, Adult stem cell, Stem Cell Biology and Therapy, Embryonic Stem Cells, culture and the potential benefits of stem cell technology Module

UNIT – III
Therapeutic applications of stem cells: Gene Therapy: Introduction, History and evolution of Gene therapy, optimal disease targets, Failures and successes with gene therapy and future prospects, Genetic Perspectives for Gene Therapy, Gene Delivery methods: Viral vectors and Non-viral Vectors

UNIT – IV
Ethical Issues associated with stem cell-based regenerative medicine field Regulatory and Ethical Considerations of stem cell and Gene Therapy, Assessing Human Stem Cell Safety, Use of Genetically Modified Stem Cells in Experimental Gene Therapies

Stem Cell Regeneration: Application of stem cell Therapy (SCT) for degenerative neuronal

diseases (Parkinson disease, Motor neuron disease) and demyelinating diseases (Multiple sclerosis) Stem Cell Therapy in stroke, Stem Cell Therapy in spinal cord regeneration. Stem Cell Therapy for muscular dystrophies

Reference Books:

1. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press
2. Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
3. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer,
4. Stem Cell Biology and Gene Therapy. Quesenberry PJ, Stein GS, eds. (£65.00.) Wiley, 1998.
5. Progress in gene therapy, Volume 2,Pioneering stem cell/gene therapy trials, Roger Bertolotti, Keiya Ozawa and H. Kirk Hammond, VSP international science publishers
6. Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,
7. Human Embryonic Stem Cells: The Practical Handbook by Stephen Sullivan and Chad A Cowan.

Practicals:

1. Isolation of stem cell from endometrial tissue
2. Stem cell counting and viability checking
3. Cell proliferation assay
4. Growth curve and PDT analysis
5. Characterization of stem cells
6. Embryo culture and in-vitro fertilization techniques
7. Embroid body formation
8. Differentiation of stem cells into various lineages
9. Cancer stem cell- isolation
10. Case studies of stem cell therapy for various diseases

Programme : M. Sc., Biotechnology
Type of Course : Core
Course Code : BTE-303
Core - 9(A) : Environmental Biotechnology
Semester : III

Course Objectives:

This course aims to

- Introduce Types, methods for the measurement of pollution and Environmental Monitoring by using biosensors.
- To understand various approaches and principles in bioremediation
- Learn the usage of extremophiles for Biomedical & biotechnological applications
- Understand the usage of extremophiles for Biomedical & biotechnological applications,

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Demonstrate different Types, methods for the measurement of pollution and Environmental Monitoring by using biosensors.	K3
CO2	Explain concepts & principles of Bioremediation and Microbiology for degradation of xenobiotics in environment.	K5
CO3	Know Microbes in extreme environment, microbial biofilms, Biofouling & corrosion, antifouling paints, Biofertilizers, Biopesticides, Vermiculture.	K4
CO4	Understand the microbial groups involved in biogas production & interactions, Biodiversity-levels and environmental safety guidelines.	K6

UNIT – I

Environmental Pollution : Types of pollution, methods for the measurement of air pollution, air pollution & its control through Biotechnology, Biofilters, Bioscrubbers, Biotrickling filter, Environmental Monitoring using biosensors.

Water pollution & its control: measurement of water pollution, waste water treatment – physical, chemical & biological treatment processes .microbiology of waste water treatment-aerobic process-activated sludge, oxidation ditches, trickling filters, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic Digestion, Treatment schemes for waste waters of dairy distillery, tannery, Skin & Hide processing, sugar, antibiotic Industries

UNIT – II

Bioremediation: concepts & principles of Bioremediation, in-situ & ex-situ bioremediation, bioremediation of heavy metal ions, concepts of phyto remediation. Role of genetically modified & genetically engineered microbes. Microbiology of degradation of xenobiotics in environment, degradative plasmids, hydrocarbons, role of oxygenases in degradation metabolism of hydrocarbons, biosafety in relation to transgenic microorganisms, plants & animals.

