(For the Candidates Admitted From 2023 - 2024 Onwards)
HOLY CROSS COLLEGE (AUTONOMOUS) TIRUCHIRAPPALLI
UG - COURSE PATTERN (2023-2024 ONWARDS) – TANSCHE
SCHOOL OF LIFE SCIENCES
PG & RESEARCH DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

Semester	Part	Course	Title of the Paper	Code	Hours	Credits
I	I	Language	General Tamil/Hindi/French	U23TL1GEN01/ U23HN1HIN01/ U23FR1FRE01	6	3
	II	English	General English	U23EL1GEN01	6	3
	III	Core Course I	Cell and Molecular Developmental Biology	U23BT1CCT01	4	4
		Core Course - II Practical	Practical I - Cell and Molecular Developmental Biology	U23BT1CCP02	4	3
		Allied Course I	Biological Chemistry	U23BT1ALT01	4	4
		Allied Course II Practical	Biological Chemistry	U23BT1ALP02	2	2
	IV	SEC I (NME I)	Organic Beverage Production	U23BT1SET01	2	2
		Foundation Course	Biology to Biotechnology	U23BT1FCT01	2	2
		Value Education			-	-
		Total			30	23
II	I	Language	General Tamil/Hindi/French	U23TL2GEN02/ U23HN2HIN02/ U23FR2FRE02	5	3
	II	English	General English	U23EL2GEN02	5	3
	III	Core Course III	Microbial technology	U23BT2CCT03	5	4
		Core Course - IV Practical	Practical II – Microbial technology	U23BT2CCP04	4	3
		Allied Course III	Microbiology	U23BT2ALT03	4	4
		Allied Course IV Practical	Microbiology Practical	U23BT2ALP04	2	2
	IV	SEC II	Prebiotics in Nutraceuticals	U23BT2SET02	2	2
		SEC III	Rural Development and Student Social Responsibility	U23BT2SET03	2	2
		Massive Open Online Course (MOOC)	Online Course	U23EX2ONC01		2 Extra Credits
		Value Education			-	-
		Internship				2

(For the Candidates Admitted From 2023 - 2024 Onwards)
I B.Sc. BIOTECHNOLOGY – I Semester

Course Title	CORE COURSE I – CELL AND MOLECULAR DEVELOPMENTAL BIOLOGY
Code	U23BT1CCT01
Course Type	Theory
Semester	I
Total Hours	60
Hours/Week	4
Credits	4
Marks	100

CONSPECTUS

This course focuses on the structural, functional and molecular aspects of the cellular and sub cellular mechanisms and their research applications. It also emphasis on the knowledge acquiring on the process of reproduction in animals.

COURSE OBJECTIVES

1. To relate the structural and functional properties of prokaryotic and eukaryotic cells.
2. To understand the ultrastructure and functions of cellular components for protein trafficking and cell permeability.
3. To comprehend the mechanism of protein synthesis.
4. To demonstrate the organization, ultrastructure and chemistry of chromosomes.
5. To criticize the mechanism of cell cycle during meiosis and mitosis.

UNIT I:

Cell theory and Cell Structure **12 HRS**

Discovery of Cell and Cell theory.

Cell as basic unit of life: viral, bacterial, fungal, plant and animal cells.

Ultra structure of cell: prokaryotic & eukaryotic cell, primary functions of biomacromolecules and biomicromolecules in the cell.

Extra reading: Electron microscope

UNIT II: **12 HRS**

Intracellular organelles

Cell wall, cell membrane, cytoplasm, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, Microbodies , Flagella,Cilia, Centrosome and Centrioles chloroplast, structure and function of cytoskeleton and its role in motility.

Plasma membrane – ultrastructure - unit membrane and fluid mosaic models Permeability functions- passive, facilitated, active, exo and endocytosis. Introduction to signal transduction. Ribosomes- structure, composition & assembly and functions

Chromosome- structure and functions. DNA modification in specialized chromosomes. Chromatin, heterochromatin and euchromatin.

Extra reading: Microfilaments

UNIT III: **12 HRS**

Cell Division

Cell division - Mitosis – stages, Check points of cell cycle, spindle mechanics and mitotic inhibitors, Meiosis – stages and significance, Cell cycle control. senescence and necrosis.

Cellular differentiation - Cell junctions - Cell Adhesion - ExtraCellular Matrix

Cell to cell communications - Signal transduction - G - Protein Coupled Receptors Signal transduction pathways.

Extra reading: Spindle fibres

UNIT IV: **12 HRS**

Central dogma of Molecular biology

Structure and functions of DNA and RNA -Central Dogma of the cell. DNA -Replication in prokaryotes.

Transcription in Prokaryotes and Eukaryotes - RNA Processing - Genetic code.

Translation - Similarities and differences in prokaryotic and eukaryotic translation - Post Translational Modifications - Protein Sorting - Protein degradation.

Extra reading: Proof reading

UNIT V: **12 HRS**

Developmental Biology

Gametogenesis - Spermatogenesis and Oogenesis in mammals.

Fertilization- Types of cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals- Organogenesis.

Embryonic stem cell development, Methods to culture embryo. Assisted Reproductive Technology, Embryo transfer and Amniocentesis.

Extra reading: PCOD, PCOS

PRESCRIBED TEXT BOOKS

- Verma P.S., & Agarwal V.K., (2016). Cell Biology. S. Chand and Company Ltd, New Delhi.
- Agarwal V.K., (2020). Molecular Biology. S. Chand and Company Ltd., New Delhi.
- Vasundra Rao (1994). Developmental Biology – A modern synthesis. Oxford IBH, New Delhi.
- Balinsky, B.I., (1981) Introduction to Embryology. V Ed. Saunders Toppan.

SUGGESTED REFERENCE BOOKS

● Harvey Lodish., Arnold Berk., Chris A. Kaiser., Monty Krieger., Anthony Bretscher., Hidde Ploegh., Angelika Amon., Matthew P. Scott., (2018). Molecular Cell Biology. VII edition Freeman W.H., & Company, New York.

● Geoffrey M. Cooper /Robert E. Hausman., (2013). The Cell- A Molecular Approach. Sinauer Associates, Inc 6th Edition.

● Gerald K., (2013). Cell Biology. VII edition International Student Version, Wiley publication.

● De Robertis D.P., (2012), Cell and Molecular Biology. 8th Edition, Lippincott Williams and Williams.

● Stephen R., Bolsover *et al* (2004). Cell Biology, A Short Course. John Wiley& Sons.

● Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, (2002). Molecular Biology of the Cell. IV edition, Garland Publishing, New York.

● Balinsky, B.I., 1981. 5 edition. An Introduction to Embryology. W. B. Saunders Co., Philadelphia.

● Verma , P.S., Agarwal, V.K., and Tyagi., 1995. Chordate embryology. S. Chand & Co., New Delhi. 5. Berril, N.T., Karp, G., 1988. Development. Tata McGraw Hill Co., New York.

WEBSITE REFERENCES

- https://www.cellbio.com/education.php
- https://www.onlinebiologynotes.com
- https://thebiologynotes.com/
- https://www.microscopemaster.com/
- https://global.oup.com/uk/orc/biosciences/cellbiology/wang/student/weblinks/ch16/
- https://dnalc.cshl.edu/websites/
- https://www.cellsignal.com/contents/science/cst-pathways/science-pathways
- https://nptel.ac.in/courses/102/106/102106025/11.

Note: Learners are advised to use latest edition of books

COURSE OUTCOMES

CO No.	Course Outcomes	Cognitive Level (K1-K6)
CO-1	Recall the detailed structural aspects of prokaryotic and eukaryotic cells and its functions	**K1**
CO-2	Examine in detail the factors affecting the regulation of RNA and protein synthesis and their properties.	**K2**
CO-3	Apply their knowledge in cellular mechanism their anomalies with the knowledge of cell cycle events, its regulation and association of checkpoints in programmed cell death.	**K3**
CO-4	Analyze the various stages of embryonic development and their underlying patterns.	**K4**
CO-5	Critical assessment of genetically affected disease due to chromosomal aberrations.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	-	-	-	-	-	-	1	3	3
CO 2	1	2	-	-	-	-	1	3	2
CO 3	-	2	-	-	1	1	2	2	1
CO 4	2	1	-	-	1	1	2	2	2
CO 5	3	2	3	3	3	3	3	2	2

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	2	1	2
CO3	2	3	3
CO4	3	3	3
CO5	3	3	3

(For the Candidates Admitted From 2023 - 2024 Onwards)
I B.Sc. BIOTECHNOLOGY- I Semester

Course Title	**MAJOR CORE 2: PRACTICAL - CELL AND MOLECULAR DEVELOPMENTAL BIOLOGY**
Code	**U23BT1CCP02**
Course Type	**Practical**
Semester	**I**
Hours/Week	**4**
Credits	**3**
Marks	**100**

CONSPECTUS

The course imparts working principle of molecular biology, cell biology and developmental biology.

COURSE OBJECTIVES

1. To differentiate structural and functional variations between prokaryotic and eukaryotic cells.
2. To illustrate the detailed structural aspects of cell organelles.
3. To compare and contrast the different stages of mitosis and meiosis.
4. To study the organism's developmental stage

I. Cell Biology

1. Identification of plant, fungi, bacterial and animal cells.- Staining & microscopic
2. Microscopic visualization of different human cells.
3. Preparation of polytene chromosomes in salivary gland of *Chironomous* larva
4. Study of mitotic stage in onion root tip.
5. Study of mitosis and meiosis from permanent slides.
6. Preparation of buccal cells.
7. Study of meiosis in Grasshopper testis.

II. Molecular Biology

1. Isolation of the following Genomic DNA

a. Human (Buccal cells)
b. Plant
c. Bacterium (*E. coli*)

2. Separation of DNA by AGE
3. Estimation of DNA (DPA method).
4. Estimation of RNA (Orcinol method).
5. Molecular weight determination of proteins - SDS-PAGE
6. Native PAGE.

III. Developmental Biology

1. Observation of live chick embryo – 24hrs, 48hrs, 72hrs & 96 hrs.
2. Study of the developmental stages of tadpole / Earthworm.
3. Types of placenta in mammals.
4. Tadpole tail regeneration.

PRESCRIBED TEXT BOOKS

- K.V. Chaitanya, (2013). Cell and molecular biology: Lab manual. PHI publishers, ISBN 978-81-203-800-4.

SUGGESTED REFERENCE BOOKS

- Renu Gupta., Seema Makhija., Ravi Toteja., (2018). Cell Biology: Practical Manual Paperback.
- Julio E.Celis., (1998). Cell Biology: A Laboratory Handbook. Second edition, Vol 4.

WEBSITE REFERENCES

- https://laboratoryinfo.com/
- https://www.microscopemaster.com/
- http://www.ihcworld.com/_protocols/lab_protocols/cell-biology-lab-manual-heidcamp.htm

COURSE OUTCOMES

CO No.	Course Outcomes	Cognitive Level (K1-K6)
CO-1	Gain knowledge in the structural composition of prokaryotes and eukaryotes	**K1**
CO-2	Identify the different stages of cell cycle regulation for the growth development	**K2**
CO-3	Apply their knowledge in forensic science for crime investigation by isolating DNA	**K3**
CO-4	Analyze the molecular weight of proteins using SDS-PAGE	**K4**
CO-5	Evaluate the time taken for the tadpole tail regeneration	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)
PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For the Candidates Admitted From 2023 – 2024 Onwards)
I B.Sc. BIOTECHNOLOGY- I Semester

Course Title	ALLIED COURSE 1 - BIOLOGICAL CHEMISTRY
Total Hours	60 hrs
Hours/Week	4hrs/week
Code	U23BT1ALT01
Course Type	Theory
Credits	4
Marks	100

CONSPECTUS

This course provide an overall understanding of biomolecules and their interactions in the metabolic pathways of living systems

COURSE OBJECTIVES

1. Discern the role of carbohydrates their properties and explains the metabolic pathway of carbohydrates.
2. Embrace the basics of amino acid and protein structure, classification and metabolism.
3. Delineate the basic classification, metabolism and functions of lipids and fatty acids.
4. Recapitulate the basic classification, metabolism and functions of nucleic acids.
5. Expound the basics of vitamins and minerals, its classification, functions and deficiency diseases.

UNIT I **12 HRS**

Atomic theory

Atomic theory, formation of molecules, electronic configuration of atoms- s & p shapes of atomic orbitals. Periodic table, periodic classification, valency.

Types of chemical bonds. Classification of organic compounds -. Hybridization in methane, ethane, acetylene, and benzene. Definition with examples- electrophiles, nucleophiles and free radicals.

Types of reactions with an example: addition, substitution, elimination, condensation and polymerization. Electrophilic substitution reaction in benzene, nitration and sulphonation.

Extra Reading /Key words: Elementary particles

UNIT II **12 HRS**

Acids and Bases

Acids & Bases properties and differences, Concepts of acids and bases- Arrhenius, Lowry-Bronsted and Lewis.

Concentration of solution, ways of expressing concentrations of solutions – per cent by weight, normality, molarity, molality, mole fraction. pH of solution, pH scale, measurement of pH.

Buffer solutions, properties of buffers, Henderson-Hasselbalch equation, mechanism of buffer action of acidic buffer and basic buffer.

Extra Reading /Key words: Monoprotic acid

UNIT III **12 HRS**

Water and Biomolecules

Importance of Biochemistry - the chemical foundation of life. Water: its unique properties, ionization of water, buffering action in biological system, properties and characteristics of water.

Carbohydrates – nomenclature, significance, classification, and properties. Ring structure of sugars and conformations of sugars.

Metabolism of Carbohydrates – Glycogenesis, Glycogenolysis, Cori's cycle, Glycolysis, TCA cycle, bioenergetics of carbohydrate metabolism.

Extra Reading /Key words: ATP yield.

UNIT IV **12 HRS**

Lipids and Nucleic acids

Classification of Lipids. Characteristics, Properties and Biological importance of lipids – saturated, unsaturated, PUFA

Metabolism of Fatty acids, triglycerides, phospholipids, cholesterol. B-oxidation of fatty acids, bile acids and salt formation.

Classification of nucleic acids. Purine and Pyrimidine biosynthesis, de novo and salvage pathways. Classification and types of DNA & RNA. Watson and Crick model. Metabolism of Nucleic acids, Salvage pathway.

Extra Reading /Key words: Metabolic disorders

UNIT V **12 HRS**

Proteins, vitamins & minerals and hormones

Classification and structure of amino acids. Structural conformation of proteins. Classification of proteins. Properties and biological importance of amino acids and proteins. Degradation of Amino acids and Urea Cycle.

Vitamins – Fat soluble vitamins, Water Soluble vitamins, B-complex vitamins, Vitamin C – Soruces, requirements and deficiency disorders. Minerals - micro and macro minerals – requirements, deficiency and toxicity

Hormones - Role in metabolism. ATP production. Oxidative phosphorylation, Electron transport chain and Photophosphorylation.

Extra Reading /Key words: Second messengers

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Abhilasha Shourie, Shilpa S, Chapadgoankar & Anamika Singh., (2020). Textbook of Biochemistry. 1st Edition.
2. J.L. Jain, (2016). Fundamentals of Biochemistry. S.Chand publication, 7th edition.
3. A.C. Deb, (2016). Fundamentals of Biochemistry, New central book agencies, 7th edition.
4. Satyanarayana .U, (2016). Biochemistry. MJ publishers 3rd edition.

SUGGESTED REFERENCE BOOKS

1. Alison Snape, Despo Papachristodoulou, William H. Elliott, Daphne C. Elliott, (2014). Biochemistry and Molecular Biology. V edition, Oxford University press.
2. Lehninger., David Lee Nelson, Michael M. Cox, (2013). Principles of Biochemistry. VI edition, W.H. Freeman and Company, New York.
3. Harper, Murray, R.K., Granner, D. K., Mayes, P.A., Rodwell, V.W., (2003). Biochemistry. Prentice Hall International Inc.
4. Geoffrey L. Zubay, William W. Passon, Dennis L.,() Vance, Principles of Biochemistry. IV edition, W.M.C. Brown Publishers, Australia.
5. Lehninger, (2013). Principles of Biochemistry. 4th edition WH Freeman and Company NY.
6. Lubert Stryer, (2007). Biochemistry. Stanford University 5th Edition W H Freemann and company San Francisco.
7. Bahl Arun, Bahl B. S., (2016). A Textbook of Organic Chemistry. 22nd Edition, S. Chand & Sons publications.

WEBSITE REFERENCES

- http/dwb4.unl.edu/chem869p/chem869plinks/s
- www.longwood.edu/staff/buckalewdw/C3%20Biomolecules.pp
- https://www.britannica.com › science › biochemistry
- https://]ww.sciencedirect.com › topics › agricultural-and-biological-sciences
- https://biochemistry.org › education › careers › becoming-a-bioscientist › w

COURSE OUTCOMES

CO No.	Course Outcomes	Cognitive Level (K1-K6)
CO-1	Outline the chemical composition and properties of biomolecules.	**K1**
CO-2	Summarize and explain the structural conformations of proteins, their properties and metabolism.	**K2**
CO-3	Classify lipids based on their structure, functions and properties and explain its metabolic pathways.	**K3**
CO-4	Discuss the chemistry and functions of various vitamins, minerals and their sources.	**K4**
CO-5	Evaluate the nutrients in foods and their specific functions in maintaining health	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	-	-	-	-	-	-	1	3	3
CO 2	1	2	-	-	-	-	1	3	2
CO 3	-	2	-	-	1	1	2	2	1
CO 4	2	1	-	-	1	1	2	2	2
CO 5	3	3	3	3	3	3	3	3	3

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	2	1	2
CO3	1	2	2
CO4	3	2	2
CO5	3	3	2

(For the Candidates Admitted From 2023 - 2024 Onwards)
I B.Sc. BIOTECHNOLOGY- I Semester

Course Title	ALLIED COURSE 2 - BIOLOGICAL CHEMISTRY - PRACTICAL
Total Hours	30 hrs
Hours/Week	2hrs/week
Code	U23BT1ALP02
Course Type	Practical
Credits	2
Marks	100

CONSPECTUS

This course encompass the relevance of biological macromolecules, quantitative and qualitative analysis of biomolecules, insight into the effect and role of structure in reactivity of biomolecules, and a thorough appreciation of the role of biomolecules and their activities.

