DEPARTMENT OF BIOTECHNOLOGY

M.Sc. Biotechnology

M.Sc. Biotechnology

Course Contents & Syllabi

NEP

Dolphin (PG) Institute of Biomedical & Natural Sciences, Dehradun-248007

Dolphin PG Institute of Biomedical and Natural Science, Dehradun

(An Autonomous College)

Department of Biotechnology: Composition of Board of Studies

S. No.	Category	Name	Signature
1.	Head of the Department-Chairperson	Dr. Shalini Singh	
2.	All Faculty members of the Department	Ms. Deepti Gulati Dr. Sachin Singh Ms. Tripti Garg	
3.	Two subject experts from outside the parent University nominated by the academic council.	Dr. Santan Barthwal Scientist G and Head, Division, Genetics and Tree Improvement, Forest Research Institute, Dehradun Dr. Nishesh Sharma, Head, Department of Biotechnology, School of Applied and Life Sciences, Uttaranchal University, Dehradun	
4.	One expert nominated by the Vice- chancellor	Dr. Gopal Joshi, Professor, Department of Biotechnology, HNBGU, Garhwal, Uttarakhand.	
5.	One representative from industry nominated by the principal	Dr. Virender Bhardwaj GM, Quality and Standards, Kala Amb, HP	
6.	One member of the college alumni nominated by the principal	Dr. Manisha Nanda, Associate Prof., Department of Microbiology, Graphic Era Deemed to be University, Dehradun	

The Academic Ordinance Governing UG & PG Programs under NEP-2020 DIBNS shall applicable to all Certificate Programs, Diploma Programs, Under Graduate (3 or 4 years) Programs, Post Graduate (1-2 years) Programs offered by the Institute except those programs where any concerned Statutory Council stated otherwise.

M.Sc. Biotechnology (Hons.)

Curriculum and Syllabus

Min. Credit Requirement- 80

Content framework

Programme: M.Sc. Biotechnology

Introduction

Biotechnology is a field of science where biology and technology come together to provide solution to various problems.

- It gives students thorough understanding of the biological sciences together with the abilities to use that understanding in the biotechnology sector.
- In addition to providing students with expertise in fields like molecular biology, biochemistry, genetics, and bioinformatics, this field is extremely relevant in today's society and has the potential to revolutionize the way we create food, pharmaceuticals, and other things.
- A B.Sc. Biotechnology degree will enable a student to recognize and address issues in the biotechnology sector. Specialization options include bioprocessing, biomanufacturing, agriculture, biomedicine, and bioremediation jobs in the future.

Eligibility:

- A bachelor's degree with Honours/ Honours with Research with a minimum of 160 credits for a 1-year/2-semester PG programme at level 6.5 on the NHEQF.
- A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4 semester PG programme at level 6.5 on the NHEQF.
- A student is eligible for a PG programme in a discipline corresponding to either major or minor(s) discipline in UG programme. In this case, the Institute can admit the students in the PG programme based on the student's performance in the UG programme or through an entrance examination. However, irrespective of the major or minor disciplines chosen by a student in a UG programme, a student is eligible for admission in any discipline of PG programmes if the student qualifies the National level or University level entrance examination in the discipline of the PG programme.

Future prospects/ Job availability/ Scope

There are numerous Best Biotechnology Companies in India where students can find employment. There are many different job profiles in these firms, and candidates can select the one that best suits their talents and qualifications. The following are some fundamental jobs that are closely associated with the field of biotechnology.

i. **Pharmaceutical Companies:**
   Biotechnology professionals work in pharmaceutical companies to develop new drugs and therapies. They may be involved in research and development, clinical trials, and regulatory affairs. Example : **Windlas Biotech, Mankind Pharma, Ind Swift laboratories Ltd., Lupin biotech, Zelle biotechnology, Biocon, Panacea Biotech**.

ii. **Biotech Startups**:
Many startups are founded with the aim of developing innovative biotechnologies. These companies often focus on areas such as personalized medicine, gene editing, or synthetic biology. Example: **XCode Life Sciences**, **Sea6 Energy**, **Bharat Biotech**.

iii. **Agricultural Biotechnology Companies:**
Companies in this sector use biotechnology to develop genetically modified crops, improve agricultural practices, and enhance crop yields. **Example: Sowbhagya Biotech, Advanta India, DuPont India, Godrej Agrovet, Maxeema Biotech, National Agro Foundation, Poabs Biotech, Poseidon Biotech, Rise n' Shine Biotech Pvt. Ltd**.

iv. **Biomanufacturing Companies:**
Biomanufacturing companies produce biopharmaceuticals, vaccines, and other biologics using living organisms or biological systems.
Biotechnologists in these companies are involved in process development, production, and quality control. Example: **Biocon, Jubilant Pharmova, Serum Institute of India, Shubham Biotechnology**.

v. **Environmental Biotechnology Companies:** These companies focus on developing biotechnological solutions for environmental remediation, waste treatment, and renewable energy production. Example: **Elies Biotech Private Limited, Aavanira Biotech Pvt. (L)**.

vi. **Diagnostic and Medical Device Companies**: Biotechnology professionals work in companies that develop diagnostic tests, medical devices, and equipment used in healthcare settings. Example: **Transasia Bio-Medicals Ltd, Medtronic India Pvt. Ltd, Johnson & Johnson**.

Job availability

- Clinical Research Associate
- Medical Transcriptionist
- Medical writer
- Lecturer
- Food safety officer

Programme Objectives:

- To build careers for the students in Biotechnology wherein they apply their academic knowledge and experimental skills and make them more efficient for the job prospects offered by the Biotechnology industry and research.
- **Problem-Solving Abilities**: Develop critical thinking and problem-solving skills necessary to tackle complex biological problems and innovate new biotechnological solutionsm, so that the student can become a critical thinker, problem solver and solution provider to the society.
- **Preparation for Careers and Higher Education**: Prepare students for a wide range of career opportunities in research, development, manufacturing, quality control, sales, and entrepreneurship within the biotechnology industry, as well as for higher education in graduate or professional programs.

Programme Outcomes:

The NEP 2020 has placed significant emphasis on outcome-based education, which highlights the importance of specific learning outcomes for each course.

PO1:	**Complex problem-solving:** Biotechnology postgraduates will have the ability to apply their knowledge of Biotechnology to analyse and resolve problems in various settings, using appropriate practical tools, experimental methods, and computational techniques.
PO2:	**Critical thinking:** Biotechnology postgraduates will be able to analyze and evaluate information, identify and define problems, develop and implement solutions, and make evidence-based decisions.
PO3:	**Creativity**: Biotechnology postgraduates will able to design solutions for complex scientific problems and execute them by considering the environmental, societal and public safety aspects appropriately.
PO4:	**Communication Skills:** Biotechnology postgraduates will demonstrate written and oral communication skills in communicating Biotechnology-related topics.
PO5:	**Analytical reasoning/thinking:** Biotechnology postgraduates will have the ability to apply their Biotechnology knowledge to analyze and resolve problems in various settings, using appropriate practical tools, experimental methods, and computational techniques.
PO6:	**Research-related skills**: Biotechnology postgraduates will get academic exposure through the various Internships offered by reputed National Research Institutes during their UG tenure. They will be able to utilize the small summer/ winter recesses through their involvement in small projects under careful guidance of reputed faculties and may get the flavor of the current trend of research.
PO7:	**Coordinating/collaborating with other**s: Biotechnology postgraduates will be able to collaborate effectively with others, including peers, colleagues, and interdisciplinary teams, to achieve common goals.
PO8:	**Leadership readiness/qualities:** Biotechnology postgraduates will have an ability to develop the quality of leadership which will help them to be a part of any organization as well as create a positive energy in their work field to achieve any assigned target.
PO9:	**'Learning how to learn skills:** Biotechnology postgraduates will have a curiosity-driven and self-directed approach to learning, as well as the ability to ask insightful questions and explore new areas of knowledge.
PO10:	**Digital and technological skills:** Biotechnology postgraduates should be proficient in the use of digital tools and information and communication technologies (ICT), including programming languages, simulation software, and data analysis tools.
PO11:	**Multicultural competence and inclusive spirit:** Biotechnology Postgraduates will have acquisition of knowledge of the values and beliefs of multiple cultures and a global perspective to honor diversity.
PO12:	**Value inculcation:** Biotechnology postgraduates will be aware of the global and national issues related to science and technology, as well as their roles and responsibilities as Indian and global citizens as well.
PO13:	**Autonomy, responsibility and accountability:** Biotechnology postgraduates should exercise responsibility and demonstrate accountability in applying knowledge ensuring safety and security at workplaces.
PO14:	**Environmental awareness and action:** Biotechnology postgraduates should have a strong ethical and environmental awareness and the ability to apply ethical reasoning in decision-making, including consideration of social, cultural, and environmental impacts.
PO15:	**Community engagement and service:** The Biotechnology postgraduates should be able to demonstrate the capability to participate in community-engaged services and

	activities for promoting the well-being of society through the scientific approach.
PO16:	**Empathy:** The Biotechnology postgraduates will be able to demonstrate the ability to give regard to points of view of another individual or group, and to identify and understand other people's emotions.