UNIT –III

Microbes in extreme environment: extremophiles, Biomedical & biotechnological applications, microbial biofilms, Biofouling & corrosion, antifouling paints, biotechnological approach to biofoulng control, aerobic & anaerobic induced corrosion. Biofertilizers, Biopesticides, vermiculture. Microbial leaching, Metal transformation, accumulation and immobilization by microbes. Application of microbes in mining and petroleum industry. Microbial enhanced oil recovery.

UNIT – IV

Bio fuels, biogas, microbial groups involved in biogas production & interactions, factors affecting biogas production. Biodiversity-levels of biodiversity, mega diversity centres, hot spot analysis, biodiversity conservation (in-situ & ex-situ), Role of biotechnology in conservation of biodiversity, environmental safety guidelines.

References:

1. MetCalfe and Eddy Inc., Wastewater Engineering: Treatment, Disposal and Reuse", 4th Edition, McGraw Hill Book Co., 2003
2. Mackenzie L. Davis and David A. Cornwell, Introduct6ion to Environmental Engineering, 4th Edition, McGraw Hill Book Co.,2006.Michael T. Madigan, John M. Martinko& Jock Parker, Brock Biology of Micro organisms, Pearson Education, International Prentice Hall, 2003.
3. Michael J. Pelczar, JR, E.C.S. Chan & Noel R. Krieg, Microbiology, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
4. K. Vijaya Ramesh, Environmental Microbiology, MJP Publishers, Chennai, 2004.
5. A.G. Murugesan, C. Raja Kumari, Environmental Science & Biotechnology - Theory& Techniques, MJP Publishers, 2005.
6. Environmental microbiology by RainaM.Maier Ian L.Pepper& Charles P.Gerba,Academic press, 2000.
7. Environmental Chemistry, A.K. De. Wiley Eastern Ltd., New Delhi
8. Introduction of Biodeterioration, D. Allsopp and K.J. Seal, ELBS/Edward Arnold
9. Microbial Ecology – "Fundamentals and applications" by Atlas R.M., Bartha R. Benjamin/ cummings publishing company, Inc. 4th edition. 1998
10. Aquatic Microbiology: Am Ecological Approach, by Ford, T.E. (ed.) Blackwell, Boston. 1993
11. Power un seen: How microbes rule the world. By Dixon, B. Freeman/ Spectrum, Oxford. 1994.
12. Environmental Microbiology. By. Mitchell. R. Wiley, New York. 1992.
13. Introduction to Environmental Sciences, Y. Anjaneyulu- BS Publications, 2004

Practicals

1. Determination of biochemical oxygen demand (BOD) of water
2. Determination of chemical oxygen demand (COD) of water
3. Estimation of chlorides from polluted and non polluted water
4. Estimation of carbonates from polluted and non polluted water
5. Estimation of Ammonia content in water samples.
6. Estimation of total dissolved solids and conductivity relation.

Programme : M. Sc., Biotechnology
Type of Course : Core
Course Code : BTE-303
Core - 9(B) : Solid Waste Management
Semester : III

Course Objectives:

Student will be able to

1. Know about different types of solid waste
2. Understand about the Storage, Collection and Transportation of Municipal Solid Waste.
3. Learn about concept of composting of solid waste
4. Define Biomedical and E-waste management

Course outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Know about definition of solid waste, different solid waste- domestic Waste, commercial waste, industrial waste, market waste, agricultural waste, biomedical waste	K1
CO2	Discuss about the Storage, Collection and Transportation of Municipal Solid Waste.	K2
CO3	Discuss about the principle and process of composting waste..	K5
CO4	Explain the Solid waste management techniques, solid waste management hierarchy waste prevention and waste reduction techniques	K2
CO5	Define Bio medical Waste. Sources and generation of Biomedical Waste and its classification Bio medical waste Management technologies.	K4

UNIT-1

Introduction: Definition of solid waste, different solid waste- domestic Waste, commercial waste, industrial waste, market waste, agricultural waste, biomedical waste, E-waste, hazardous waste, institutional waste, etc.Sources of solid waste, Classification of solid waste -hazardous and noN hazardous waste..Physical and chemical characteristics of municipal solid waste

UNIT-II

Storage, Collection and Transportation of Municipal Solid Waste.-Collection, segregation, storage and transportation of solid waste.Tools and Equipment-Litter Bin, Broom, Shovels, Handcarts, Mechanical road sweepers, Community bin - like movable and stationary bin.Transportation vehicles with their working capacity -Animal carts, Autovehicles, Tractors or Trailers, Trucks, Dumpers, Compactor vehicles. Transfer station- meaning, necessity, location.Role of rag pickers and their utility for society

UNIT-III

Composting of Solid Waste-Concept of composting of waste, Principles of composting process. Factors affecting the composting process. Methods of composting-Manual Composting-Bangalore method, Indore Method, Mechanical Composting-Dano Process, Vermi composting.