COURSE OBJECTIVES

1. Accomplish insight into basic reactions of biomolecules.
2. Ascertain the presence of biomolecules like carbohydrates, proteins, lipids, etc. in known and unknown samples.
3. Arbitrate the properties of carbohydrates, proteins, lipids and their importance in biological systems.
4. Evaluate and analyze the biochemical composition of various samples.

Systematic analysis of Organic compounds

1. Functional group tests (Carboxylic acid (Benzoic acid, phthalic acid), Phenol, Urea, Benzaldehyde, Aniline (Aniline not to be given for exam)
2. Detection of elements (N, Halogens)
3. Distinguish between aliphatic and aromatic compounds.
4. Distinguish between Saturated and unsaturated compounds

Volumetric Analysis:

1. Estimation of Glycine- Formal Titration.
2. Determination of Ascorbic acid – DCPIP method.
3. Estimation of Ferrous sulfate using standard Mohr's salt

Qualitative Analysis

1. Qualitative analysis of carbohydrates - Glucose, Fructose, Lactose, maltose, sucrose, starch & glycogen.
2. Qualitative analysis of amino acids - Tyrosine, Tryptophan, Arginine, Proline and Cysteine.

Colorimetric Analysis

1. Estimation of glucose
2. Estimation of Cholesterol- Zak's method
3. Estimation of proteins – Bradford's method

PRESCRIBED TEXT BOOKS

1. J. Jayaraman, (2011). Laboratory Manual in Biochemistry, New Age International Pvt Ltd Publishers.
2. S. K. Sawhney Randhir, Singh., (2005). Introductory Practical Biochemistry. Alpha Science International Ltd, 2nd edition.
3. Irwin H.Segel, (1991). Biochemical calculations. Liss, Newyork.

SUGGESTED REFERENCE BOOKS

1. Dr. O P Panday, D N Bajpai, Dr. S Giri, (2016). Practical Chemistry. S Chand, Revised edition.
2. Hands Thacher Clarke, (2007). A hand book of Organic: Qualitative and quantitative Analysis.
3. N.S. Gnanapragasam and G. Ramamurthy, (1998). Organic Chemistry Lab manual, S.Viswanathan Co. Pvt. Ltd.

WEBSITE REFERENCES

- biotech01.vlabs.ac.in
- www.bch.cuhk.edu.hk>vlab2
- www.barnesandnoble.com

COURSE OUTCOMES

CO No.	Course Outcomes	Cognitive Level (K1-K5)
CO-1	Perform and estimate the amount of chemical substance present in a solution qualitatively. To analyze and detect the nature of various organic class of compounds qualitatively.	**K1**
CO-2	Qualitatively analyze the carbohydrates and amino acids and report the type of carbohydrate based on specific tests. Differentiate the carbohydrates based microscopic examination of the crystal.	**K2**
CO-3	Understand the methods of acidimetry, alkalimetry and permanganometry	**K3**
CO-4	Quantify Ascorbic acid in lemon by Dichlorophenol indo phenol dye method, Glycine by sorensons formal titration method.	**K4**
CO-5	Assessment of the quantity of aminoacids in the protein sample and to acquire the specific characteristic nature of amino acid.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)
PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For the Candidates Admitted From 2023 – 2024 Onwards)
I B. Sc. BIOTECHNOLOGY – I Semester

Course Title	**NON MAJOR ELECTIVE - ORGANIC BEVERAGE PRODUCTION (Theory cum lab)**
Code	**U23BT1SET01**
Course Type	**Theory**
Semester	**I**
Total Hours	**60**
Hours/Week	**2**
Credits	**2**
Marks	**100**

CONSPECTUS

This course focus on the beverages, types of beverages using fruits and vegetables and method of production. It also emphases acquiring knowledge on the process of beverages production.

COURSE OBJECTIVES

1. To relate the fermented and non-fermented beverages production.
2. To understand the vegetable and fruit as a source for the production of beverage.
3. To comprehend the carbonated and non-carbonated beverage production.
4. To demonstrate the distilled and non-distilled beverages.
5. To criticize the additives usage during beverage production and its shelf-life enhancement.

UNIT I **6 HRS**

Introduction and history of growth, type of beverages: fruit & vegetable juices,
Fermented and non-fermented beverages, synthetic beverages,
Carbonated and non-carbonated beverages.

Keywords/ Extra reading: Citric fruits

UNIT II **6 HRS**

Fruit and Vegetable Beverages: Juice extraction, clarification
Preservation, packaging, concentration and drying.
Various beverages from fruit juices, their preparation and preservation.

Keywords/ Extra reading: Preservatives

UNIT III **6 HRS**

Non-carbonated and carbonated synthetic beverages
Ingredients, source of carbon dioxide, chemical and physical properties of carbon dioxide,
Carbonating process, packaging of carbonating beverages.

Keywords/ Extra reading: Contaminants

UNIT IV **6 HRS**

Alcoholic Beverages,Non-distilled beverages - Beer and wine and distilled beverages: vodka, rum, gin, whisky and Brandy
Non Alcoholic Beverages - kombucha, kefir and some soft drinks like ginger beer
Additives for beverages: Natural and synthetic sweeteners and colours, Acids, emulsifiers, preservatives, flavours and flavour enhancers. Quality control of beverage: Quality standards for beverages, chemical, microbial and sensory evaluation.

Keywords/ Extra reading: Toddy

UNIT V **6 HRS**

1. Production of wine
2. Estimation of alcohol content in the wine
3. Production of organic beverage from dry ginger
4. Production of herbal beverage from flowers
5. Alcoholic Beer production at laboratory scale
6. Production of organic beverage for stomach related ailments

Keywords/ Extra reading: Microbial screening

PRESCRIBED TEXT BOOKS

- Hui YH, Ase SH, Jytte J, Peggy SS and Fidel Toldra., (2004). Handbook of Food and Beverage fermentation Technology, Food Science and Technology.
- N. Shankuntala Manny and M. Shadaksharaswamy., (2020). Foods: Facts and Principles.

SUGGESTED REFERENCE BOOKS

- Introduction: Distillation Methods and Stills - Handbook of Alcoholic Beverages - Wiley Online Library
- Preservatives Used in the Production of Alcoholic Beverages - Handbook of Alcoholic Beverages - Wiley Online Library
- History and Development of Alcoholic Beverages - Handbook of Alcoholic Beverages - Wiley Online Library

WEBSITE REFERENCES

- https://www.beveragetechnology.in
- (PDF) Alcoholic Beverages (researchgate.net)
- 17.4A: Wine, Beer, and Alcohol - Biology LibreTexts
- Fruit Wines and Other Nongrape Wines - Handbook of Alcoholic Beverages - Wiley Online Library

Note: Learners are advised to use latest edition of books

COURSE OUTCOMES

CO No.	Course Outcomes	Cognitive Level (K1-K6)
CO-1	Outline the manufacturing of fermented and non-fermented beverages.	**K1**
CO-2	Understand the manufacture of carbonated and non-carbonated beverages.	**K2**
CO-3	Comprehend the vegetable and fruit as a source of beverage manufacturing	**K3**
CO-4	Criticise the difference between distilled and non-distilled beverages.	**K4**
CO-5	Evaluate the nutrients in Beverages and their specific functions in maintaining health	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

PO-CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	2	3	2	3	3	2		3	-
CO 2	2	-	-	-	2	1	1	-	1
CO 3	3	3	-	1	1	2	-	1	-
CO 4	2	3	1	-	2	1	1	3	1

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	2	1	1
CO2	1	2	1
CO3	2	1	3
CO4	1	2	2

(For the Candidates Admitted From 2023 – 2024 Onwards)

I B.Sc. BIOTECHNOLOGY – I Semester

Course Title	FOUNDATION COURSE - BIOLOGY TO BIOTECHNOLOGY
Total Hours	30
Hours/Week	2 Hrs/ Wk
Code	U23BT1FCT01
Course Type	Theory
Credits	2
Marks	100

CONSPECTUS

To develop a complete acquaintance with the eukaryotic and prokaryotic cells, structure and function of DNA and RNA, central dogma of cells, vectors and its role in genetic engineering and the application of biotechnology.

COURSE OBJECTIVES

To enable the learners to:

1. Demonstrate the structure of eukaryotic and prokaryotic cells.
2. Outline and examine structure and function of molecules.
3. Criticize and relate to the concept of processing of central dogma of cells and its components.
4. Critically assess the types of nuclei's acids and their functions and predict the vectors involved in gene manipulation.
5. Arbitrate the revolution of biotechnology in various fields emphasizing the welfare of all living beings.

UNIT I **6 HRS**

Cells: Discovery and of cells and cell theory - Structure of prokaryotic, eukaryotic, plant and animal cells

UNIT II **6 HRS**

Nucleic acids: Purine and pyrimidines, nucleosides and nucleotides

UNIT III **6 HRS**

DNA: Structure, properties, types, forms and functions

UNIT IV **6 HRS**

RNA: Structure, properties, types, forms and functions

Unit V **6 HRS**

Types of biotechnology – Red, white, green and blue biotechnology

PRESCRIBED TEXT BOOKS

1. Freifelder, D., (2015). Essentials of molecular Biology. Fourth edition, Jones and Bartlett Publications Inc.

2. Primrose, S.B, Twyman, R.W., (2006). Principles of Gene Manipulation and Genomics. VII edition, Wiley Blackwell.

3. Brown. T.A., (2001). Gene Cloning and DNA Analysis - An Introduction. IV Edition, Wiley Blackwell Scientific Publications.

SUGGESTED REFERENCE BOOKS

1. Gerald Karp, (2013). Cell Biology. VII edition International Student Version, Wiley publication.
2. Primrose S. B., (2001). Molecular Biotechnology. Panima Publications, New Delhi
3. Lodish, Harvey, Arnold, Matsudaira, Paul, Kaiser, Chris A., Krieger, Monty Scott, Matthew P., Zipursky, Lawrence, Darnell, James., (2004). Molecular Cell Biology. W.H. Freeman and Company.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- www.bio.org
- www.techtarget.com

COURSE OUTCOMES (CO)

The learners will be able to:

CO No.	Course Outcomes	Cognitive Level
CO-1	Acquire basic knowledge on the structure and function of eukaryotic and prokaryotic cells.	**K1**
CO-2	Observe the structure and function of molecules such as carbohydrates, proteins and lipids and its importance in cellular mechanism.	**K2**
CO-3	Describe the structure, function of DNA, RNA and mechanism of central dogma of cells.	**K3**
CO-4	Examine in detail about the vectors and its role in gene manipulation.	**K4**
CO-5	Persuade the various techniques used in food, agricultural and industrial products by scientific methods and expertise in various biotechnological applications.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	-	-	-	-	-	-	1	3	3
CO 2	1	2	-	-	-	-	1	3	2
CO 3	-	2	-	-	1	1	2	2	1
CO 4	2	1	-	-	1	1	2	2	2

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	2	2	2
CO2	2	1	2
CO3	2	3	3
CO4	3	3	3

(For The Candidates Admitted From 2023 – 2024 Onwards)
I B.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	**CORE COURSE 3 – MICROBIAL TECHNOLOGY**
Code	**U23BT2CCT03**
Course Type	**Theory**
Semester	**II**
Total Hours	**75**
Hours/Week	**5**
Credits	**4**
Marks	**100**

CONSPECTUS

This course deals with the knowledge on the taxonomical classification of microorganisms, features of beneficial & pathogenic microbes and their industrial applications.

COURSE OBJECTIVES

1. Understand the history of microbiology and its five-kingdom classification.
2. Distinguish the morphological features of different types of bacteria and gene transfer mechanisms.
3. Delineate the classification and pathogenesis of bacteria, virus, algae and fungus.
4. Enlighten the knowledge on epidemiology of microbial epidemic and pandemic diseases and the host microbe interaction in the disease.
5. Exhibit knowledge on biopesticides, bio fertilizers prebiotics and probiotics and evaluate the role of microbes in food intoxications, fermented products.

UNIT I **15 HRS**

Introduction

History of Microbiology – major discoveries related to the field of microbiology, Antonie Von Leeuwenhoek, Louis Pasteur, Robert Koch and Edward Jenner.

Whittaker's classification and characteristic features of microorganisms – virus, bacteria, algae, fungi and protozoa and role of microbes in biotechnology.

Methods in microbial culture, sterilization methods – physical and chemical methods, inoculation and incubation, preparation of pure culture and maintenance. Identification of bacteria – 16s rRNA sequencing.

Extra reading/Keywords: *Ribotyping*

UNIT II **15 HRS**

Bacteria

Classification based on morphology – shape and flagella, staining, nutrition and extreme environment' Bergey's manual of classification.

Bacterial growth – measurement of growth, nutritional requirements, types of culture media, culture and growth characteristics.

Gene transfer mechanism – conjugation, transformation and transduction.

Extra reading/Keywords: *Vertical gene transfer*

UNIT III **15 HRS**

Virus, algae and fungi

Viruses – Classification based on their genetic material – RNA & DNA. Viral host: plant viruses –CMV and TMV; animal viruses – HIV, hepatitis virus; bacterial viruses – bacteriophage, M13. ICTV classification of viruses.

Algae – cyanobacteria, N_2 fixation. Fungi – mushrooms, candida – superficial mycosis**.**

Culture of fungi, virus and algae. Antibiotic in clinical use – mode of action, resistance to antibacterial agents - MRSA, ESBL.

Extra reading/Keywords: *TMV using carborundum*

UNIT IV **15 HRS**

Medical microbiology

Microbial disease – host and pathogen interaction, mode of transmission, clinical features, lab diagnosis and treatment strategies.

Airborne disease – pneumonia, chicken pox, influenza, tuberculosis. foodborne disease – typhoid, aspergillosis, viral hepatitis – water borne disease- cholera, amoebiasis.

Sexually transmitted disease- AIDS, gonorrhea, trichomoniasis- vector-borne disease- dengue, malaria, bacterial and viral diseases- meningitis, leprosy, tetanus, polio, rabies, herpes.

Extra reading/Keywords: *Molecular basis of Covid-19 pathogenesis.*

UNIT V **15 HRS**

Environmental and industrial microbiology

Food microbiology – microbial food spoilage, food poisoning, physico-chemical methods in food preservation.

Dairy microbiology – pasteurization, microbial fermentation, prebiotics and probiotics, fermented milk products – yoghurt and cheese, industrial fermentation of ethanol, penicillin and enzymes.

Biopesticides – *Bacillus thuringiensis* and baculoviruses, Biofertilizers – *Azospirillum*, spirulina and blue green algae.

Extra reading/Keywords: *Biogeochemical cycle, Plastic degrading microbes*

Note: Texts given in the Extra reading/Key words must be tested only through assignment and seminars.

PRESCRIBED TEXT BOOKS

1. Willey, J., Sherwood, L., Woolverton, C.J., (2017), Prescott's Microbiology, Edition X, McGraw-Hill Education, ISBN: 978-1259281594.
2. Ananthanarayan, Paniker's, (2017), Textbook of Microbiology, Edition X, The Orient Blackswan, ISBN: 978-9386235251.
3. Prescott, Harley, Klein, (2016), Microbiology, Edition X, McGraw – Hill.
4. Madigan, M.T., Martinko, J.M., Bender, K.S., Buckley, D.H., Stahl, D.A., (2015), Brock biology of microorganisms, Pearson Higher Ed.
5. Tortora, G.J., Funke, B.R., Case, C.L., (2013). Microbiology. An Introduction, Edition XI, A La Carte Pearson.

