SWAMI VIVEKANAND SUBHARTI UNIVERSITY
UGC Approved Meerut

# Ordinance No. :- V-126-B-34

**(Approved in Academic council meeting held on 11.03.2026**
**Proposed to be ratified in forthcoming executive council)**

## Evaluation Scheme and Syllabus

## of

# B.Sc. Biotechnology

## FOUR – YEAR UNDER GRADUATE PROGRAM

## (AS PER NEP-2020)

## Keral Verma Subharti College of Science

## Swami Vivekanand

# SUBHARTI UNIVERSITY

## Meerut

## (Effective from session 2025-26)

K V Subharti College of Science
S V Subharti University
NH-58, Byepass Road, Meerut

## PROGRAM OBJECTIVES

PO1: Build Strong Foundations in Life Sciences and Biotechnology

PO2: Develop Competence in Biotechnological Tools, Techniques, and Analytical Methods PO3: Foster Scientific Inquiry, Research Aptitude, and Problem-Solving Skills

PO4: Promote Digital, Computational, and Bioinformatics Competencies

PO5: Cultivate Innovation, Entrepreneurship, and Industry Readiness

PO6: Strengthen Ethical Reasoning, Biosafety Awareness, and Responsible Research Practice

PO7: Develop Effective Communication, Documentation, and Presentation Skills

PO8: Encourage Lifelong Learning and Adaptability to Emerging Technologies

PO9: Integrate Interdisciplinary Knowledge for Real-World Problem Solving

PO10: Foster Holistic, Socially Responsible, and Value-Driven Education

## PROGRAM OUTCOMES

PSO1: Biological Literacy and Conceptual Understanding

PSO2: Computational and Programming Proficiency

PSO3: Bioinformatics Databases, Tools, and Analytical Skills

PSO4: Scientific Reasoning, Research Aptitude, and Problem-Solving

PSO5: Data Science, Machine Learning, and AI Applications in Life Sciences

PSO6: Laboratory Skills and Experimental Competence

PSO7: Ethical, Legal, and Social Responsibility in Biosciences

PSO8: Effective Communication and Documentation Skills

PSO9: Entrepreneurship, Innovation, and Industry Readiness

PSO10: Multidisciplinary Integration and Holistic Thinking

PSO11: Digital Fluency and Financial/Digital Citizenship

PSO12: Lifelong Learning, Adaptability, and Professional Growth

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## CREDIT DISTRIBUTION TABLE

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**

**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**

**Department of Life Science**

**B.Sc Biotechnology**
**(Session 2025-26 onwards)**

| | | I | II | III | IV | V | VI | VII | VIII | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Major | 6 | 6 | 9 | 15 | 10 | 14 | 16 | 4 | 80 |
| 2 | Minor | 3 | 3 | 3 | 3 | 6 | 6 | 4 | 4 | 32 |
| 3 | Multi Disciplinary | 3 | 3 | 3 | | | | | | 9 |
| 4 | Ability Enhancement Course | 2 | 2 | 2 | 2 | | | | | 8 |
| 5 | Skill Enhancement Course | 3 | 3 | 3 | | | | | | 9 |
| 6 | Value Added Course | 3 | 3 | | | | | | | 6 |
| 7 | Internship | | | | | 4 | | | | 4 |
| 8 | Research | | | | | | | | 12 | 12 |
| | Total | **20** | **20** | **20** | **20** | **20** | **20** | **20** | **20** | **160** |

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**EVALUATION SCHEME**
**YEAR I**

| SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KERAL VERMA SUBHARTI COLLEGE OF SCIENCE | | | | | | | | | | | | | | |
| Department of Biotechnology | | | | | | | | | | | | | | |
| Course Name - B.Sc Biotechnology | | | | | | | | | | | | | | |
| Batch:2024 -25 | | | | | | | SEM:I | | | | | | | |
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | | Internal Assessment | | External Assessment | Total | Remark |
| | | | | L | T | P | | | | | | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | Attendance (5) | quiz/PPT/Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| 1 | Major 1 | BSBT-101 | Cell Biology and Genetics | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Practical Major 1 | BSBT-101P | Cell Biology and Genetics Lab | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Minor 1 | BSBT-102 | A. Micro organisms for human welfare B. Biotechnology and Human Welfare C. Biochemistry in health and disease | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Multi Disciplinary | M-DIS-SM | Soil Microbiology | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Ability Enhancement Course | AEC-01 | English Communication | 2 | 1 | 0 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Skill Enhancement Course | SEC-AE | Advance Excel | 1 | 0 | 3 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 7 | Value Added Course | VAC-AILS | AI for Life Sciences | 1 | 0 | 3 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 8 | IKS / Rastra bodh | IKSRB-01 | | 2 | 1 | 0 | 2 | 5 | 5 | 10 | 30 | 50 | Qualifying |
| TOTAL CREDITS / ASSESSMENT | | | | | | | 20 | 35 | 70 | 105 | 490 | 700 | |
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# SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT

## KERAL VERMA SUBHARTI COLLEGE OF SCIENCE

### Department of Biotechnology

| Batch:2024 -25 | | | | | | | | SEM:II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
| | | | | L | T | P | | | | | | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| 1 | Major 2 | BSBT-201 | Fundamentals of Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Practical Major 2 | BSBT-202P | Fundamentals of Biotechnology Lab | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Minor 2 | BSBT-203 | Bioresource Technology and Bioproducts | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Multi Disciplinary 2 | M-DIS- | | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Ability Enhancement Course 2 | AEC- | Environment Science | 2 | 1 | 0 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Skill Enhancement Course 2 | SEC- | | 1 | 0 | 3 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 7 | Value Added Course 2 | VAC-DFL | Digital and Financial Literacy | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 8 | IKS / Rastra bodh | IKSRB-02 | | 2 | 1 | 0 | 2 | 5 | 5 | 10 | 30 | 50 | Qualifying |
| TOTAL CREDITS / ASSESSMENT | | | | | | | 20 | 35 | 70 | 105 | 490 | 700 | |

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## MAJOR COURSES SYLLABUS

| | | |
|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**First(1) | **Semester:**First(I) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-101** | **CourseTitle:CELL BIOLOGYANDGENETICS** | |
| **CourseOutcomes (COs)** | | |
| Thiscourseintroducestheprinciplesofcellbiologyandgenetics.Aftercompletionofthis course, students will be able to:<br>• Understandthecellasabasicunitoflife,itsstructure,function,andtheorganelles involved.<br>• Comprehendstructuralandfunctionaldetailsofplasmamembraneandcellular communication.<br>• Learnaboutchromosomes,theirstructure,organization,andprocessesofcelldivision.<br>• GraspfundamentalprinciplesofMendelianandnon-Mendeliangenetics.<br>• Explorethegeneticbasisofmutations,sexdetermination,andpopulation genetics. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | No.ofLectures |
|---|---|---|
| | **CellasaBasic UnitandCellular Organelles**<br>• Conceptofthecell,historicalperspectives,discovery, and Cell Theory.<br>• UltrastructureofProkaryoticandEukaryoticcells(plant and animal).<br>• Structure and functions of cellular organelles: EndoplasmicReticulum,GolgiComplex,Mitochondria, Chloroplast, Ribosomes, Lysosomes, Peroxisomes, Nucleus, Vacuole, Cytosol.<br>• Cytoskeletonstructures:Microtubules,Microfilaments, Intermediate filaments. | **12** |

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|---|---|---|
| **II** | **Surface Architecture**<br>• Plasmamembraneandcellwallstructureandfunctionin eukaryotes.<br>• Ultrastructureofplasmamembrane–FluidMosaic Model, membrane fluidity. | **10** |
| | • Membranetransport:Symport,Antiport,Uniport,Active and Passive Transport.<br>• Differentiationofcellsurface:Basementmembrane, Tight junctions, Gap junctions, Desmosomes, Hemidesmosomes. | |
| **III** | **ChromosomesandCell Division**<br>• Introductiontochromosomes:Discovery,morphology, Centromere, Secondary constriction, Telomere, Chromonema.<br>• Euchromatin and Heterochromatin, chemical composition,Karyotype,Genomeorganization.<br>• Cellcycleanddivision:Phases,Mitosis,Meiosis, regulation, checkpoints, involved enzymes.<br>• Significance of cell cycle, Interphase nucleus, Achromaticapparatus,Synaptonemalcomplex.<br>• Cellsenescenceandprogrammedcelldeath. | **14** |

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|---|---|---|
| **IV** | **Genetics**<br>• Introductionandhistoricalbackground.<br>• Mendelian inheritance: Laws of Dominance, Segregation,IncompleteDominance,Codominance, Independent Assortment.<br>• Testcross,Backcross.<br>• Non-Mendelian inheritance: Gene interaction (complementary,supplementary,13:3ratio),Epistasis, Maternal inheritance.<br>• Sex-linkedinheritance,Chromosometheoryof inheritance, Linkage and crossing over.<br>• Multipleallelism(e.g.,Humanbloodgroups),Polygenic inheritance (e.g., skin colour). | **12** |
| **V** | **MutationandPopulation Genetics**<br>• Mutations:Types,Spontaneousvs.Induced,Physical and Chemical mutagens.<br>• Sexdeterminationinplantsandanimals;Allosomesand Autosomes. | **12** |
| | • Non-Mendelianinheritancepatterns:Mitochondrial inheritance, Complex inheritance, Environmental variation, Heritability, Behavioural traits.<br>• Populationgenetics:Phenotype,Genotype,Gene frequency, Hardy-Weinberg Law.<br>• Factors affecting Hardy-Weinberg equilibrium: Mutation,Selection,Migration,Geneticdrift,Geneflow.<br>• Inheriteddisorders:Allosomal(KlinefelterandTurner's syndromes), Autosomal (Down's syndrome) | |

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**SuggestiveReadingBooks:**

- *AlbertsBetal.(2002)Molecularbiologyofthecell,GarlandPublications*
- *Burke,JD,(1970)CellBiology,Williamand Wilkins*
- *GardnerE.J.,SimmonsM.J.andSnustadD.P.(2003)PrinciplesofGenetics,8thEd., John Wiley & Son Publications*
- *Clark,CA.(1970)HumanGeneticsandMedicine, EdwardArnold,London*
- *DaleJW.(1990)Moleculargeneticsofbacteria.JohnWileyandSons.*
- *DarnellJ.LodishH,BaltimoreD,(1990)MolecularCellBiology,ScientificAmerican Books*
- *DeRobertisEDP&RobertisEMF(1980)CellBiology&MolecularBiology,Saunders College.*

**Course:CellBiologyandGeneticsLab(BSBT-101P)(PracticalMajorI) List of Practical**

1. *Studyand maintenanceof simpleand compoundmicroscope*
2. *UseofMicrometreandcalibration,measurementofonionepidermalcellsandyeast*
3. *Studyofdivisionalstagesinmitosisfromonionroottips*
4. *Studyofdivisionalstagesinmeiosisingrasshoppertestes/onionorRheoflower buds.*
5. *Mountingofpolytene chromosomes*
6. *Buccalsmear–Barr bodies*
7. *KaryotypeanalysisHumanandOnionHuman–NormalandAbnormal–Downand Turner's syndromes*
8. *Isolation and staining of Mitochondria*
9. *Isolation and staining of Chloroplast*
10. *RBCcellcountsby Haemocytometer*
11. *Simplegeneticproblemsbasedontheory*

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| **Programme/Class:**B.Sc. | **Year:**First(1) | **Semester:**Second(II) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-201** | **CourseTitle:FUNDAMENTALS OFBIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Thiscourseintroducesthefundamentalconceptsandapplicationsofbiotechnology.After completion of this course, students will be able to:<br>• Understandthehistoricalevolution andmodernscopeof biotechnology.<br>• Differentiatebetweentraditionalandmodernbranchesofbiotechnology.<br>• Recognizekeyapplicationsinagriculture,food,healthcare,andthe environment.<br>• Understandtheroleofbiotechnologyindiagnostics,therapeutics,andvaccine development.<br>• Learnthebasicsoffermentationtechnologyandindustrial biotechnologyprocessed | | |
| **Credits:**4 | **CoreCompulsory** | |
| **Maximummarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **ScopeandIntroductiontoBiotechnology**<br>• History&IntroductiontoBiotechnology,Definition, Traditional vs. Modern Biotechnology<br>• Branches of Biotechnology: Plant,Animal, Marine, Agricultural,Healthcare,Industrial,Pharmaceutical, Environmental Biotechnology | **12** |
| II | **Applicationsof Biotechnology**<br>• BiotechnologyinAgriculture:GMFood,GMPapaya, GM Tomato<br>• FungalandInsectResistantPlants(e.g.,BTCotton,BT Brinjal): Pros and Cons<br>• Cropand LivestockImprovement<br>• GoldenRice,MolecularPharming,Plant-Based Vaccines<br>• EthicalIssuesandIntellectualPropertyRights(IPR)in Biotechnology | **12** |