Techniques for Disposal of Solid Waste- Solid waste management techniques solid waste management hierarchy waste prevention and waste reduction techniques Land filing technique, Factors to be considered for site selection, Land filling methods-Area method, Trench method and Ramp method, Leachate and its control, Biogas from landfil, Advantages and disadvantages

of landfill method, Recycling of municipal solid waste Incineration of waste: Introduction of incineration process, Types of incinerators Flash, Multiple chamber Incinerators, Products of incineration process with their use, Pyrolysis of waste -Definition, Methods

UNIT- IV

Biomedical and E-waste management

Definition of Bio medical Waste. Sources and generation of Biomedical Waste and its classification Bio medical waste Management technologies. Definition, varieties and ill effects of E- waste, Recycling and disposal of E-waste

References :

1.Gupta O.P, Elements of Solid Hazardous Waste Management, Khanna Book Publishing Co., Delhi Ed. 2018

2. Bhide, A. D., Solid Waste Management, Indian National Scientific Documentation Centre, New Delhi.

3. George Techobanoglous, Kreith, Frank., Solid Waste, McGraw Hill Publication, New Delhi.

4. Sasikumar, K., Solid Waste Management, PHI learning, Delhi.

5. Hosetti, B.B., Prospect and Perspectives of Solid Waste Management, New Age International Publisher Disaster Management, Fly ash generation & utilization, Primary, secondary &tertiary & advance treatment of various effluents Solid Waste Management CPCB. New Delhi.

7. Ecotechnology for pollution control & environmental manage ment - By R.K. Trivedi & Arvind Kr. Basic Environmental Technology - J.A. Nathanson

Practicals:

1. Rules for waste management disposal
2. Role of CPCB(Central Pollution Control Board).
3. Characterization of municipal solid waste including heavy metals: Particle density, ignitibility, and bulk density,
4. Characterization of municipal solid waste-moisture content, porosity.
5. Incineration Process
6. Concept of composting of waste
7. Methods of composting

Programme **: M. Sc. Biotechnology**
Type of Course **: Practical V**
Course Code **: BTE 304**
Practical I **:** Practical V (related to CC 8 & 9)
Semester **: III**

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 305
Skill Oriented Course 5(A) : Food and Industrial Biotechnology
Semester : III

Course Objectives:

1. The students would acquire basic knowledge on Principles of food processing. Food spoilage.
2. To enable students to understand concept of microbial Production of Alcohols & Beverages
3. The students will be able to acquire knowledge about Biotechnological approaches in dairy industries
4. The students will learn about Role of enzymes in Brewing, Baking and in the production of flavours

Course Outcomes:

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

CO	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Principles of food processing. Food spoilage	K3
CO2	Explain concept of microbial Production of Alcohols & Beverages	K2
CO3	Illustrate various Methods Biotechnological approaches in dairy industries	K5
CO4	Understand the Principles of Role of enzymes in Brewing, Baking and in the production of flavours	K6

UNIT – I

Food Technology: Principles of food processing. Food spoilage - Physical & Microbial. Food preservation techniques and their applications. Food additives - colours, sweetners - natural & artificial. Probiotics and their uses - Probiotic foods - mode of action – properties - pre requisites - starter cultures. Production of Yogurt, Cheese, Saurkart, Temphe Production and applications in food preservation using bacteriocins from lactic acid bacteria. Biotechnological approaches in food industry.