SUGGESTED REFERENCES

1. Tortora, G.J., Funke, B.R., Case, C.L., (2015), Microbiology: An Introduction, Edition XII, Pearson Education.
2. Black., J.G., (2008), Microbiology Principles and Explorations, Edition VII.
3. Glazer, Nikaido, (2007), Microbial Biotechnology, Edition II, Cambridge University Press.
4. Jeffry, C., Jones, P., Bartlett, (2006), Fundamentals of Microbiology, Edition VII.
5. Brenner, D.J., Krieg, N.R., Staley, J.T., (2005), Bergey's manual of systematic bacteriology. Edition II, New York: Springer.
6. Jay, J.M, Loessner, M.J., Golden, D.A., (2005), Modern Food Microbiology. Edition VII, CBS Publishers and Distributors, Delhi, India.
7. Adams, Martin. R., Moss, Maurice, O., (2004), Food Microbiology, Edition III, Royal Society of Chemistry Cambridge.
8. John, L.I., Catherine, A.I., (2004), Introduction to Microbiology – A case History Approach, Thomson Asia Pvt. Ltd.
9. Atlas R.M., Bartha, R.R., (2004), Microbial Ecology - Fundamentals and applications, Pearson education limited.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6428495/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7150083/
- https://europepmc.org/article/pmc/pmc7150148
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3427559/

COURSE OUTCOMES

CO No.	COURSE OUTCOMES	COGNITIVE LEVEL (K1-K6)
CO-1	Define the common microbial pathogens having beneficiary and non-beneficiary roles.	**K1**
CO-2	Summarize the characteristics features with inherent physiological processes for disease diagnosis and antibiotic resistance of microbes.	**K2**
CO-3	Employ the knowledge on the microbial pathogenesis and correlate their clinical manifestations to be used in disease management and prevention.	**K3**
CO-4	Appraise the role of microbes in food and agricultural industry products by scientific methods.	**K4**
CO-5	Predict novel technologies and develop expertise in industrial biotechnological applications.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)
PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO – Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO1	2	-	-	-	-	1	-	2	2
CO2	3	1	-	-	-	-	-	3	2
CO3	3	1	1	-	-	1	1	3	2
CO4	3	2	1	1	2	1	2	3	3
CO5	3	3	2	2	2	3	3	3	3

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	1	1	-
CO2	1	2	1
CO3	2	3	1
CO4	3	3	2
CO5	3	3	3

(For The Candidates Admitted From 2023 – 2024 Onwards)

I B.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	**CORE COURSE 4: PRACTICAL II – MICROBIAL TECHNOLOGY**
Code	**U23BT2CCP04**
Course Type	**Practical**
Semester	**II**
Hours/Week	**4**
Credits	**3**
Marks	**100**

CONSPECTUS

The course imparts knowledge and hands on skills in microbial staining, isolating and culturing techniques and study the bacterial growth curve kinetics and susceptibility on antibiotics.

COURSE OBJECTIVES

1. Characterize the morphological features of microbes through staining techniques and biochemical tests.
2. Describe the skills in culture media preparation, sterilization, isolation and serial dilution techniques.
3. Perform the isolation, identification and examination of microbes from various samples and study the count and motility of the isolated microorganisms.
4. Employ the efficiency of pasteurization method in microbial growth control.
5. Determine the bacterial growth curve kinetics and antibiotic susceptibility.

PRACTICAL

1. Identification of microbes
   a. Staining techniques- simple, gram's, capsule (negative), spores
   b.Biochemical characterization - catalase, oxidase, IMViC and TSI tests.
2. Culture medium – preparation of nutrient broth, preparation of agar slants
3. Inoculation techniques- pour plate, spread plate and streak plate methods.
4. Motility tests: Hanging drop technique.
5. Isolation of bacteria from soil and water samples.
6. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
7. Serial dilution and plating.
8. Colony counting.
9. Starch plate assay.
10. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
11. Determination of growth curve of bacteria – *E. coli.*
12. Minimum inhibitory concentration assay.
13. Time-kill kinetics assay.
14. Antibiotic sensitivity test- agar well diffusion- demonstration.

PRESCRIBED TEXT BOOKS

1. Amita, J., Jyotsna, A., Vimala, V., (2018). Microbiology Practical Manual, Edition I,. Elsevier India.
2. Sundararaj, T., (2005), Microbiology Lab Manual, Edition I.
3. Dubey R.C., Maheswari, D.K., 2002, Practical Microbiology, S. Chand Publishing.
4. Cappucino J.G. Sherman MBN, (1996), A lab manual Benjamin Cummins, New York.
5. Kannan, N., (1996), Laboratory manual in General Microbiology, Palani Publications.
6. Gunasekaran, P., (1996), Laboratory manual in Microbiology. New Age International Ld., Publishers, New Delhi.

SUGGESTED REFERENCES

1. Talib VH (2019). Handbook Medical Laboratory Technology. (2nd Edition). CBS.
2. Wheelis M, (2010). Principles of Modern Microbiology, 1st Edition. Jones and Bartlett Publication.
3. Lim D. (1998). Microbiology, 2nd Edition, WCB McGraw Hill Publications.

WEBSITE REFERENCES

- http://www.biologydiscussion.com/micro-biology/sterilisation-and-disinfection-methods-and-principles-microbiology/24403.
- https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf
- https://www.cliffsnotes.com/studyguides/biology/microbiology/introduction-to-microbiology/a-brief-history-of-microbiology

Note: Learners are advised to use the latest edition of books

COURSE OUTCOMES

CO No.	COURSE OUTCOMES	COGNITIVE LEVEL (K1-K5)
CO-1	Recollect the morphological and biochemical characterization of microbes.	**K1**
CO-2	Comprehend the microbial culture techniques.	**K2**
CO-3	Demonstrate the knowledge of isolating microbial pathogens from various sources and perform quantitative assessment.	**K3**
CO-4	Examine the microbial growth kinetics.	**K4**
CO-5	Evaluate the growth inhibition of microbes with antibiotic susceptibility assays.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO – Course Outcomes

(For The Candidates Admitted From 2023 – 2024 Onwards)
I B.Sc. BIOINFORMATICS – SEMESTER II

Course Title	**ALLIED COURSE – MICROBIOLOGY**
Code	**U23BT2ALT03**
Course Type	**Theory**
Semester	**II**
Total Hours	**60**
Hours/Week	**4**
Credits	**4**
Marks	**100**

CONSPECTUS

This course deals with the knowledge on the taxonomical classification of microorganisms and their gene regulation and genome expression analysis.

COURSE OBJECTIVES

1. Understand the basic concepts and history of microbiology, familiarize the classification of microorganisms and the structure and functions of a typical prokaryotic cell.
2. Categorize the bacterial strain according to their morphological feature and integrate them with beneficiary associated lives.
3. Exemplify the classification and significance of fungi and viruses in the microbial world.
4. Appraise the concept and regulatory mechanisms of microbial genes.
5. Correlate the significance between structural, functional and comparative genomics for understanding microbial diversity.

UNIT I **12 HRS**

Introduction to microbiology

History and development of Microbiology, development of fields of Microbiology in 20th century, the spontaneous generation controversy, germ theory of disease, Microbes and fermentation, physical and chemical methods of sterilization, pure cultures and aseptic techniques.

Binomial nomenclature, Haeckel's three kingdom classification, Woese's three kingdom classification systems and their utility – archaea, eubacteria, eukarya.

Organization of prokaryotic and eukaryotic cell. Study of microbial structure – principles of microscopy, simple and compound microscope, monocular and binocular microscopes, dark, phase contrast and fluorescent microscopes.

Extra reading/Keywords: *Current methods of microbial identification.*

UNIT II **12 HRS**

Bacteriology

Classification of bacteria: Based on morphology – shape and flagella, staining, nutrition and extreme environment. Bacterial growth curve. Bacterial growth and metabolism.

Bacterial respiration, nutrition and reproduction; Bacterial Pathogenesis.

Bacteria in Extreme Environment – Special features of the thermophilic, methanogenic, and halophilic archaea, Photosynthetic bacteria, Cyanobacteria, Anoxygenic photosynthetic bacteria – purple bacteria and green bacteria, oxygenic photosynthetic bacteria – cyanobacteria – general characteristics, external and internal features, physiology and ecology.

Extra reading/Keywords: *Magnetotactic bacteria***.**

UNIT III **12 HRS**

Mycology, Virology and Medical Microbiology

Fungi and yeast – general classification and characteristics – rhizopus, penicillium, fusarium, lichens, mycorrhiza. Fungal nutrition and reproduction.

Virus – classification of virus, based on their genetic material – RNA viruses – rhabdoviruses, reoviruses and DNA viruses – adenoviruses and baculoviruses, virus entry and viral pathogenesis – lytic phase and lysogenic phase.

Medical Microbiology - study of common bacterial and viral diseases in man, causative organisms, mode of transmission, pathogenicity, symptoms and preventive measures – gastro-intestinal, respiratory, nervous and genital systems.

Extra reading/Keywords: *SARS Covid-19*

UNIT IV **12 HRS**

Microbial genetics

Genome organization – E. coli, Saccharomyces, Tetrahymena, Gene Transfer Mechanism – conjugation, transformation and transduction. Gene transposable elements.

Mutations and mutagenesis, definition and types of mutations, physical and chemical mutagens, molecular basis of mutations, uses of mutations, mechanisms of genetic variations. DNA mutations – types and effects. Selection and isolation of mutants. DNA repair mechanisms.

Control of gene expression. Positive gene regulation, negative gene regulation and attenuation, using the lac, gal, trp, ara and tol operons, with emphasis on recent advances.

Extra reading/Keywords: *Riboswitches.*

UNIT V **12 HRS**

Applied Microbiology

Industrial microbiology – food products and preservation. Dairy microbiology – microbial food spoilage and preservation. Economically important microbial products – enzynes, vitamins, vaccines and antibiotics.

Environmental microbiology – common pathogenic microbes in water, soil and air. Population and community dynamics. Biogeochemical cycling and microorganisms in biodeterioration and bioremediation. Agricultural microbiology – beneficial and pathogenic microbes.

Microbial genomics – gene analysis and techniques. Isolation of DNA and RNA from microbes. DNA sequence – whole genome sequencing by Sanger's method. Introdcution to structural and functional genomics. Genomic analysis of pathogenic microbes and extremophiles.

Extra reading/Keywords: *Plastic degrading microbes*

Note: Texts given in the Extra reading/Key words must be tested only through assignment and seminars.

PRESCRIBED TEXT BOOKS

1. Willey, J., Sherwood, L., Woolverton, C.J., (2017), Prescott's Microbiology, Edition X, McGraw-Hill Education, ISBN: 978-1259281594.
2. Ananthanarayan, Paniker's, (2017), Textbook of Microbiology, Edition X, The Orient Blackswan, ISBN: 978-9386235251.
3. Madigan, M.T., Martinko, J.M., Bender, K.S., Buckley, D H., Stahl, D.A., (2015), Brock biology of microorganisms. Pearson Higher Ed.

SUGGESTED REFERENCES

1. Tortora., G.J., Funke, B.R., Case, C.L., (2015), Microbiology: An Introduction, Edition XII, Pearson Education.
2. Glazer, Nikaido, (2007), Microbial Biotechnology, Edition II, Cambridge University Press.
3. Jeffry, C., Jones, P., Bartlett., (2006), Fundamentals of Microbiology, Edition VII.
4. Brenner, D.J., Krieg, N.R., Staley, J.T., (2005), Bergey's manual of systematic bacteriology. Edition II, New York: Springer.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6428495/
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7150083/
- https://europepmc.org/article/pmc/pmc7150148
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3427559/

COURSE OUTCOMES

The learners will be able to

CO No.	Course Outcomes	Cognitive Level (K1-K6)
CO-1	Understand history, relevance of microbiology and the working of various microscopes and their application.	**K1**
CO-2	Summarize the characteristics features and classification of bacteria.	**K2**
CO-3	Exploring the microbial characteristics features and its relevance towards human pathogenesis.	**K3**
CO-4	Appraise the gene regulatory mechanisms in microbes.	**K4**
CO-5	Develop new techniques for microbial genome sequencing and analysis and predict the phylogenetic relationship.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO – Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO1	2	2	1	1	1	2	3	3	3
CO2	2	2	1	1	1	2	2	3	3
CO3	3	3	2	1	2	2	3	3	3
CO4	3	2	2	1	2	3	2	3	3
CO5	3	3	3	2	2	3	3	3	3

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	1	1	1
CO2	3	2	2
CO3	3	2	2
CO4	3	3	3
CO5	3	3	3

(For The Candidates Admitted From 2023 – 2024 Onwards)

I B.Sc. BIOINFORMATICS – SEMESTER II

Course Title	**ALLIED PRACTICAL – MICROBIOLOGY**
Code	**U23BT2ALP04**
Course Type	**Practical**
Semester	**II**
Hours/Week	**2**
Credits	**2**
Marks	**100**

CONSPECTUS

The course imparts knowledge and hands on skills in microbial staining, isolating and culturing techniques and susceptibility testing of antibiotics on pathogenic strains.

COURSE OBJECTIVES

1. Gain the knowledge of microscopy and staining concepts.
2. Acquire skills in culture media preparation, sterilization, isolation and serial dilution techniques.
3. Determine the antibiotic susceptibility against pathogenic strains.
4. To understand and implement disposal and safety measures.

PRACTICAL

1. Introduction of aseptic techniques: Methods of bacterial control: Mechanical(filtration); Physical (Heat, Radiation); Chemical (Alcohol): principles & operations
2. Preparation of microbiological media simple and complex media for isolation of bacteria, actinomycetes and fungi from natural sources.
3. Serial dilution and Inoculation techniques- pour plate, spread plate and streak plate methods and Colony counting.
4. Bacterial Growth Curve.
5. Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa.
6. Staining methods – (a). Simple staining to study the size, shape and arrangement of bacterial cells and (b) Differential staining technique.
7. Sampling and quantification of microorganisms in air, soil and water.
8. Biochemical identification of bacteria – IMViC Test,
9. Motility test- Hanging drop method.
10. Antibiotic sensitivity test- agar well diffusion- demonstration.

PRESCRIBED TEXT BOOKS

1. Amita, J., Jyotsna, A., Vimala, V., (2018), Microbiology Practical Manual. Edition I. Elsevier India.
2. Sundararaj, T., (2005), Microbiology Lab Manual Edition I.
3. Dubey R.C., Maheswari D.K., (2002), Practical Microbiology. S. Chand Publishing.
4. Cappucino J.G., Sherman M.B.N., (1996), A lab manual Benjamin Cummins, New York.
5. Kannan, N., (1996), Laboratory manual in General Microbiology. Palani Publications.
6. Gunasekaran, P., (1996), Laboratory manual in Microbiology, New Age International Ld., Publishers, New Delhi.

SUGGESTED REFERENCE BOOKS

1. Talib, V.H., (2019), Handbook Medical Laboratory Technology, Edition II. CBS.
2. Wheelis, M., (2010). Principles of Modern Microbiology, Edition I. Jones and Bartlett Publication.
3. Lim D., (1998), Microbiology, Edition II, WCB McGraw Hill Publications.

WEBSITE REFERENCES

- http://www.biologydiscussion.com/micro-biology/sterilisation-and-disinfection-methods-and-principles-microbiology/24403.
- https://www.ebooks.cambridge.org/ebook.jsf?bid=CBO9781139170635
- https://www.grsmu.by/files/file/university/cafedry//files/essential_microbiology.pdf
- https://www.cliffsnotes.com/studyguides/biology/microbiology/introduction-to-microbiology/a-brief-history-of-microbiology

COURSE OUTCOMES

CO No.	COURSE OUTCOMES	COGNITIVE LEVEL (K1-K6)
CO-1	Identify the structural differences between microbes	**K1**
CO-2	Comprehend the microbial culture techniques.	**K2**
CO-3	Demonstrate the knowledge of isolating microbial pathogens from various sources and perform quantitative assessment.	**K3**
CO-4	Integrate the morphological, physiological, biochemical identification of microbes.	**K4**
CO-5	Evaluate the bacterial growth and inhibition with antibiotic susceptibility assay.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)
PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO – Course Outcomes

PO – CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO1	3	2	-	-	-	-	2	3	3
CO2	3	2	1	-	-	1	2	3	3
CO3	3	2	2	1	1	2	3	3	3
CO4	3	2	1	1	2	2	2	3	3
CO5	3	3	1	1	2	3	3	3	3

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO1	3	2	3
CO2	3	3	1
CO3	3	2	1
CO4	3	3	2
CO5	3	3	2

(For The Candidates Admitted From 2023 – 2024 Onwards)

COURSE TITLE	NON-MAJOR ELECTIVE - PREBIOTICS IN NUTRACEUTICALS
Code	U23BT2SET02
Course Type	Theory
Semester	II
Total Hours	30
Hours/Week	2
Credits	2
Marks	100

CONSPECTUS

This course deals with health-promoting nutritional factors and bioactive constituents, their potential health implications and mechanisms of action.

COURSE OBJECTIVES

1. Understand the significance of nutrient and non-nutrient foods.
2. Comprehend the key components of probiotic microbes and how they affect health.
3. Discuss the effects of prebiotics on human health and potential applications in risk reduction of diseases.
4. Discuss the properties, structure and functions of various nutraceuticals.
5. Analyse nutraceutical foods as remedies for various chronic diseases and disorders.

UNIT I **6 HRS**

Introduction to probiotics, prebiotics and nutraceuticals.

Keywords/ Extra reading: *Synbiotics*

UNIT II **6 HRS**

Probiotics - Important features and health effects of probiotic micro-organisms.

Keywords/ Extra reading: *Probiotics in weight loss*

UNIT III **6 HRS**

Prebiotics - Effects on human health, perspective for food applications – dietary fibre, resistant starch, gums.

Keywords/ Extra reading: *Potential applications in risk reduction of diseases*

UNIT IV **6 HRS**

Applied aspects of nutraceuticals - bee pollen, grape tea, wheat grass, mushroom extract, kelp and spirulina, and blue tea.

Keywords/ Extra reading: *Proanthocyanidins and flaxseed oil as Nutraceuticals.*

UNIT V **6 HRS**

Benefits of prebiotics and probiotics – infants, adolescents and adults.

Keywords/ Extra reading: *Food as remedies.*

PRESCRIBED TEXTBOOKS

1. Wildman, R.E., (2019), Handbook of Nutraceuticals and Functional Foods. Edition III. CRC Press.
2. Vattem, D.A., Maitin V., (2016), Functional Foods, Nutraceuticals and Natural Products – Concepts and Applications. DEStech Publications, Inc
3. Gupta, R.C., (2016), Nutraceuticals: Efficacy, Safety and Toxicity. Academic Press.
4. Saarela, Maria, (2011), Functional Foods Concept to Product. Edition II, Woodhead Publishing.