MOOCS/SWAYAM/NPTEL

SWAYAM (Study Webs of Active learning for Young Aspiring Minds) is an online portal to provide best teaching-learning experience. SWAYAM is an initiative of Govt of India to promote access for open-learning. Any Students can register to this portal for online courses. SWAYAM is an instrument for a self-actualization providing opportunities for life-long learning. Dolphin PG Institute has taken a step forward towards establishing an SWAYAM- NPTEL local Chapter under the National Programme on Technology Enhanced Learning (NPTEL). The primary aim of this Chapter is to facilitate our students in acquiring knowledge through enriched NPTEL video lectures and obtaining NPTEL certificates for the courses they undertake. This initiative also aims to enhance our students' employability in the industry or prepare them for further higher education in various fields. Dr. Aasheesh Raturi, faculty member of the Physics department, has been appointed as the Single Point of Contact (SPOC) for the NPTEL DIBNS Local Chapter and officially recognized by IITM. The responsibilities of the SPOC is to identify mentors from different departments who will encourage students to enrol in relevant NPTEL courses, oversee their progress on a weekly basis, motivate them to complete assignments, register for NPTEL exams, and guide them towards successfully completing the NPTEL courses.

1. MOOCs Courses - Click here
2. SWAYAM Courses – Click here
3. NPTEL Courses- Click here

SWAYAM courses will be incorporated in the curriculum and assignments, assessments or projects into the overall evaluation criteria for the skill enhancement/ multidisciplinary/ value added /vocational courses ensuring that students are actively participating and benefiting from the online learning experience.

Department will monitor the students' progress and engagement in SWAYAM courses throughout the semester.

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Semester-wise Credit distribution of 2 years M.Sc. Biotechnology

	Title of Course	Code	Credits
	I Semester		
	Theory		
1.	Bio-Analytical Techniques	BTC001	3+1
2.	Biochemistry	BTC002	3+1
3.	Cell Biology	BTC003	3+1
4.	Microbiology & Microbial Genetics	BTC004	3+1
5.	Genetics	BTC005	3+1
	Generic Elective Course (from other departments)/Online Course from MOOC/NPTEL		2
	Practical		
	Lab Course I	BTC006	2
	Lab Course II	BTC007	2
	Total Credits		**26**
	II Semester		
	Theory		
1.	Molecular Biology	BTC008	3+1
2.	Plant Biotechnology	BTC009	3+1
3.	Enzymology & Enzyme Technology	BTC010	3+1
4.	Immunology & Immunotechnology	BTC011	3+1
5.	Bioprocessing & Industrial Biotechnology	BTC012	3+1
	Generic Elective Course (from other departments)/Online Course from MOOC/NPTEL		2
	Practical		
	Lab Course I	BTC013	2
	Lab Course II	BTC014	2
	Total Credits		**26**
	III Semester		
	Theory		
1.	Recombinant DNA Technology	BTC015	3+1
2.	Bioinformatics and Computational Biology	BTC016	3+1
3.	Animal Biotechnology	BTC017	3+1
4.	Research Methodology and Biostatistics	BTC018	3+1
5.	Environmental Biotechnology	BTE001	3+1
	Pharmaceutical Drug Designing	BTE002	
	Agricultural Biotechnology	BTE003	
	Food & Beverage Technology	BTE004	
	Synthetic Biology	BTE005	
	Herbal Biotechnology	BTE006	
	Practical		
	Lab Course I	BTC019	2

	Lab Course II	BTC020	2
	Total Credits		**26**
	IV Semester		
	Dissertation	BTC021	**20**
	OR		
	Biotechnology Innovation & Entrepreneurship	BTC022	3+1
	Biofertilizer & Organic Farming	BTC023	3+1
	Stem Cell Biology	BTC024	3+1
	IPRs, Bioethics & Biosafety	BTC025	3+1
	Generic Elective Course (from other departments)/Online Course from MOOC/NPTEL/ Internship to be done from Industry after Semester III.		4
	Total Credits		**20**
	Grand Total		**96**

Bio-Analytical Techniques
Semester I
(Credits = T+P = 3+1)
THEORY

Course Code: BTC001 **Total Lectures: 36**

Course Objective:
The students will learn use of diverse biological procedures in the identification and isolation of distinct biological molecules.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: Learn many uses of microscopy in a variety of disciplines, such as cell biology, microbiology, immunology, cancer research, and drug development.
CO2: Obtain a thorough understanding of the concepts and uses of chromatography and electrophoresis in the separation, examination, and purification of biomolecules.
CO3: Explain the basic ideas of X-ray crystallography and spectroscopy.
CO4: Explain the basic ideas and uses of tracer technology in biological research and medical diagnostics.
CO5: Explain the various blotting methods, such as Northern, Western, and Southern blotting, and distinguish between them according to the target molecule (DNA, RNA, or protein).

Course Content

Unit I
Principles of microscopy; Light microscopy; Fluorescence microscopy; Confocal microscopy; use of fluorochromes: applications of fluorescence microscopy. Electron Microscopy: SEM and TEM

Unit II
Electrophoresis and chromatography Agarose and polyacrylamide gel electrophoresis (native and denaturing), Immuno-electrophoresis, Isoelectric Focusing, column chromatography (ion exchange, gel permeation, affinity), GLC and HPLC.

Unit III
Spectroscopy and X–ray crystallography; Principles of colorimetry and UV-Vis spectrophotometry, Mass spectrometry, MALDI, X-Ray Crystallography, SPR.

Unit IV
Principles of fluorescence, Tracer Technology, Dose response relationship, Radioisotopes in Diagnostics and Biotechnology, Geiger-Mueller Counter, Scintillation Counters. Non-Radioactive tracer Technology; Metabolic and physiological tracer techniques, non-radioactive labels (fluorescence and nonradioisotopes), labeling and detection methods using fluorescent molecules.

Unit V
Blotting techniques: Southern blotting, northern blotting, western blotting.

Lab Course Based on BTC001 (Bio-Analytical Techniques)

1. Cell disruption using grinding and homogenizing.
2. Centrifugation for fractionation of homogenate.
3. Spectrophotometric/ colorimetric estimation of proteins.
4. Chromatographic separation of proteins.
5. Fluorescence detection of nucleic acids.

Units	Suggested Readings	Reference Books	E-Content
I	**Analytical Techniques in Biosciences: From Basics to Applications** 1st Edition - October 21, 2021 Editors: Chukwuebuka Egbuna, Kingsley C. Patrick-Iwuanyanwu, Muhammad Ajmal Shah, Jonathan C. Ifemeje, Azhar Rasul	**Analytical Techniques in Biochemistry and Molecular Biology** Rajan Katoch Springer **Techniques in Life Science** By Rahul Pandey ISBN: 9789390675104 Publisher: BFC Publications Published: March 2021	https://onlinecourses.swayam2.ac.in/cec20_bt22/preview
II	**Analytical Techniques in Biosciences: From Basics to Applications** 1st Edition - October 21, 2021 Editors: Chukwuebuka Egbuna, Kingsley C. Patrick-Iwuanyanwu, Muhammad Ajmal Shah, Jonathan C. Ifemeje, Azhar Rasul **Analytical Techniques in Biochemistry and Molecular Biology** Rajan Katoch Springer **Techniques in Life Science** By Rahul Pandey ISBN: 9789390675104 Publisher: BFC Publications Published: March 2021	**Basic Techniques in Biochemistry, Microbiology and Molecular Biology** By Aakanchha Jain, Richa Jain, Sourabh Jain Softcover ISBN: 978-1-4939-9863-0 Publisher: Humana New York, NY (Springer)	https://onlinecourses.swayam2.ac.in/cec20_bt22/preview
III	**Techniques in Life Science** By Rahul Pandey ISBN: 9789390675104 Publisher: BFC Publications Published: March 2021 **Basic Techniques in Biochemistry, Microbiology**	**Laboratory Manual for Biotechnology** (by Ashish S./ Das Surajit & Singh Anchal Verma) ISBN-13: 978-9383746224 Publisher : S Chand **Principles and techniques**	https://onlinecourses.swayam2.ac.in/cec20_bt22/preview

	and Molecular Biology By Aakanchha Jain, Richa Jain, Sourabh Jain Softcover ISBN: 978-1-4939-9863-0 Publisher: Humana New York, NY (Springer)	**of practical biochemistry.** Wilson, K., & Walker, J. (Eds.). (2000). Cambridge University Press.	
IV	**Techniques in Life Science** By Rahul Pandey ISBN: 9789390675104 Publisher: BFC Publications Published: March 2021 **Biotechnology: Principles and Applications** by S K Jain **Laboratory Manual for Biotechnology** (by Ashish S./ Das Surajit & Singh Anchal Verma) ISBN-13: 978-9383746224 Publisher : S Chand	**Principles and techniques of practical biochemistry.** Wilson, K., & Walker, J. (Eds.). (2000). Cambridge University Press.	https://onlinecourses.swayam2.ac.in/cec20_bt22/preview
V	**Principles and techniques of practical biochemistry.** Wilson, K., & Walker, J. (Eds.). (2000). Cambridge University Press. **Molecular Biology of the Gene** b y James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, and Richard Losick	**Lehninger Principles of Biochemistry** by David L. Nelson and Michael M. Cox.	https://onlinecourses.swayam2.ac.in/cec20_bt22/preview

Biochemistry
Semester I
(Credits = T+P = 3+1)
THEORY

Course Code: BTC002 **Total Lectures: 36**

Course Objective:
This course aims to provide students with a comprehensive understanding of biochemical principles essential for biotechnological applications, focusing on acid-base chemistry, bioenergetics, carbohydrate metabolism, protein structure-function relationships, enzyme kinetics, lipid metabolism, and nucleic acid metabolism.