UNIT – II

Microbial Production of Alcohols & Beverages: Wine, beer, ethanol & acetone-butanol, Organic acids: Citric acid and acetic acid (Vinegar). Aminoacids: Aspartic acid and Lysine. Antibiotics: Penicillin & streptomycin. Enzymes: Amylases & proteases. Vitamins: $B_2, B_{12.}$

UNIT – III

Biotechnological approaches in dairy industries - Immobilized enzymes- methods-merits-application - Acceleration of cheese ripening - merits and demerits- application- Enzyme modified cheese- need- advantage- their utilization in ripening of cheese. Bio Sweeteners - Bio Preservatives- Bio peptides-productions-functions-Bio detergents-applications- Bio films mechanism effects its control.

UNIT – IV

Role of enzymes in Brewing, Baking - fungal -amylase for bread making; maltogenic -amylases for anti-staling; xylanses and pentosanases as dough conditioners; lipases or dough conditioning; oxidases as replacers of chemical oxidants; synergistic effect of enzymes

Role of enzymes in the production of flavours - enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides, MSG; flavours

from hydrolyzed vegetable/animal protein

REFERENCES

1. Frazier, W.C., and D.C. Esthoff: Food Microbiology, 4 th ed., McGraw-Hill, New York,1988.
2. Fermentation : A Practical approach. 1990. B. Mc Neil and L.M. Harvey. IRL Press. PP 226.
3. Manual of Industrial Microbiology and Biotechnology. 1986. Edited by Arnold L. Demain and Nadine. A. Solomon. PP 466.
4. Bioreactors in Biotechnology – A Practical Approach. AR. Seregg.
5. Industrial Microbiology by Samuel Cate Prescott and Cecil Gordon Dunn
6. Industrial Microbiology by L.E.J.R.Casida

Practical Course books

1. Manual of Industrial microbiology and biotechnology. 1986. Edited by Arnold L. Demain and Nadine. A.Solomon. PP 466.
2. Vanderzant, C., and D. Splittstoesser. : Compendium of Methods for the Microbiological Examination of Foods, American Public Health Association, Washington, D.C. 1992.

Practicals

1. Estimation of citric acid by titrimetry method.
2. Fermentative production of ethanol by yeast
3. Estimation of ethanol by colorimetric method.
4. Production of wine from grapes.
5. Production of Saukeraut
6. Bacterial examination of milk by dye reduction method
7. Identification microbial contamination in milk
8. Isolation of probiotics (Lactobacillus sp.) from curd.
9. Production of Cheese

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 305
Skill Oriented Course 5(B) : Medical Biotechnology and Vaccinology
Semester : III

Course Objectives:

Students will be able to Illustrate

1. The origin, significance,diagnosis & techniques. Know about the biology of diseases.
2. Study about the prognosis and diagnosis.
3. Explain about principle and applications of modern therapeutics.
4. Discuss about vaccine and vaccine technologies.

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss about the origin, significance,diagnosis & techniques. Know about the biology of diseases.	K1
CO2	Study about the prognosis and diagnosis.	K4

CO3	Explain about principle and applications of modern therapeutics.	K2
CO4	Discuss about vaccine and vaccine technologies.	K6

UNIT-I

Introduction – Origin, significance & worldwide market of Medical Biotechnology. Revolution in clinical diagnosis, Antibody and Nucleic Acid Hybridization techniques, Imaging techniques (Nanodiagnosis).

The Biology of disease- Infectious diseases, inflammatory diseases, the molecular basis of Senescence and cell death, Neurodegenerative diseases and Chromosome abnormalities.

UNIT-II

Prognosis and Diagnostics- Immunodiagnostics, genetic diagnosis, protein markers and identification of disease specific markers, microarrays, automated workstations, genetic testing-neonatal screening. Biosensors in clinical diagnosis, Use of nucleic acid probes and antibodies in clinical diagnosis and tissue typing. Nanotechnology in diagnosis.