SUGGESTED REFERENCES

1. Bajpai, D., Dwivedi H., (2023), Advances in food science and Nutrition, Volume – 1, Scripown Publications.
2. Rotimi E., Aluko, (2012), Functional Foods and Nutraceuticals, Springer.

WEBSITE REFERENCES

- https://www.webmd.com/drugs/2/drug-154514/probiotic-with-prebiotic-oral/details
- https://www.scientificarchives.com/article/microencapulsation%3A-probiotics-prebiotics-and-nutraceuticals

Note: Learners are advised to use the latest edition of books

COURSE OUTCOMES

CO No.	COURSE OUTCOMES	COGNITIVE LEVEL (K1-K6)
CO-1	Demonstrate understanding of macronutrients and micronutrients.	**K1**
CO-2	Understand the mechanisms of action and to analyse the probiotic-food interactions.	**K2**
CO-3	Analyze the prebiotic effects on digestive health.	**K3**
CO-4	Discuss the application of nutraceuticals in health.	**K4**
CO-5	Evaluate current trends and challenges in nutraceutical foods research.	**K5**

(K1=Remember, K2=Understand, K3=Apply, K4=Analyze, K5=Evaluate)

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO – Course Outcomes

PO-CO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1	3	1	-	-	-	-	-	1	1
CO 2	3	2	-	1	-	-	1	1	2
CO 3	3	2	1	1	1	1	1	2	3
CO 4	3	3	2	2	1	2	2	3	3
CO 5	3	3	2	2	2	3	3	3	3

PSO – CO MAPPING

CO/PO	PSO1	PSO2	PSO3
CO 1	-	-	-
CO 2	1	1	-
CO 3	1	2	1
CO 4	2	2	2
CO 5	3	3	3

HOLY CROSS COLLEGE (AUTONOMOUS) TIRUCHIRAPPALLI
PG - COURSE PATTERN (2023-2024 ONWARDS) – TANSCHE
SCHOOL OF LIFE SCIENCES
PG & RESEARCH DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS

PO No.	**Programme Outcomes** ***Upon completion of the post graduate. degree programme, the graduate will be able to***
PO-1	Exhibit a profound mastery of fundamental concepts, theories, methodologies, and tools in their field, equipping them to skillfully analyze and evaluate issues that pertain to their area of expertise.
PO-2	Conduct original and independent research to create findings and solutions to address the societal problems.
PO-3	Apply employability skills to confidently navigate in the job market and excel in competitive examinations in diverse professional settings.
PO-4	Demonstrate a strong commitment to ethical and moral values, actively engage in activities that promote social responsibility, decision making as inspired leaders to contribute positively for the betterment of society both locally and globally
PO-5	Embrace a commitment to lifelong learning and professional development, possessing the skills to adapt to the evolving trends, engage in self-directed learning and continuously enhance their expertise.
PO-6	Use knowledge in scientific experiment along with engineering technologies to use living organisms and biological systems to make products that advance healthcare, medicine, agriculture, food, pharmaceuticals and environmental control to fulfill the needs of the society.
PO-7	Apply modern skills, techniques, and scientific tools to face real-world challenges and pursue diverse career paths in academia, research institutions and industry.

	Programme Specific Outcomes ***Upon completion of the courses the student would be able to***
PSO-1	Use thorough knowledge in technical abilities inevitable to interact with disciplinary and trans-disciplinary aspects of biotechnology.
PSO-2	Analyze and evaluate the need for scientific revolution interacting with their biological sources to produce improved healthcare products and envisioning their sustainable development.
PSO-3	Apply innovative technologies, protocols, biomedical tools and kits to meet the needs of clinical and research laboratories with expertise in molecular techniques through lifelong learning.

(For The Candidates Admitted From 2023-2024 Onwards)
HOLY CROSS COLLEGE (AUTONOMOUS), TIRUCHIRAPALLI –620 002
SCHOOL OF LIFE SCIENCES
PG & RESEARCH DEPARTMENT OF BIOTECHNOLOGY
CHOICE BASED CREDIT SYSTEM
LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK (LOCF)
PG COURSE PATTERN - TANSCHE

Sem.	Course	Title of the paper	Code	Hours	Credits
I	Core Course I	Molecular Cell Biology	P23BT1CCT01	6	4
	Core Course II	Biochemistry	P23BT1CCT02	5	3
	Core Course III	Molecular Genetics	P23BT1CCT03	5	3
	Core Course IV Practical	Practical I (Molecular Cell Biology, Molecular Genetics, Biochemistry)	P23BT1CCP04	6	4
	Elective I	Bioinstrumentation/ Agricultural Biotechnology	P23BT1ECT01/ P23BT1ECT02	4	3
	Elective II	Enzymology/ Organic Farming	P23BT1ECT03/ P23BT1ECT04	4	3
	Value Education			**-**	**-**
	Total			**30**	**20**
II	Core Course V	Genetic Engineering	P23BT2CCT05	4	4
	Core Course VI	Animal and Plant Biotechnology	P23BT2CCT06	5	5
	Core Course VII – Practical-II	Practical II – (Genetic Engineering and Genomics & Proteomics)	P23BT2CCP07	4	4
	Core Course VIII-Practical-III	Practical III (Animal Biotechnology & Plant Biotechnology)	P23BT2CCP08	4	4
	Elective III	Genomics and Proteomics/Nanobiotechnology	P23BT2ECT05/ P23BT2ECT06	4	3
	Elective IV (Generic -)			4	3
	SEC I - NME I			4	2
	Value Education			1	
	Massive Open Online Course (MOOC)			-	2 Ex Credits
	Internship				2
	Self Study-Value added course(VAS)	Reviewing Manuscript	P23BT2SST01		2 Ex Credits
	Total			**30**	**27+4**

Major Elective offered

Semester	Course	Title of the Paper	Code	Hrs/ Week	Credit
II	Major Elective	Applied Bioinformatics	P23BT2ECT07	4	3

Non Major Elective

Semester	Course	Title of the Paper	Code	Hrs/ Week	Credit
II	Non Major Elective	Biotechnology in everyday life	P23BT2SET01	4	2

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	CORE COURSE I – MOLECULAR CELL BIOLOGY
Total Hours	90
Hours/Week	6 Hrs/ Wk
Code	P23BT1CCT01
Course Type	Theory
Credits	4
Marks	100

GENERAL OBJECTIVE

To make the learners to develop an exhaustive acquaintance with the structural, functional and molecular aspects of the cellular and sub cellular mechanisms and their research applications.

COURSE OBJECTIVES

To enable the learners

CO No.	Course Objectives
CO-1	Elucidate and demonstrate the structure and cellular functions associated with macromolecules in a cell.
CO-2	Comprehend the process of cell communication and signaling and associate the interaction of molecules in the process of signaling.
CO-3	Outline and examine the structural function of a chromosome and mechanism of DNA replication.
CO-4	Deconstruct and relate to the concept of processing of RNA and protein synthesis.
CO-5	Critically assess and predict the mechanism of gene regulation and the genetic base of tumorigenesis.

UNIT – I **18 HRS**

History of a cell: Definition, history, application of a cell. Prokaryotic and Eukaryotic cell- structure and function. Cell theory, Properties of cell.

Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure and function of cytoskeleton and its role in motility.

Mitosis and meiosis: their regulation, steps in cell cycle, and control of cell cycle.

Extra Reading (Key words): Red hot mitochondria.

UNIT – II **18 HRS**

Cytoskeleton and cell motility: Microtubules, actin and filament based motile system, membrane organization and transport across membrane.

Cellular interaction and cell signaling – Microvilli, intracellular communication and gap junction, Cell signalling and regulation**:** Hormones and their receptors, cell surface receptors, signalling through G-protein coupled receptors, receptor tyrosine kinase, signal transduction pathways, second messengers, bacterial and plant two component signalling systems, bacterial chemotaxis. Cascades of induction, interactions, paracrine factors.

Signal transduction cascade – RTK pathway, JAK-STAT pathway, Hedgehog family, Wnt family, TGF- β superfamily. Cell adhesion and roles of different adhesion molecules, extracellular matrix, neurotransmission.

Extra Reading (Key words): Piezo1 Protein in cell signaling

UNIT – III **18 HRS**

Chromosome- structure and functions. DNA modification in specialized chromosomes. Chromatin, heterochromatin and euchromatin. Nucleic acids- structure, their stability, polymorphisms, sugar puckering, base stacking, cot curves, C-value paradox - prokaryotic and eukaryotic DNA and its replication. Mitochondrial and Chloroplast DNA.

DNA Replication-Types and mechanism of DNA replication. Unit of replication, fidelity of replication, extrachromosomal replicons. Denaturation - Renaturation kinetics. DNA damage, DNA Modifications.

DNA repair mechanisms – DNA mutations – types and detection of mutations -. RNA binding proteins,

Ribonucleoproteins, RNA-protein recognition and interactions.

Extra Reading (Key words): *Gene free chromosomal region*

UNIT – IV **18 HRS**

Transcription and processing of RNA:- Prokaryotic and eukaryotic - Regulatory signal elements: promoter, motifs. Transcription factors and machinery, formation of initiation complex, transcription activators and repressors, RNA polymerases, capping, elongation and termination, RNA processing, RNA editing, splicing, polyadenylation, structure and function of different types of RNA, RNA transport.

RNA types and functions - Non-coding RNAs: structure and function - si RNA and miRNAs. Catalytic RNA. Genetic code, Properties and Wobble hypothesis. Overlapping genes.

Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post- translational modification and inhibitors of protein synthesis. Protein localization-synthesis of secretory and membrane proteins - Protein sorting - Vesicular traffic in secretion.

Extra Reading (Key words): *Cell-free protein synthesis in protein therapeutics*

UNIT –V **18 HRS**

Regulation of Gene Expression-Types, Operon concept - Lac, Trp and Ara operons - Gene regulation in eukaryotes – myosin and hemoglobin synthesis- Down-stream regulation - SNAPs and SNAREs -TAG protein destruction - DNA re-arrangement.

Insertional elements and Transposons - Plant, Bacterial and Animal, Structure- organization and transposition. Homologous recombination and non-homologous recombination of genes - Holiday junction - Rec A and other recombinases.

Tumorigenesis – Theories regarding tumor formation. Biological clock and Mutation theory. Site-specific and Oligonucleotide directed mutagenesis. Oncogenes and Tumour Suppressor Gene. Genetic pathways for PCD Anti- and pro-apoptotic proteins.

Extra Reading (Key words): *Stem cell vaccine to protect cancer*

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Freifelder, D. (2015), Essentials of molecular Biology, fourth edition, Jones and Bartlett Publications Inc.
2. De Robertis DP (2017) Cell and Molecular Biology, 8th Edition, Lippincott Williams and Williams.

SUGGESTED REFERENCE BOOKS

1. Gerald Karp, (2013), Cell Biology, VII edition International Student Version, Wiley publication.
2. Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. Scott, (2012), Molecular Cell Biology, VII edition, W.H. Freeman and Company, New York.
3. Ajoy Paul. Textbook of Cell and Molecular Biology (2011). Books & Allied Ltd Publishers. ISBN-10: 8187134747.
4. David P Clark, (2009) Molecular Biology. (Understanding the genetic revolution), Elsevier Academic Press.
5. Geoffrey M. Cooper, Robert E. Hausman (2007), The Cell - A Molecular Approach, Sinauer Associates, Inc.
6. Lewin, B. (2007), Genes IX, Jones and Bartlett Publishers
7. James D Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine and Richard Losick, Benjamin Cummings (2004). Molecular Biology of the Gene, Fifth Edition
8. Lodish, Harvey, Arnold, Matsudaira, Paul, Kaiser, Chris A., Krieger, Monty Scott, Matthew P., Zipursky, Lawrence, Darnell, James (2004), Molecular Cell Biology, W.H. Freeman and Company.
9. Gerald Karp (2002) Cell and Molecular Biology, Third edition, John Wiley and sons.
10. Darnell, J.E., Lodish, H. and Baltimore, D. (2000), Molecular Cell Biology, Fourth edition, W.H. Freeman and Company, New York.
11. Primrose S. B, (2001), Molecular Biotechnology – Panima Publications, New Delhi.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.commonsense.org/education/lists/best-molecular-and-cell-biology-apps-and-websites
- https://www.edx.org/learn/molecular-biology
- https://alison.com/course/understanding-molecular-biology

COURSE OUTCOMES (CO)

The learners will be able to

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Predict the structural and functional details of various cell organelles and their properties.	PSO 3	U
CO-2	Construct a model depicting the cell cycle and its regulatory mechanism.	PSO 1, 3	Ap
CO-3	Illustrate the major components and pathways of cell signaling.	PSO 1,4	Ap
CO-4	Differentiate the structure, function and numerical alterations of chromosomes in prokaryotes and eukaryotes.	PSO 3	An
CO-5	Reason out the mechanism of construction, damage and repair of DNA and interactions.	PSO 2, 4	U
CO-6	Examine in detail the factors affecting the regulation of RNA and protein synthesis and their properties.	PSO 3,5	An

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	CORE COURSE II - BIOCHEMISTRY
Total Hours	75
Hours/Week	5 Hrs/ Wk
Code	P23BT1CCT02
Course Type	Theory
Credits	3
Marks	100

GENERAL OBJECTIVES

This paper presents the study of identification and quantitative determination of the substances, studies of their structure, determining how they are synthesized, metabolized and degraded. The students will get an overall understanding of structure of atoms, molecules and chemical bonds, enzyme kinetics, biopolymers and metabolic reactions in living systems.

COURSE OBJECTIVES

After completion the student will be able to

CO No.	Course Objectives
CO-1	Distinguish the role of carbohydrates their properties and explains the metabolic pathway of carbohydrates.
CO-2	Comprehend the basics of amino acid and protein structure, classification and metabolism.
CO-3	Outline the basic classification, metabolism and functions of lipids and fatty acids.
CO-4	Outline the basic classification, metabolism and functions of nucleic acids.
CO-5	Explain the basics of vitamins and minerals, its classification, functions and deficiency diseases.

UNIT I **15 HRS**

Biomolecules –Chemical composition and bonding. Properties of water – acids, bases, buffer- pKa, ionization, pH, reaction kinetics, thermodynamics, colligative properties.

Carbohydrate and its metabolism – Structure and classification- Bioenergetics-glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers– **Kreb's cycle** - gluconeogenesis – HMP pathway.

Extra Reading /Key words: Regulation of Pyruvate dehydrogenase and TCA cycle.

Unit II **15 HRS**

Carbohydrates: Classification, monosaccharides, D and L designation, open chain and cyclic structures, epimers and anomers, mutarotation, reactions of carbohydrates (due to functional groups - hydroxyl, aldehyde and ketone. Amino sugars, Glycosides.

Structure and biological importance of disaccharides (sucrose, lactose, maltose, isomaltose, trehalose), tri-saccharides (raffinose, melezitose), structural polysaccharides (cellulose, chitin, pectin) and storage polysaccharides (starch, inulin, glycogen).

Glycosaminoglycans, Bacterial cell wall polysaccharides.

Extra Reading /Key words: Glycoproteins and blood group substances

Unit III **15 HRS**

Lipids: Classification, saturated and unsaturated fatty acids, structure and properties of fats and oils (acid, saponification and iodine values, rancidity). General properties and structures of phospholipids. Prostaglandins- structure, types and biological role.

Lipoproteins- types and functions, Bio-membranes: Membrane composition and organization - Fluid mosaic model.

Pigments & Vitamins – Structure, Classification and Properties. Minerals – Definition and properties.

Extra Reading /Key words: Metabolic profile of liver, Adipose tissue and brain

Unit IV **15 HRS**

Amino Acids: Classification, structure, stereochemistry, chemical reactions of amino acids due to carbonyl and amino groups. Titration curve of glycine and px values. Essential and nonessential amino acids, non-

protein amino acids. Peptide bond - nature and conformation. **Naturally occurring peptides** - glutathione, enkephalin. Proteins: Classification based on solubility, shape and function. Determination of amino acid composition of proteins.

General properties of proteins, denaturation and renaturation of proteins. Structural organization of proteins- primary, secondary, tertiary and quaternary structures.

Extra Reading /Key words: Hemoglobin and myoglobin

Unit V **15 HRS**

Nucleic acids: Structure of purines and pyrimidines. Nucleosides and Nucleotides; biologically important nucleotides.

Nucleic acids as the genetic material - experimental evidences; Chargaff's rules. Formation of phosphodiester bond and its stability, Structure of DNA-Watson and Crick model, different forms of DNA, types of RNA, Structure of RNA: mRNA, tRNA, Rrna.

Physico-Chemical properties of nucleic acids - Denaturation and Renaturation, hyper chromic effect, Tm, melting curves.

Extra Reading /Key words: Disorders of nucleic acid metabolism

PRESCRIBED TEXT BOOKS:

1. Mary K. Campbell and Shawn O. Farrell (2011), Biochemistry, 5th Edition, Thomson Brooks/Cole, Indian Edition.
2. Donald Voet and Judih C. Voet (2004) Biochemistry, Third edition, John Wiley and Sons, Inc.
3. Stryer, L., (2003), Biochemistry, V edition, W. H. Freeman and Co.