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| **III** | **FoodBiotechnology**<br>• EnhancingFoodQualityvia Biotechnology<br>• UnitOperationsinFoodProcessing<br>• QualityFactorsinPre-processedFood<br>• FoodDeteriorationand Control<br>• RheologyofFood Products<br>• MicrobialRoleinFoodProduction:Yeast,Bacteria,and Other Microorganisms | **12** |
| | • RegulatoryAspectsandSocialAppraisalofFood Biotechnology | |
| **IV** | **BiotechnologyResearchin India**<br>• BiotechnologyInstitutionsin India(Publicand Private)<br>• BiotechSuccessStoriesandPolicyInitiatives<br>• Biotechnologyin theDevelopingWorld<br>• PublicPerceptionof Biotechnology<br>• RoleofBiotechnologyinDiagnostics andTherapeutics<br>• VaccineDevelopmentandPCR,DNASequencing, Fingerprinting | **12** |
| **V** | **FermentationTechnology**<br>• DefinitionandApplicationsofFermentationTechnology<br>• MicrobialFermentation<br>• IndustrialProductionofChemicals:AceticAcid,Citric Acid, Ethanol<br>• Antibiotics,Enzymes,and Beverages | **12** |
| **Suggestivereadingbooks**<br>• *B.D.Singh,"Biotechnology:ExpandingHorizons"KalyaniPublishers* | | |

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**Course:FundamentalsofBiotechnologyLab(BSBT-202P)(PracticalMajorII) List of Practical**

1. *Studyoflaboratoryinstrumentsusedinbiotechnology(e.g.,micropipette,centrifuge, autoclave, spectrophotometer).*
2. *Observationandidentificationofgeneticallymodified(GM)foods(e.g.,GMtomato,GM papaya).*
3. *DNAextractionfromplanttissue(e.g.,bananaor spinach).*
4. *DemonstrationofPCR(PolymeraseChainReaction).*
5. *Microbialfermentationforethanolproductionusingyeastandsugar.*
6. *Preparationofyogurtusinglacticacid bacteria.*
7. *Testingantimicrobialactivityofnaturalplantextracts(e.g.,garlic,neem)usingagar well diffusion method.*
8. *Qualitativetestforcitricacidinfermentedlemonjuice.*
9. *Casestudy-basedanalysisofethicalissuesandintellectualpropertyrights(IPR)in biotechnology.*

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# YEAR II

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**
**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**
**Department of Biotechnology**

| Batch:2024 -25 | | | | | | | | SEM:III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
| | | | | L | T | P | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | | | | | | |
| 1 | Major 3 | BSBT-301 | **Biomolecules and Metabolism** | 4 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Major 4 | BSBT-302 | **Molecular Biology** | 4 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Practical 3 (based on Major 3 and 4) | BSBT-303P | | 0 | 0 | 4 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Minor 3 | BSBT-304 | A. Bioprocess Engineering B. Gene Therapy C. Drug Designing | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Multi Disciplinary 3 | M-DIS- | | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Ability Enhancement Course 3 | AEC- | Disaster Risk Management | 2 | 1 | 0 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 7 | Skill Enhancement Course 3 | SEC- | | 1 | 0 | 3 | 3 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | **35** | **70** | **105** | **490** | **700** | |

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**
**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**
**Department of Biotechnology**

| Batch:2024 -25 | | | | | | | | SEM:IV | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
| | | | | L | T | P | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | | | | | | |
| 1 | Major 5 | BSBT-401 | Immunology and Immunotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Major 6 | BSBT-402 | **Bioanalytical Techniques** | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Major 7 | BSBT-403 | Genetic Engineering and Gene Therapy | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Practical 4 (based on Major (5+6+7) | BSBT-404P | | 0 | 0 | 4 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Minor 4 | BSBT-405 | **Genomics and Proteomics** | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Ability Enhancement Course 3 (Course on NCC/NSS/NGO,s/ Scout Guide / Sports) | AEC- | Course on NCC/NSS/NGO,s/ Scout Guide / Sports | 2 | 1 | 0 | 2 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | **30** | **60** | **90** | **420** | **600** | |

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Third(III) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-301** | **CourseTitle:BIOMOLECULESAND METABOLISM** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandthestructure,function,andclassificationofmajorbiomoleculessuchas carbohydrates, proteins, lipids, and nucleic acids.<br>• Explaintheprinciplesofbioenergeticsand thermodynamicsinbiologicalsystems.<br>• Describemetabolicpathwaysofcarbohydratesandlipidsandtheir regulation.<br>• Acquireknowledgeofenzymologyincludingenzymekinetics,classification,and coenzymes.<br>• Understandthebiologicalsignificanceofnucleotidesandmetabolic integration. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **AminoAcids,ProteinsandCarbohydrates**<br>• Aminoacids:Structureand properties.<br>• Proteins:Classification,forcesstabilizingstructure, levels of structural organization.<br>• Proteinpurification,denaturationandrenaturation, fibrous and globular proteins.<br>• Carbohydrates: Structure, function and properties of monosaccharides,disaccharides,andpolysaccharides.<br>• Homopolysaccharides,heteropolysaccharides, mucopolysaccharides, bacterial cell wall polysaccharides.<br>• Glycoproteinsandtheirbiological functions. | **14** |

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|---|---|---|
| **II** | **BioenergeticsandMetabolismIntroduction**<br>• Lawsofthermodynamics,freeenergy,enthalpy,entropy, equilibrium constant.<br>• Redoxpotential,electronflow,redoxcouplingandATP bioenergetics, high-energy compounds.<br>• Introductiontometabolism:Anabolic,catabolicand amphibolic pathways. | **10** |
| | • Enzymes in metabolism: Protein and non-protein (ribozymes),cofactors,prostheticgroups,apoenzymes, holoenzymes, inhibitors, modulators.<br>• Enzymeclassification(IUBMB),Fischer'sand Koshland's hypotheses. | |
| **III** | **Lipidsand Nucleic Acids**<br>• Lipids:Classification,structureandfunctionoffatty acids, essential fatty acids.<br>• Phospholipids,sphingolipids,glycolipids,cerebrosides, gangliosides, prostaglandins, cholesterol.<br>• Nucleicacids:Structureandfunction,nucleosidesand nucleotides, purines and pyrimidines.<br>• PropertiesofDNAandRNA,biologicallyimportant nucleotides.<br>• DNAstructures:A,B&Zforms,denaturationand renaturation. | **12** |

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| **IV** | **EnzymesandCoenzymes**<br>• Enzymes:Nomenclature,classification,holoenzyme, apoenzyme,cofactors,coenzymes,prostheticgroups, metalloenzymes.<br>• Monomericandoligomericenzymes,activationenergy, transition state.<br>• Enzyme activity, specific activity, active site characteristics,typesofspecificityandtheories.<br>• Extremophilicenzymes:Biocatalystsfromthermophilic and hyperthermophilic archaea/bacteria.<br>• RolesofNAD$^+$,NADP$^+$,FMN/FAD,CoenzymeA,TPP, PLP, lipoic acid, biotin, vitamin $B_{12}$, tetrahydrofolate, and metal ions. | **12** |
| **V** | **CarbohydrateMetabolism**<br>• Glycolysis:Reactions,energetics,regulation;fateof pyruvate (aerobic and anaerobic).<br>• Pentosephosphatepathway:Reactionsandsignificance.<br>• Gluconeogenesis,glycogenolysis,andglycogen synthesis. | **12** |
| | • TCAcycle,electrontransportchain(ETC),oxidative phosphorylation.<br>• β-oxidation offattyacids. | |

**SuggestiveReadingBooks:**


- *Berg,J.M.,Tymoczko,J.L.andStryer,L.(2006).Biochemistry.VIEdition.W.H Freeman and Co.*
- *Buchanan,B.,Gruissem,W.andJones,R.(2000)BiochemistryandMolecularBiologyof Plants. American Society of Plant Biologists.*
- *Nelson,D.L.,Cox,M.M.(2004)LehningerPrinciplesofBiochemistry,4thEdition,WH Freeman and Company, New York, USA.*
- *Hopkins,W.G.andHuner,P.A.(2008)IntroductiontoPlantPhysiology.JohnWileyand Sons.*
- *Salisbury,F.B.andRoss,C.W.(1991)PlantPhysiology,WadsworthPublishingCo.Ltd.*


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| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Third(III) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-302** | **CourseTitle:MOLECULARBIOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandthemolecularorganizationandfunctionofcellularcomponentsand membranes.<br>• ComprehendthestructureandpropertiesofDNAandRNAinprokaryoticand eukaryotic systems.<br>• ExplorethemechanismsofDNAreplication,transcription,and translation.<br>• Learngeneregulationmechanismsinbothprokaryoticand eukaryotic systems.<br>• Analyzegeneticcodeinterpretation,post-transcriptionalandpost-translational modifications. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoMolecularBiologyandCellularStructure**<br>• Overviewofmolecularbiology,evolutionofcellsand organelles.<br>• Typesofcells:Prokaryoticandeukaryotic variations. | **12** |
| | • Cellgrowth,adhesion,junctions,andextracellular matrix.<br>• Cellmembranestructure:Fluidmosaicmodel, membrane fluidity and asymmetry.<br>• Activeandpassivemembrane transport.<br>• Cellcyclephases andcheckpoints. | |

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| **II** | **MolecularNatureof GeneticMaterial**<br>• StructureofDNA:Primary,secondary,andtertiary structures.<br>• Doublehelixtypes;EvolutionofDNAandRNA.<br>• RNA:Types andmolecularstructure.<br>• Geneticcode,informationtransferfromDNAtoRNA, and translation overview. | **10** |
| **III** | **GeneRegulationandDNAReplication**<br>• Generegulationinprokaryotes:Lacoperon,catabolic repression, Trp operon.<br>• Geneexpressionineukaryotes.<br>• Plasmids:Types,maintenance, and functions.<br>• DNAreplication:Semi-conservativemechanismin prokaryotes and eukaryotes.<br>• Enzymes in replication: DNA polymerases, proofreading,andpost-replicationmodifications. | **14** |
| **IV** | **TranscriptionandRNAProcessing**<br>• Transcription:Synthesis ofRNAfromDNAtemplate.<br>• RNApolymerase,initiation,elongation,andtermination of transcription.<br>• Post-transcriptionalandco-transcriptionalmodifications of RNA. | **12** |
| **V** | **ProteinBiosynthesis**<br>• Translationof geneticcodeandmRNA.<br>• RoleofrRNAin proteinsynthesis.<br>• Formationofpolypeptides:Elongationandtermination steps.<br>• Overviewofpost-translationalmodifications | **12** |

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**SuggestiveReadingBooks:**

- *MolecularBiologyoftheGene–ByJ.D.Watson,T.A.Baker,S.P.Bell,A.Gann,M. Levine and R. Losick*
- *Lodish.H,Berk.A,Lawrence,A,Matsudaira.A,Baltimore.DandDernell.J.Molecular Cell Biology (Fourth Edition). – W.H. Freeman and Company. 2009*
- *MolecularBiologybyT.A.Brown*
- *GenomesbyT.A.Brown*
- *Sambrooketal2000.MolecularcloningVolumesI,II&III,ColdSpringHarbor Laboratory Press New York, U SA*

**Course:BiomoleculesandMetabolismandMolecularBiologyLab(BSBT-303P)(Practical of Major 3 and 4)**

**ListofPractical:**

1. *Qualitativetestsforsugars,aminoacids,proteins&lipids*
2. *Quantitativeestimationofproteins(Folin-Phenol).*
3. *Quantitativeestimationofsugars(DNS method)*
4. *QuantificationofDNA(diphenylaminemethod)*
5. *QuantificationofRNA(orcinolmethod)*
6. *PreparationofsolutionsforMolecularBiologyexperiments*
7. *IsolationofDNAfromanimal/Plant/bacterial cells.*
8. *IsolationofDNAfromPlant*
9. *IsolationofDNAfromBacterial*
10. *Quantitation of DNAbySpectrophotometry*
11. *AgarosegelelectrophoresisofgenomicDNA.*

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| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Forth(IV) |
| **Department:**Biotechnology | | |
| **CourseCode:BSBT-401** | **CourseTitle:IMMUNOLOGYAND IMMUNOTECHNOLOGY** | |

**CourseOutcomes (COs)**

Thiscourseprovidesacomprehensiveoverviewoftheimmunesystemandbiotechnological applications in immunology. After completion of this course, students will be able to:

- Understandthecomponentsandfunctioningof themammalian immunesystem.
- Comprehendthemolecularstructureandfunctionsofimmunoglobulinsand T-cell receptors.
- Explorethegeneticmechanismsregulatingantibodydiversityandimmunological memory.
- Learnvariousimmuno-techniquesandtheir applicationsindiagnostics.
- Analyzeautoimmunediseasesandmodernapproachestoimmunizationandvaccination.