UNIT-III

Modern Therapeutics-Stem cells in therapy, Gene Therapy: basic approaches to gene therapy, vectors used in gene therapy, applications of gene therapy in cancer, genetic disorders and AIDS. Therapeutic proteins, interleukins, interferons – principle, production and applications. Biotechnological approaches to obtain blood products: Tissue plasminogen activator and erythropoietin. Nutraceuticals- Food derived bioactive peptides. production of single cell protein. Chiral technology - Principle and applications

UNIT IV

Vaccines and Vaccine Technologies- History of vaccines, Conventional vaccines: Bacterial and Viral vaccine. Vaccine based on routes of administration. Minicells as vaccines, impact of genetic engineering on vaccine production. New Vaccine Technologies - Rationally designed vaccines, DNA vaccination, Mucosal vaccination, New approaches for vaccine delivery, Engineering virus vectors for vaccination, Vaccines for targeted delivery systems. Disease specific vaccines: Tuberculosis vaccine, Malaria vaccine, HIV/AIDS vaccine. New Emerging diseases and vaccine needs –Ebola, Zika, SARS-CoV2.

Text Books:

1. Pongracz J, Keen M. Medical Biotechnology. First Edition, Churchill Livingstone, Elsevier Publication, UK, 2009.
2. Trivedi PC. Medical Biotechnology, First Edition, Aavishkar Publisher Distrib. Jaipur, India, 2008.
3. Albert Sasson. Medical Biotechnology: Achievements, Prospects and Perceptions. United Nations University Press, 2005.
4. Kun LY. Microbial Biotechnology – Principles and applications. World Science publications, 2004
5. Glick BR & Patten CL. Molecular Biotechnology: Principles and applications of Recombinant DNA, Fifth Edition, ASM press, 2017.

References:

1. Marks AR &Neiil US. Textbook of Molecular Medicine - Science in Medicine, Jones and Bartlett Learning, New Delhi; 2010.
2. Glazer AN, Nikaido H. Microbial Biotechnology – Fundamentals of Applied Microbiology WH Freeman, New York 1994.
3. Vyas. Methods in Biotechnology and Bioengineering, CBS publications, 2003.
4. Marshak et al., Stem cell Biology. CSHL publications, 2002.

Practicals:

1. Biochemical test for identification of bacteria
2. Extraction and separation of Antigen proteins from Bacteria & protozoa
3. Estimation of blood glucose.
4. Estimation of cholesterol in blood.
5. Estimation of iron in blood.

6. Biological synthesis of nanoparticles
7. Detection of plasmodium pathogen using peripheral smear
8. Widal test.

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 305
Skill Oriented Course 6(A) : IPR, Biosafety, Bioethics & Bioentrepreneurship
Semester : III

Course Objectives:

Students should be able to

- Gain Knowledge of economic and legal impacts of biotechnology
- Get an insight into Biological Safety Cabinets & their types
- Understand the Intellectual property Rights
- Understand the process of filing a patent

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Illustrate about Bioethics:Socio – economic and legal impacts of biotechnology, rDNA guidelines, national and international guidelines, experimental protocols approval, levels of containment.	K1
CO2	Explain Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganism.	K2
CO3	Define IPR, Types of IPR, Patents to Trade secrets, copyrights, trademarks – legal Implications, Evaluation of patenting.	K5
CO4	Discuss about the Recent Amendments, filing of a patent application – Precautions before patenting- disclosure/non-disclosure. Know Franchising Enterpreneurshipopportunities for Enthusiastic young Women Biotechnologists.	K2

UNIT – I

Bioethics:Socio – economic and legal impacts of biotechnology, rDNA guidelines, national and international guidelines, experimental protocols approval, levels of containment. (a) Use of genetically modified organisms, their release in the environment, Ethics and Genetic Engineering, Patent of Genes. Human cloning, Stem cells, Regulatory requirements for drugs and biologics. GLP, GMP. Testing of Drugs on Human Volunteers Public and Non-Governmental Organizations (NGOs) Participation in Biosafety and Protection of Biodiversity.

UNIT-II

Introduction, biosafety issues; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms. Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture

UNIT – III

Intellectual property Rights: Definition of IPR, Types of IPR, Patents to Trade secrets, copyrights, trademarks – legal Implications, Evaluation of patenting, IP relevance to Biotechnology and few case studies, Application GATT & IPR, WTO Act, Global & Indian biodiversity act.

UNIT – IV

Indian Patent Act 1970, Recent Amendments filing of a patent application – Precautions before patenting- disclosure/non-disclosure – Role of a country patent office, U.S. Patent Trademark Office, U.S. Patent system Vs Indian Patent System.