SUGGESTED BOOKS FOR REFERENCE:

1. Alison Snape, Despo Papachristodoulou, William H. Elliott, Daphne C. Elliott, (2014). Biochemistry and Molecular Biology, V edition, Oxford University press.
2. David Lee Nelson, Michael M. Cox, (2013). Lehninger Principles of Biochemistry, VI edition, W.H. Freeman and Company, New York.
3. William H. Elliott, Daphne C. Elliott., 2009. Biochemistry and molecular biology. Oxford University Press.
4. Campbell MK and Farell SO (2003) Biochemistry Forth Edition, Thomson Learning Books.
5. Murray, R.K., Grannor, D.K., Mayes, PA .and Rodwell, V.W., (2000), Harper's Biochemistry, McGRAW Hill Pvt. Ltd., New Delhi.
6. Geoffrey L.Zubay, William W. Passon, Dennis L. Vance, (1998), Principles of Biochemistry, IV edition, W.M.C. Brown Publishers, Australia.

WEBSITE REFERENCES

- https://libguides.reading.ac.uk/biological-sciences/e-resources
- https://guides.library.ucla.edu/c.php?g=180262&p=1187298

COURSE OUTCOMES

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Outline the chemical composition and properties of biomolecules.	PSO 1	R, U
CO-2	Demonstrate the structure, classification and metabolism of carbohydrates.	PSO 2	R
CO-3	Summarize and explain the structural conformations of proteins, their properties and metabolism.	PSO 2	U
CO-4	Illustrate nucleic acid metabolism and the classification and properties of vitamins and minerals.	PSO 3	R
CO-5	Classify lipids based on their structure, functions and properties and explain its metabolic pathways.	PSO 3	An
CO-6	Discuss the chemistry and functions of various vitamins, minerals and their sources.	PSO 4	U, An

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	**CORE COURSE III – MOLECULAR GENETICS**
Total Hours	**75**
Hours/Week	**5 Hrs/ Wk**
Code	**P23BT1CCT03**
Course Type	**Theory**
Credits	**3**
Marks	**100**

GENERAL OBJECTIVE

The paper imparts a thorough knowledge on the basics of all the Genetics concepts, molecules and its regulation. The student will get to understand the core concepts of molecules and genetics.

COURSE OBJECTIVES

To enable the learners

CO No.	Course Objectives
CO-1	To understand the fundamentals of genetic material in living system
CO-2	To enable them with better understanding about the defects in genetic material and to modify them for the proper functioning
CO-3	To have an overview of all kinds of diagnostic techniques for such molecular mechanisms.
CO-4	Critically assess and predict the mechanism of Transmission Genetics
CO-5	Outline and examine the use of human genome

Unit I **15 HRS**

General concept of a gene- gene families, Mendelian inheritance, non-Mendelian inheritance, Sex linked inheritance, Identification of DNA as the genetic material.

Organization of prokaryotic and eukaryotic genome, DNA supercoiling, Chromatin organization-histone and DNA interactomes.

DNA markers –VNTR, STR, microsatellite, SNP and their detection techniques.

Extra Reading: Genetic disorders

Unit II **15 HRS**

DNA replication mechanisms- Accessory proteins for the DNA replication, Regulation of replication initiation in prokaryotes and eukaryotes.

Types of mutations - nomenclature Spontaneous and virus induced mutation, Radiation induced mutation. Ionizing radiation, UV radiation, crossing over and linkage

Chromosomal Abnormalities and associated genetic diseases - Genetic Testing (Prenatal & Postnatal); Techniques in the study of chromosomes and their applications, Recombination – models.

Extra Reading: Microarrays

Unit III **15 HRS**

DNA Damage and Repair-Internal and external agents causing DNA damages (Oxidative damages, Depurinations, Depyrimidinations, O6-methylguanines, Cytosine deamination, single and double strand breaks); Mechanisms of DNA damage (transition, transversion, frameshift, nonsense mutations)

Repair mechanisms – (Photo reactivation, excision repair, mismatch repair, post replication repair, SOS repair); Discovery: Early experiments of McClintock in maize. Insertion sequences in prokaryotes.

Complex transposons – Mechanisms, control consequences and application of transposition by simple and complex elements.

Extra Reading: Comet Assay

Unit IV **15 HRS**

Transmission Genetics: Chi square analysis, autosomal inheritance and molecular basis- -Mutations-molecular & phenotypic perspective-Population genetics: Hardy-Weinberg equilibrium.

Gene mapping: Linkage maps, tetrad analysis, mapping with molecular markers and using somatic cell hybrids.

Karyotyping – usefulness of chromosomes in understanding Genetic variation, Genetics of eukaryotes gene linkage and chromosome mapping.

Extra Reading: Punnet square

Unit V **15 HRS**

Human genome- Organization of the human genome, human multigene families. Human genome project: Mapping of the human genome: Physical mapping and Genetic mapping. **Footprints of evolution** -, human DNA instability. Chromosome walking. Introduction to human genome project- telomere to telomere, Ancestry by variations.

Applications of molecular genetics- Disease diagnosis, Epigenetic testing, Prognostic and diagnostic markers, Development of molecules in Biopharma, Therapeutic advancements, Disease heritability, improving existing biological outcomes, Vaccine development and Gene therapy and other molecular genetics based therapeutic approaches.

Extra Reading: HGP

PRESCRIBED TEXT BOOKS

1. Simmons., & Snustad., (2006). Principles of Genetics Gardner, 8th Edition.
2. D. Peter Snustad., & Michael J. Simmons., (2015). Principles of Genetics, Seventh Edition, Wiley.
3. James D. Watson., (2017). Molecular Biology of the Gene, Seventh edition, Pearson.
4. Krebs JE et al., (2017). Lewin's Gene XII, Twelth edition, Jones & Bartlett Publishers.

SUGGESTED BOOKS FOR REFERENCES

1. Geoffrey M. Cooper., & Robert E. Hausman., (2003). The Cell- A Molecular Approach, 3rd Edition.
2. Kavitha B. Ahluwalia., (2010). Genetics, New Age International Pvt Ltd and Publishers, New Delhi.
3. P.S Verma., & A.K Agarwal., Genetics, (Rack 3, Central Library).
4. Robert Brooker., (2011). Genetics- Analysis and Principles, 4th edition, McGraw Hill.
5. Leland Hartwell., Leroy Hood., Michael Goldberg., Ann Reynolds., Lee Silver., (2010). Genetics: From Genes to Genomes, 4th Edition, McGraw Hill.
6. Rastogi Smita., & Neelam Pathak., (2010). Genetic Engineering, Oxford University Press, New Delhi. (Rack 3, Central Library).

WEBSITE REFERENCES

- https://www.genome.gov/GenomeEd/resources
- https://insidescienceresources.wordpress.com/2017/11/14/web-based-molecular-biology-tools/
- http://bbruner.org/107net99.htm

COURSE OUTCOMES

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Outline the basics of gene as the fundamental aspect of life.	**PSO 1**	**R, U**
CO-2	Understanding the fundamentals of hereditary materials and their role in functioning of human system.	**PSO 2**	**R**
CO-3	Able to identify the damage in hereditary material and malfunctioning of genes to help in eradicating the disease.	**PSO 2**	**U**
CO-4	Capable of understanding the Gene editing techniques	**PSO 3**	**R**
CO-5	Able to understand the human Genome and features	**PSO 3**	**An**
CO-6	With the wide technical knowledge, the students able to modify the genes and restore the functions of the hereditary material.	**PSO 4**	**U, An**

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	MAJOR CORE 4– PRACTICAL –I (MOLECULAR CELL BIOLOGY, BIOCHEMISTRY, MOLECULAR GENETICS)
Total Hours	90
Hours/Week	6 Hrs/ Wk
Code	P23BT1CCP04
Course Type	Practical
Credits	4
Marks	100

GENERAL OBJECTIVE

This practical focuses on the working principles of Molecular and cellular Biology, Biomedical and Bioinstrumentation techniques.

A. Molecular Cell Biology

1. Identification of different phases of mitosis – Onion root tip
2. Identification of different phases of Meiosis in grasshopper testis / flower buds.
3. Giant chromosome studies in Chironomous larvae
4. Preparation of single cell suspension from spleen and thymus
5. Cell counting and cell viability
6. Histochemical staining to localize proteins
7. Histochemical staining to localize carbohydrates
8. Histochemical staining to localize lipid

B. Biochemistry

1. Estimation of Proteins by Lowry's method
2. Estimation of Proteins by Biuret method
3. Estimation of Proteins by Bradford method
4. Estimation of RNA by orcinol method
5. Estimation of DNA by diphenylamine method
6. Estimation of Carbohydrate by Anthrone method
7. Separation of amino acids by Paper Chromatography
8. Separation of sugars by Paper Chromatography
9. Separation of amino acids by thin layer chromatography

C. Molecular Genetics

1. Isolation of genomic DNA from Human (Buccal cell)
2. Isolation of genomic DNA from Bacterium (*E. coli*)
3. Isolation of genomic DNA from Plant (Cauliflower)
4. Agarose gel electrophoresis of DNA
5. Transfer of DNA from gel – Southern Blotting
6. Transfer of RNA from gel – Northern Blotting
7. Restriction digestion of DNA

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	**ELECTIVE I - BIOINSTRUMENTATION**
Total Hours	**60**
Hours/Week	**4 Hrs/ Wk**
Code	**P23BT1ECT01**
Course Type	**Theory**
Credits	**3**
Marks	**100**

GENERAL OBJECTIVE

` To make the learners become familiar with fundamental principles of biomedical instrumentation and learns about different biological signals, their acquisition, measurements and related constraints used in biomedical engineering research labs and hospitals.

COURSE OBJECTIVES

To enable the learners

CO No.	Course Objectives
CO-1	Elucidate and demonstrate the tranducers and principles of biomedical instruments.
CO-2	Comprehend the process of medical imagining techniques such as diagnostic radiology and PET scanner.
CO-3	Outline working principle and applications of microscopic techniques in cellular function.
CO-4	Deconstruct the principle and working mechanism of analytical and spectroscopic techniques.
CO-5	Critically evaluate the applications of electrophoretic techniques in biotechnology.

Unit I **12 HRS**

Transducers: Photoelectric transducers – Flow transducers – Piezoelectric transducers and their applications, biological receptors and receptor characteristics.

Cell resting potential and action potentials - Single neuron recording, patch-clamp recording, Origin of bio potentials Electrocardiogram (ECG), Electroencephalogram (EEG),
Electromyogram (EMG), Electrooculogram (EOG), Electroretinogram (ERG)

Recording Electrodes – Electrode-tissue interface, polarization, skin contact impedance.

Extra Reading (Key word): Electrode Jellies

Unit II **12 HRS**

Medical imaging techniques: Basics of diagnostic radiology – Production - Nature and properties of X rays - X-ray machine, SPECT Scanner – PET Scanner - MRI, fMRI, computerized axial tomography scan - Biosensors – types and applications. Bio-electronics.

Analytical instruments in Biomedical Engineering: oximeter, spectrophotometer, colorimeter, blood gas analyzer, blood cell counter.

Radio labelling techniques - Properties of different types of radioisotopes used in biology, molecular imaging of radioactive material - safety guidelines - P3 laboratory - BARC approval -waste disposal management. Radioactivity detectors - GM Counters, Liquid and solid scintillation counters, Radiation dosimeters. Autoradiography.

Extra Reading (Key words): FLISA

Unit III **12 HRS**

Laboratory instrumentation: Principle, working, applications of laminar clean air flow, autoclave, incubators, weighing balances, water bath and hot air oven.

Microscopic techniques - Principles, structural components, applications and working of microscope – Compound, Dark Field, Fluorescent, Phase contrast, Inverted.

Electron microscopy - Scanning Electron Microscopy, Transmission Electron Microscopy- Biological sample preparation for SEM and TEM, Scanning tunneling and high voltage electron microscopes. CLSM and AFM- their uses and image processing methods.

Extra Reading (Key words): Cryo-Electron Microscopy

UNIT – IV **12 HRS**

Spectroscopic techniques - UV and visible, fluorescence, gamma ray and infrared spectroscopy, Atomic absorption spectroscopy, Nuclear Magnetic Resonance (NMR), Electron Spin Resonance (ESR), Surface plasma resonance

Mass Spectroscopy - Circular Dichroism spectroscopy and X-ray crystallography technique. Lasers, Spectro fluorimetry, turbidometry and nephelometry.

Analytical Techniques- Principle, working and applications of redox and pH meter. Colorimetry-Principles, instrumentation and applications of Micro Colorimetry (DSC and ITC).

Extra Reading (Key words): Raman spectroscopy in antibiotic discoveries

UNIT – V **12 HRS**

Centrifugation –concepts of relative centrifugal force and sedimentation coefficient. Factors affecting Sedimentation velocity, Standard Sedimentation Coefficient, Centrifugation of associating systems. Principle and applications of Preparative Centrifuge –Differential and Gradient centrifugation; Analytical centrifuges- Ultra centrifuge.

Chromatography - Principle and applications of Paper, Thin layer, Column, HPLC, Gas-liquid, Ion-exchange, Affinity and Gel permeation, GC-MS, MALDI TOF, LC-MS.

Electrophoretic techniques- Principles and applications of electrophoresis – AGE, PAGE, SDS-PAGE, DGGE, cellulose acetate, continuous flow and capillary electrophoresis, DNA sequencing gels, RNA electrophoresis, Isoelectric focusing, PFG, 2D gel electrophoresis and 2D-DIGE. Immuno electrophoresis.

Extra Reading (Key words): Microchip in separation of DNA fragments, hPAGE

Note: Texts given in the Extra reading /Key wordsmust be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Khandpur R.S., (2004). Handbook of Biomedical Instrumentation, Tata McGraw, New Delhi.
2. Cromwell Leslie., Fred J. Weibell., Erich A. Pfeiffer., (2004). Bio medical Instrumentation and Measurements, PHI, 2nd edition.
3. Webster John., (2003). Medical instrumentation, John Wiley and sons, New York.
4. Geddes L.A., & L.E. Baker., (1989). Principle of Applied Bio medical Instrumentation, 3rd edition Wiley Interscience Publication.

SUGGESTED BOOKS FOR REFERENCE

1. Mitra S.K., (2013). Digital signal processing, Tata McGraw Hill Limited.
2. Reddy D.C., (2005). "Biomedical Signal Processing-Principles & Techniques", Tata McGraw Hill.
3. Tompkins Wills J., (1993). Biomedical digital signal processing", Prentice Hall of India Pvt.Ltd. New Delhi.
4. Richard Aston Merrill., (1990). Principles of Biomedical Instrumentation and Measurement, Publishing Company.
5. Geddes L.A., & Bake L. E., (1989). Principles of Applied Biomedical Instrumentation, John Wiley & Sons.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.classcentral.com/tag/instrumentation
- https://nwtc.libguides.com/c.php?g=43794&p=277944
- https://iworx.com/products/biomedical-engineering/bik-ta-bioinstrumentation-physiology-teaching-kit/

COURSE OUTCOMES (CO):

The learners will be able to

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Identify the underlying working principle of various biomedical instruments with their specific applications.	**PSO 1**	**U**
CO-2	Interpret the role of diagnostic tool in medical imaging techniques.	**PSO 2**	**R**
CO-3	Integrate the use of microscopic principle for analyzing the anatomy of a cell.	**PSO 2**	**U**
CO-5	Integrate spectroscopic techniques in their research projects and utilize them to discover the structure of novel compounds.	**PSO 4**	**An**
CO-6	Compare the principles and applications of various electrophoretic techniques and invent new applications for electrophoresis.	**PSO 4**	**U**

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)

I M.Sc. BIOTECHNOLOGY

Course Title	MAJOR ELECTIVE 1 – AGRICULTURAL BIOTECHNOLOGY
Total Hours	60
Hours/Week	4 Hrs./Wk.
Code	P23BT1ECT02
Course Type	Theory
Credits	3
Marks	100

GENERAL OBJECTIVE

To make the learners to expose the basic scientific evidence and technical aspects of agricultural biotechnology. It clarifies major scientific, ecological and sociological aspects of biotechnology in agriculture and food production.

COURSE OBJECTIVES

To enable the learners

CO No.	Course Objectives
CO-1	Learn basics of plant physiological functions, processes and its importance in crop production
CO-2	Develops the knowledge of improved productivity in modern agriculture.
CO-3	Understand the fundamental aspects of agricultural microbiology and applications
CO-4	Describe the role organic farming in soil fertility.
CO-5	Transform the knowledge of agriculture into agribusiness and agro-based industries.

UNIT I **12 HRS**

Physiology and cell biology of plants: Crop physiology and its importance in agriculture. Overview of plant cell: bio membrane, organelles and the cytoskeleton.

Absorption of Water, Mineral Nutrition and BNF: Active and passive absorption of water. Diffusion and osmosis. Water potential and its importance. Stomatal Physiology, transpiration and water use efficiency. Mengele'sclassification of mineral nutrients in plants. Nutrient uptake mechanisms. Functional roles and deficiency symptoms of macro and micro nutrients.

Extra Reading/Key words: Nomenclature of plant

UNIT II **12 HRS**

Photosynthesis and Lipid Metabolism Photosynthesis: Light and dark reactions - C3, C4 and CAM; Respiration: Glycolysis, TCA cycle and electron transport chain; Fat Metabolism. Fatty acid synthesis and breakdown.

Plant Growth Regulators and Growth Analysis: Auxins, cytokines, gibberellins, Abscisic acid and ethylene- physiological roles and agricultural uses. Physiological aspects of growth and development of major crops - growth analysis and role of physiological growth parameters in crop productivity.