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

CO1: Understand the principles of acid-base chemistry, including conjugate acid-conjugate base pairs, pH, buffers, and ionization of solutions.
CO2: Describe the pathways and regulatory mechanisms involved in carbohydrate metabolism, including glycolysis, gluconeogenesis, and the citric acid cycle.
CO3: Explain the structural features of proteins, their classifications, and the functional implications of their primary, secondary, tertiary, and quaternary structures.
CO4: Analyze enzyme kinetics and inhibition, including the Michaelis-Menten equation, different types of enzyme inhibition, and factors influencing enzyme activity.
CO5: Discuss the metabolism of lipids, including fatty acid oxidation, biosynthesis, and the regulatory mechanisms of fatty acid metabolism, as well as nucleic acid metabolism focusing on purine and pyrimidine biosynthesis and degradation pathways.

Course Content:

Unit I

Acid-base chemistry: Bronsted concept of conjugate acid-conjugate base pairs, Ionization of solutions, pH, Important biological buffers, Henderson-Hasselbalch equation, Buffer capacity, Polyproteic acids, Amphoteric salt, Ionic strengths; Bioenergetics: Concept of free energy, Standard free energy, Enthalpy, Entropy, High energy phosphate compounds, Phosphate group transfer, Free energy of hydrolysis of ATP, Oxidation-reduction, Redox potential.

Unit II

Carbohydrates: Classification, structure and functions; Carbohydrate Metabolism: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis; Citric acid cycle and its regulation, Energy generation in biological systems: Electron transport Chain and Oxidative phosphorylation, electron carriers, Artificial electron donors, Inhibitors and uncouplers of oxidative phosphorylation, Chemiosmotic theory of ATP synthesis, Pentose phosphate pathway and its regulation.

Unit III

Proteins: Structural features and classification of amino acids, General reactions of amino acid metabolism (Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids), Peptide bond, Properties and functions of primary, secondary, tertiary and

quaternary structure of proteins, Ramachandran plot, Factors affecting secondary and tertiary structures, Hydropathy index, Protein domain and motifs. Enzymes: Classification (rationale, overview and specific examples) Zymogens and their activation. Enzyme substrate complex: Concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced-Fit Hypothesis, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax, Enzyme Inhibition.

Unit IV

Fatty Acids: Classification and structure. Fatty Acid Metabolism: Fatty Acid Oxidation and regulation, β-oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids, β-oxidation in peroxisomes, Ketone bodies and their overproduction. Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, Synthesis of triglycerols, Cholesterol biosynthesis and regulation. Fatty acids; Saponification, acid value and iodine value of fats; Rancidity of fats; Storage and structural lipids; Special mention of sphingomyelins, cerebrosides and gangliosides; Vitamins: Structure and function of fat soluble vitamins.

Unit V

Nucleic Acid Metabolism: Purine biosynthesis and its regulation, Pyrimidine biosynthesis and its regulation. Formation of deoxyribonucleotides. Salvage pathway for Purine and Pyrimidine nucleotides, Degradation of purines and pyrimidines into uric acid and urea.

Lab Course based on BTC002 (Biochemistry)

1. Qualitative and Quantitative test for amino acids.
2. Qualitative and Quantitative test for carbohydrates.
3. Tests for reducing sugars.
4. To detect the presence of Glucose in the given sample by GOD-POD method.
5. To estimate total Protein in the given sample by Biuret method.
6. To detect the presence of cholesterol in the given sample by end point method.

Units	Suggested Readings	Reference Books	E-Contents
I	**"Physical Chemistry for the Life Sciences"** by Peter Atkins and Julio de Paula **"Principles of Bioenergetics"** by Vladimir P. Skulachev and Mikhail V. Markov	**"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., and Lubert Stryer **"Lehninger Principles of Biochemistry"** by David L. Nelson and Michael M. Cox	https://www.khanacademy.org/science/chemistry https://conductscience.com/introduction-to-bioenergetics/
II	**"Biochemistry: A Short Course"** by John L. Tymoczko, Jeremy M. Berg,	**"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto	https://courses.lumenlearning.com/suny-ap2/chapter/carbohydra

	and Lubert Stryer **"Fundamentals of Biochemistry: Life at the Molecular Level"** by Donald Voet and Judith G. Voet	Jr., and Lubert Stryer **"Lehninger Principles of Biochemistry"** by David L. Nelson and Michael M. Cox	te-metabolism-no-content/ https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5851778/
III	**"Proteins: Structure and Function"** by David Whitford **"Fundamentals of Enzyme Kinetics"** by Athel Cornish-Bowden	**"Lehninger Principles of Biochemistry"** by David L. Nelson and Michael M. Cox **"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., and Lubert Stryer	https://www.toppr.com/guides/biology/biomolecules/enzymes/ https://www.utsouthwestern.edu/edumedia/edufiles/education_training/programs/stars/goodman-enzymes-proteins.pdf
IV	**"Lipid Biochemistry: An Introduction"** by Michael I. Gurr, John L. Harwood, Keith N. Frayn, Denis J. Murphy, and Robert H. Michell **"Advanced Nutrition and Human Metabolism"** by Sareen S. Gropper and Jack L. Smith	**"Lehninger Principles of Biochemistry"** by David L. Nelson and Michael M. Cox **"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., and Lubert Stryer	https://www.creative-proteomics.com/resource/what-is-fatty-acid-metabolism.htm https://courses.lumenlearning.com/suny-ap2/chapter/lipid-metabolism/
V	**"Biochemistry"** by Reginald H. Garrett and Charles M. Grisham **"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter	**"Lehninger Principles of Biochemistry"** by David L. Nelson and Michael M. Cox **"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., and Lubert Stryer	https://www.uobabylon.edu.iq/eprints/publication_4_19662_533.pdf https://www.osmosis.org/learn/Nucleotide_metabolism

Cell Biology
Semester I
(Credits = T+P = 3+1)
THEORY

Course Code: BTC003 **Total Lectures: 36**

Course Objective:
To provide a comprehensive understanding of the structure, function, and dynamic processes of cells, including their molecular components and interactions, essential for applications in biotechnology and biomedical research.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: Describe the historical development of cell biology, including the significance of cell theory, and compare the cellular organization and structures between prokaryotic and eukaryotic cells.
CO2: Explain the structure and function of key cellular components such as the cell wall, plasma membrane, organelles (mitochondria, chloroplasts, etc.), and the cytoskeleton, integrating knowledge from cell fractionation techniques.
CO3: Analyze the composition and dynamics of cell membranes, including the fluid mosaic model, membrane transport mechanisms (passive and active), and molecular mechanisms of vesicular trafficking.
CO4: Outline different cell signaling mechanisms, including autocrine, paracrine, and endocrine signaling, and describe signal transduction pathways involving second messengers, protein kinases, and their roles in cellular responses.
CO5: Discuss the molecular events and regulation of the cell cycle, including checkpoints, cyclins, and CDKs, and analyze the role of oncogenes, tumor suppressor genes, and cellular responses such as apoptosis and senescence in cancer biology.

Course Content:
Unit I
Historical overview of cell biology; Cell theory and its significance; Cellular organization: prokaryotic vs. eukaryotic cells; Cell structure and function: cell wall, plasma membrane, cytoplasm, nucleus, organelles (mitochondria, chloroplast, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes), ribosomes, cytoskeleton, cell fractionation; Cell-cell interactions: cell adhesion molecules (CAMs), tight junctions, desmosomes, gap junctions.

Unit II
Membrane composition: lipid bilayer, membrane proteins, carbohydrates; Membrane dynamics: fluid mosaic model, membrane fluidity, lateral and transverse diffusion, membrane asymmetry; Membrane transport mechanisms: passive diffusion, facilitated diffusion, active transport (primary and secondary), ion channels, ion pumps, co-transporters; Membrane trafficking:

vesicular transport, endocytosis, exocytosis, intracellular vesicle trafficking; Molecular mechanism of vesicular trafficking; Membrane receptors: structure, function.

Unit III

Protein Sorting: Anterograde & Reterograde mode of protein trafficking, Vesicular traffic in the secretory and Endocytic pathway: Transport from Endoplasmic reticulum through the Golgi network to Lysosome, Endocytosis, Exocytosis, Molecular mechanisms of vesicular transport and maintenance of compartments diversity. Voltage-gated channels, Ligand-gated channels, Na^+ , K^+ and Ca^{2+} channels, pumps as channels.