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| **Credits:**4 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **OverviewofImmune Response**<br>• Componentsofthemammalianimmune system<br>• Structureandfunctionofimmunoglobulins<br>• Humoralandcellularimmune responses<br>• Tlymphocytes(cytotoxic,helper,suppressorTcells)<br>• Tcellreceptors<br>• GenomerearrangementsinBlymphocytes<br>• Antibodyaffinitymaturation,classswitching<br>• Tcellreceptorgeneassemblythroughsomatic recombination | **12** |

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| **II** | **RegulationofImmunoglobulinGeneExpression**<br>• Clonalselectiontheory<br>• Allotypes,idiotypes,and allelic exclusion<br>• Immunologicmemory<br>• Heavychaingene transcription<br>• Geneticbasisof antibodydiversity<br>• Germlinevs.somaticmutationhypothesis<br>• Alternatesplicing,variablejoiningsites,somatic mutation | **12** |
| | • Roleofantibodiesincomplementactivationandwith effector cells, Monoclonal antibodies | |
| **III** | **MHCandImmuno-techniques**<br>• MajorHistocompatibilityComplexes(MHCIandII), antigen processing<br>• Immunitytovariouspathogens,immuneevasion mechanisms<br>• Antigen-antibodyreactions:agglutination,precipitation<br>• Bloodgrouping,Coomb'stest,ELISA,RIA, immunoelectrophoresis | **12** |
| **IV** | **VaccinesandImmunization Strategies**<br>• Typesofvaccines:DNA,recombinant,bacterial,viral, tumor vaccines<br>• Adjuvantsandcytokines invaccination<br>• Passivevs.active immunization<br>• Immunizationprograms andWHO'srole | **12** |

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| **V** | **AutoimmuneDisordersandImmune Deficiency**<br>• Conceptofautoimmunityandautoimmune diseases<br>• Factors andmechanismsinvolvedinautoimmunity<br>• Breakdownofself-tolerance<br>• Transplantrejectionandmolecularmimicry<br>• Diagnosisandtreatment ofautoimmune diseases<br>• Replacementtherapy,suppressionofautoimmunity<br>• ImmunedeficiencyandAIDS | **12** |
| **Suggestivereadingbooks**<br>• *GoldsbyRA,KindtTJ,OsborneBA.(2007).Kuby'sImmunology.6theditionW.H. Freeman and Company, New York.*<br>• *CellularandMolecularImmunology.Abbas,A.K.etal.,ElsevierSaundersCo.,2015* | | |

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| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Fourth(IV) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-402** | **CourseTitle:BIOANALYTICAL TECHNIQUES** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandfundamentalsolutionchemistryandbuffersystemsusedinbiological studies.<br>• Learntheprinciplesandapplicationsofspectroscopy,centrifugation,andtheirrolein bioanalysis.<br>• Gaintheoreticalandpracticalknowledgeofchromatographyforseparationof biomolecules.<br>• Understandelectrophoretictechniquesandtracermethodsforthedetectionandanalysis of biological macromolecules.<br>• ExploreadvancedbiophysicaltechniquesincludingX-raycrystallography,fluorescence spectroscopy, and NMR for structure prediction of biomolecules. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | No. of Lectures |
|---|---|---|
| **I** | **SolutionChemistryandBuffers**<br>• Water:Structureand interaction,waterasa solvent.<br>• pH,Bronsted-Lowryconceptofacidsandbases, ionization.<br>• Buffers:Henderson-Hasselbalchequation,biological buffer systems (bicarbonate, phosphate, Tris).<br>• Determinationofmolecularweight:Molarity,molality, normality, equivalent weight. | **10** |

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|---|---|---|
| **II** | **Spectroscopyand Centrifugation**<br>• Colorimetry:Basicprinciplesandapplications.<br>• UV-VisibleandIRspectroscopy:Beer-Lambert'slaw, instrumentation, applications.<br>• Centrifugation: Principle and types, sedimentation coefficient,sedimentationvelocity,ultracentrifugation.<br>• Applications:Separationofmacromoleculesand subcellular fractionation. | **12** |
| **III** | **ChromatographicTechniques**<br>• Basicprinciplesandtypesof chromatography.<br>• Paperchromatography,thinlayerchromatography (TLC).<br>• Columnchromatography:Gelexclusion,adsorption,ion exchange, affinity.<br>• Applicationsinseparationofbiomolecules. | **12** |
| **IV** | **ElectrophoresisandTracerTechniques**<br>• Electrophoresis:Principleandtypes.<br>• DNAandRNA gelelectrophoresis.<br>• Proteingelelectrophoresis:SDS-PAGE,nativePAGE, documentation.<br>• 2D-electrophoresis,isoelectricfocusing.<br>• Tracertechniques:Radioactivityprinciples,isotopes, radioactive decay (α, β, γ).<br>• Scintillationcountingandapplicationsofradioisotopes in biology. | **14** |
| **V** | **Biophysical Techniques**<br>• Crystallography:Basicconcepts,symmetryelements, laws, X-ray crystallography, determination of crystal structures.<br>• Fluorescence:Concepts,emission,chemiluminescence, luminometry.<br>• NMRspectroscopy:Basicsandusein2D&3Dstructure prediction of biomolecules. | **12** |

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**SuggestiveReadingBooks:**

- *PrincipleandTechniquesofBiochemistryandMolecularbiology,7thedByKeithWilson and Jhon Walker, Cambridge Press*
- *RodneyBoyer,ModernExperimentalBiochemistry,PearsonEducation;3 Edition*

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| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Forth(IV) |
| **Department:**Biotechnology | | |
| **CouseCode:BSBT-403** | **CourseTitle:GENETIC ENGINEERINGAND GENE THERAPY** | |

**CourseOutcomes (COs)**

Aftercompletionofthiscourse, studentswillbe able to:

- Understandtheprinciplesandhistoricaldevelopmentofgeneticengineering.
- Identifyand describedifferent typesof vectors and DNA-modifyingenzymes.
- Explainvariousgenetransfermethodsinprokaryotes,eukaryotes, andplants.
- Applygenomeeditingtechnologiessuch asCRISPR-Cas9 andsite-directed mutagenesis.
- Understandapplicationsofgeneticengineeringinhealthcare,agriculture,and therapeutics.
- Comprehendgenetherapystrategiesandtechnologiessuchasgenesilencingand knockout models.

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| **Credits:**4 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| **Unit** | **Topics** | **N0. of Lectures** |
|---|---|---|

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| **I** | **IntroductionandToolsofGeneticEngineering**<br>• Scopeand Historyof Genetic Engineering<br>• Vectors:Nomenclature,Properties,Types:Plasmids, Phage-based vectors (Phagmids, Cosmids),Yeast vectors,Artificialchromosomes,Plantandanimal vectors, Cassette vectors<br>• DNAModifyingEnzymes:Nucleases,Restriction Endonucleases, Phosphomonoesterase, Alkaline Phosphatase,PolynucleotideKinase,DNALigase,DNA Polymerases, Reverse Transcriptase, Terminal DeoxynucleotidylTransferase,PolyAPolymerase<br>• GeneTransferTechniques-<br>• PhysicalMethods:Microinjection,Electroporation, Biolistics, Somatic Cell Fusion, Pronuclear Microinjection<br>• ChemicalMethod:Liposomes<br>• BiologicalMethod:Virus-MediatedTransfection | **14** |
| **II** | **MolecularToolsandApplications**<br>• Restrictionand Modification Systems<br>• RestrictionMapping<br>• SouthernandNorthernHybridization<br>• GenomicandcDNALibrary:Preparationand Comparison<br>• Screeningof Recombinants,ReverseTranscription<br>• GenomeMappingandDNAFingerprinting<br>• ApplicationsofGeneticEngineeringinAnimals: TransgenicMice,RoleofEmbryonicStemCellsinGene Targeting<br>• Therapeutic Products: Blood Proteins, Human Hormones,ImmuneModulators,Vaccines(One Example Each) | **12** |

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| **III** | **GenomeEditingandProteinInteraction Studies**<br>• GenomeEditing:PrinciplesandApplications<br>• Techniques:Site-DirectedMutagenesis,Other Methods<br>• DNA-ProteinInteractions:EMSA,DNaseFootprinting, Methyl Interference Assay, Chromatin Immunoprecipitation (ChIP)<br>• Protein-ProteinInteraction:YeastTwo-HybridSystem, Phage Display<br>• ProteinEngineering:ConceptsandApplications(any two examples), Chimeric Protein Production | **12** |
| **IV** | **GeneticEngineeringinPlantsandGene Therapy**<br>• GeneticEngineeringinPlants:Agrobacterium tumefaciens and A. rhizogenes, Ti Plasmids<br>• StrategiesforPlantGeneTransfer:DirectDNATransfer Methods, Gene Targeting, Plant Virus Vectors<br>• GeneTherapy<br>• VectorEngineeringandGeneDeliveryStrategies,Types: Gene Replacement, Augmentation, Correction, Editing, Regulation<br>• KnockoutandTransgenicTechnologies<br>• GeneSilencing:Ribozyme,Antisense,RNAInterference (RNAi) | **12** |
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| **V** | **AdvancedGeneticEngineeringTechniques**<br>• PolymeraseChainReaction(PCR)andits variants<br>• DNAsequencingtechniques:SangerandNext Generation Sequencing<br>• CRISPR-Cas9andothergenomeeditingtools(ZFNs, TALENs)<br>• Genesilencing:RNAi,antisenseRNA,siRNA<br>• Moleculardiagnosticsand biosensors | **10** |

**SuggestedReadings:**

- *BrownTA.(2006).GeneCloningandDNAAnalysis.5thedition.BlackwellPublishing, Oxford, U.K.*
- *ClarkDPandPazdernikNJ.(2009).Biotechnology-ApplyingtheGeneticRevolution. Elsevier Academic Press, USA.*
- *BiotechnologybyB.D.Singh(KalyaniPublishers).*

**Course:ImmunologyandImmunotechnologyandBioanalyticalTechniquesandGenetic Engineering and Gene Therapy Lab (BSBT-404P) (Practical IV of Major 5, 6 and 7)List of Practical**

1. *Bufferpreparation-Phosphate/Acetate/Citrate*
2. *Operationofshakers,incubators,pHmetersandcentrifuges*
3. *Determinationofabsorptionmaximaofgivenchemicals.*
4. *ValidationofBeersandLambertLaw*
5. *SeparationofaminoacidsbyPaperChromatography/ThinLayerChromatography methods*
6. *SDS-polyacrylamideslabgelelectrophoresisofproteinsunderreducingconditions*
7. *Separationofserumfromblood.*
8. *SingleImmunodiffusionanalysisusingspecificantibodyandantigen*
9. *Doubleimmunodiffusion test usingspecific antibody and antigen.*
10. *Haemagglutination assay.*
11. *Enzyme-LinkedImmunosorbentAssay(ELISA)Demonstration*
12. *Bloodgroupanalysis*
13. *Plasmid DNAisolation.*
14. *RestrictiondigestionofpBR322*
15. *Ligationusingsuitablevector*

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16. *Southern hybridization*
17. *PreparationofCompetent Cell*
18. *Transformation&bluewhitescreening.*

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# YEAR III

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**
**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**
**Department of Biotechnology**

| Batch:2024 -25 | | | | | | | | SEM:V | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
| | | | | L | T | P | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | | | | | | |
| 1 | Major 8 | BSBT-501 | Plant Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Major 9 | BSBT-502 | Animal Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Practical 5 (based on Major (8+9) | BSBT-503P | | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Minor 5 | BSBT-504 | **Microbial Remediation** | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Minor 6 | BSBT-505 | A. Microbial Enzyme production and its application<br>B. Plant Microbe Interaction | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Internship | BSBT-506I | | 2 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | **15** | **30** | **45** | **210** | **300** | |

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**
**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**
**Department of Biotechnology**

| Batch:2024 -25 | | | | | | | | SEM:VI | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
| | | | | L | T | P | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| THEORY and PRACTICAL SUBJECTS | | | | | | | | | | | | | |
| 1 | Major 10 | BSBT-601 | **Fundamentals of Nano Biotechnology** | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Major 11 | BSBT-602 | Environmental Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Major 12 | BSBT-603 | Industrial Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Practical 6 (based on Major (10+11+12) | BSBT-604P | | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 5 | Minor 7 | BSBT-605 | A. Stem Cell Biology<br>B. Vaccine Development | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Minor 8 | BSBT-606 | A. Stem Cell Biology<br>B. Vaccine Development | 3 | 1 | 0 | 3 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | **20** | **40** | **60** | **420** | **540** | |

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| **Programme/Class:**B.Sc. | **Year:**Third(III) | **Semester:**Fifth(V) |
| **Department:**Biotechnology | | |
| **CouseCode:BSBT-501** | **CourseTitle: PLANTBIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandclassicalandmodernapproachesinplantbiotechnology.<br>• Demonstrateknowledgeofmicropropagationand itscommercialpotential.<br>• Explaininvitrohaploidproductionandsomaclonalvariationfor cropimprovement.<br>• Applyprotoplast fusion and somatichybridizationtechniques.<br>• Usemolecularmarkersincropimprovementandtransgenicplantdevelopment. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **Introduction**<br>• Definition,classicalvs.modernapproach,Productionof disease-free plants: explant, shoot tip culture, shoot tip grafting, viricidal compounds<br>• Micropropagation:Basictechniques,automation,scope as a commercial venture<br>• Tissue culture as a source of genetic variability: Somaclonalandgametoclonalvariation,selection, sourcesand causes, applicationsincrop improvement<br>• Applicationsofsomatichybridsincropimprovement | **12** |

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| **II** | **Invitro Haploid Production**<br>• Androgenicmethods:Antherculture,microsporeculture, and androgenesis<br>• Significanceanduseof haploids<br>• Ploidylevel and chromosome doubling, diploidization<br>• Gynogenichaploidsandfactorsaffectinggynogenesis<br>• Chromosomeeliminationtechniquesforhaploid production in cereals | **12** |
| **III** | **ProtoplastIsolationandFusion**<br>• Methods ofprotoplastisolation,protoplast development<br>• Somatichybridization:identificationandselectionof hybrid cells<br>• Cybrids:Conceptandsignificance<br>• Potentialand limitationsof somatichybridization<br>• Somaclonalvariation:Nomenclature,methods, applications, basis, and disadvantages | **10** |
| **IV** | **MolecularBreedingandTransgenics**<br>• Molecularmarkers:Concepts,methodologies,rolein crop improvement and biodiversity conservation<br>• Marker-assistedselectionandQTLmapping<br>• Transgenicplants:Examplesandsignificance<br>• Molecularfarming:Productionofnutraceuticals,edible vaccines, and desired products<br>• Applications:Biofertilizers,bioplastics, biocontrol agentsinbiotechnology | **12** |