Extra Reading/Key words: Isolation of compounds from plant materials

UNIT – III **12 HRS**

Biological Nitrogen Fixation: Symbiotic, associative and asymbiotic microbes involved in nitrogen fixation. Azolla, blue green algae and mycorrhiza. Rhizosphere and phyllo sphere. Microbes in human welfare: silage production, bio fertilizers, bio pesticides, biofuel production and biodegradation of agro-waste.

Extra Reading/Key words:. Agrobacterium mediated gene transfer

UNIT – IV **12 HRS**

Organic matter and soil fertility: Soil organic matter - soil fertility management - soil quality management - water management, pest management, soil biology and nutrition - Inorganic nutrition in soil. Field indicators of biological and nutritional problems.

Indian organic farming: Progress of organic farming in India, regulations, project and initiatives.

Organic manures and fertilizers: Concentrated organic manures, effect of organic manures on soil properties, farms utilizing animal manures.

Types of organic fertilizers: Animal manure, biosolids, commercial organic fertilizers, phosphate rich organic manures, Inorganic fertilizers, problems of inorganic fertilizers. Irrigation - tillage, rotations,

fallows.

Extra Reading (Key words):manure a source of cellulose, Halogenated organic pollutant

UNIT – V **12 HRS**

Agribusiness

Transformation of agriculture into agribusiness, various stakeholders and components of agribusiness systems. Importance of agribusiness in the Indian economy and New Agricultural Policy.

Agro-based industries: Distinctive features, importance and needs of agro-based industries. Classification of industries and types of agro based industries. Institutional arrangement, procedures to set up agro-based industries. Constraints in establishing agro-based industries.

Extra Reading/Key words: IPR

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Subba Reddy, S and P. Raghu Ram. 2018. Agricultural Finance and Management. Oxford & IBH Publishing Company Private Ltd., India.
2. Lincoln Taiz, Eduardo Zeiger, Ian M. Moller, and Angus Murphy. 2018. Plant Physiology and Development, International Sixth Edition. Sinauer; Oxford University Press; USA.
3. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley and David A. Stahl. 2017. Brock Biology of Microorganisms.15th Edition. Pearson. UK.
4. Freddie L. Barnard, John C. Foltz, and Elizabeth A. Yeager. 2016. Agribusiness Management. 5th edition, Routledge. UK
5. Frank B. Salisbury. 2006. Plant physiology. 4th edition.Sinauer Associates, Inc., USA.

BOOKS FOR REFERENCE

1. Subba Rao, N.S. 2017. Soil Microbiology. 5th Edition(PB),Published by Medtec. University Book Store. New Delhi, India
2. Aneja K.R. 2017.Fundamental Agricultural Microbiology. New Age International Publishers, India.
3. Ronald Kay and William Edwards and Patricia Duffy. 2015. Farm Management. 8th edition, McGraw-Hill Education, USA.
4. Buchanan. B. B. 2015. Biochemistry and Molecular Biology of Plants. 2nd Edition. WileyBlackwell, USA.
5. Peter Barry and Paul Ellinger. 2011. Financial Management in Agriculture. 7th edition, Pearson. UK.
6. Bagyaraj D. J. and G.Rangaswami. 2007.Agricultural Microbiology 2nd Edition. PHI Learning Private Limited. India.
7. Mohr, H and P. Schopfer. 1995. Plant physiology, Springer-Verlag, Germany.

Note : Learners are advised to use latest edition of books

WEBSITE REFERENCES

- https://ecourses.icar.gov.in/
- https://www.classcentral.com/course/food-production-agricultural-technology-plant-bio-14399
- https://www.edx.org/learn/biotechnology

COURSE OUTCOMES (CO)

The learners will able to

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	outline diverse physiological process and summarize the mechanisms of uptake, transport and translocation of water and nutrients in plants	PSO 2	U
CO-2	Explain carbon cycles in plants, lipid metabolism and growth regulators in plant growth	PSO 1	An
CO-3	Utilize microbes as models to study genetics	PSO 2	U
CO-4	Apply organic farming to improve soil fertility and high quality crops.	PSO 2	Ap
CO-5	Acquire knowledge on transforming agriculture into agribusiness.	PSO 3	C

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)
I M.Sc. BIOTECHNOLOGY

Course Title	ELECTIVE 2 - ENZYMOLOGY
Total Hours	60
Hours/Week	4 Hrs/ wk
Code	P23BT1ECT03
Course Type	Theory
Credits	3
Marks	100

GENERAL OBJECTIVE

To develop an exceptional knowledge about the mode of action of enzymes, kinetics, isolation and its regulation.

COURSE OBJECTIVES

To enable the learners

CO No.	Course Objectives
CO 1	Gain knowledge on enzyme classification, nomenclature, isolation and purification methods.
CO 2	Familiarize on the reaction kinetics
CO 3	Acquire knowledge on enzyme specificity and catalysis.
CO 4	Study the concepts of the mechanism of enzyme action
CO 5	Know the different types of Co-enzymes.

UNIT I: **12 HRS**

Enzymes - Introduction, Classification, nomenclature and general propertie effect of pH, substrate and temperature on enzyme catalysed reactions.

Extraction Isolation and purification of enzymes - precipitation, centrifugation

Separation of enzymes - chromatography and electrophoresis and liquid-liquid extraction methods.

Extra Reading /Key words*: Allosteric activation*

UNIT II: **12 HRS**

Kinetics of catalysed reaction: Single substrate reactions, bisubstrate reactions

Michaelis - Menten, Briggs Haldane relationship: Determination and significance of kinetic constants, Limitations of Michaelis-Menten Kinetics

Enzyme kinetics: Line weaver burk plot, Hanes wolf equation, Eadie hoofstee equation, Inhibition of enzyme activity

Extra Reading / Key words: *Monods Kinetics*

UNIT III: **12 HRS**

Enzyme catalysis: enzyme specificity and the concept of active site, determination of active site. Stereospecificity of enzymes.

Mechanism of catalysis: Proximity and orientation effects, general acid-base catalysis, concerted acid - base catalysis

Nucleophilic and electrophilic attacks: catalysis by distortion, metal ion catalysis

Extra Reading/ Keywords: *Zymogene*

UNIT IV: **12 HRS**

Theories on mechanism of catalysis - Mechanism of enzymes action: mechanism of action of lysozyme, chymotrypsin, carboxypeptidase and DNA polymerase.

Multienzymes system : Catalysis and regulation

Enzyme activity and regulation: pyruvate dehydrogenase and fatty acid synthetase complex

Extra Reading/Key words: *prodrug approach*

UNIT V **12 HRS**

Coenzyme action. Enzyme regulation: General mechanisms of enzyme regulation, Allosteric enzymes, sigmoidal kinetics and their physiological significance

Allosteric enzymes: Symmetric and sequential modes for action. Reversible and irreversible covalent

modification of enzymes,

Immobilized enzymes: Clinical and industrial applications of enzymes, Enzyme Engineering

Extra Reading/Key words*: Biomimetics*

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Nicholas C.Price and Lewis Stevens., 2010. Fundamentals of Enzymology. Oxford University Press, New Delhi
2. Lehninger, Nelson and Cox, 2005, Principles of Biochemistry - 4th edition, WH Freeman and Company, New York, USA
3. Principles of Biochemistry with human focus - Garrett and Grisham, 2002, Harcourt College Publishers, Orlando, Florida, USA.

SUGGESTED REFERENCE BOOKSS

1. Geoffrey L, Zubay, Biochemistry -, 1998, 4th edition. 23
2. Donald Voet, Judith Voet and Pratt, 1995, Fundamentals of Biochemistry, 2nd edition.
3. Harper.s Biochemistry - Murray et al, 2000, 25th edition, Appleton and Lange Publishers.
4. Enzymes – Trevor Palmer 2002.

Note: Learners are advised to use latest edition of books

WEBSITE REFERENCEs

- www.lsbu.ac.uk/biology/enztech/
- www. lsbu.ac.uk/biology/enzyme/
- http://www.aetlted.com/tech/applications.html

COURSE OUTCOMES

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Scrutinize the methods of isolation, and purification of enzymes.	PSO-1	**R**
CO-2	Articulate the mechanism of enzyme action.	PSO-2	**U**
CO-3	Produce commercial enzymes through enzyme engineering	PSO-2	**Ap**
CO-4	Recognize the proper method of activation of enzymes and multienzyme systems.	PSO-5	**Ap**
CO-5	Scrutinize the enzyme immobilization methods for various applications.	PSO-3	**An**

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For The Candidates Admitted From 2023-2024 Onwards)

I M.Sc., BIOTECHNOLOGY

Course Title	MAJOR ELECTIVE I1 – ORGANIC FARMING
Total Hours	60
Hours/Week	4
Code	P23BT1ECT04
Course Type	Theory
Credits	3
Marks	100

GENERAL OBJECTIVES

To appreciate the importance of Organic farming systems for the enhancement and conservation of soil ecosystem.

COURSE OBJECTIVES

To enable learners to:

CO No.	Course Objectives
CO-1	Identify the various biological and nutritional problems in India and select the appropriate organic management systems for different organic farms in India.
CO-2	Explain and assess the role organic manures and fertilizers in creating and maintaining an appropriate condition for soil improvement and fertility.
CO-3	Develop novel strategies for weed collection, management and control in developing agricultural farms.
CO-4	Outline the history of organic farming and discuss the objectives and values of organic farming.
CO-5	Criticize the role of green manuring for biofertilization in enhancing crop improvement.

UNIT I **12 HRS**

Organic matter & soil fertility

Organic matter and soil fertility: Soil organic matter - soil fertility management - soil quality management - water management, pest management, soil biology and nutrition - Inorganic nutrition in soil. Field indicators of biological and nutritional problems.

Indian organic farming: Progress of organic farming in India, regulations, project and initiatives.

Extra Reading (Key words)*: manure a source of cellulose.*

UNIT II: **12 HRS**

Organic fertilizers

Organic manures and fertilizers: Concentrated organic manures, effect of organic manures on soil properties, farms utilizing animal manures.

Types of organic fertilizers: Animal manure, biosolids, commercial organic fertilizers, phosphate rich organic manures, Inorganic fertilizers, problems of inorganic fertilizers. Irrigation - tillage, rotations, fallows.

Extra Reading (Key words): *Halogenated organic pollutants.*

UNIT III **12 HRS**

Weed management in organic farming

Weed management in organic farming: Cultural methods of weed control, tillage, tillage combined with irrigation, timing, cropping systems – Integration of organic farming -externalities of green revolution, lowland rice ecologies, vanishing rice lands economic sustainability issues. Form of agriculture in organic farming-standards and methods.

Extra Reading (Key words): *Methane Emission-manure management.*

UNIT IV **12 HRS**

Organic farming

History of organic farming: pre-world war II, past-world war II, 21st century, economics of organic farming, benefits of organic farming - improvement in soil fertility, pest and disease management.

Values of organic farming - Objective, precautionary principle, sustainability, animal husbandry.

Extra Reading (Key words*): Soil carbon sequestration.*

UNIT V **12 HRS**

Green manuring

Green manuring: Introduction, production and distribution, types of green manuring, techniques of green manuring, kind of green manuring

Biofertilizers**:** Cause and effect of rhizobium, technology, aspects of biofertilizers, important role of biofertilizers in crop production, efficient strain of bacterial biofertilizers.

Extra Reading (Key words*): Green roofing.*

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Bhupendra kumar, (2014). Biofertilizers and Organic Farming, Centrum Press, New Delhi.
2. Gaur A.C., (2006). Handbook of Organic Farming and Biofertilizers, Ambica Book Agency, Jaipur.

SUGGESTED REFERENCE BOOKS

1. Panda H, (2013). Handbook of Organic Farming and Processing, Asia Pacific Business Press Inc.
2. Ajay Sharma and Rajeshwar S. Chand, (2010). Plant Protection Practices in Organic Farming, International Book Distributors, New Delhi.
3. Dushyent Gehlot, (2010). Organic Farming: Components and Management, Agrobios Publisher.
4. Dahama A.K., (2009). Organic Farming of Sustainable Agriculture, Agrobios Publisher.
5. Swaminathan C., Swaminathan V and K. Vijayalakshmi (2007). Panchsgavya Boon to Organic Farming, International Book Distributors, New Delhi.
6. Panda H, (2013). Handbook of Organic Farming and Processing, Asia Pacific Business Press Inc.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://ofrf.org/online-courses/
- https://eorganic.info/transitioning/learningmodules
- https://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Compilation_techniques_organic_agriculture_rev.pdf

COURSE OUTCOMES

The learners will be able to:

CO No.	Course Outcomes	PSOs Addressed	Cognitive Level
CO-1	Implement soil fertility and quality management initiatives for improving organic farming in India;	**PSO 3**	**U**
CO-2	Produce organic manures and fertilizers and promote their usage in agricultural lands;	**PSO 1**	**An**
CO-3	Develop and create awareness of novel weed management strategies to improve economic sustainability of rice lands;	**PSO 2**	**C**
CO-4	Investigate and educate others on the values of organic farming;	**PSO 3**	**E**
CO-5	Produce and distribute green manure and bio fertilizers or commercial use.	**PSO 2**	**C**

R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

PO – Programme Outcomes, PSO – Programme Specific Outcomes, CO- Course Outcomes

(For the Candidates Admitted From 2023 – 2024 Onwards)
HOLY CROSS COLLEGE (AUTONOMOUS) TIRUCHIRAPPALLI- 620002
PG & RESEARCH DEPARTMENT OF BIOTECHNOLOGY & BIOINFORMATICS
CHOICE BASED CREDIT SYSTEM
I M.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	CORE COURSE 5 - GENETIC ENGINEERING
Total Hours	60
Hours/Week	4
Code	P23BT2CCT05
Course Type	THEORY
Credits	4
Marks	100

GENERAL OBJECTIVE

To make the learners to understand the mechanism of cloning, manipulating, gene transfer techniques and DNA finger printing and related techniques on gene sequencing, to diagnose the genetic defects and produce the curative molecule for the same.

COURSE OBJECTIVES

To enable the learners

CO No.	COURSE OBJECTIVES
CO-1	Experiment with the basic tools and techniques of gene cloning in new innovative strategies and identify new vectors and make an attempt to design novel artificial vectors.
CO-2	Examine the appropriate selection and screening technique for a specific recombined DNA.
CO-3	Demonstrate the specific techniques for chemically synthesizing a gene and sequencing
CO-4	Describe the applications of genetic engineering in various field and therapeutics.
CO-5	Demonstrate the role of animal models to study pathogenicity, cancer, diabetes, cardio diseases, pulmonary infections, drug targeting and vaccine development.

UNIT I **12 HRS**

Scope of gene manipulation, milestones in genetic engineering, biosafety issues. Genetic engineering guidelines. Isolation and synthesis of the desired gene.

Molecular tools – restriction enzymes - discovery, host controlled restriction-modification. Enzymes involved in cloning - DNA ligase, DNA polymerases, reverse transcriptase, terminal transferases, T_4 polynucleotide kinases, methylases, DNases, ribonucleases, alkaline phosphatases, S1 nuclease and other enzymes. Linkers, adapters and homopolymer tails, terminal dinucleotides. Role of CRISPR & CAS9 in genome editing.

Vector and gene expression – vectors and its types- promoter, MCS, ori, and marker genes – lac Z. Construction of pBR 322, pBR325, pUC 18 and 19 vectors and expression vectors. Animal viruses as vectors-types, gene cloning vectors, plasmids, bacteriophages, cosmids, phagemids. Artificial chromosomes – construction and its use in gene cloning, c-DNA and genomic DNA libraries- construction of genomic libraries-using λ gt 10 and 11 vectors. *In-vitro* packaging of λ phage and amplification of libraries. Cloning in yeast *Saccharomyces cerevisiae*. Specialized cloning vectors for cDNA. Synthesis of specific RNA *in-vitro*.

Extra Reading /Key words: *Cold active enzymes.*

UNIT II **12 HRS**

Gene transfer and expression **–** chemical mediated gene transfer**,** expression of cloned gene, factors influencing cloned gene expression, expression strategies for heterologous genes, expression in bacteria, yeast, insect cell lines and mammalian cells.

Alternative strategies of gene cloning **–** cloning of differentially expressed genes. Site-directed Mutagenesis. Code use in different organisms, codon usage database, codon optimization to increase the expression of recombinant protein.

Selection and screening of transformants – insertional inactivation, α-complementation, immunological screening, molecular probes, dot blot, zoo blot, Southern hybridization, colony hybridization and Molecular Beacons. Use of Reporter genes. DNA and RNA labelling by radioactive and non-radioactive methods.

Extra Reading/Key words: *Alpha viruses, Flaviviral vectors, Next-Generation Genome Engineering in Vegetable Crops*

UNIT III **12 HRS**

Chemical synthesis of genes – phosphodiester, phosphotriester and phosphite ester methods, principles and strategies. Oligonucleotide synthesis and application, synthesis of complete gene.

PCR - methodology, essential features of PCR, primers, Taq polymerases, reverse transcriptase-PCR, types of PCR – nested, inverse, RAPD-PCR, RACE PCR, Real time PCR. Applications of PCR. Gene tagging in gene analysis and its application. Strategies of gene delivery, gene replacement/ augmentation, gene correction, gene editing and silencing.

DNA sequencing methods **–** conventional and next generation sequencing methods. Capillary gel electrophoresis for DNA sequencing. Mapping of DNA and map construction, chromosomal walking, jumping.