Technopreneurship, Women entrepreneurship, Portfolio entrepreneurship, Franchising. Entrepreneurship opportunities for Enthusiastic Young Women Biotechnologists. Role of institutions in promoting entrepreneurship- Funding opportunities and incubation centers.

Text Books:

1. Introduction to Plant Biotechnology, H S Chawla
2. M K Sateesh .Bioethics and Biosafety. Kindle Edition
3. Shomini Parashar, Deepa Goel IPR, Biosafety and Bioethics Pearson India 2013

Reference Books:

1. Private Power, Public Law: The Globalization of Intellectual Property Rights By Susan K. Sell Cambridge University Press, 2000
2. Essentials of Intellectual Property: Law, Economics, and Strategy By Alexander I. Poltorak; Paul J. Lerner Wiley, 2011 (2nd edition)
3. Diane O. Fleming, Debra L. Hunt Biological Safety: Principles and Practices, 4th Edition. ASM 2006.

Practicals

1 Filing a Patent
2 Protection of Biodiversity and Case studies
3 Case study on Bt-Cotton
4 Case study on Golden rice
5. Case study on Bt – Brinjal
6. Intellectual property rights and protection
7. Assessing Entrepreneur Potential
8. Assessment of problem-solving ability

Programme : M. Sc. Biotechnology
Type of Course : Skill Oriented Course
Course Code : BTE 306
Skill Oriented Course 6(B) : Basics for Organic Farming and Bioentrepreneurship
Semester : III

Course Objectives:

- To study basic concept of organic farming, essentialities of organic farming
- To study about the processing technologies like solar drying, freeze drying, hot air chambers and use of bio-degradable materials & Biofertilizers
- To study the certification Process and Economics of Organic farming
- To understand the franchising enterpreneurship opportunities for enthusiastic young Women Biotechnologists

Course Outcomes:

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

CO Nos	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss about the preparation of bio-pesticide inputs recommended for organic farming	K1
CO2	Study about the processing technologies like solar drying, freeze drying, hot air chambers and use of bio-degradable materials & Biofertilizers.	K2
CO3	Define about Certification Process and Economics of Organic farming.	K5
CO4	Know Franchising Enterpreneurship opportunities for Enthusiastic	K2

	young Women Biotechnologists Explain the Importance of Finance for Bio business –Sectorial support by Government of India - policies, and frameworks	

UNIT I

Introduction to Organic Farming. Preparation of bio-pesticide inputs recommended for organic farming : Name of the input, Source and Preparation and Time, rate and purpose of application : Panchagavya , Lantana leaf extract 10% , Derisom , Pestoneem , Vermiwash , Botanicals , Anonine. **Essentialities of Organic Farming:** Soil and water conservation: Measures like stone pitching/contour wall construction are to be taken up to prevent soil erosion. Contamination control.

UNIT II

Processing: Processing technologies like solar drying, freeze drying, hot air chambers are permitted. Irradiation of agricultural produce is not permitted. Labelling and Packaging. Use of bio-degradable materials Biofertilizers – Definition, kinds, microbes as biofertilizers, Symbioticassociates – Rhizobium taxonomy, Physiology, Host cell – Rhizobium interactions, inoculants and mass cultivation.

Biopesticides – Definition, kinds and commerce of biopesticide, Bacillus thuringiensis, insect viruses and entomopathogenic fungi – its characteristics, physiology, mechanism of action and application

UNIT III

Certification Process and Economics of Organic farming: Certification of organic farms. Role of Certification agency. Central and Stage Certification agencies. Certification Process and its benefits. **Economics of Organic Farming** : Cost and Net Return of organic production Vs inorganic production. The cost of cultivation, handing of bulky nature of organic manures. Benefit: Cost ratio of important cropping systems experimented under NPOF.

UNIT IV

Technopreneurship- Women entrepreneurship, Portfolio entrepreneurship, Franchising. Enterpreneurship oppurtunities for Enthusiastic young Women Biotechnologists. Role of institutions in promoting entrepreneurship- Funding opportunities and incubation centers.