Unit IV

Cell signaling pathways: autocrine, paracrine, endocrine signaling; Signal transduction mechanisms: receptor activation, second messengers (cAMP, IP3, DAG), protein kinases, phosphorylation cascades; Intracellular signaling networks: G-protein coupled receptors (GPCRs), receptor tyrosine kinases (RTKs), MAP kinase pathway, PI3K/AKT pathway, JAK/STAT pathway, nuclear receptors; Cellular responses to extracellular signals: gene expression regulation, cytoskeletal rearrangements, cell motility, differentiation.

Unit V

Cell cycle and Cell division: General strategy & regulation, Molecular mechanism of mitosis and meiosis; Molecular events and regulation of cell cycle: checkpoints, cyclins, cyclin-dependent kinases (CDKs); Cancer- Biology: Types of cancer, Onset of cancer, Proto-oncogenes and tumor suppressor genes, Oncogenic mutations affecting cell proliferation, Cell cycle and Genome stability, Apoptosis, autophagy; senescence; necrosis; Stem cell biology: stem cell types, stem cell niche, pluripotency, differentiation.

Lab Course based on BTC003 (Cell Biology)

1. To study permanent slides of mitosis and meiosis.
2. To demonstrate endosmosis and exosmosis in living plant cell potato osmometer.
3. Squash preparation of onion root tips to study different stages of mitosis.
4. Study of plasmolysis in epidermal peel of leaf.
5. Preparation of blood smear.

Units	Suggested Readings	Reference Books	E-Content
I	**"Essential Cell Biology"** by Bruce Alberts, Dennis Bray, Karen Hopkin, and Alexander Johnson **"The Biology of the Cell"** by Geoffrey M. Cooper and Robert E. Hausman	**"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter **"Cell and Molecular Biology: Concepts and Experiments"** by Gerald Karp	https://www.toppr.com/guides/biology/cell-structure-and-function/introduction-to-cell/ https://www.britannica.com/science/cell-biology

II	**"Cell and Molecular Biology: Concepts and Experiments"** by Gerald Karp **"The Cell: A Molecular Approach"** by Geoffrey M. Cooper and Robert E. Hausman	**"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter **"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., and Lubert Stryer	https://www.thoughtco.com/cell-membrane-373364 https://study.com/academy/lesson/cell-membrane-transport-selective-permeability-types.html
III	**"Essential Cell Biology"** by Bruce Alberts, Dennis Bray, Karen Hopkin, and Alexander Johnson **"Molecular Cell Biology"** by Harvey Lodish, Arnold Berk, Chris A. Kaiser, and Monty Krieger	**"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter **"Cell Biology"** by Thomas D. Pollard, William C. Earnshaw, and Jennifer Lippincott-Schwartz	https://www.sscollegejehanabad.org/study-material/467490407Protein%20trafficking%20(pg)_CellBiology_zoology_narendra.pdf https://utkaluniversity.ac.in/wp-content/uploads/2022/06/Protein-Sorting-and-Transport-Endoplasmic-reticulum.pdf
IV	**"Cell Biology"** by Thomas D. Pollard, William C. Earnshaw, and Jennifer Lippincott-Schwartz **"Signal Transduction and Human Disease"** by Toren Finkel and J. Silvio Gutkind	**"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter **"Cell Signaling"** by Wendell Lim, Bruce Mayer, and Tony Pawson	https://www.khanacademy.org/science/ap-biology/cell-communication-and-cell-cycle/cell-communication/a/introduction-to-cell-signaling https://byjus.com/biology/cell-signalling/
V	**"Molecular Cell Biology"** by Harvey Lodish, Arnold Berk, Chris A. Kaiser, and Monty Krieger **"Essential Cell Biology"** by Bruce Alberts, Dennis Bray, Karen Hopkin, and Alexander Johnson	**"Molecular Biology of the Cell"** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter **"The Cell: A Molecular Approach"** by Geoffrey M. Cooper and Robert E. Hausman	https://rwu.pressbooks.pub/bio103/chapter/the-cell-cycle-and-mitosis/ https://www.pnas.org/doi/full/10.1073/pnas.94.7.2776

Microbiology and Microbial Genetics
Semester I
(Credits = T+P = 3+1)
THEORY

Course Code: BTC004 **Total Lectures: 36**

Course Objective:
This course aims to provide a comprehensive understanding of microbiology, covering the scope, classification, structure, growth, and genetic mechanisms of microorganisms.

Course Outcomes: On the completion of the course, the students will be able to:
CO1. Understand theories and concepts of microorganisms.
CO2. Describe the morphology of prokaryotic cells and different stains and staining techniques
CO3. Understand the composition and preparations of various liquids and solids culture media and growth of microorganisms.
CO4. Impart knowledge about the structure and cultivation techniques of animal viruses and bacteriophages.
CO5. Understand the concepts of microbial genetics, including gene transfer mechanisms (transformation, conjugation, and transduction).

Course Content:
Unit I
Scope and relevance of microbiology; Discovery of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; Microbial Classification: Two Kingdom system and its Drawbacks, Three domain concept, Five kingdom system, Six kingdom system, Eight kingdom system, Bergey's system of Bacterial classification; Phenotypic and Genotypic basis of classification.

Unit II
Ultrastructure of bacterial cells and their functions: Flagella, cilia, pili, S-layer, cytoplasmic inclusions, ribosomes, and nucleoid; Morphology of bacteria: Shape, size, arrangements, structure, and properties of cell wall and cell membrane; Capsule (Types, composition, and function); Introduction to staining principles, dyes and stains; Staining methods such as Simple, Negative, Gram, Endospore, Acid-fast, and Fungal staining; Measurement of growth (cell number and cell count).

Unit III
Cultural Media: Classification of liquid and solid media; Simple, Complex, Synthetic media; Selective media, Enriched media, Enrichment media, Differential media, Sugar media, Transport media, culture media for fungi; Control of Microbial Growth; Microbial growth; Growth curve of batch and continuous cultivation, Diauxic growth curve, Asynchronous and synchronous growth; Factors affecting growth.

Unit IV
Discovery of viruses; Characteristic features of viruses, viroids, virusoids, and prions; Baltimore scheme of classification; Morphology and ultrastructure: Capsids and their arrangements, Types

and composition of envelopes, Viral genome (Types and structures); Isolation and cultivation of viruses using embryonated eggs, experimental animals, and cell culture; Bacteriophage: Structural organization, Cultivation, Replication.

Unit V

Modes of genetic recombination in bacteria: Transformation - Mechanism of transformation, Competence, DNA uptake by competent cells; Conjugation - F-factor, Conjugal transfer process, High-frequency recombination (Hfr) strains; Transduction - Generalized and specialized transduction.

Lab Course Based on BTC004 (Microbiology and Microbial Genetics)

1. Study of common instruments used in microbiology laboratory.
2. Preparation of basic liquid media (Nutrient Broth) and solid media (Nutrient Agar) for routine microbial cultivation.
3. Morphological study of bacteria using simple staining techniques.
4. Gram staining technique to differentiate between gram-positive and gram-negative bacteria.
5. Techniques for isolation and purification of pure cultures.
6. Preparation and differentiation of MacConkey agar for lactose and non-lactose fermenter identification.
7. Identification of hemolytic microorganisms using Blood agar.
8. Detection of coliforms in water samples using presumptive, confirmed, and completed tests.

Units	Suggested Readings	Reference Books	E-Content
I	**Microbiology: An Introduction.** Tortora GJ, Funke BR, Case CL. Pearson Education. **Prescott's Microbiology.** Wiley JM, Sherwood LM, Woolverton CJ. McGraw-Hill International. **Microbiology-General and Applied.** by A. Mani, A.M.Selvaraj (Author), N.Arumugam L.M. Narayana. 1st Ed. Saras Publication.	**Brock Biology of Microorganisms.** Madigan MT, Martinko JM, Dunlap PV, Clark DP. Pearson International Edition. **Fundamental Principles of Bacteriology.** Salle AJ. Tata McGraw-Hill Education.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f58f https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f58e https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f596