Extra Reading /Key words: *NER gene expression and marker genes.*

UNIT IV **12 HRS**

Applications of genetic engineering in crop improvement – Herbicide resistance, insect resistance, resistance against viral infection, improvement of nutritional qualities, improvement, improvement of crops against abiotic stress. Plant Genetic Engineering -production of transgenic plants. Production of GM food – *flavr savr* tomato.

Production of recombinant proteins – insulin, somatostatin and somatotropin and pharmaceutical compounds. Nucleic acid sequence as diagnostic tool. Plants and animal cell as a bioreactor. Applications in forensic medicine. Medical genetics, DNA microarray, gene therapy, Human Genome Project.

Applications of genetic engineering- biopharmaceutical industries-recombinant vaccine, genetic vaccine. Animal genetic engineering - trait improvement in animals, production of human proteins in milk, improvement in wool production, production of therapeutic proteins-monoclonal antibodies.

Extra Reading /Key words: *Duck weed and sea grapes in r DNA technology*

UNIT V **12 HRS**

Molecular pharming **–** transgenic animals as models of human diseases, protein engineering, metabolic engineering. Expression of dsRNA in animals and plants and its applications. Prospects of RNAi in medicine and agriculture.

Knock out gene animal models **–** importance and challenges of animal biomedical research. Gene knock-out technology and animal models for genetic disorders. Animal models for infectious diseases studies – pathogenicity, cancer, diabetes, cardiac diseases, pulmonary infections, drug targeting and vaccine approaches.

Ethical concerns on the use of animals in biological research. Guidelines for rDNA research activities – biosafety levels, maximum containment laboratories.

Extra Reading/Key words: *CRISPR*

Note: Texts given in the Extra reading/Key words must be tested only through assignment and seminars.

PRESCRIBED TEXT BOOKS

1. Das H.K. (2023), Genetic engineering: Replication, expression, cloning, manipulation. Wiley Blackwell Scientific Publications.
2. Miglani G.S. (2016), Genetic Engineering Principles, Procedures and Consequences Hb, Narosa publishers.
3. Primrose, S.B, Twyman, R.W. (2016), Principles of Gene Manipulation and Genomics, Edition VIII, Blackwell Publishers.
4. Glick B.R and Pasternak Jack J, (2003), Molecular Biotechnology – Principles and Applications of Recombinant DNA, Edition III, American Society for Microbiology.
5. Brown. T.A., (2001), Gene Cloning and DNA Analysis – An Introduction, Edition IV, Wiley Blackwell Scientific Publications.

SUGGESTED REFERENCES

1. Brown, T (2010), Gene Cloning and DNA Analysis: An Introduction. John Wiley & Sons.
2. Glick B.R., Pasternak J.J., (2010), Molecular Biotechnology. ASM Press.
3. Primrose S.B., Twyman R., (2009), Principles of Gene Manipulation and Genomics. John Wiley & Sons.
4. Nicholl D.S.T., (2008), Introduction to Genetic Engineering, Edition III, Cambridge University

Press.UK.
5. Watson J.D., Caudy A.A., Myers R.M., Witkowski J.A., (2007), Recombinant DNA: Genes and Genomics: A short course, Edition III, W.H. Freeman and Co Ltd.
6. Winnacker E.L., (2003), From Genes to Clones: Introduction to Gene Technology. WILEY-VCH Verlag GmbH, Weinheim, Germany Reprinted by Panima Publishing Corporation, New Delhi.
7. Primrose S.B, (2001), Molecular Biotechnology, Panima Publications, New Delhi.
8. Verma. P.S and Agarwal. V.K. (2009), Genetic Engineering, S. Chand Publishing.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.khanacademy.org/science/biology/biotech-dna-technology/dna-cloning-tutorial/a/restriction-enzymes-dna-ligase
- https://bmrat.org/index.php/BMRAT/article/view/692
- https://www.sciencedirect.com/science/article/pii/S0974694313003289

COURSE OUTCOMES (CO):

The learners will be able to

CO No.	COURSE OUTCOMES	PSOs ADDRESSED	COGNITIVE LEVEL
CO-1	Experiment with new molecular tools employed in genetic engineering.	PSO 1	R, U
CO-2	Differentiate various types of cloning and expression vectors and integrate them in research.	PSO 2	R
CO-3	Implement gene transfer techniques for producing transformants and select appropriate screening strategies.	PSO 2	Ap
CO-4	Integrate appropriate DNA profiling tools and techniques in their research projects.	PSO 3	An
CO-5	Design an experiment to produce recombinant proteins, vaccines and pharmaceutical compounds.	PSO 4	E

PO – Programme Outcomes; CO – Course Outcome; R- Remember; U- Understand; Ap – Apply; An – Analyse; E- Evaluate; C – Create

(For the Candidates Admitted From 2023 – 2024 Onwards)
I M.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	**CORE COURSE 6 – ANIMAL AND PLANT BIOTECHNOLOGY**
Code	**P23BT2CCT06**
Course Type	**THEORY**
Semester	**II**
Total Hours	**75**
Hours/Week	**5**
Credits	**5**
Marks	**100**

GENERAL OBJECTIVE

To make the learners to understand the theoretical and practical aspects of animal and plant biotechnology. Also the student learns animal and plant recombinant DNA technologies and protein engineering.

COURSE OBJECTIVES

To enable learners to:

CO NO.	COURSE OBJECTIVES
CO-1	Impart theoretical knowledge on various techniques of plant biotechnology like tissue culture, plant genetic transformation and their application in industries.
CO-2	Emphasize importance of secondary metabolites and production in plants.
CO-3	Develop concepts, principles and processes in animal biotechnology.
CO-4	Demonstrate the concept and different types in animal cell culture and animal cell lines.
CO-5	Utilize molecular biology techniques to genetically engineer the animals to improve sustainability, productivity and suitability for pharmaceutical and industrial

UNIT I **15 HRS**

Introduction of plant tissue culture, composition of media, micropropagation, organogenesis, somatic embryogenesis, haploid and triploid production, protoplast isolation and fusion, hybrid and cybrid, synthetic seed production.

Secondary metabolites in plants – phytochemicals – glycosides and flavonoids, anthocyanins and coumarins, lignans, terpenes, volatile oils and saponins, carotenoids and alkaloids, biogenesis, therapeutic applications

Gene transfer techniques: Agrobacterium-plant interaction – virulence, Ti and Ri plasmids, opines and their significance, T-DNA transfer. Genetic Transformation- Agrobacterium-mediated gene delivery, direct gene transfer – PEG-mediated, electroporation, particle bombardment and alternative methods; Screenable and selectable markers, characterization of transgenics, gene targeting.

Extra Reading (Key words): *Pollen and Anther culture*

UNIT II **15 HRS**

Plant engineering towards the development of enriched food products, plant growth regulators. Molecular Marker aided breeding- RFLP maps, linkage analysis, RAPD markers, STS Mirco satellite, SCAR, SSCP, QTL, map-based cloning and molecular marker assisted selection.

Somatic Hybridization- protoplast culture and somatic hybridization, protoplast isolation, its culture and usage, somatic hybridization applications. Somatic embryogenesis – Principle, protocol and importance.

Somaclonal variations - sources of somaclonal variations, selection of soma clones, progeny testing of soma clones, applications of somaclonal variations to crop improvement, embryo rescue. Artificial seeds – production, applications and limitations. Anther culture and production of androgenic haploids.

Extra Reading/Key words: *Plant pollination*

UNIT III **15 HRS**

Transgenic animals – production and application, transgenic animals in livestock improvement, transgenic animals as model for human diseases. Stem Cells – properties, types, therapy, prospects and ethics in stem cell research.

Nuclear magnetic resonance methods of monitoring cell metabolism culturing animal cells in fluidized bed reactors. Application of animal cell culture for in vitro testing of drugs, in production of human and animal

viral vaccines and pharmaceutical proteins.

Culture scale up and mass production of biologically important compounds. Harvesting of products, purification and assays.

Extra Reading/Key words: *Endocrine gland and its hormones*

UNIT IV **15 HRS**

Biotechnological approaches to obtain blood products- tissue plasminogen activator and erythropoietin, vaccine technology- subunit vaccines, drawbacks of existing vaccines, criteria for the successful vaccine, peptide vaccine, minicells as vaccines, impact of genetic engineering on vaccine production, viral vector vaccines and AIDS vaccine chiral technology.

Animal health disease diagnosis, hybridoma technique, monoclonal antibodies, application of probes for disease diagnosis of existing and emerging animal diseases. Prophylaxis – vaccines, oral vaccines DNA vaccines in animal disease. Cell culture- primary and established culture, organ culture, tissue culture.

Disaggregation of tissue and primary culture- cell separation, slide and coverslip cultures, flask culture, test tube culture techniques, cell synchronization, cryo preservation. Scaling up of animal cell culture, cell line and cloning micromanipulation and cloning, somatic cell cloning. Karyotyping, measuring parameters for growth, measurement of cell death, apoptosis and its determination, cytotoxicity assays

Extra Reading/Key words: *SARS CoV 2* virus *& vaccine*

UNIT V **15 HRS**

Applications of animal biotechnology in Medicine – introduction to fermentation technology, bioreactors for large-scale production of animal cells. Production of hormones and special secondary metabolites –insulin, growth hormone and interferon.

Gene therapy – principles of gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, social ethical issues.

Immunodiagnostics and vaccine technology – outline to immunodiagnostics-monoclonal antibodies, hybridoma technology, starter to vaccines, killed and attenuated vaccines, modern methods of vaccine generation, stem cell technology, cell banking.

Extra Reading/Key words: *Innate and Acquired Immunity*

Note: Texts given in the Extra reading /Key words must be tested only through assignment and Seminars.

PRESCRIBED TEXT BOOKS

1. Razdan M. K., (2011), Plant tissue culture, Oxford and IBH publishing Company Pvt. Ltd, New Delhi.
2. Mishra, S.P.., (2009), Plant Tissue Culture, Ane Books Pvt Ltd.
3. Ranga. M.M., (2004), Animal Biotechnology, Edition II, Agrobios (India), Jodhpur.
4. Freshney R.I., (2000), Culture of Animal cells: Manual of Basic technique, Edition IV. John Wiley Publications.
5. Roberta Smith (2000) Plant Tissue Culture: Techniques and Experiments. 2nd ed., Academic Press.
6. Chawla HS. (2000) Introduction to Plant Biotechnology, Taylor and Francis Inc Science Publishers, U.S.

SUGGESTED REFERENCES

1. Verma A., Singh A., (2013), Animal Biotechnology: Models in Discovery and Translation, Academic Press.
2. Altman A., Hasegawa P.M., (2012), Plant Biotechnology and Agriculture: Prospects for the 21st Century, Academic Press.
3. Altman A., Hasegawa P.M., (2011), Plant Biotechnology and Agriculture: Prospects for the 21st Century. Academic Press.
4. Stewart N.C., Jr., (2008), Plant Biotechnology and Genetics: Principles, Techniques and Applications, John Wiley & Sons
5. Slater A., Scott N., Fowler M., (2008), Plant Biotechnology – The genetic manipulation of plants, Oxford University Press, Oxford.
6. Watson J.D., Caudy A.A., Myers R.M., Witkowski J.A., (2006), Recombinant DNA: Genes and Genomics: A short course, Edition III, W.H. Freeman and Co Ltd.
7. Primrose, S.B., Twyman, R.W. (2006), Principles of Gene Manipulation and Genomics, Edition VII, Wiley Blackwell.
8. Stewart Sell, (2003) (Ed) Stem Cells Handbook, Humana Press, NY.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://www.aminotes.com/2019/05/plant-biotechnology-notes_4.html
- https://study.com/academy/topic/plant-animal-biotechnology.html
- https://www.agrimly.in/p/plant-biotechnology-ebooks-and-enotes.html

COURSE OUTCOMES (CO):

CO No.	COURSE OUTCOMES	PSOs ADDRESSED	COGNITIVE LEVEL
CO-1	Acquaint theoretical knowledge on a variety of plant biotechnology techniques viz., tissue culture, plant genetic transformation, and industry applications.	PSO 2	Ap
CO-2	Accomplish the significance secondary metabolites and their production in plants.	PSO 3	An
CO-3	Demonstrate the concepts, principles and processes in animal biotechnology.	PSO 4	U
CO-4	Appertain the tissue culture concepts to develop industrially and commercially important products.	PSO 2	Ap
CO-5	Evaluate the pros and cons of techniques that genetically engineer the animals to improve sustainability, productivity and suitability for pharmaceutical and industrial applications.	PSO 5	Ap, An

PSO – Programme Specific Outcome; CO – Course Outcome; R – Remember; U – Understand; Ap – Apply; An – Analyse; E – Evaluate; C – Create

(For the Candidates Admitted From 2023 – 2024 Onwards)
I M.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	CORE COURSE 7 - PRACTICAL II – (GENETIC ENGINERING & GENOMICS AND PROTEOMICS)
Code	P23BT2CCP07
Course Type	PRACTICAL
Semester	II
Total Hours	60
Hours/Week	4
Credits	4
Marks	100

OBJECTIVE

This course embrace on comprehending the fundamentals of current approaches for manipulating genes in plants and animals using molecular techniques, as well as providing insight into the genomic and proteomic revolution and the computational requirements of contemporary molecular analysis.

A. GENETIC ENGINEERING

1. Preparation of plasmid DNA by alkaline lysis method and agarose gel electrophoresis.
2. Staining of gels – Silver, Methylene blue DNA staining
3. Elution of DNA from agarose gel.
4. Restriction enzyme digestion, Restriction mapping of plasmid DNA, Ligation.
5. Preparation of competent cells and transformation by $CaCl_2$ method and Selection of transformants by X-Gal method
6. Cloning of fragments in PBR322 (Demo)
7. Insertional inactivation/Blue white screening (Demo)
8. Detecting the DNA profile by RFLP, RAPD
9. Amplification of DNA – PCR
10. Synthesis of DNA from mRNA by RT-PCR
11. Determination of molecular weight of DNA
12. RT-PCR for COVID-19 (Demo)

B. GENOMICS AND PROTEOMICS

1. Isolation of total RNA from samples
2. Analysis of the quality and integrity of the RNA for genomic applications by Bioanalyzer (Demo)
3. Synthesis of cDNA from total RNA
4. Evaluation of the synthesized cDNA by using RT-PCR applications
5. Evaluation of Gene Expression by Real-Time Quantitative PCR –SYBR green-based and Taqman based assays(Demo)
6. NCBI – Genome database
7. Dfam database
8. Genome Visualization - proksee
9. Comparative genomics – VISTA
10. UCSC – Genome Browser
11. Analysis of relative protein expression by western blotting
12. Separation of proteins by 2D gel electrophoresis-Demo
13. Separation of metabolites with GC/MS and data analysis – (demo)
14. Phosphoproteome Database:Phosphositeplus
15. Protein Databases: NCBI-Protein, HPRD, Human protein Atlas
16. Pathway Analysis tool: EcoCyc
17. Pathway databases:NetPath, Reactome, KEGG
18. Protein protein interaction database – STRING
19. Swiss – 2DPAGE

(For the Candidates Admitted From 2023 – 2024 Onwards)

I M.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	**CORE COURSE 8 - PRACTICAL III – (ANIMAL AND PLANT BIOTECHNOLOGY)**
Code	**P23BT2CCP08**
Course Type	**PRACTICAL**
Semester	**II**
Total Hours	**60**
Hours/Week	**4**
Credits	**4**
Marks	**100**

OBJECTIVE

To provide a comprehensive and hands-on understanding of animal and plant cell culture techniques, tissue culture methodologies, and biotechnological processes.

A. ANIMAL BIOTECHNOLOGY

1. Introduction to Animal Cell culture: Procedure for handling cells and medium.
2. Cleaning and sterilization of glassware and plastic tissue culture flasks
3. Preparation of tissue culture media
4. Preparation of sera for animal cell culture
5. Preparation of single cell suspension from chicken liver (Primary cell culture).
6. Trypsinization of established cell culture.
7. Cell counting and viability - staining of cells: (a) Vital Staining (Trypan blue, Erythrosin); (b) Giemsa staining.
8. MTT Assay
9. LDH Assay

B. PLANT BIOTECHNOLOGY

10. Plant tissue culture media preparation
11. Plant tissue culture sterilization techniques.
12. Generation of Callus from leaf
13. Generation of Callus from root
14. Generation of Callus from bud
15. Generation of Callus from shoot apex
16. Maintenance of callus culture.
17. Cell suspension culture
18. Anther culture
19. Pollen culture
20. Embryo culture.
21. Isolation of plant protoplast
22. Culture of plant protoplast.
23. Protoplast viability test.
24. Localization of nucleus using nuclear stain.
25. Agrobacterium culture maintenance and isolation of plasmid DNA.
26. Mass culture of Chlorella /Spirulina
27. Preparation of synthetic seeds

(For the Candidates Admitted From 2023 – 2024 Onwards)
I M.Sc. BIOTECHNOLOGY – SEMESTER II

Course Title	ELECTIVE III – GENOMICS AND PROTEOMICS
Total Hours	60
Hours/Week	4
Code	P23BT2ECT05
Course Type	THEORY
Credits	3
Marks	100

GENERAL OBJECTIVE

This course provides an overview of the genomic and proteomic architecture, its variations, and regulatory mechanisms of the genome. The course topics include the databases, tools and various techniques in genome and proteome analysis.