Entrepreneurship, **Entrepreneur, Enterprise**. Qualities of a successful entrepreneur. Stages of Entrepreneurship. Business Plan development schemes for women entrepreneurs. Current trends in entrepreneurship. History of evolution of Bio Business, Importance of Finance for Bio business – Sectorial support by Government of India - policies, and frameworks.

References:

1. Subba Rao, N.S. 2000 Soil Microbiology. Oxford and IBH Publishing Co.Ltd.
2. Verma A and Hock B. 1995. Mycorrhiza.
3. Yaacovokan, 1994 - Axospirillum, CBC press.
4. Wicklow, D.T. and B.E. Soderstrom. 1997, Environmental and microbial relationships. Springer

Practicals:

1. Visit of organic farms to study the various components and their utilization.
2. Preparation of enrich compost
3. Preparation of Vermicompost
4. Cost of organic production system
5. Quality aspect
6. Assessing Entrepreneur Potential
7. Assessment of problem-solving ability
8. Creativity in Business

9. Conducting market survey to know the demand for different products

Programme : **M. Sc. Biotechnology**
Type of Course : **Practical**
Course Code : **BTE- 304**
Practical VI : Practical VI (related to SOC 5 & 6)
Semester : **III**

Programme : **M. Sc. Biotechnology**
Type of Course : **Open Online Trans-disciplinary Course (1) MOOCS / SWAYAM**
Course Code : **BTE 308**
Semester : **III**

Programme : **M. Sc. Biotechnology**
Type of Course : **Open Online Skill Development Course's MOOCS / SWAYAM**
Course Code : **BTE 401**
Semester : **IV**

Programme : **M. Sc. Biotechnology**
Project : **Multi-Disciplinary Project**
Type of Course : **Project**
Course No. : **BTE 402**
Semester : **IV**

Dissertation – Thesis Submission, Project External Evaluation and Viva-voce

M. Sc. Biotechnology :: Model Question paper

Semester I/II/III-CORE-I Paper

Time 3 Hrs **Max marks 70**

Attempt any five from part A (5 x 4=20 marks) and all from part B (4 x 12.5=50 marks)

PART A (5 x 4=20 marks)

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4 x 12.5=50 marks)

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B

M. Sc. Biotechnology :: Model Question paper

Semester I/II/III-CORE/SOC Paper

Time 2 Hrs **Max marks: 50**

Attempt any five from part A (5 x 4=20 marks) and all from part B (4 x 7.5=30 marks)

PART A (5x 4=20 marks)

1. Unit 1
2. Unit 1
3. Unit 2
4. Unit 2
5. Unit 3
6. Unit 3
7. Unit 4
8. Unit 4

PART B (4 x 7.5=30 marks)

9. Unit 1 A or B
10. Unit 2 A or B
11. Unit 3 A or B
12. Unit 4 A or B

Eligibility and Credit Requirement for admission in M. Sc. Biotechnology Programme

i. A 3 year B.Sc. Degree with either Biotechnology as Major or Minor discipline with minimum of 120 credits for 2 years M. Sc. Biotechnology Programme.

ii. A student with B.Sc. Degree with either Biotechnology as Major or Minor discipline with 4 year Honours / Honours with Research is eligible for lateral entry into 2nd year M. Sc. Biotechnology Programme (i.e., III Semester) of the M. Sc. Biotechnology Programme, for whom 20% of supernumerary seats shall be sanctioned in 2nd year (i.e., III Semester).

iii. While awarding **M. Sc. Biotechnology** degree for one year **M. Sc. Biotechnology** with lateral entry the Provisional Certificate and the **M. Sc. Biotechnology** Degree shall clearly mention that one year **M. Sc. Biotechnology** degree is awarded after completing 4 year UG Honours / Honours Research Programme.

4. Multiple Entry and Exit Options:

i. If the Student exits after successful completion of all courses of 1st year **M. Sc. Biotechnology**
Programme, in a single attempt, such students may be awarded **M. Sc. Biotechnology Diploma**.

ii. Such students may be permitted to take re-admission and continue the **M. Sc. Biotechnology** programme with in a period of **Three years** from the date of exit.

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