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| **V** | **PlantTransformationforProductivityand Performance**<br>• Herbicideresistance:Atrazine<br>• Insectresistance:Btgenes,non-Btproteinslikeprotease inhibitors<br>• Diseaseresistance:Virus(chitinase,β-1,3-glucanase), fungal (PR proteins, thionins), nematodes<br>• Malesterilityandchangesincarbohydratecomposition and storage (e.g., ADP-glucose pyrophosphatase)<br>• Productionofalkaloids,biodegradableplastics,edible vaccines<br>• Oleosin-partitioningtechnologyfor enhancedproduct extraction | **14** |
| | **SuggestedReadings:**<br>• *IntroductiontoPlantBiotechnology,H.S.Chawla, Science Publishers, 2002* | |

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| **Programme/Class:**B.Sc. | **Year:**Third(III) | **Semester:**Fifth(V) |
| **Department:**Biotechnology | | |
| **CouseCode:BSBT-502** | **CourseTitle:ANIMAL BIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Uponsuccessful completionofthiscourse,studentswillbeableto:<br>• Understandfundamentalprinciplesofanimalcellandtissueculturetechniques.<br>• Applyknowledgeofgenetransfer methods andtransgenesis in animals.<br>• ComprehendanimalbreedingstrategiesincludingIVFandcloning.<br>• Interpretadvancementsingenomeanalysisand gene therapy.<br>• Explorestemcellculture,applications,andassociatedethicalissues. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

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| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoAnimalCellandTissue Culture**<br>• Laboratoryorganization,mediapreparation,aseptic manipulation.<br>• Invitroculturemethodologies:primarycellculture, secondary and continuous cell lines. Growthkineticsofcultured cells. | **12** |
| II | **GeneTransferandTransgenesisin Animals**<br>• Physical,chemical,andviralgenetransfermethods.<br>• Introductionto transgenesis.<br>• Transgenicanimals:Mice,Cow,Pig,Sheep,Goat,Bird, Insect.<br>• Applicationincontrolofanimaldiseases:Foot-and-mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis. | **12** |
| III | **AnimalBreedingandConservation Biology**<br>• Artificialinsemination,<br>• invitrofertilization(IVF),andcloning.<br>• Embryotransfer techniques.<br>• Introductiontostemcelltechnologyandapplications. | **12** |
| IV | **GenomeAnalysisandGenetic Engineering**<br>• OverviewofHumanGenome Project.<br>• Geneticmodificationinmedicine:genetherapyandits types.<br>• Genetherapyvectors,CRISPR technology.<br>• Humangeneticengineering–problemsandethical concerns. | **12** |

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| **V** | **StemCellTechnologyand Applications**<br>• Definition,properties,proliferationandcultureofstem cells.<br>• Typesofstemcells:embryonicandadult.<br>• Stemcellbiologyandtherapeuticuses.<br>• Ethicalandlegalissuesinstemcelltechnology. | **12** |
| **SuggestedReadings:**<br>• *Animalcellculturetechniques,IanFreshney,Wiley-Leiss* | | |
| **Course:PlantBiotechnologyandAnimalBiotechnologyLab(BSBT-503P)(PracticalVof Major 8 and 9)**<br>**ListofPractical**<br>1. *PlantTissueculturetechnique-PreparationofMedia*<br>2. *Preparationofcomplexnutrientmedium (Murashige&Skoog's medium)*<br>3. *Toselection,Prue,sterilizeandprepareanexplantforculture.*<br>4. *Significanceofgrowthhormonesinculturemedium.*<br>5. *Todemonstratevariousstepsof Micropropagation.*<br>6. *CallusInductionandshootregeneration.*<br>**7.** *Shoot multiplication*<br>8. *Sterilizationtechniques:TheoryandPractical:Glasswaresterilization,Media sterilization, Laboratory sterilization*<br>9. *Sourcesofcontaminationanddecontaminationmeasures.*<br>10. *Cellcountingandcellviability*<br>11. *PreparationofHanksBalancedsalt solution*<br>12. *PreparationofMinimalEssentialGrowthmedium* | | |

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| **Programme/Class:**B.Sc. | **Year:**Third(III) | **Semester:**Sixth (VI) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-601** | **CourseTitle:FUNDAMENTALSOF NANOBIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse,studentswillbeable to:<br>• Understandthefoundationalconceptsofnanobiotechnologyanditsevolutionfrom biotechnology.<br>• Learntheintegrationofmolecularbiologyandnanotechnologyfordesigning biomolecules.<br>• Exploretheprinciplesand mechanismsof nano-scalebiomolecular systems.<br>• Analyzethepotentialofnanotechnologyinmedicine,includingdrugdeliveryand diagnostics.<br>• Examinemodernapplicationsofnanobiotechnologyinbiosensors,artificiallife,and hybrid materials. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoNanobiotechnology**<br>• Overview: FromBiotechnologytoBionanotechnology.<br>• Bio-nanomachinesinaction.<br>• Modernbiomaterialsandthelegacyofbiological evolution. | **10** |
| II | **BiomolecularDesignandTools**<br>• Designof biomoleculesin biotechnology.<br>• RecombinantDNA technology.<br>• Monoclonalantibodies andtheirapplications.<br>• Biomolecularstructuredetermination.<br>• Molecularmedicineand therapeuticapplications. | **12** |

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| **III** | **FunctionalPrinciplesof Nanobiotechnology**<br>• Information-drivennano assembly.<br>• Energeticsandchemicaltransformationsat nanoscale.<br>• Regulation,biomolecularmotors,sensing,andself-replication.<br>• Machine-phasenanobiotechnology. | **12** |
| **IV** | **Nanomedicine**<br>• Applicationsindrugdevelopment:Anti-AIDS drugs.<br>• Immunotoxinsastargetedcellkillers.<br>• Artificialblood substitutes.<br>• Cyclicpeptidesderived fromnanotubes. | **13** |
| **V** | **Applicationsof Nanobiotechnology**<br>• Harnessingmolecularmotors.<br>• DNAcomputingandmolecularprogramming.<br>• Moleculardesignusingbiologicalselection.<br>• Artificiallifeandhybridbiomaterials.<br>• Biosensorsandtheirapplicationsindiagnostics. | **13** |

**SuggestiveReadingBooks:**

- *Synthesis,Properties,andApplicationsofOxideNanomaterials,editedbyJoséA. Rodriguez, Marcos Fernández-García*
- *Nanochemistry:AChemicalApproachtoNanomaterials,ByGeoffreyA.Ozin,AndréC. Arsenault, Ludovico Cademartiri*
- *Nanomaterials,NanotechnologiesandDesign:AnIntroductionforEngineers.DanielL. Schodek, Paulo Ferreira, Michael F. Ashby*
- *NanomaterialInterfacesinBiology:MethodsandProtocols,PaoloBergese,Kimberly Hamad- Schifferli*
- *OpticalPropertiesandSpectroscopyofNanomaterials,JinZ. Zhang*

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SWAMIVIVEKANANDSUBHARTIUNIVERSITY
(EstablishedunderU.P.Govt. Actno.29of2008andapprovedundersection2(f)ofUGCAct1956)
Ph.0121-2439578,2439052,3058031,3058032;Telefax:0121-2439067
e-mail:registrar@subharti.org,Website:www.subharti.org

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| **Programme/Class:**B.Sc. | **Year:**Third(III) | **Semester:**Sixth (VI) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-602** | **CourseTitle:ENVIRONMENTAL BIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Thiscourseprovidesfoundationalknowledgeofenvironmentalbiotechnology,focusingon sustainable practices, bioremediation, bioenergy, waste management, and regulatory frameworks. After completing this course, students will be able to:<br>• Understandthe environmentalimpactofconventionalandmodernfuels.<br>• Explainmicrobialandplant-based solutionsforpollution mitigation.<br>• Evaluatewastetreatmenttechnologiesandtheroleofbiofertilizers.<br>• Describebioleachingandtheenvironmentalroleofgeneticallymodified organisms.<br>• InterpretmajorIndianenvironmentallawsand globalclimatechangeinitiatives. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **ConventionalandModernFuels:EnvironmentalImpact**<br>• Conventionalfuels:Firewood,plant-derived,animal-based, water, coal, gas<br>• Modernfuels:Methanogenicbacteria,biogas,microbial hydrogen production<br>• Conversionofsugarsto alcohol (Gasohol) | **10** |
| II | **BioremediationandMicrobial Degradation**<br>• Bioremediationofoilspills,heavymetals,detergents (soil and water)<br>• Microbial degradation of lignin, cellulose, pesticides, aromaticandchlorinatedhydrocarbons,andpetroleum products<br>• Phyto-remediation | **12** |

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| **III** | **WasteTreatmentandBiofertilizers**<br>• Municipalandindustrialwastetreatment<br>• Roleofnitrogen-fixingbacteria(symbioticand asymbiotic)<br>• Algalandfungalbiofertilizers,particularlyVAM (Vesicular Arbuscular Mycorrhiza) | **12** |
| **IV** | **MicrobialMiningandGMOsinthe Environment**<br>• Bioleachingandmicrobialenrichmentofores(Gold, Copper, Uranium),<br>• Environmentalsignificanceofgeneticallymodified microbes, plants, and animals | **13** |
| **V** | **EnvironmentalLegislationandClimate Policy**<br>• Constitutionalprovisions:Article48A,Article51A(g), derived rights<br>• Majorenvironmentallaws:TheWildLife(Protection) Act, 1972, The Water (Prevention and Control of Pollution) Act, 1974, The Forest (Conservation) Act, 1980,TheAir(PreventionandControlofPollution)Act, 1981, The Environment (Protection) Act, 1986, The BiologicalDiversityAct,2002,NoisePollution (Regulation and Control) Rules, 2000<br>• NationalGreenTribunal | **13** |

**SuggestiveReadingBooks:**


- *P.K.Mohapatra,TextbookofEnvironmentalBiotechnology,I.K.International Publishing House; 1st Ed. edition.*
- *SreeKrishnaV(2007)BioethicsandBiosafetyinBiotechnology,Newageinternational publishers*


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e-mail:registrar@subharti.org,Website:www.subharti.org

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**Third(III) | **Semester:**Sixth (VI) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-603** | **CourseTitle: INDUSTRIAL BIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Uponsuccessful completion ofthiscourse,studentswill beableto:<br>• Understandtheprinciplesand scopeofindustrialbiotechnology.<br>• Explainthebasicsofmicrobialfermentationandbioprocesstechnology.<br>• Illustratetheproduction processofvariousindustrialmetabolitesandenzymes.<br>• Applyconceptsofenzymetechnology,biocatalysis,anddownstreamprocessing.<br>• Comprehendindustrialbiosafetystandardsandintellectualpropertyrights (IPR). | | |
| **Credits:**4 | **CoreCompulsory** | |
| **Maximum Marks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoIndustrial Biotechnology**<br>• Definition,scope,andimportance;Historyand development of industrial biotechnology<br>• Differencesbetweenindustrialmicrobiologyand biotechnology<br>• Microbial diversityinindustrial processes<br>• Isolation,screening,andimprovementofindustrial microorganisms; Industrially important microbes: *Aspergillus*,*Penicillium*,*Saccharomyces*,*Streptomyces*, *E. coli* | **10** |
| II | **FermentationTechnology**<br>• Basicprinciplesoffermentation<br>• Typesoffermentation:Batch,fed-batch,continuous;<br>• Fermenterdesignand components<br>• Sterilization,aeration,agitation,pHandtemperature control<br>• Downstreamprocessing:separation,purification,and product recovery<br>• Solidstateandsubmerged fermentation | **12** |

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| **III** | **ProductionofMetabolitesand Biochemicals**<br>• Production ofprimaryand secondarymetabolites; Alcohol(ethanol),organicacids(citricacid,lacticacid); Antibiotics (penicillin, streptomycin); Vitamins (B12, riboflavin); Amino acids (glutamic acid, lysine)<br>• Enzymes(amylase,protease,cellulase,lipase);Industrial solvents and biopolymers; Scale-up of microbial processes | **12** |
| **IV** | **EnzymeandBioproduct Technology**<br>• Sources,production,andimmobilizationof enzymes<br>• Applicationsinfood,textile,detergent,pharmaceutical, and paper industries<br>• Biotransformationandbiocatalysis;SingleCellProtein (SCP) and Single Cell Oil (SCO)<br>• Biofuels:bioethanol,biogas, biodiesel<br>• Bioplasticsandbiodegradablematerials | **13** |
| **V** | **IndustrialBiosafety,QualityControl,andIPR**<br>• GoodManufacturingPractices(GMP)andGood Laboratory Practices (GLP)<br>• Qualitycontrol and assurance in industrial biotech; Biosafetyregulationsforindustrialmicroorganisms<br>• Environmentalconcernsandwastemanagement<br>• IntellectualPropertyRights(IPR)inindustrial biotechnology<br>• Casestudies: Biocon,SerumInstitute | **13** |