COURSE OBJECTIVES

To enable the learners

CO NO.	COURSE OBJECTIVES
CO1	Describes in detail on prokaryotic, eukaryotic genome organization and tools for genome analysis
CO2	Provides with the skills of genomic data analysis provides general and unique aspects of sequencing methods.
CO3	Understand the structure of cellular proteins and methods for structure prediction and analyzes the methodology of MALDI-TOF analyzers
CO4	Familiarize the terminology, underlying principles and strategies, and the protein interaction technical methodologies involved.
CO5	Discuss the computational methods involved in proteomics.

UNIT I **12 HRS**

Gene architecture **–** structure and organization of Eukaryotic and prokaryotic genome nuclear, mitochondrial and chloroplast genomes. Repetitive DNA contents of genome – interspersed repeats: LINES, SINES, LTR elements, SINES types: ALU elements, MIR, MIR3 – tandem repeats, Transposons, Microsatellites – gene protein relations. Coding and non-coding regions – gene related sequences - NTS, ETS and ITS, 3' UTR, 5' UTR, Pseudogenes.

Tools for genome analysis – Finding genes and regulatory regions – PCR, RFLP, DNA fingerprinting, RAPD, SNP detection, FISH.

Gene mapping – Genetic and physical maps – BAC libraries and shotgun libraries preparation, Physical map, Cytogenetic map, Contig map, Restriction map, UCSC browser.

Extra Reading/Key Words: *Agrigenomics and epigenomics*

UNIT II **12 HRS**

Sequencing technologies **–** introduction to sequencing, Maxam and Gilbert method, Sanger's sequencing techniques and applications, Next generation sequencing (NGS), de novo sequencing.

Genome assembly - DNA Sequencing databases - genome assembly and mapping to reference genomes, mapping tools (bowtie, maq etc,), sequence alignment formats: sequence alignment map (SAM) format, binary alignment map (BAM) format.

Genome projects – human genome project, HapMap project, GWAS, evolutionary genomics, metagenomics.

Extra Reading/Key *Words: Analysis of epigenomic datasets; Epigenomic variation of Plant improvement genes*

UNIT III **12 HRS**

Overview of protein structure – primary, secondary, tertiary and quaternary structure – relationship between protein structure and function. In vitro protein synthesis and *in vivo* protein expression and purification from bacteria, yeast, Baculovirus and human – techniques to study post-translational modifications *in vivo* and *in vitro*.

Protein expression analysis – 2D-PAGE, protein microarray, mass spectrometry – mass spectrometry - ion source (MALDI, spray sources), analyzer (ToF, quadrupole, quadrupole ion trap) and detector, western blotting.

Protein sequencing: chemical and enzymatic protein fragmentation, amino acid sequence analysis, Edman degradation, *de novo* protein sequencing by mass spectrometry.

Extra Reading (Key words): *Selected Reaction Monitoring-MS (SRM-MS) and Multiple Reaction Monitoring-MS (MRM-MS.*

UNIT IV **12 HRS**

Complex peptide mixture analysis: liquid chromatography coupled to mass spectrometer (LC-MS), proteomic approach to posttranslational modification analysis – quantitative proteomics, clinical proteomics, and disease biomarkers, mass spectral tissue imaging and profiling.

Protein-protein interactions, experimental methods, co-immune precipitation, affinity purification, yeast two-hybrid assays, FRET.

Protein interaction maps, Protein arrays – definition, applications, diagnostics, expression profiling.

Extra Reading (Key words): *Clinical Proteomic Technology Assessment for Cancer (CPTAC 1)*

UNIT V **12 HRS**

Computational methods: gene neighbor and gene cluster methods. Phylogenetic footprinting, Gene fusion method, Protein profiling, Protein chips, Molecular-Docking. Database, Server and tools for analysis of protein-protein interaction and docking.

Tools of analyzing Proteomics data (ExPASy server) and GCG utilities and EMBOSS. Protein protein interaction database – STRING

Quantitative and Targeted Proteomics: Introduction to quantitative proteomics- Differential proteomics, post-translational modifications, Targeted proteomics- Parallel reaction monitoring, Multiple reaction monitoring, Targeted proteomics software- Skyline

Extra Reading (Key words): *Pathway analysis (KEGG Database)*

PRESCRIBED TEXT BOOKS

1. Pevsner, J,(2015), Bioinformatics and Functional Genomics, Edition III, John Wiley & Sons.
2. Brown T.A., Genomes (20020, Edition II, BIOS Scientific Publishers, Oxford, UK
3. Liebler D.C., (2001), Introduction to Proteomics – Tools for the New Biology by Humana Press.
4. Sjuzdak G., (1996), Mass Spectrometry for Biotechnology, Academic Press.
5. Veenstra T.D., Yates J., (2019), Proteomics for Biological Discovery, Wiley Publications.

SUGGESTED REFERENCES

1. Strachan, T., Read, A., (2019), Human Molecular Genetics, Edition V, Garland Science.
2. Lovric, J., (2011), Introducing Proteomics: From concepts to sample separation, Mass spectrometry and data analysis, John Wiley & amp; Sons publisher.
3. Gibson G., Muse, S.V., (2009), A Primer of Genome Science, Edition III, Sinauer Associates, Inc.
4. Pevsner, J., (2009), Bioinformatics and Functional genomics, Edition II, Wiley-Blackwell.
5. Lesk, A.M., (2007), Introduction to Genomics, Oxford University Press, USA.
6. Jones L.B., (2007), Genes IX, Edition IX, Barlett Publishers.
7. Baxevanis A.D., Ouellette B.F.F., (2006), Bioinformatics A practical guide to the analysis of Genes and Proteins, A. John Wiley and Sons, Inc., Publications.
8. Pennigto. S.R, Dunn.M.J., (2002), Proteomics, Viva Books Private Limited, New Delhi.
9. Fitzgerald, P.J., (2005), An introduction to Human Molecular Genetics: Mechanism of Inherited diseases, Edition II, Science Press.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://opentextbc.ca/biology/chapter/10-3-genomics-and-proteomics/
- https://edurev.in/studytube/Lecture-Notes--Genomics-to-Proteomics/2ece106d-3de0-4852-a5d3-8730a128cb1c_p?gad_source=1&gclid=CjwKCAiAmZGrBhAnEiwAo9qHiZWdUgsRtLB1ZauN5FsYh9EBdT-bnve9E89ySp-h2wSvFPSbOrc5hxoCTAUQAvD_BwE
- https://www.idex-hs.com/news-events/stories-and-features/detail/proteomics-vs-genomics
- https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/General_Biology_1e_(OpenStax)/3%3A_Genetics/17%3A_Biotechnology_and_Genomics/17.5%3A_Genomics_and_Proteomics

COURSE OUTCOMES (CO):

The learners will be able to

CO No.	COURSE OUTCOMES	PSOs ADDRESSED	COGNITIVE LEVEL
CO-1	Explain the genes & genomes patterns to annotate for a specific requirement.	PSO 1	R
CO-2	Construct genome maps using genome databases and predict gene functions by structural and functional gene annotations.	PSO 2	U
CO-3	Identify the types of information that proteomic and metabolomic techniques provide, and their impact when combined with complementary methods	PSO 2	U
CO-4	Apply the online databases as tools in the comprehensive analysis of the results gained from proteomic methods.	PSO 3	Ap
CO-5	Demonstrate how the proteomic can be used in both the study and diagnosis of disease states in order to apply them to their own research endeavors.	PSO 3	An

PO – Programme Outcomes; CO – Course Outcome; R – Remember; U – Understand; Ap – Apply; An – Analyse; E – Evaluate; C – Create

(For the Candidates Admitted From 2023 – 2024 Onwards)
I M.Sc. BOTANY – SEMESTER II

Course Title	ELECTIVE IV – APPLIED BIOINFORMATICS
Total Hours	60
Hours/Week	4
Code	P22BT3ECT07
Course Type	Theory
Credits	3
Marks	100

GENERAL OBJECTIVE

The main objective of this course is to introduce general concepts of Bioinformatics to introduce most of the effectively used Bioinformatics databases and their applications.

COURSE OBJECTIVES

To enable the learners:

CO No.	COURSE OBJECTIVES
CO-1	Learn about the bioinformatics databases, databanks, and data format and data retrieval from the online sources.
CO-2	Explain the essential features of the interdisciplinary field of science for better understandingbiological data.
CO-3	Outline the types of biological databases.
CO-4	Demonstrate different online bioinformatics tools.
CO-5	Summarize the strong foundation for performing further research in bioinformatics.

UNIT I **12 HRS**

Internet Basics – File Transfer Protocol - The World Wide Web – Internet resources – databases – types – applications – NCBI data model – SEQ-Ids – bio sequences.

Bio sequence sets – sequence annotation – sequence description.

Human genome project – background, goals, main conclusion of human genome project, human genome variation – SNPs and HapMap Project.

Extra Reading / Key words: *Biological databases*

UNIT II **12 HRS**

Database – primary and secondary databases – Format Vs. Content

Genbank Flatfile – submitting DNA sequences to the databases – DNA/RNA – population, phylogenetic, and mutation Studies – protein-only submissions.

Consequences of DNA Model – EST/STS/GSS/HTG/SNP and genome centers – contact points for submission of sequence data to DBJ/EMBL/Genbank.

Extra Reading / Key words: *OMIM*

UNIT III **12 HRS**

Introduction to Structures – Protein Data Bank (PDB) – molecular modeling database at NCBI Structure.

File Formats – visualizing structural information – database structure viewers.

Advanced structure modeling – structure similarity searching.

Extra Reading /Key words: *MMDB*

UNIT – IV **12 HRS**

Introduction – evolutionary basis of sequence alignment – modular nature of proteins.

Optimal alignment methods – substitution scores and gap penalties.

Database Similarity Searching – FASTA – BLAST (BlastP, BlastN, etc.,) – position specificscoring matrices, spliced alignments.

Extra Reading /Key words: *PAM*

UNIT – V **12 HRS**

Using protein sequences protein identity based on composition – physical properties based on Sequence - motifs and patterns.

Secondary structure and folding classes - specialized structures or features – Chou-Fasman – GOR methods.

Prediction of 3D structures - comparative modeling.

Extra Reading /Keywords: *Tools used for Homology modelling*

Note: Texts given in the Extra reading /Key words must be tested only through assignment and

Seminars.

PRESCRIBED TEXT BOOKS

1. Lesk, A. M., (2019), Introduction to bioinformatics, Edition V, Oxford: Oxford University Press.
2. Pevsner, J., (2015), Bioinformatics and functional genomics, Hoboken, N.J., Wiley-Blackwell.
3. Selzer P.M., Marhöfer R.J., Rohwer A., (2012), Applied Bioinformatics: An Introduction. Springer Nature (SIE.).
4. Bourne, P.E., Gu, J., (2009), Structural Bioinformatics, Hoboken, NJ: Wiley-Liss.
5. Baxevanis, A.D., Ouellette, B.F., (2001), Bioinformatics: A practical guide to the analysis of genes and proteins, New York: Wiley-Interscience.
4. Mount, D.W., (2001), Bioinformatics: Sequence and genome analysis, Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

SUGGESTED REFERENCES

1. Green, M.R., Sambrook, J., (2012), Molecular Cloning: A laboratory manual, Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Primrose, S.B., Twyman, R.M., Primrose, S.B., Primrose, S.B., (2006), Principles of gene manipulation and genomics. Malden, MA: Blackwell Pub.
3. Campbell, A.M., Heyer, L.J., (2003), Discovering genomics, proteomics, and bioinformatics. San Francisco: Benjamin Cummings.
4. Liebler, D.C., (2002), Introduction to proteomics: Tools for the new biology, Totowa, NJ: Humana Press.
5. Old, R.W., Primrose, S.B., Twyman, R.M., (2001), Principles of gene manipulation: An introduction to genetic engineering. Oxford: Blackwell Scientific Publications.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://freecomputerbooks.com/Applied-Bioinformatics.html
- https://github.com/SuLab/Applied-Bioinformatics
- https://egyankosh.ac.in/bitstream/123456789/85311/2/BBCS-185.pdf

COURSE OUTCOMES

The learners will be able to:

CO NO.	COURSE OUTCOMES	PSOs ADDRESSED	COGNITIVE LEVEL
CO-1	Familiarize with the tools of DNA sequence analysis.	**PSO1**	**R**
CO-2	Use and explain the application of bioinformatics.	**PSO2**	**U**
CO-3	Master the aspects of protein-protein interaction, BLAST and PSI-BLAST.	**PSO2**	**Ap**
CO-4	Describe the features of local and multiple alignments.	**PSO3**	**An**
CO-5	Interpret the characteristics of phylogenetic methods and bioinformatics applications.	**PSO3**	**E**

PO – Programme Outcomes, CO – Course Outcome, R – Remember, U – Understand, Ap – Apply, An – Analyse, E – Evaluate, C – Create.

(For the Candidates Admitted From 2023 – 2024 Onwards)

SEMESTER II

Course Title	SEC 1 - NME 1 - BIOTECHNOLOGY IN EVERYDAY LIFE
Code	P23BT2SET01
Course Type	Theory
Semester	II
Total Hours	60
Hours/Week	4
Credits	2
Marks	100

GENERAL OBJECTIVE

The general objective of biotechnology in everyday life is to enhance and improve the quality of life for individuals, society, and the environment through the responsible application of biotechnological tools, processes, and products. Biotechnology achieves this objective by developing innovative solutions to various challenges faced by humanity.

COURSE OBJECTIVES

To enable the learners:

CO No.	COURSE OBJECTIVES
CO-1	Study the role of microbial diversity and microflora associated with human and animal interaction between microbes, design procedures for the production of various industrially important compounds
CO-2	Understand the fundamental concept and various applications of biotechnology in different fields.
CO-3	Differentiate the techniques involved in the animal biotechnology for production of superior livestock, uses in therapy, cloning etc.
CO-4	Examine the role of biotechnology in waste treatment and environmental remediation, and the potential for sustainable solutions to environmental problems
CO-5	Evaluate the applications of biomimetic, enzymes, and bioinformatics in biotechnology, and their potential for innovation and commercialization.

UNIT I **12 HRS**

General overview and concept of biotechnology.

Fermented foods (cheese and bread), and probiotics, Alcoholic beverages (beer, wines),

Study of Microbial flora from fermented products, antimicrobial agents (antibiotics), vitamins.

Extra Reading/Key words: *Bioprocessing, Probiotics.*

UNIT II **12 HRS**

Microbial diversity – bacteria, viruses, fungi.

Beneficial and harmful microbes, normal microflora associated with humans and animals.

Microbes in human and animal nutrition and health.

Extra Reading/Key words: *Symbiosis, Beneficial microorganisms.*

UNIT III **12 HRS**

Animal biotechnology - transgenic animals (e.g., mice, fish).

In vitro fertilization and (IVF) and embryo transfer (ET), test-tube babies.

Ethical issue, animal cloning, therapeutic cloning.

Extra Reading/Key words: *Genetically modified animals, Regenerative medicine.*

UNIT IV **12 HRS**

Bio-fertilizers, bio-pesticides, bioplastics.

Treatment of industrial wastes. Bioleaching. Bioremediation (plant and microbial).

Sewage/Waste processing and utilization.

Extra Reading/Key words: Biopolymer materials, Waste-to-energy technology

UNIT V **12 HRS**

Introduction to Biomimetic and their applications.

Dark Biotechnology (bio-warfare biological weapons and Bioterrorism).

Concept of Bioinformatics and Databases in Biotechnology

Extra Reading/Key words: Bionic technology, biologically inspired engineering

PRESCRIBED TEXT BOOKS

1. Kuhad, Chander, R., (2013), Biotechnology for Environmental Management and Resource Recovery, Springer Publishers.
2. Stevens, H., (2018), Biotechnology and Society: An Introduction, University of Chicago Press.
3. Mitchell, B., (2007), Biotechnology and the Human Good, Edition I, Georgetown University Press.

SUGGESTED REFERENCES

1. Godbey, W.T., (2014), An Introduction to Biotechnology: The Science, Technology and Medical Applications. Netherlands, Elsevier Science.
2. Jogdand, S.N., (2012), Environmental Biotechnology. Himalaya Publishing House.
3. Houdebine, L.M., (2003), Animal Transgenesis and Cloning, John Wiley & Sons.

Note: Learners are advised to use latest edition of books.

WEBSITE REFERENCES

- https://archive.bio.org/articles/biotechnology-solutions-everyday-life
- https://www.techtarget.com/whatis/definition/biotechnology
- https://www.btci.org/k-12-programs/resources-for-biotechnology-education/

COURSE OUTCOMES (CO):

The learners will be able to

CO No.	COURSE OUTCOMES	PSOs ADDRESSED	COGNITIVE LEVEL
CO-1	Define the term 'Biotechnology' and appreciate its scope.	PSO-1	R
CO-2	Discuss the national and global significance of biotechnology and the key events in the development of biotechnology.	PSO-1	U
CO-3	Understand the interaction of microbes with plants based on benefits and harmful effects,application of microflora in the improvement of environment	PSO-1	R
CO-4	Understand the multidisciplinary nature of biotechnology and the associated role that has been played by "enabling technologies" in the development of biotechnology.	PSO-2	Ap
CO-5	Understand the principles and methods of genetic engineering in plants, animals and microorganisms.	PSO-2	Ap, An
CO-6	Evaluate the impact of biotechnology on human health, agriculture, industry, and the environment.	PSO-3	An

PO – Programme Outcomes; CO – Course Outcome; R – Remember; U – Understand; Ap – Apply; An – Analyse; E – Evaluate; C – Create.