II	**Microbiology.** Pelczar MJ, Chan ECS, Krieg NR. 5th Ed. McGraw Hill Book Company. **General Microbiology.** Stanier RY, Ingraham JL, Wheelis ML, Painter PR. McMillan. **Essentials of Microbiology** by Jain. 2019. **ISBN:** 9788131254875. Elsevier.	**General Microbiology.** Powar CB, Daginawala HI. *Volume I.* Himalaya Publishing House Private Limited, Pune, India. **A Textbook Of Microbiology** by Dubey R C, 5th Edition S Chand & Company. **Introductory Microbiology-I** by Dr.R Krishna Murthy. 2022. Sankalp Publication. ISBN 9789391190071.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb23 https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f586 https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb29
III	**Elementary Microbiology.** Modi HA. Vol I, Fundamentals of Microbiology. S Chand and Company. **A Textbook of Microbiology.** Dubey RC, Maheshwari DK. S Chand and Company, New Delhi, India. **Fundamentals of Microbiology** by Jeffrey C. Pommerville. 12th Edition. Jones & Bartlett Learning	**Antisepsis, Disinfection, and Sterilization: Types, Action and Resistance.** McDonnell GE. Wiley, United States. **Bergey's Manual of Systematic Bacteriology.** Garrity G (editor). *Volume Two: The Proteobacteria, Part A: Introductory Essays.* Springer. **Handbook of Microbiological Media.** Atlas RM. Taylor and Francis, Ukraine.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f591 https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f594 https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb2d
IV	**Introduction to Virology** edited by Paul Mahoney. 2018. Callisto Reference. **Textbook Of Virology (Pb)** by Singh Vinod, IBDC. 2010. ISBN 9788181894748.	**Principles of Virology** by S.J. Flint, L.W. Enquist, V.R. Racaniello, A.M. Skalka 5th Ed. American Society for Microbiology. 2009. **Textbook of Medical Virology** by Mishra B. 2nd Ed. CBS Publishers & Distributors Pvt Ltd, India	https://vidyamitra.inflibnet.ac.in/index.php/content/index/5507d376e41301134d12f59a https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cbdd https://vidyamitra.inflibnet.ac.in/index.php/con

			tent/index/5a3a598e8007becc2565cbe1
V	**Genetics Of Bacteria** by Shrivastava, Sheela, Springer Nature. 2018. ISBN 9788132237761. **Bacterial Genetics And Genomics** 1st Edition by Lori A.S. Snyder, Taylor & Francis.	**Microbial Genetics (Pb)** by Chaudhuri, Keya, The Energy And Resources Institute. **A Textbook of Microbial Genetics** Pradeep D. Devkate, Samina R. Khan, Dipak G. Puri, Sachin S. Shinde.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb37 https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb3d https://vidyamitra.inflibnet.ac.in/index.php/content/index/5a3a598e8007becc2565cb3f

Genetics
Semester I
(Credits = T+R = 3+1)
THEORY

Course Code: BTC005 **Total Lectures: 36**

Course Objective:
This provides an overview of classical genetics—Linkage & Crossing over—and covers the fundamentals of Mendelian, population, and hereditary genetics.

Course Outcomes:
CO1: Explain the basic ideas of Mendelian genetics.
CO2: Students will be able to describe the chromosomal foundation of inheritance patterns.
CO3: Understanding the fundamental concepts of mutations and chromosomal alterations,
CO4: Function of mitochondria and chloroplasts DNA in inheritance.
CO5: Understanding about Transposable Genetic Elements and microbial gene transfer

Course Content:
Unit I
History of genetics, Mendelian principles, monohybrid and dihybrid crosses, dominance, codominance and incomplete dominance, gene interaction and epistasis, concept of gene and cistron, cis-trans complementation experiment, lethals and sub-lethals; Multiple alleles-ABO blood groups in humans, Rh blood group incompatibility. Relevant numericals based on the topics given.

Unit II
The Chromosome theory of heredity. Linkage, recombination and crossing over, Sex linked, sex-limited and sex-influenced characters, Sex Chromosome and sex determination; dosage compensation of X-linked genes; Gene mapping methods: Linkage maps, tetrad analysis. Relevant numericals based on the topics given.

Unit III
Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical,
Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Unit IV
Complex patterns of inheritance, quantitative traits, Inbreeding and resemblance between relatives; Maternal Effect; Cytoplasmic inheritance: mitochondria and chloroplasts.

Unit V
Transposable Genetic Elements: characteristics, types, examples and applications of Transposable elements.

Units	Suggested Readings	Reference Books	E-Content
I	**Principles of genetics.** Snustad, D. P., & Simmons, M. J. (2015). John Wiley & Sons. **Genetics: From Genes to Genomes** by Peter J. Russell	**Genetics: Analysis and Principles** by Robert J. Booker	**https://www.vidyawarta.com/01/wp-content/uploads/2019/09/book_A_Text_Book_of_Genetics.pdf** **https://learn.genetics.utah.edu/**
II	**Principles of genetics.** Snustad, D. P., & Simmons, M. J. (2015). John Wiley & Sons. **Genetics: From Genes to Genomes** by Peter J. Russell	**Genetics** by Benjamin A. Pierce	**https://www.vidyawarta.com/01/wp-content/uploads/2019/09/book_A_Text_Book_of_Genetics.pdf** **https://learn.genetics.utah.edu/**
III	**Principles of genetics.** Snustad, D. P., & Simmons, M. J. (2015). John Wiley & Sons. **Genetics: From Genes to Genomes** by Peter J. Russell	**Genetics: From Genes to Genomes** by Benjamin Lewin	**https://www.vidyawarta.com/01/wp-content/uploads/2019/09/book_A_Text_Book_of_Genetics.pdf** **https://learn.genetics.utah.edu/**
IV	**Principles of genetics.** Snustad, D. P., & Simmons, M. J. (2015). John Wiley & Sons.	**Plant Cell Biology** by Taiz and Zeiger	**https://www.vidyawarta.com/01/wp-content/uploads/2019/09/book_A_Text_Book_of_Genetics.pdf** **https://learn.genetics.utah.edu/**
V	**Principles of genetics.** Snustad, D. P., & Simmons, M. J. (2015). John Wiley & Sons. **Concepts of genetics** Klug, W. S., & Cummings, M. R. (2003). (No. Ed. 7, pp. xxviii+-693). **Integrating genetic**	**Fundamental genetics.** Ringo, J. (2004). Cambridge University Press. **Brock Biology of Microorganisms** by Michael T. Madigan John M. Martinko, Kelly S. Bender, Garland E. Stahl, David A. Stahl, and Thomas	**https://www.vidyawarta.com/01/wp-content/uploads/2019/09/book_A_Text_Book_of_Genetics.pdf** **https://learn.genetics.utah.edu/**

	approaches into the discovery of anticancer drugs. Hartwell, L. H., Szankasi, P., Roberts, C. J., Murray, A. W., & Friend, S. H. (1997). *Science*, *278*(5340), 1064-1068.	D. Brock.	

Molecular Biology
Semester II
(Credits = T+P = 3+1)
THEORY

Course Code: BTC008 **Total Lectures: 36**

Course Objective:
To provide an in-depth understanding of the molecular mechanisms underlying the storage, replication, and expression of genetic information, including the regulation of these processes and the implications for biotechnology.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: Describe key experiments that established nucleic acids as carriers of genetic information and discuss their significance in the context of molecular biology.
CO2: Explain the chemical and physical properties of DNA and RNA, their structural variations, and the organization of genetic material within chromosomes.
CO3: Compare and contrast DNA replication and transcription processes in prokaryotes and eukaryotes, including regulatory mechanisms and inhibitors.
CO4: Illustrate the process of translation, the genetic code, and regulatory mechanisms in both prokaryotic and eukaryotic systems, emphasizing the role of operons and DNA-binding motifs.
CO5: Identify different types of DNA damage and repair mechanisms, and assess the impact of various mutations on genetic stability and function.

Course Content:

Unit I

Historical overview; Experimental evidences for nucleic acid as carrier of genetic information (Griffith's transformation, Avery-MacLeod-McCarty's experiment, Hershey-Chase experiment); Chemical and physical properties of genetic material; Structure and forms/types of DNA and RNA; Molecular structure of chromosome in eukaryotes: centromeres; structure of chromatin and packaging of DNA into chromosome; Basic concepts of epigenetic regulation, such as DNA methylation and histone modifications; Chromatin control: chromatin writers, readers and erasers; Polytene and Lampbrush chromosomes; DNA denaturation and renaturation.

Unit II

Central Dogma; DNA replication in prokaryotes and eukaryotes: Experimental evidence, Modes of replication, Mechanism of replication, Inhibitors of replication, the end-replication problem and telomerase; Transcription in prokaryotes and eukaryotes: Mechanism of transcription; regulatory elements such as enhancers and silencers; activators and repressors, Inhibitors of transcription; RNA processing: processing of heterogeneous nuclear RNA: capping, polyadenylation, splicing of mRNA; processing of tRNA and rRNA; Reverse transcription.

Unit III

Basic features of genetic code; Translation in prokaryotes and eukaryotes: Mechanism of translation; Inhibitors of translation; Co- and post translational modifications, protein sorting and degradation; Gene expression and regulation in prokaryotes; operon concept, inducible and repressible operons, lac operon and trp operon. Gene expression and regulation in eukaryotes; DNA binding motifs in regulatory proteins.

Unit IV

DNA Damage; DNA Repair (photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, SOS repair, homologous and non-homologous end joining); Mutations: nonsense, missense, frameshift and point mutations; intragenic and intergenic suppression;

Unit V

Recombination: mechanism of homologous recombination, site specific recombination. Transposition: Insertion sequences and transposable elements in prokaryotes and eukaryotes, Mechanism of transposition; RNA interference and antisense RNA; Ribozymes.