**SuggestiveReadingBooks:**


- *StanburyPF,WhitakerAandHallSJ.(2006).PrinciplesofFermentationTechnology. 2ndedition, Elsevier Science Ltd.*
- *CasidaLE.(1991).IndustrialMicrobiology.1stedition.WileyEasternLimited.*
- *CruegerWandCruegerA.(2000).Biotechnology:AtextbookofIndustrial Microbiology.2nd edition. Panima Publishing Co. New Delhi.*
- *PatelAH.(1996).IndustrialMicrobiology.1stedition,MacmillanIndiaLimited.*
- *Salisbury,WhitakerandHall.PrinciplesoffermentationTechnology*


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**Course:FundamentalsofNanobiotechnology.EnvironmentalandIndustrial Biotechnology (BSBT-604P) (Practical VI of Major 10, 11 and 12)**

**Listofpractical**

1. *CalculationofBODofwater sample.*
2. *CalculationofCODofwater sample.*
3. *Testingofalkalinityofwatersample*
4. *Testingofhardnessandconductivityofpollutedwatersample*
5. *Inoculumpreparationandsterilization*
6. *Immobilizationofbacterial cells*
7. *Performanenzymeassaydemonstratingitshydrolyticactivity (protease/peptidase/glucosidase etc).*
8. *ProductionandanalysisofAmylase.*
9. *Synthesisofsilvernanoparticlesusingplantextracts*
10. *UV-Visiblespectrophotometricanalysisofnanoparticles*
11. *CharacterizationofnanoparticlesusingDynamic LightScattering(DLS)*
12. *ObservationofnanoparticlesusingScanningElectronMicroscopy(SEM)*
13. *Antibacterialactivityassay ofsynthesized nanoparticles*
14. *Encapsulationofenzymesordrugsusingbiopolymer nanoparticles*

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# YEAR IV

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**

**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**

**Department of Botechnology**

**Course- B.Sc. Biotechnology**

**Batch:2024 -25** — **SEM:VII**

| S./No. | Course Type | Course Code | Course Name | Teaching Load | | | Credits | Internal Assessment | | | External Assessme | Total | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | Attendance (5) | quiz/PPT/ Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| | THEORY and PRACTICAL SUBJECTS | | | | | | | | | | | | |
| 1 | Major 13 | BSBT-701 | **Bioethics, Biosafety and IPR** | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Major 14 | BSBT-702 | **Computational biology and bioinformatics in research** | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Practical 7 (based on Major 13+14) | BSBT-703P | | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| 3 | Major 15 | BSBT-704 | Medical Biotechnology | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Minor 9 | BSBT-705 | **Literature review and Scientific writing** | 3 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 6 | Practical 8 (based on Major 15) | BSBT-706P | | 0 | 0 | 4 | 2 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | **30** | **60** | **90** | **420** | **600** | |

**SWAMI VIVEKANAD SUBHARTI UNIVERSITY MEERUT**

**KERAL VERMA SUBHARTI COLLEGE OF SCIENCE**

**Department of Biotechnology**

**Course- B.Sc. Biotechnology**

**Batch:2025-26** — **SEM:VIII**

| S./No. | Course Type | Course Code | Course Nmae | Teaching Load | | | CREDITS | Internal Assessment | | | External Assessme | Total | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | THEORY and PRACTICAL SUBJECTS | | | L | T | P | | Attendance (5) | Quiz/PPT / Assignment (10) | Mid Sem Test (15) | End Sem Exam (70) | | |
| 1 | Major 16 | BSBT-801 | **Research Methodology** | 4 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 2 | Minor 10 | BSBT-802 | A. Enterpreneurship in Biotechnology<br>B. Enterpreneurship in Biochemistry<br>C. Enterpreneurship in Microbiology | 3 | 1 | 0 | 4 | 5 | 10 | 15 | 70 | 100 | |
| 4 | Research Project / Dissertation | BSBT-803RP/DS | | 2 | 1 | 0 | 12 | 5 | 10 | 15 | 70 | 100 | |
| **TOTAL CREDITS / ASSESSMENT** | | | | | | | **20** | | **90** | | **210** | **300** | |

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| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Seventh (VII) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-701** | **CourseTitle:BIOETHICS,BIOSAFETYANDIPR** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbe able to:<br>• Understandtheprinciplesandlevels ofbiosafetyinbiotechnological research.<br>• Analyzeethical,legal,andsocietalissuesrelatedtobiotechnologyandgenetic manipulation.<br>• Comprehendtheimportance,process,andlegalframeworkofpatents,especiallyin biological systems.<br>• LearnaboutnationalandinternationalregulatoryframeworksforGMOsand biotechnology research.<br>• Gaininsightintoprojectformulation,financialanalysis,andfundingopportunitiesin biotechnology ventures. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| **I** | **Biosafety**<br>• Introductionandhistoricalperspectiveofbiosafety.<br>• Objectivesandriskassessmentinbiotechnological research.<br>• Regulationofphysicalandbiologicalcontaminants.<br>• Fieldtrialsand introductionofGMOs.<br>• BiosafetyguidelinesinIndia.<br>• Biosafetylevelsinplant, animal,and microbial research. | **12** |

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| **II** | **Bioethics**<br>• Introductionto bioethics.<br>• Ethicalissuesinbiotechnology:legalandsocio-economic implications.<br>• Health and safetyconcerns.<br>• Ethicalconcernsingenecloningandenvironmental engineering.<br>• Humancloningandstem cellresearchethics.<br>• Potentialbenefitsandchallengesofcloning. | **10** |
| **III** | **PatentsandIntellectualPropertyRights(IPR)**<br>• Basicsandessential requirementsof patents.<br>• Internationalpatentinglandscape.<br>• Patentingbiological materials.<br>• SignificanceofpatentsinIndia.<br>• Patentapplicationproceduresand grantingprocess.<br>• Patentprotectionforbiotechnological inventions.<br>• OverviewofIndianPatentAct(1970)andAmendments (2002). | **14** |
| **IV** | **RegulatoryFrameworkinBiotechnology**<br>• RegulationofrecombinantDNAtechnology(RDT) research.<br>• Foodandingredientregulation.<br>• RegulatoryframeworkforGMOsinIndia.<br>• RecombinantDNAGuidelines(1990).<br>• GuidelinesforTransgenicPlantResearch(1998).<br>• PreventionofFoodAdulterationAct(1955).<br>Food Safety and Standards Bill (2005). | **12** |

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| **V** | **ProjectManagementandFinancial Analysis**<br>• Conceptofproject:types,identification,formulation, design.<br>• Networkanalysis andprojectreporting.<br>• Projectappraisalmethods.<br>• Financialanalysis:ratioanalysis,investmentevaluation, break-even and profitability analysis.<br>• Budgetingandplanning.<br>• Biotechnologyfunding:financingoptions,venture capital, and funding mechanisms in India. | **12** |

**SuggestiveReadingBooks:**

- *Beier,F.K.,Crespi,R.S.andStraus,T.BiotechnologyandPatentprotection-Oxfordand IBH Publishing Co. New Delhi.*
- *IntellectualpropertyrightsandBio-Technology(BiosafetyandBioethics),Anupam Singh,*
- *SassonA,BiotechnologiesandDevelopment,UNESCO Publications.*
- *SinghK,IntellectualPropertyrightsonBiotechnology,BCIL,NewDelhi*
- *RegulatoryFrameworkforGMOsinIndia(2006)MinistryofEnvironment and Forest.*

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Seventh (VII) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-702** | **CourseTitle:COMPUTATIONALBIOLOGYAND BIOINFORMATICS IN RESEARCH** | |
| **CourseOutcomes (COs)** | | |

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| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandthe foundationsand historyof bioinformaticsandcomputational biology.<br>• Gainfamiliaritywithmajor biologicaldatabasesandtheirapplications.<br>• Learnsequencealignment,databasesearching, andgenomeannotationtools.<br>• Performphylogeneticandsequencesimilarityanalysesusingonlinetoolslike BLAST and FASTA.<br>• Interpretbiologicaldataforresearch applicationsusingcomputational tools. |

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| **Credits:**4 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoBioinformaticsandDatabases**<br>• Introductionand historyof bioinformatics.<br>• Conceptofhomologyinbiologicalsequences.<br>• Sequenceinformationsources:EMBL,GenBank, Entrez, UniGene.<br>• Typesofbiologicaldatabases:PrimaryandSecondary.<br>• Nucleotidesequencedatabases:EMBL,DDBJ, GenBank.<br>• Overviewandstructureofdatabasesandtheirweb access. | **12** |
| II | **ProteinDatabasesandData Generation**<br>• Proteindatabases:PDB,SWISSPROT,TREMBL.<br>• Understandingthe structureand retrieval of data.<br>• Datageneratingtechniquesinbioinformatics. | **10** |
| | • Challengesindatamanagementandinterpretation. | |

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| **III** | **SequenceAlignmentandAnalysis**<br>• DetectingOpenReadingFrames (ORFs).<br>• Basicsofsequenceassembly.<br>• Mutationandsubstitution matrices.<br>• Pairwisesequencealignment:Conceptsand applications.<br>• IntroductiontoBLAST, onlineuse,andinterpretation.<br>• Multiplesequencealignment basics. | **12** |
| **IV** | **DatabaseSearchingandGenomeAnnotation**<br>• Databasesearchingtools: SRS, Entrez.<br>• SequencesimilaritysearchesusingBLASTandFASTA.<br>• Datasubmissionmethods.<br>• Genomeannotation:Patternrecognition,repeat finding.<br>• Geneidentificationtools andtheirapplications. | **12** |
| **V** | **PhylogeneticsandComparativeAnalysis**<br>• Sequenceandphylogenyanalysisoverview.<br>• DetectingORFsandinterpretingsequencedata.<br>• Useof BLAST andsequence assemblyreview.<br>• Pairwiseandmultiplesequencealignments.<br>• Phylogeneticanalysisandinterpretationofevolutionary relationships. | **14** |

**SuggestiveReadingBooks:**


- *GhoshZ.andBibekanandM.(2008)Bioinformatics:PrinciplesandApplications.*
- *OxfordUniversityPress.*
- *Wünschiers,R.(2004).ComputationalBiology:Unix/Linux,dataprocessingand*
- *programming.Springer.*
- *Zvelebil,M.J.,&Baum, J.O.(2008). Understandingbioinformatics.GarlandScience.*


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**Course:Bioethics,BiosafetyandIPRandComputationalbiologyandbioinformaticslab (BSBT-703P) (Practical VII of Major 13 and 14)**

**ListofPractical**

1. *Projectdesigningandwriting*
2. *Reviewtheliteraturesofacceptedpatents*

3. *Developmentofcreativeideasforcommercializationoftechnology*
4. *Sequenceinformation resource*
5. *Understandinganduseofvariouswebresources:EMBL,GenBank,Entrez,Unigene, Protein information resource (PIR)*
6. *Understandingandusing:PDB,Swissport,TREMBL*
7. *UsingvariousBLASTandinterpretationofresults.*
8. *Retrievalofinformationfromnucleotidedatabases.*
9. *Sequencealignmentusing BLAST.*
10. *Multiplesequencealignmentusing Clustal W.*

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| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Seventh (VII) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-704** | **CourseTitle:MEDICAL BIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Aftersuccessful completionofthiscourse, studentswill beable to:<br>• Understandthescope,applications,andevolutionofmedicalbiotechnology.<br>• Explaintheprinciplesandtechniquesusedinmedicaldiagnosticsandtherapeutics.<br>• Applyknowledgeof geneticengineeringtoolsindiseasediagnosis and therapy.<br>• Discusstheroleof biotechnologyinvaccine development and drug production.<br>• Analyzeethical,social,andregulatoryconcerns relatedtomedicalbiotechnology. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| **I** | **IntroductiontoMedical Biotechnology**<br>• Definition,scope,andsignificanceinhealthcare<br>• Historicaldevelopments andkeymilestones<br>• Roleindiagnosis,therapy,anddiseaseprevention<br>• Basicconceptsofcells, genes, biomolecules<br>• Introductiontothehumangenomeandgenetic disorders | **12** |

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| **II** | **ToolsandTechniquesin MedicalBiotechnology**<br>• BasicsofrecombinantDNAtechnology<br>• PolymeraseChainReaction(PCR):principleand applications<br>• Blottingtechniques:Southern,Northern,Western<br>• ELISA:principleand types | **10** |
| | • DNAfingerprintingandmedicalapplications<br>• OverviewofCRISPR-Cas9gene editing | |
| **III** | **Medical Diagnostics**<br>• Typesofdiseases:genetic,infectious,non-infectious<br>• Moleculardiagnostics:PCR,LAMP,microarrays<br>• Immunodiagnostics:ELISA,RIA,lateralflowtests<br>• Biosensorsandpoint-of-carediagnosticdevices<br>• Prenataldiagnosticsandnewborn screening<br>• Casestudy:COVID-19diagnostics(RT-PCR,antigen tests) | **12** |
| **IV** | **Therapeuticsand Vaccines**<br>• Basicsofvaccinedevelopment,typesofvaccines<br>• Monoclonalantibodiesandtherapeuticproteins<br>• Recombinantinsulinandtherapeutic molecules<br>• Genetherapy:conceptandcaseexamples(e.g.,SCID)<br>• RNA-basedtherapeutics,mRNAvaccines<br>• Biotechnologyincancer therapy:targetedtherapybasics | **12** |
| **V** | **Ethical,Social,andRegulatory Issues**<br>• Bioethics:privacy,consent,discrimination<br>• Safetyingeneticmodificationandclinicaltrials<br>• IntellectualPropertyRights(IPR):basics and importance<br>• Regulatorybodies:ICMR,DBT,CDSCO,WHO<br>• Publichealthchallengesandbiotech opportunities<br>• Biotechstart-upsandcareerscopeinmedical biotechnology | **14** |