Lab Course based on BTC008 (Molecular Biology)

1. Preparation of buffers for Molecular Biology experiments.
2. Visualization of DNA by Agarose Gel Electrophoresis.
3. Qualitative and Quantitative analyses of nucleic acid by Spectrophotometric method.
4. Estimation of concentration of DNA by Diphenylamine method.
5. Estimation of concentration of RNA by Orcinol method.
6. Estimation of G+C content of a given DNA sample by denaturation and plotting of melting curve

Units	Suggested Readings	Reference Books	E-Content
I	**Principles of Genetics** by D. Peter Snustad and Michael J. Simmons. 7th Ed. Wiley. **Molecular Biology** by David Friefelder. 2004. Narosa Publication.	**Molecular Biology** by N. Arumugam. Saras Publications. **Molecular Biology Principles of Genome Function** by Craig and Green. Oxford University Press.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/570b82b98ae36ccd3ed6602c https://onlinecourses.swayam2.ac.in/cec20_ma13/preview
II	**Molecular Biology** by David P. Clark and Nanette J. Pazdernik **Molecular Biology of the Gene** by James D. Watson et al. 7th Ed. Pearson Publication.	**Molecular Biology-Fundamental Process.** IFAS Publications. **Molecular Biology: Principles and Practice.** Cox et al. 1st Ed. W. H. Freeman and Co. Ltd.	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA== https://study.com/academy/lesson/dna-replication-review-of-enzymes-replication-bubbles-leading-and-

			lagging-strands.html
III	**Molecular Biology: Principles and Practice**" by Michael M. Cox, Jennifer A. Doudna, and Michael O'Donnell **Genes XII** by Benjamin Lewin, 12th Ed. Jones and Bartlett Publishers, Inc.	**Molecular Biology: A Complete Course** (Pb 2012) By Singh R.N. **Molecular Cell Biology.** Lodish et al. 6th Ed. W. H. Freeman and Co. Ltd.	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA== https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA== https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA== https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA==
IV	**Lewin's Essential Genes** by Jocelyn E. Krebs, Elliott S. Goldstein, and Stephen T. Kilpatrick **Molecular Cell Biology** by Harvey Lodish et al.	**Molecular Biology of the Gene.** James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick. 5th edition. Cold Spring Harbor Laboratory Press (2003). **Cell and Molecular Biology Vol 1 (Pb 2016)** By Jacobs M. Volume 1.	https://vidyamitra.inflibnet.ac.in/index.php/content/index/570b82b98ae36ccd3ed6604c
V	**Molecular Biology of the Gene.** James D. Watson. 8th Ed. Affiliated East West Press. **Molecular Biology : Principles Of Genome Function** by Nancy Craig and Rachel Green and Carol Greider and Gisela Storzand And Cynthia Wolberger, Oxford University Press	**Cell And Molecular Biology** by De Robertis 8th Edition 2020 **Molecular Biology of the Cell** by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. 6th Ed. W. W. Norton Publisher.	https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA== https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=2rAs1Puvga4LW93zMe83aA==

Plant Biotechnology
Semester II
(Credits = T+P = 3+1)
THEORY

Course Code: BTC009 **Total Lectures: 36**

Course Objective:
It gives introduction to the various transformation techniques employed in plant Systems and describes the application of genetically modified plants in the various fields of Science.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: The students will gain a thorough understanding of the concepts of plant tissue culture.
CO2: Students will be able to analyze the large-scale clonal multiplication of significant plants for horticulture and agriculture.
CO3: Exhibit a thorough comprehension of single-cell culture, the concepts of protoplast technology, and the use of cell suspension culture techniques in the generation of secondary metabolites.
CO4: Explore the possible uses and drawbacks of somaclonal variation, haploid plant production, and cryopreservation in the context of contemporary plant breeding.
CO5: Examine and apply plant genetic engineering concepts critically in order to create transgenic plants with enhanced agronomic qualities.

Course Content:

Unit I

Historical background of plant tissue culture, Plant tissue culture practical application and conventional plant breeding; Tissue culture media - composition and preparation- solid media and liquid media. Types of plant tissue Culture: Seed, Embryo (mature, Immature), Embryo rescue technique, Callus culture.

Unit II

Micro propagation of plants- Stages, Approaches, applications and limitations. Organogenesis and somatic embryogenesis in plant tissue culture- development of plantlets - Root formation, transfer of plantlets to the soil, hardening. Advantages of micropropagation in agriculture and horticulture. Shoot-tip meristem culture - raising virus free plants for rapid clonal multiplication of agricultural and horticultural plants

Unit III

Cell suspension cultures and its application in the production of secondary metabolites and single cell culture. Protoplast technology -protoplast isolation, fusion, protoplast culture, somatic hybridization, selection of somatic hybrid cells, culturing and development of somatic hybrid plants, symmetric and asymmetric hybrids, cybrids - Application of somatic hybridization plant improvement and breeding

Unit IV

Somaclonal variation- significance in plant breeding. Production of haploid plants - anther and pollen culture, homozygous plants and its importance in genetics and plant breeding. Cryopreservation of plant cells, tissues and organs for germplasm conservation.

Unit V

Plant genetic engineering - transgenic plants and its application in agriculture, different methods of plant genetic transformation. Agrobacterium mediated gene transfer in plants, Agrobacterium tumefactions, infection and molecular mechanism of tumor formation , Ti plasmids and Ri plasmids, binary vectors, genetic markers, reporter genes and its application in genetic engineering. Transgenic plants for enhanced shelf life (Flave Savr Tomato), enhanced nutrition (golden rice), and improved insect resistance (Bt Crops). Edible vaccines.

Lab Course Based on BTC009 (Plant Biotechnology)

1. Study of various sterilization techniques used in plant tissue culture.
2. Study of Basic MS Medium Composition and preparation
3. To perform seed culture of any crop plant
4. To perform embryo culture of chickpea embryo
5. To perform micropropagation of any plant

Units	Suggested Readings	Reference Books	E-Content
I	**Introduction to plant biotechnology** Chawla, H. S. (2011). (3/e). CRC Press.	**An introduction to plant tissue culture.** Razdan, M. K. (2002). Oxford and IBH publishing.	https://pravara.in/wp-content/themes/twentyseventeen/essentials/pdf/elearn/Principles-of-Plant-Biotechnology.pdf https://annamalaiuniversity.ac.in/studport/download/agri/gen/resources/GPB%20316%20PLANT%20BIOTECHNOLOGY%20(2+1)%20-%20Online%20Study%20Material.pdf https://www.unom.ac.in/webportal/uploads/library/gcl-opac/lifeplantbio.html
II	**Introduction to plant biotechnology** Chawla, H. S. (2011). (3/e). CRC Press.	**An introduction to plant tissue culture.** Razdan, M. K. (2002). Oxford and IBH publishing.	https://pravara.in/wp-content/themes/twentyseventeen/essentials/pdf/elearn/Principles-of-Plant-Biotechnology.pdf https://annamalaiuniversity.ac.in/studport/download/agri/gen/resources/GPB%20316%20PLANT

			%20BIOTECHNOLOGY%20(2+1)%20-%20Online%20Study%20Material.pdf https://www.unom.ac.in/webportal/uploads/library/gcl-opac/lifeplantbio.html
III	**Introduction to plant biotechnology**. Chawla, H. S. (2011). (3/e). CRC Press.	**Principles of Plant Biotechnology** by S.S. Bhojwani	https://pravara.in/wp-content/themes/twentyseventeen/essentials/pdf/elearn/Principles-of-Plant-Biotechnology.pdf https://annamalaiuniversity.ac.in/studport/download/agri/gen/resources/GPB%20316%20PLANT%20BIOTECHNOLOGY%20(2+1)%20-%20Online%20Study%20Material.pdf https://www.unom.ac.in/webportal/uploads/library/gcl-opac/lifeplantbio.html
IV	**Introduction to plant biotechnology**. Chawla, H. S. (2011). *(3/e)*. CRC Press. **Plant Biotechnology: Principles and Applications** by S.K. Verma and A. K, Malik	**Plant Tissue Culture: Theory and Practice** by Bhojwani and Razdan	https://pravara.in/wp-content/themes/twentyseventeen/essentials/pdf/elearn/Principles-of-Plant-Biotechnology.pdf https://annamalaiuniversity.ac.in/studport/download/agri/gen/resources/GPB%20316%20PLANT%20BIOTECHNOLOGY%20(2+1)%20-%20Online%20Study%20Material.pdf https://www.unom.ac.in/webportal/uploads/library/gcl-opac/lifeplantbio.html
V	**Introduction to plant biotechnology** Chawla, H. S. (2011). *(3/e)*. CRC Press. **Role of biotechnology in medicinal and aromatic plants.** Khan, I. A., &	**Plant biotechnology: the genetic manipulation of plants.** Slater, A., Scott, N., &	https://pravara.in/wp-content/themes/twentyseventeen/essentials/pdf/elearn/Principles-of-Plant-Biotechnology.pdf https://annamalaiuniversity.ac.in/

	Khanum, A. (1998). **Modern concept of biotechnology.** Kumar, H. D. (1998). Vikas Publishing House.	Fowler, M. (2008). OUP Oxford. **Public perception of biotechnology. Basic biotechnology,** Smith, J. E. (2001). 3-16.	studport/download/agri/gen/resources/GPB%20316%20PLANT%20BIOTECHNOLOGY%20(2+1)%20-%20Online%20Study%20Material.pdf https://www.unom.ac.in/webportal/uploads/library/gcl-opac/lifeplantbio.html

Enzymology & Enzyme Technology
Semester II
(Credits = T+P = 3+1)
THEORY

Course Code: BTC010 **Total Lectures: 36**

Course Objective:
To equip students with a deep understanding of enzymes, encompassing their classification, structure-function relationships, catalytic mechanisms, regulatory pathways, and diverse applications in biotechnology.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: Demonstrate proficiency in explaining the classification, structure, and catalytic mechanisms of enzymes, including substrate specificity, enzyme kinetics, and factors influencing enzyme activity.
CO2: Apply principles of enzyme assays to quantitatively measure enzyme activity, interpret Michaelis-Menten kinetics and Lineweaver-Burk plots, and determine kinetic parameters (Km, Vmax), and evaluate enzyme inhibition mechanisms.
CO3: Analyze the regulatory mechanisms governing enzyme activity, including feedback inhibition, enzyme induction, repression, and covalent modification. Apply principles of enzyme engineering, including rational design and directed evolution, to modify enzyme properties for specific applications.
CO4: Evaluate the industrial applications of enzymes in diverse sectors such as food processing, pharmaceuticals, bioremediation, and biocatalysis. Assess the role of enzymes in enhancing process efficiency and sustainability in these industries.
CO5: Explore advanced topics in enzymology, including metabolic engineering for pathway optimization, enzyme applications in nanotechnology and biosensors, and their implications for medical diagnostics and environmental monitoring.

Course Content:
Unit I
Enzymes: Definition, classification, and nomenclature; Structure and function of enzymes: Active site, substrate specificity, enzyme kinetics, and enzyme-substrate interactions; Mechanisms of enzyme catalysis: Lock and key model, induced fit model, and transition state theory; Factors affecting enzyme activity: pH, temperature, substrate concentration, enzyme concentration, and cofactors.

Unit II
Enzyme assays: Principles, methods, and applications in quantifying enzyme activity; Enzyme kinetics: Michaelis-Menten kinetics, Lineweaver-Burk plot, determination of kinetic parameters (K_m, V_{max}), and enzyme inhibition; Allosteric enzymes: Cooperative binding, allosteric regulation, and kinetic behavior of allosteric enzymes; Enzyme immobilization: Techniques for enzyme immobilization, advantages, and applications in enzyme technology.

Unit III
Regulation of enzyme activity: Feedback inhibition, enzyme induction, repression, and covalent modification; Enzyme engineering: Rational design, directed evolution, and protein engineering techniques for modifying enzyme properties; Enzyme stability and optimization: Strategies for enhancing enzyme stability, tolerance to extreme conditions, and optimization of enzyme activity.

Unit IV
Enzymes in biocatalysis: Overview of industrial applications in food, pharmaceuticals, detergents, textiles, biofuels, and bioremediation; Enzymes in food processing: Role of enzymes in brewing, baking, dairy processing, fruit juice extraction, and meat tenderization; Enzymes in pharmaceuticals: Enzyme-based drug synthesis, enzyme inhibitors, and enzyme replacement therapy; Enzymes in bioremediation: Biodegradation of pollutants, enzyme-assisted soil and water remediation, and microbial consortia for environmental cleanup.

Unit V
Metabolic engineering: Application of enzymes in metabolic pathway engineering, biosynthesis of novel compounds, and bioproduction of valuable chemicals; Enzymes in nanotechnology: Enzyme-nanoparticle conjugates, enzyme immobilization on nanomaterials, and nanobiocatalysis; Enzyme-based biosensors: Principles of enzyme-based biosensors, enzyme electrodes, and applications in medical diagnostics and environmental monitoring.

Lab Course based on BTC010 (Enzymology & Enzyme Technology)

1. To measure and compare enzyme activity using spectrophotometric methods.
2. To investigate the effect of pH on enzyme activity using a simple assay method.
3. To study the effect of temperature on enzyme activity and stability.
4. To study the effect of substrate concentration on enzyme activity.
5. To investigate enzyme inhibition using a simple assay method.

Units	Suggested Readings	Reference Books	E-Content
I	**"Biochemistry"** by Jeremy M. Berg, John L. Tymoczko, and Lubert Stryer **"Principles of Biochemistry"** by David L. Nelson and Michael M. Cox	**"Enzymes: Biochemistry, Biotechnology, Clinical Chemistry"** by Trevor Palmer **"Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins"** by Nicholas C. Price and Lewis Stevens	https://www.medicalnewstoday.com/articles/319704 https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-structure-and-function/a/enzyme-structure-and-function
II	**"Biochemical Calculations: How to Solve Mathematical**	**"Enzymes: Biochemistry, Biotechnology, Clinical Chemistry"** by Trevor	https://teachmephysiology.com/biochemistry/molecules-and-

	Problems in General Biochemistry" by Irwin H. Segel **"Enzyme Kinetics: Behavior and Analysis of Rapid Equilibrium and Steady-State Enzyme Systems"** by Irwin H. Segel	Palmer **"Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins"** by Nicholas C. Price and Lewis Stevens	signalling/enzyme-kinetics/ https://www.jove.com/v/5692/enzyme-assays-to-study-enzyme-activity-and-kinetics
III	**"Biocatalysis: Fundamentals and Applications"** edited by Kurt W. W. P. S. T. Hultin and G. H. Behrens **"Protein Engineering: Principles and Practice"** by Robert W. Hogue and David H. W. Liu	**"Enzyme Engineering: Methods and Protocols"** edited by R. Michael Keefe **"Enzyme Technology"** by M. N. Gupta, A. K. Shukla, and N. K. Gupta	https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S001174BS/P001200/M010884/ET/1479287392P5M17eTextNov7.pdf https://www.caver.cz/fil/publications/angew_2013.pdf
IV	**"Enzyme Technology: Principles and Practice"** edited by J. G. V. H. M. Branden and H. N. Matthews **"Biocatalysis: Fundamentals and Applications"** edited by Kurt W. W. P. S. T. Hultin and G. H. Behren	**"Industrial Enzymology"** by A. L. Demain and N. A. Solomon **"Enzymes in Industry: Production and Applications"** edited by Thomas Scheper	https://sepmag.eu/blog/industrial-uses-of-enzymes/ https://byjus.com/biology/applications-of-enzymes/
V	**"Enzyme Engineering: Principles and Practice"** by David S. Clark and Chester G. Van Hoof **"Enzyme-based Biosensors: Principles and Applications"** by José M. Fernández-Lafuente	**"Metabolic Engineering: Principles and Methodologies"** by Gregory N. Stephanopoulos, Aristides M. Koutinas, and C. A. D. Koutinas **"Nanobiotechnology: Concepts, Applications and Perspectives"** edited by C. M. Niemeyer and C. A. Mirkin	https://academic.oup.com/plphys/article/179/3/918/6116613 https://iopscience.iop.org/article/10.1088/1361-6528/acda35

Immunology and Immunotechnology
Semester II
(Credits = T+R = 3+1)
THEORY

Course Code: BTC011 **Total Lectures: 36**

Course Objective:
To provide students with a comprehensive understanding of immunology, covering historical perspectives, immune system components, immune responses, and advanced techniques in immunological research and applications.

Course Outcomes: On the completion of the course, the students will be able to:
CO1: Demonstrate a thorough understanding of the historical development of immunology, the components of the immune system, and the roles of major immune cell types and organs.
CO2: Explain the mechanisms underlying humoral and cellular immunity, including antigen recognition, processing, and presentation by B cells and T cells, and the role of nonspecific immune mechanisms in defending against pathogens.
CO3: Apply theoretical knowledge to practical techniques such as immunological assays, immunoassays for disease diagnosis, and molecular techniques used in immunology research.
CO4: Analyze and differentiate between autoimmune disorders, hypersensitivity reactions, immunodeficiency disorders, and transplant rejection mechanisms.
CO5: Evaluate advanced topics in immunology, including recombinant DNA technology for producing antigens and antibodies, hybridoma technology for monoclonal antibody production, and innovative therapies like CAR-T cell therapy and gene editing in immune cells.

Course Content:
Unit I
Historical overview of immunology; Components of the immune system: innate and adaptive immunity; Hematopoiesis; Cells of the immune system: B lymphocyte, T lymphocyte, NK cells, Monocyte/Macrophages, Dendritic cells, Eosinophils, Basophils, Neutrophils, Mast cells; Organs and tissues of the immune system: bone marrow, thymus, lymph nodes, spleen, mucosa-associated lymphoid tissue (MALT); Overview of immune responses: humoral immunity, cellular immunity; Nonspecific immune mechanisms: Surface defenses, Tissue defenses, Opsonization, Inflammatory reactions.

Unit II
Antigens: Structure and properties; Haptens; Immunogenicity; Structure and function of antibodies (immunoglobulins): classes, isotypes, antigen-binding sites; Generation of antibody diversity: somatic recombination, hypermutation, isotype switching; Major histocompatibility complex (MHC) molecules: structure, antigen presentation, MHC class I and II pathways; T-cell receptor (TCR) structure and diversity; Antigen recognition by B cells and T cells: antigen processing, presentation, and activation. Complement System: Structure, properties and functions of different components, Complement activation pathways (Classical, alternate and lectin pathways), Biological consequences of complement activation, Complement assay.