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**SuggestiveReadingBooks:**

- *MolecularBiotechnology-PrinciplesandApplicationsofrecombinantDNA.ASMPress, Washington. B.B. Nanda and R.K. Tiwari,*
- *ForensicScienceinIndia:AVisionfortheTwentyFirst Century,SelectPublishers,New Delhi(2001).M.K.BhasinandS.Nath,RoleofForensicScienceintheNewMillennium, University of Delhi, Delhi (2002).*
- *S.H.JamesandJ.J.Nordby,ForensicScience:AnIntroductiontoScientificand Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005).*

**Course:MedicalBiotechnologyLab(BSBT-706P)(PracticalVIIofMajor15) List of Practical**

1. *Estimationofbloodglucoseusingglucometerorcolorimetric method*
2. *Determinationofbloodgroup(ABOandRhtyping)*
3. *HemoglobinestimationusingSahli'sorcyanmethemoglobinmethod*
4. *Totalanddifferentialleukocytecountusingbloodsmear*
5. *Widaltestfordetectionoftyphoidfever*
6. *ELISAdemonstrationfordetectionofinfectiousdisease(e.g., HIVor hepatitis)*

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| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Eight (VIII) |
| **Department:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-801** | **CourseTitle: RESEARCH METHODOLOGY** | |
| **CourseOutcomes (COs)** | | |
| Aftercompletionofthiscourse, studentswillbeable to:<br>• Understandthefundamentalsandobjectivesofresearchandthevarioustypesand methodologies used.<br>• Formulateresearchproblems,hypotheses,anddesignappropriateresearchstudies.<br>• Learndatacollectionmethods,basicdataanalysis, andrepresentationtechniques.<br>• Gainskillsinscientificwriting,documentation,anduseofreferencingtoolsand software.<br>• Understandthe ethical aspectsofresearch andlearn howtoapplyforresearchfunding. | | |
| **Credits:**4 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | N0. of Lectures |
|---|---|---|
| I | **IntroductiontoResearchMethodology**<br>• Definitionandobjectives ofresearch.<br>• Typesofresearch:Basic,Applied,Quantitative, Qualitative.<br>• Characteristicsofgood research.<br>• Scientificmethod and hypothesis formulation.<br>• Literaturereviewandidentifyingresearch gaps. | **10** |
| II | **ResearchDesignandPlanning**<br>• Researchproblem formulation.<br>• Variables:Independent,Dependent, Confounding.<br>• Experimentalandcontrolgroups.<br>• Samplingmethods: Probabilityand non-probability.<br>• Studydesigns:Experimental,Observational,Casestudy, Cross-sectional, Longitudinal. | **12** |

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| **III** | **DataCollectionandAnalysis**<br>• Typesof data:PrimaryandSecondary.<br>• Methods:Survey,Observation,Interviews,Experimental methods.<br>• Tools:Questionnaires, Labinstruments, Databases.<br>• Datapresentation:Tables,Graphs, Charts.<br>• Basics of statistical analysis: Mean, Median, Mode, StandardDeviation,t-test,Chi-squaretest(introductory).<br>• Useofsoftware:MS Excel, GraphPad. | **14** |
| **IV** | **ScientificWritingand Communication**<br>• Structureofscientificdocuments:Reports,Theses, Articles.<br>• Components:Abstract,Introduction,Methodology, Results, Discussion, Conclusion.<br>• Referencingstyles:APA,MLA, Vancouver.<br>• Useofreferencemanagers:Zotero, Mendeley.<br>• Avoidingplagiarism, importanceof originality.<br>• Oralandposterpresentationskills. | **12** |
| **V** | **Ethicsin ResearchandFunding**<br>• Research ethicsandscientificmisconduct.<br>• Informedconsentandconfidentiality.<br>• RoleofInstitutionalEthicsCommittees(IEC).<br>• Biosafetyand bioethicsinbiotechnology.<br>• Overviewofmajorfundingagencies:DBT,DST,UGC, CSIR, ICMR.<br>• Guidelinesforpreparingandsubmittingresearch proposals. | **12** |

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**SuggestiveReadingBooks:**

- *KothariR.C.(2005):ResearchMethodology,2ndEdition,NewAgeInternational Publisher Ltd., New Delhi.*

## MINOR COURSES SYLLABUS

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**First(I) | **Semester:**First(I) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-102** | **CourseTitle:BIOTECHNOLOGYANDHUMAN WELFARE** | |
| **CourseOutcomes (COs)** | | |
| • Understandtheprinciplesofproteinengineering,enzymeandantibioticproductionfor industrial and healthcare applications.<br>• Comprehendthedevelopmentoftherapeuticagentsanddiagnostictools,includinggene therapy and recombinant vaccines.<br>• Analyzethebiotechnologicalinterventionsinagricultureincludinggenetransfer, nitrogen fixation, and livestock improvement.<br>• Explainenvironmentalbiotechnologyapproachesforpollutantdegradation,waste management, and development of biodegradable products.<br>• Applymolecularbiologytechniquesinforensicsciencetosolvecrimesandverify biological relationships. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **Maximummarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **Industryand Health**<br>• Proteinengineering;enzymeandpolysaccharide synthesis, activity and secretion.<br>• AlcoholandAntibioticformation.<br>• Developmentofnon-toxictherapeuticagents, recombinant live vaccines.<br>• Genetherapy<br>• Diagnostics,monoclonalinE.coli,humangenome project. | **6** |
| II | **Agriculture**<br>• N2fixation:transferofpestresistancegenestoplants.<br>• Interactionbetweenplantsand microbes<br>• Qualitativeimprovementoflivestock. | **3** |

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| **III** | **Environment**<br>• Chlorinatedandnon-chlorinatedorganpollutant degradation;<br>• Degradationofhydrocarbonsandagriculturalwastes<br>• Stressmanagement<br>• Developmentofbiodegradablepolymers. | **3** |
| **IV** | **Forensicscience**<br>• Introductoryto Forensicscience<br>• Solvingviolentcrimessuchas murder<br>• Solvingclaimsofpaternityandtheftusingvarious methods of DNA finger printing. | **3** |
| **SuggestiveReadingBooks:**<br>• *SateeshMK (2010)BioethicsandBiosafety,I.K.InternationalPvtLtd.*<br>• *SreeKrishnaV(2007)BioethicsandBiosafetyinBiotechnology,Newageinternational publishers.* | | |

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**First(I) | **Semester:**Second(II) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-203** | **CourseTitle:BIORESOURCETECHNOLOGYAND BIOPRODUCTS** | |
| **CourseOutcomes(COs)**<br>• Fundamentalunderstandingofthebioresourcesanditsapplicationsforattainmentof social objectives (energy, environment, product, sustainability).<br>• Acquireknowledgewithrespecttothepropertiesofthebioresourcesandtheconversion technologies.<br>• Exhibitingknowledgeof thesystemsused forbioresourcesandbioresource technology.<br>• Understandingaboutanalysisofdataandtheirapplicationsindesignofthesystemsand development of the bioprocess. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| **Unit** | **Topics** | **No.ofLectures** |
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|---|---|---|
| **I** | **Bioresources**<br>• Naturalandanthropogenic;importanceofbio-resources and their utilization.<br>• Naturalbio-resources:agricultural,forestryandaquatic biomass. | **3** |
| | • Biomassavailability,productionandfoodsecurity,non-edible biomass characteristics.<br>• Anthropogenicbio-resources:Organicwastes-domestic and industrial; characteristics of municipal sewage / sludge and industrial sludges. | |
| **II** | **Conversionprocesses**<br>• Biochemical,thermo-chemicalandphysico-chemical conversion processes<br>• Biochemicalprocesses:Microbialanaerobicandaerobic processes<br>• Enzymaticprocesses;fermentationforalcoholsand acids; penicillin and other therapeutic products. Productionofsinglecellprotein(SCP)<br>• Bio-pulping,Biogasification. | **3** |
| **III** | **Thermo-chemicalprocesses**<br>• Pyrolysis(cokeandpyro-oils),oxidation-combustion<br>• Gasification:downdraft,updraftandfixedbed gasification,fluidizedbedandentrainedbedgasification<br>• Variousmethodsofmanufactureofactivatedcarbons | **3** |
| **IV** | **Biofuels**<br>• Biofuelsandbiomaterials,specialtychemicals(gylcol, acetic acid and downstream chemicals)<br>• Anhydrousalcohols-ethanolandbutanol<br>• Biodiesel,bio-aviationturbinefuel(BATF)<br>• Physico-chemicalprocesses: Pretreatment, steam/acid/alkalihydrolysis,effectoftemperatureon hydrolysis | **6** |

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**SuggestiveReadingBooks:**

- *Tripathi,G.,"BioresourceTechnology",CBSPublications(2002).*
- *Pandey,A.,"ConciseEncyclopaediaofBioresourceTechnology",CRCPress(2004).*
- *Shuler,M.,Kargi,F.,"BioprocessEngineering,BasicConcept",PrenticeHallofIndia Pvt. Ltd. (2004)*

| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Third(III) |
|---|---|---|
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-304** | **CourseTitle: BIOPROCESSENGINEERING** | |

**CourseOutcomes (COs)**

- Understandprinciples,history,andtypes ofbioprocesstechnologyandfermentation.
- Learnmicrobialgrowth kinetics,bioprocesscontrol,andfermenterdesign.
- Applydownstreamprocessingtechniques and wastemeasurement methods.
- Evaluateindustrialwastewatertreatmentanddisposalmethods.
- Integrateknowledgeofbioprocesstechnologytooptimizeandinnovateindustrial microbial processes for various applications.

| **Credits:**3 | **CoreCompulsory** |
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| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| **Unit** | **Topics** | **No.ofLectures** |
|---|---|---|
| **I** | • Introductiontobioprocess engineering.<br>• Bioreactors:batch,fedbatchandcontinuous bioreactors<br>• Usesofimmobilizedenzymes,bioreactorsusing immobilized enzymes.<br>• Specialized bioreactors: pulsed, fluidized and photo-bioreactors.Mediaforindustrialfermentation,airand media sterilization<br>• Sourcesofmicrobesforindustrialuse,kineticsof microbialgrowthanddeath,measurementandcontrolof bioprocess parameters. | **6** |

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| **II** | • Introductiontofermentation-Typesoffermentation processes (Submerged & solid static)<br>• Mediaformulation-Syntheticandcompletemedia<br>• Sterilization(batch&continuous)–Air,Filterand Mediasterilization–Operation:Inoculumpreparation and sampling. | **3** |
| **III** | • Purification&characterizationof proteins/byproducts<br>• Upstreamanddownstreamprocessing,<br>• Removalmicrobialcellsfrombioreactors,foam preparation,filtration,dryingandcrystallization<br>• Experimentalmodelfordesignof fermentationsystems<br>• Anaerobic fermentations. | **3** |
| **IV** | • Fermenters:Designofa fermenter<br>• Types:Stirredtank,Fluidizedbed,Immobilizedbed bioreactors,Photobioreactors,Airliftbioreactorsandits other types. | **3** |

**SuggestiveReadingBooks:**


- *StanburyP.F.,Whitaker.A&Hall.S.J.,PrinciplesofFermentationTechnology(2nd edition), Aditya Books Private Ltd., 2000.*
- *Crueger,W.andCrueger,A.,Biotechnology:ATextbookofIndustrialMicrobiology(2nd edition), Panima Publishing Corporation, New Delhi, 2000.*
- *WaitesM.J.,MorganN.L.,RockeyJ.S.,IndustrialMicrobiology(2ndedition),Blackwell Science, 2002.*
- *DemainL.&DaviesE.,ManualofIndustrialMicrobiologyandBiotechnology(2nd edition), ASM Press, Washington, 2004.*
- *ShulerM.L.andKargiF.,BioprocessEngineering:BasicConcepts(2ndedition), Prentice Hall, 2002.*


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| **Programme/Class:**B.Sc. | **Year:**Second(II) | **Semester:**Fourth(IV) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-405** | **CourseTitle:GENOMICSANDPROTEOMICS** | |
| **CourseOutcomes (COs)** | | |

- UnderstandtheprinciplesandapplicationsofvariousDNAsequencingmethods, including traditional (Maxam-Gilbert, Sanger) and advanced (pyrosequencing) techniques.
- Explaingenomesequencingstrategiessuchasshotgunandhierarchicalmethodsand apply knowledge of genome assembly using computational tools.
- Useandnavigategenomedatabasesandweb-basedtoolssuchasNCBI,ENSEMBL, VISTA, and UCSC Genome Browser for genome data analysis and retrieval.
- Describethestructureandchemicalpropertiesofproteinsandunderstandthephysical forces(hydrogenbonding,vanderWaals,electrostatic,hydrophobicinteractions)that influence protein structure and stability.
- Applytechniques for determiningprotein sizeandstructure, includingsedimentation analysis, gelfiltration,SDS-PAGE,andEdman degradation.

- Demonstrate understanding of proteomics and analyze proteomes using techniques like 2D-PAGEandmassspectrometry,includingproteinsamplepreparation,separation,and identification.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| **I** | • Introductionto Genomics<br>• DNAsequencingmethods– manual & automated: Maxam&GilbertandSangersmethod. Pyrosequencing<br>• GenomeSequencing:Shotgun&Hierarchical(clone contig) methods<br>• Computertoolsforsequencingprojects:Genome sequence assembly software. | **6** |
| **II** | • Managingand DistributingGenome Data<br>• Webbasedserversandsoftwaresforgenomeanalysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome.<br>• SelectedModelOrganisms'GenomesandDatabases. | **3** |

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| **III** | • Introductiontoproteinstructure,Chemicalpropertiesof proteins.<br>• Physicalinteractionsthatdeterminethepropertyof proteins.<br>• Short-rangeinteractions,electrostaticforces,vander waal interactions, hydrogen bonds, Hydrophobic interactions.<br>• Determinationofsizes(Sedimentationanalysis,gel filtration, SDS-PAGE)<br>• Determinationofcovalentstructures–Edman degradation. | **3** |
| **IV** | • Introductionto Proteomics,<br>• Analysisofproteomes.2D-PAGE.<br>• Samplepreparation,solubilization,reduction,resolution.<br>• Reproducibilityof 2D-PAGE. | **3** |
| | • Massspectrometry-basedmethodsforprotein identification.<br>• Denovosequencingusingmassspectrometricdata | |

**SuggestiveReadingBooks:**

- *GenesIXbyBenjaminLewin,JohnsandBartlettPublisher,2006.*
- *ModernBiotechnology,2ndEdition,S.B.Primrose,BlackwellPublishing,1987.*
- *MolecularBiotechnology:PrinciplesandApplicationsofRecombinantDNA,4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.*
- *MolecularCloning:ALaboratoryManual(3rdEdition)SambrookandRussellVol.Ito III, 1989.*
- *6.PrinciplesofGeneManipulation6thEdition,S.B.Primrose,R.M.TwymanandR.W. Old. Blackwell Science, 2001.*

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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Fifth(V) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-504** | **CourseTitle:MICROBIAL REMEDIATION** | |
| **CourseOutcomes (COs)** | | |

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- Understandtheprinciplesandscopeofmicrobialremediationanditsimportancein environmental biotechnology.
- Identifydifferenttypesofpollutantsandcomprehendmicrobialstrategiesfortheir degradation or transformation.
- Evaluatetheroleofaerobicandanaerobicmicrobialpathwaysinbioremediationof industrial, agricultural, and heavy metal pollutants.
- Gaininsightintopracticalapproachesincludingbiosensorsandgeneticallyengineered microbes for effective remediation strategies.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| **I** | • IntroductiontoMicrobialRemediation:Scopeand Significance<br>• TypesofEnvironmentalPollutants:Organic,Inorganic, Agrochemical, and Heavy Metals<br>• Microbialmetabolismandtransformationofxenobiotics<br>• Factorsaffectingmicrobialremediationefficiency | **3** |
| **II** | • Microbialdegradationofhydrocarbonsandoil spills<br>• Bioremediationofpesticidesandagrochemical wastes<br>• AerobicvsAnaerobicremediation pathways<br>• Casestudiesonfieldapplicationsofmicrobial remediation | **3** |
| **III** | • Microbialmechanismsforheavymetalremediation: Biosorption, bioaccumulation, bioprecipitation<br>• Useoffungi and algaeinheavymetal cleanup<br>• Bioleachingandmicrobialmining<br>• Geneticengineeringapproachesinmicrobial remediation | **6** |

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| **IV** | • Insitu andEx situremediation techniques<br>• Biosensorsforpollutantdetectionandmonitoring<br>• Role ofconsortia and synthetic biologyin remediation<br>• Futuretrends:Biostimulation,bioaugmentation, and sustainable technologies | **3** |

**SuggestiveReadingBooks:**

- *EnvironmentalMicrobiologybyR.M.Maier,I.L.Pepper,C.P.Gerba,AcademicPress.*
- *Bioremediation:PrinciplesandApplicationsbyR.L.CrawfordandD.L.Crawford, Cambridge University Press.*
- *EnvironmentalBiotechnologybyBruceE.RittmannandPerryL.McCarty,McGraw Hill.*
- *MicrobialEcology:FundamentalsandApplicationsbyRonaldM.AtlasandRichard Bartha.*
- *ManualofEnvironmentalMicrobiology(3rdEdition),EditedbyC.J.Hurstetal.,ASM Press.*

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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Fifth(V) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-505** | **CourseTitle:MICROBIALENZYMEPRODUCTION ANDITSAPPLICATION** | |

**CourseOutcomes (COs)**

- Understandthesources,types,andmechanismsofmicrobialenzymeproduction.
- Describeupstreamanddownstreamprocessesforenzymeproduction,purification,and characterization.
- Identifytheindustrialapplicationsofmicrobialenzymesinpharmaceuticals,food, textiles, and bioremediation.
- Analyzestrategiesforstrainimprovement,enzymeengineering, andregulatoryaspects of enzyme commercialization.

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| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |
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| **Unit** | **Topics** | **No.ofLectures** |
| **I** | • Introductiontomicrobialenzymes:types,classification (EC system) and significance<br>• Sourcesofmicrobialenzymes:Bacteria,fungi, actinomycetes<br>• Primaryandsecondarymetabolisminenzyme production<br>• Regulationofenzyme biosynthesis | **6** |
| **II** | • Fermentationtechnologyforenzymeproduction (submerged and solid-state)<br>• Optimizationoffermentationparameters<br>• Downstreamprocessing:extraction,purification,and concentration of enzymes<br>• Enzymeformulationand stabilization | **3** |
| **III** | • Characterizationofmicrobialenzymes:activity,kinetics, pH/temperature stability<br>• Immobilizationofenzymesandtheir advantages<br>• Geneticengineeringandstrainimprovementfor enhanced enzyme yield | **3** |
| | • Expressionsystems:Recombinantenzymeproductionin *E.coli*,yeast | |
| **IV** | • Applicationsofmicrobialenzymesinfood(amylase, protease), textiles (cellulase), pharmaceuticals (penicillinase),anddetergents(lipase)<br>• Roleinbioremediationandenvironmentalapplications Enzymes in molecular biology (Taq polymerase, restrictionenzymes)<br>• Regulatory,patenting,andcommercializationaspects | **3** |

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**SuggestiveReadingBooks:**

- *IndustrialEnzymesandBiotechnologybyAjit Sadana*
- *Enzymes:Biochemistry,Biotechnology,ClinicalChemistrybyTrevorPalmer*
- *IndustrialMicrobiologybyL.E. Casida*
- *PrinciplesofFermentationTechnologybyPeterF.Stanbury,AllanWhitaker,andStephen J.Hall*
- *Biotechnology:ATextbookofIndustrialMicrobiologybyWulfCruegerandAnneliese Crueger*
- *MicrobialBiotechnologybyAlexanderN.GlazerandHiroshiNikaido*

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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Sixth(VI) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:** | **CourseTitle:VACCINE DEVELOPMENT** | |
| **CourseOutcomes (COs)** | | |
| • Understandthehistoryand basicimmunologicalprinciplesof vaccines.<br>• Explainvarioustypesofvaccines andtheirmechanismsofaction.<br>• Demonstrateknowledgeofmodernvaccineproductiontechnologiesincluding recombinant and mRNA-based vaccines.<br>• Evaluatesafety,efficacy,regulatoryframeworks,andethicalconcernsrelatedtovaccine development. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| **Unit** | **Topics** | **No.ofLectures** |
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|---|---|---|
| **I** | **IntroductiontoVaccinesandImmunological Basis**<br>• Historyandevolution of vaccines<br>• Typesofimmunity:Activeandpassive<br>• Antigen,antibody,andimmuneresponse<br>• Principlesofvaccine-induced protection<br>• Herd immunityandcommunityprotection<br>• Idealcharacteristicsofvaccines | **6** |
| **II** | **TypesofVaccinesandTheirMechanisms**<br>• Liveattenuatedandinactivatedvaccines<br>• Toxoidvaccines<br>• Subunitandconjugatevaccines<br>• RecombinantDNAandvector-based vaccines<br>• DNAandmRNAvaccines<br>• Adjuvantsandtheirrole inenhancingimmunogenicity | **3** |
| **III** | **VaccineProductionTechnologies**<br>• Vaccinedevelopmentpipeline:Discoverytodeployment<br>• Cellcultureandfermentationinvaccineproduction<br>• Purificationandformulationofvaccines<br>• Coldchainmanagementanddeliverysystems<br>• Casestudies:COVID-19,HPV,HepatitisBvaccines<br>• Roleofbioinformaticsandreverse vaccinology | **3** |
| **IV** | **Regulatory,Ethical,andGlobalAspects**<br>• Clinicaltrials:Phases I–IV<br>• Safetyevaluationandpost-marketingsurveillance<br>• Regulatorybodies:WHO,FDA,DCGI<br>• Intellectualpropertyrightsinvaccine development<br>• Ethicalissuesinvaccinetrialsanddistribution<br>• Globalinitiatives:GAVI,COVAX,UNICEF | **3** |

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**SuggestiveReadingBooks:**

- *StanleyA.Plotkinet al. –Vaccines, Elsevier*
- *IanR.Tizard–Immunology:An Introduction*
- *LaurenSompayrac–HowtheImmuneSystemWorks Janeway's*
- *Immunobiology – Kenneth Murphy*
- *WHOGuidelinesandCDCVaccineInformationStatements*

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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Sixth(VI) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-605** | **CourseTitle:STEMCELL BIOLOGY** | |

**CourseOutcomes (COs)**

- Theobjectiveofthispaperistofamiliarizethestudentswithstemcelltechnologyandits applications for betterment of the society.
- Thecourseisdesignedtogiveabroadviewofmammalianstemcells,reviewingwhere they are found in the body, the different types and how they are cultured.
- Thetopicswillcoverthebasicbiologyofthesestemcellsaswellasbioengineeringand application of these stem cells to potential treatments of human diseases.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| **I** | **Introductiontostemcells**<br>• Definition,properties, proliferation<br>• Cultureof stem cells,<br>• Medicalapplicationsofstemcells<br>• Ethicalandlegalissuesinuseofstemcells. | **3** |

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| **II** | **Typesof stemcells.**<br>• StemCellbiologyand therapy,<br>• Types:Embryonicstemcell,adultstemcell<br>• StemCellBiologyandTherapy<br>• EmbryonicStemCells<br>• Cultureandthepotentialbenefitsofstemcelltechnology | **3** |
| **III** | **Therapeuticapplicationsof stemcells**<br>• GeneTherapy:Introduction,Historyandevolutionof Gene therapy, optimal disease targets,<br>• Failuresandsuccesseswithgenetherapyandfuture prospects,<br>• GeneticPerspectivesforGeneTherapy<br>• GeneDeliverymethods:ViralvectorsandNon-viral Vectors | **6** |
| **IV** | **EthicalIssuesassociatedwithstemcell-basedregenerative medicine field**<br>• RegulatoryandEthicalConsiderationsofstemcelland Gene Therapy,<br>• AssessingHumanStemCell Safety<br>• UseofGeneticallyModifiedStemCellsinExperimental Gene Therapies. | **3** |
| **SuggestiveReadingBooks:**<br>• *StemCellBiology,DanielMarshak,RichardL.GardenerandDavidGottlieb,Cold Spring Harbour Laboratory Press*<br>• *Stemcellbiologyandgenetherapy,BoothC.,CellBiologyInternational,Academic Press*<br>• *StemCellandGene-BasedTherapy:FrontiersinRegenerativeMedicine,Alexander Battler, Jonathan Leo, Springer,* | | |

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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Sixth(VI) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-605** | **CourseTitle:DRUGDESIGNINGAND DEVELOPMENT** | |

**CourseOutcomes (COs)**

Bythe end ofthis course,studentswill be able to:

- Understandthe principlesand stagesof drugdiscoveryand development.
- Explainmoleculartargetsandmechanisms ofdrugaction.
- Applybioinformatics andbiotechnologicaltoolsinrationaldrugdesign.
- Understandpharmacokinetics,pharmacodynamics,andtoxicological screening.
- Comprehendregulatoryguidelinesandethicalaspectsindrugdevelopment.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **IntroductiontoDrugDiscoveryandDevelopment**<br>• Definitionandscopeof drugdesignand development<br>• Historicaloverviewofdrugdiscovery<br>• Stagesofdrugdevelopment:Discovery,Preclinical, Clinical, and Post-marketing<br>• Sourcesofdrugs:Natural,synthetic,and biotechnological origins<br>• Conceptofleadcompoundandleadoptimization<br>• Overviewofpharmaceuticalbiotechnologyand biologics | **3** |
| II | **MolecularTargetsandMechanismsofDrugAction**<br>• Typesofdrugtargets:Enzymes,receptors,nucleicacids, and ion channels<br>• Receptortheoryandsignaltransduction pathways<br>• Enzymeinhibition:Competitive,non-competitive, irreversible<br>• Examplesoftarget-baseddrugdesign(e.g.,HIV protease inhibitors, kinase inhibitors) | **3** |