Unit III

Autoimmunity: mechanisms, diseases, and treatments; Hypersensitivity reactions: types I, II, III, and IV hypersensitivity; Immunodeficiency disorders: primary and secondary immunodeficiencies, acquired immunodeficiency syndrome (AIDS); Transplantation: Graft vs. host reaction and rejection; Vaccines and vaccination: types of vaccines, adjuvants, vaccine design and development; Immunotherapy: monoclonal antibodies, checkpoint inhibitors, adoptive cell therapy.

Unit IV

Recombinant DNA technology in immunology: production of recombinant antigens, antibodies, and cytokines; Hybridoma technology and monoclonal antibody production; Immunoassays for disease diagnosis: applications in infectious diseases, cancer, autoimmune disorders; Therapeutic antibodies: engineering antibodies for enhanced efficacy and reduced immunogenicity; Immune cell engineering: CAR-T cell therapy, gene editing in immune cells.

Unit V

Antigen – antibody reactions: Precipitation and agglutination reactions; Immunological assays: RIA, ELISA (enzyme-linked immunosorbent assay), Western blotting, immunofluorescence, Complement fixation test, flow cytometry; Immunoassays for quantification of antigens and antibodies; Immunohistochemistry and immunocytochemistry; Techniques for cell isolation and purification: cell sorting, density gradient centrifugation; Molecular techniques in immunology: PCR (polymerase chain reaction), DNA sequencing, gene expression analysis.

Units	Suggested Readings	Reference Books	E-Content
I	**Kuby Immunology** by Judy Owen, Jenni Punt, Sharon Stranford **"Essential Immunology"** by Ivan M. Roitt, Peter J. Delves	**Essentials of Immunology** by S. K. Gupta. 2017. Arya Publications. **Fundamentals of Immunology** by Bhasin and Shukla. 2022. Discovery Publishing House.	https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/46 https://archive.nptel.ac.in/courses/102/105/102105083/
II	**"Cellular and Molecular Immunology"** by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai **"Janeway's Immunobiology"** by Kenneth Murphy	**Textbook of Immunology** by Latha M. 2012. S. Chand & Co. **Basic Immunology** by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai. 7th Ed. Churchill Livingstone Publisher.	https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/46 https://archive.nptel.ac.in/courses/102/105/102105083/
III	**"Vaccine Design: Methods and Protocols"** edited by Sunil Thomas **"Clinical Immunology:**	**Immunology** by N. Arumugam, Dulsy Fatima. 5th Ed. Saras Publication. **Basics of Cell Biology &**	https://archive.nptel.ac.in/courses/102/105/102105083/ https://archive.nptel.ac.in/c

	Principles and Practice" by Robert R. Rich, Thomas A. Fleisher, William T. Shearer, et al.	**Immunology** by Garg P. 2023. Blue Rose Publisher.	ourses/102/105/102105083/
IV	**"Basic Immunology: Functions and Disorders of the Immune System"** by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai **"Immunology: A Short Course"** by Richard Coico, Geoffrey Sunshine	**Immunology: A short course** by Colco and Sunshine. 6th Ed. Wiley–Blackwell. **Immunology & Immunological Biotechnology** by Kumar D. 2019. Blue Rose Publishers.	https://archive.nptel.ac.in/courses/102/105/102105083/ https://archive.nptel.ac.in/courses/102/105/102105083/
V	**Handbook of Practical and Clinical Immunology,** Talwar and Gupta. 2e, Vol. I. CBS Publications.	**A Text Book of Immunology (with Practicals)** by Pasha and Muthena.	http://acl.digimat.in/nptel/courses/video/102103083/lec28.pdf

Bioprocessing & Industrial Biotechnology
Semester II
(Credits = T+P = 3+1)
THEORY

Course Code: BTC012 **Total Lectures: 36**

Course Objective:
This curriculum is intended for a Master of Science in Biotechnology course that emphasizes fermentation technology. It goes over the core ideas, practical uses, and most recent developments in this area.

Course Outcomes:
CO1: Display a thorough understanding of the biochemical and microbiological mechanisms that govern fermentation.
CO2: Students will be skilled in creating fermentation conditions that promote microbial development and product synthesis..
CO3: analyzing the impact of chemical and physical factors (agitation, temperature, oxygen, and pH) on the results of fermentation.
CO4: Exhibit a thorough comprehension of downstream processing methods, bioreactor design, and operation in order to efficiently generate high-purity bioproducts at the best possible yield.
CO5: demonstrate a thorough understanding of fermentation processes and downstream processing methods, taking environmental sustainability into account through effluent treatment.

Course Content:
Unit I
Definition and History of fermentation, Uses of fermentation technology in a range of sectors, including food, medicine, and Biofuels. Fermentation classification according to: Need for oxygen (aerobic, anaerobic); Growth mode (solid-state, submerged); Kind of product (primary and secondary metabolites)

Unit II
Role of Microorganisms in fermentation processes; Techniques for isolation and screening of appropriate microbial strains; Strain Improvement. Methods of preserving cultures (lyophilization, stock cultures); Design fermentation media: Sources of carbon and nitrogen, Growth factors, vitamins, and minerals.

Unit III
Fundamental ideas about bioreactors (fermenters): kinds, characteristics of the design (agitators, spargers, baffles); Using aseptic methods to sterilize media and equipment. Growth curves, substrate use, and Growth kinetics. Physical and chemical factors (pH, temperature, oxygen, agitation) affecting fermentation. Techniques for process control (pH, temperature, dissolved oxygen)

Unit IV

Types of Bioreactors: CSTR, Tower, Bubble Column Bioreactor, Airlift Bioreactor, Fluidized Bed Bioreactor, Photobioreactor

Downstream processing (filtration, centrifugation) Methods for recovering and purifying products: Chromatography (ion exchange, affinity). Crystallization and drying. Techniques for improving the yield and purity of products.

Unit V

Production of Etanol, Acetone and Butanol. Alcoholic Beverages. Penicillin production. Yeast production. Effluent treatment plant.

Lab Course Based on BTC012 (Bioprocessing & Industrial Biotechnology)

1 Laboratory safety rules
2 Isolation techniques of microbes
3 Formulation of culture media for fermentation process
4 Laboratory scale fermenter (benchtop fermenter)
5 Estimation of protein concentration using Lowry method

Units	Suggested Readings	Reference Books	E-Content
I	**Biotechnology: Fundamentals and Applications** by Satyanarayana U: **Industrial Microbiology: An Introduction** by Prescott,		https://www.sus.ac.in/uploads/bos/BSc%20Fermentation%20Technology%20Certificate%20Course%20Syllabus%20.pdf
II	**Industrial Microbiology: An Introduction** by Casida, Jr. **Industrial Microbiology: An Introduction** by Prescott **Principles of Fermentation Technology** by P.F. Stanbury, A. Whitaker, and S.J. Hall		https://www.sus.ac.in/uploads/bos/BSc%20Fermentation%20Technology%20Certificate%20Course%20Syllabus%20.pdf
III	**Industrial Microbiology: An Introduction** by Casida, Jr. **Industrial Microbiology: An Introduction** by Prescott **Principles of Fermentation Technology** by P.F. Stanbury, A. Whitaker, and S.J. Hall		https://www.sus.ac.in/uploads/bos/BSc%20Fermentation%20Technology%20Certificate%20Course%20Syllabus%20.pdf
IV	**Principles of Fermentation Technology by** P.F. Stanbury, A. Whitaker, and S.J. Hall		https://www.sus.ac.in/uploads/bos/BSc%20Fermentation%20Technology%20Certificate%20Course

	Principles of Bioreactor Design by D. K. Srivastava		%20Syllabus%20.pdf
V	**Principles of Fermentation Technology** by P.F. Stanbury, A. Whitaker, and S.J. Hall **Brewing Science and Practice** R.J. Whitbread and J, S. Hough **Environmental Biotechnology: Principles and Applications** by R C Dubey		https://www.sus.ac.in/uploads/bos/BSc%20Fermentation%20Technology%20Certificate%20Course%20Syllabus%20.pdf

Dolphin PG Institute of Biomedical and Natural Science, Dehradun

(An Autonomous College)

Department of Biotechnology: Composition of Board of Studies

S. No.	Category	Name	Signature
1.	Head of the Department-Chairperson	Dr. Shalini Singh	
2.	All Faculty members of the Department	Ms. Deepti Gulati Dr. Sachin Singh Ms. Tripti Garg	
3.	Two subject experts from outsidethe parent University nominated by the academic council.	Dr. Santan Barthwal Scientist G and Head, Division, Genetics and Tree Improvement, Forest Research Institute, Dehradun Dr. Nishesh Sharma, Head, Department of Biotechnology, School of Applied and Life Sciences, Uttaranchal University, Dehradun	
4.	One expert nominated by the Vice-chancellor	Dr. Gopal Joshi, Professor, Department of Biotechnology, HNBGU, Garhwal, Uttarakhand.	
5.	One representative from industrynominated by the principal	Dr. Virender Bhardwaj GM, Quality and Standards, Kala Amb, HP	
6.	One member of the college alumni nominated by the principal	Dr. Manisha Nanda, Associate Prof., Department of Microbiology, Graphic Era Deemed to be University, Dehradun	