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| **III** | **Approachesin DrugDesign**<br>• Rationaldrugdesignvs.randomscreening<br>• Computer-Aided Drug Design (CADD): Molecular modeling,docking,QSAR,pharmacophoremapping<br>• High-throughputscreening (HTS)<br>• RoleofbioinformaticsandAIin moderndrugdiscovery | **3** |
| **IV** | **BiotechnologicalandModernDrug Development**<br>• RecombinantDNAtechnologyindrugdevelopment (e.g., insulin, monoclonal antibodies)<br>• Vaccines:Types(DNA,mRNA,subunit,viralvector-based) and development process<br>• GenetherapyandCRISPR-based therapeutics<br>• Personalizedmedicineandpharmacogenomics<br>• Ethicalissuesandfutureperspectivesindrugdesign | **6** |

**SuggestiveReadingBooks:**


- *Patrick,G.L.AnIntroductiontoMedicinalChemistry,OxfordUniversityPress.*
- *Silverman,R.B.TheOrganicChemistryofDrugDesignandDrugAction,Academic Press.*
- *Lemke,T.L.etal.Foye'sPrinciplesofMedicinalChemistry,LippincottWilliams&Wilkins.*
- *WilsonandGisvold'sTextbookofOrganicMedicinalandPharmaceuticalChemistry.*
- *Rang,H.P.etal.Pharmacology,Elsevier.*
- *Nogrady,T.&Weaver,D.MedicinalChemistry:AMolecularandBiochemicalApproach.*


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| **Programme/Class:**B.Sc. | **Year:**Third (III) | **Semester:**Sixth(VI) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-605** | **CourseTitle:MUSHROOMCULTIVATION TECHNIQUES** | |
| **CourseOutcomes (COs)** | | |

Aftercompletionofthiscourse, studentswillbeable to:

- Understandthe biologyand taxonomyofedible and medicinalmushrooms.
- Learntechniquesforspawnpreparation,substrateselection,and cultivation.
- Acquirepracticalknowledgeofmushroomcultivationundercontrolledandnatural conditions.
- Understandpost-harvest processing,valueaddition,andmarketingofmushrooms.
- Appreciatethebiotechnological andcommercialpotentialofmushrooms.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **IntroductiontoMushrooms**<br>• Generalintroductionand importanceofmushrooms<br>• History,scope,andsignificanceofmushroomcultivation in India and globally<br>• Classificationofedible,medicinal,andpoisonous mushrooms<br>• Lifecycleandmorphologyofcommonmushrooms (Agaricus, Pleurotus, Volvariella, Ganoderma)<br>• Nutritionalandtherapeuticvalueofediblemushrooms<br>• Economicimportanceandemploymentopportunitiesin mushroom farming | **3** |
| II | **SpawnandSubstrate Preparation**<br>• Pureculturetechniquesandisolationofmushroom mycelium<br>• Spawn:Definition,types(grain,sawdust,compost-based), and preparation methods<br>• Maintenanceandstorage ofspawn<br>• Substrateselection:Agriculturalwastes(paddystraw, wheat straw, sawdust, etc.)<br>• Substratepasteurizationandsterilizationtechniques<br>• Preparationofcompostforbuttonmushroomcultivation | **3** |

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| **III** | **CultivationMethodsandGrowthConditions**<br>• Phasesofmushroomcultivation:composting,spawning, casing, cropping<br>• Environmentalparameters:temperature,humidity, ventilation, light, and $CO_2$ control<br>• Cultivationtechniques for: | **3** |
| | ○ **Oystermushroom(Pleurotusspp.)**<br>○ **Buttonmushroom(Agaricusbisporus)**<br>○ **Paddystrawmushroom(Volvariellavolvacea)**<br>• Commonpests,diseases,andtheir management<br>• Organicandintegratedcultivation practices | |
| **IV** | **Post-harvestManagementand Commercialization**<br>• Harvesting,cleaning,grading,packaging,andstorage techniques<br>• Processingofmushrooms:drying,canning,pickling, powdering, and value-added products<br>• Nutraceuticalandpharmaceuticalapplicationsof mushrooms<br>• Qualitycontrolandsafetyaspects<br>• Mushroomfarmdesign,economics,andbusiness planning | **6** |

**SuggestiveReadingBooks:**


- *Chang,S.T.&Miles,P.G.(2004).Mushrooms:Cultivation,NutritionalValue, Medicinal Effect, and Environmental Impact. CRC Press.*
- *Singh,R.S.&Chauhan,R.(2019).MushroomCultivation.CBSPublishers.*
- *Pathak,V.N.,Yadav,N.,&Gaur,S.N.(1998).MushroomProductionandProcessing Technology. Agrobios.*
- *Kumar,R.(2015).ModernMushroomCultivation.DayaPublishingHouse.*
- *Verma,R.N. &Bhat,J.(2000).HandbookofMushroomCultivation.IBHPublishing.*


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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Seventh(VII) |

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| **Subject:**BIOTECHNOLOGY | |
| **CouseCode:BSBT-705** | **CourseTitle:LITERATUREREVIEW AND SCIENTIFICWRITING** |
| **CourseOutcomes (COs)** | |
| • Understandthepurpose,types,andprocessofliteraturereviewinscientificresearch.<br>• Acquireskillsinsearching,retrieving,andcriticallyAnalyzingscientificliteratureusing databases and tools Develop competence in organizing scientific information, paraphrasing, andavoidingplagiarism.<br>• Learnprinciplesofscientificwritingfordifferentformatsincludingarticles,reports,and reviews.<br>• Applyreferencingstyles,citationmethods,andethicalstandardsinscientific communication. | |
| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| **I** | • Purposeandsignificance ofliteraturereview<br>• Typesofliteraturereview:Narrative,Systematic,Meta-analysis, Scoping reviews<br>• Stepsinconductingliteraturereview<br>• Identifyingresearchgapsandframingresearch questions<br>• Importanceofliteraturereviewinresearchproposal development | **3** |
| **II** | • Typesofscientificpublications:Primary,Secondary,and Tertiary<br>• Scientificdatabases:PubMed,Scopus,WebofScience, Google Scholar<br>• Searchstrategies:Keywords,Booleanoperators, Filters<br>• UseofReferenceManagementTools(Mendeley,Zotero, EndNote)<br>• Criticalappraisalofresearcharticles(usingchecklistsor frameworks) | **6** |

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| **III** | • Structureofscientificarticles:IMRADformat (Introduction, Methods, Results, Discussion)<br>• Abstractwritingandgraphicalabstractbasics<br>• Paraphrasing,Summarizing,andSynthesizingliterature<br>• Avoidingplagiarism:Tools andTechniques (Turnitin, iThenticate)<br>• Writingstyle:Clarity,Conciseness,Consistency,and Coherence | **3** |
| | • CitationStyles:APA,MLA,Vancouver,Harvard,and Chicago<br>• In-textcitationsandReferencelist preparation<br>• Ethicalstandardsinscientificpublishing:Authorship, Conflicts of Interest, Data Integrity | |
| **IV** | • ComponentsofaTechnicalReport:Titlepage,Executive summary, Introduction, Body, Conclusion<br>• WritingResearchProposals:Background,Objectives, Methodology, expected outcomes, Budget<br>• ScientificPresentations:Oral,Poster,andDigital Presentations<br>• Commonmistakesinscientificwritingandhowtoavoid them<br>• PeerReviewProcess:Submission,Review,andRevision stages<br>• Copyrights,Licensing,andOpenAccessPublishing<br>• CaseStudiesonEthical IssuesinScientificWriting | **3** |

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**SuggestiveReadingBooks:**

- *Day,R.A.&Gastel,B.—HowtoWriteandPublishaScientificPaper(Cambridge University Press)*
- *Hofmann,A.H.—ScientificWritingandCommunication:Papers,Proposals,and Presentations (Oxford University Press)*
- *Glasman-Deal,H.—ScienceResearchWritingforNon-NativeSpeakersofEnglish (World Scientific)*
- *Lang,T.A.&Secic,M.—HowtoReportStatisticsinMedicine(AmericanCollegeof Physicians)*
- *Peat,J.,Elliott,E.,Baur,L.,&Keena,V.—ScientificWriting:EasyWhenYouKnow How (BMJ Books)*

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| **Programme/Class:**B.Sc. | **Year:**Fourth(IV) | **Semester:**Eighth (VIII) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:BSBT-802** | **CourseTitle:ENTERPRENEURSHIPIN BIOTECHNOLOGY** | |
| **CourseOutcomes (COs)** | | |
| • Understandthefundamentalsofentrepreneurshipanditsimportanceinthebiotechnology sector.<br>• Identifyinnovativebusinessopportunitiesin biotechnology.<br>• Acquireknowledgeaboutbusinessplanning,regulatoryaffairs,andintellectualproperty rights.<br>• Developskillsforlaunchingand managingbiotech startups. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| **Unit** | **Topics** | **No.ofLectures** |
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|---|---|---|
| **I** | **IntroductiontoEntrepreneurship&Innovation**<br>• Conceptandneedforentrepreneurshipinlifesciences and biotechnology.<br>• Characteristics and types of entrepreneurs: Technopreneurs,socialentrepreneurs,women entrepreneurs.<br>• Entrepreneurialmotivation,creativity,andinnovation.<br>• Roleofentrepreneurshipineconomicdevelopmentand employment generation.<br>• Governmentpoliciesandsupportforbiotechstartups (e.g., Startup India, BIRAC, DBT-BIG, MSME schemes). | **3** |
| **II** | **BusinessOpportunitiesin Biotechnology**<br>• Overviewofbiotechnologysectors:Healthcare, agriculture, environment, industrial biotech.<br>• Casestudiesofsuccessfulbiotechstartupsand innovations.<br>• Marketsurvey,identificationofbiotechbusiness opportunities.<br>• Valuechaininbiotechproductdevelopment:Fromlabto market.<br>• Sustainabilityandethicalconsiderationsinbiotech entrepreneurship. | **3** |

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| **III** | **BusinessPlanningandFinancing**<br>• Elementsofabiotechbusinessplan:Executive summary,businessmodel,marketingstrategy,technical feasibility, management team, financial planning.<br>• Fundingsources:Venturecapital,angelinvestors, government grants, crowdfunding.<br>• Costestimation,break-evenanalysis,profit-loss projection.<br>• RiskmanagementandSWOTanalysisinbiotech startups.<br>• Incubationandaccelerationsupportforbiotech entrepreneurs. | **6** |
| **IV** | **RegulatoryAffairs,IPRand Commercialization**<br>• Regulatoryframeworksinbiotechnology:CDSCO, DBT, FSSAI, GEAC, AYUSH, etc.<br>• IntellectualPropertyRights(IPR):Patents,trademarks, copyrights, trade secrets.<br>• PatentfilingprocessinIndiaandinternationalsystems (WIPO, PCT).<br>• Licensing,technologytransfer,andcommercialization strategies.<br>• Bioethics,biosafety,andenvironmentalregulationsin biotech product development. | **3** |

**SuggestiveReadingBooks:**

- *BiotechnologyEntrepreneurship:Starting,Managing,andLeadingBiotechCompanies– Craig Shimasaki*
- *InnovationandEntrepreneurship–PeterF.Drucker*
- *EntrepreneurshipDevelopment–S.S.Khanka*
- *BIRAC (DBT)Reports&Guidelines –www.birac.nic.in*
- *Indian Patent OfficeManual–* [www.ipindia.gov.in](http://www.ipindia.gov.in)
- *Journals:NatureBiotechnology,JournalofCommercialBiotechnology*

## MULTI-DISCIPLINARYCOURSESSYLLABUS

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**FIRST(I) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:**M-DIS-MBMD | **CourseTitle:MEDICALBIOTECHNOLOGYAND MOLECULAR DIAGNOSTICS** | |
| **CourseOutcomes (COs)** | | |
| • Toprovideunderstandingofmolecularbasisofdiseasesandtheir diagnosis.<br>• Toacquaintstudentswithadvancedmolecularandimmunologicaldiagnostictechniques.<br>• Tointroduceapplicationsofbiotechnologyinhumanhealth,therapeutics,and personalized medicine.<br>• Todevelopawarenessaboutethical,safety,andregulatoryissuesinmedical biotechnology. | | |
| **Credits:**3 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | No.ofLectures |
|---|---|---|
| **I** | • Introductiontomedicalbiotechnology:scopeand applications.<br>• Humangenomeandgeneticbasisofdiseases– monogenic, polygenic, and chromosomal.<br>• Molecularpathogenesis ofselectedgeneticdisorders (e.g.,cysticfibrosis,thalassemia,sicklecellanemia).<br>• Genetherapy:concept,methods(exvivoandinvivo), success stories and limitations.<br>• Stemcelltechnology–types,sources,andapplications in regenerative medicine.<br>• Productionoftherapeuticrecombinantproteins(insulin, interferons, growth hormones). | **15** |

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| **II** | • Conceptandimportance ofmolecular diagnostics.<br>• Clinicalsamplecollection,handling,andnucleicacid extraction.<br>• DNAandRNA-baseddiagnostic methods: PCRanditsvariants(RT-PCR,qPCR,multiplexPCR,digital PCR). DNAsequencingand DNAmicroarraytechnology.<br>• CRISPR/Cas-baseddiagnosticsImmunodiagnostics: ELISA, Western blotting, immunofluorescence.<br>• Biosensors–principles andapplications. | **10** |
| **III** | • Pharmacogenomicsandpersonalizedmedicine.<br>• Molecularbiomarkersindiseasediagnosisand prognosis.<br>• Modernvaccines:recombinant,subunit,DNA,and mRNAvaccines.<br>• Nanobiotechnologyindiagnosticsandtargeteddrug delivery.<br>• Artificialintelligence(AI)andmachinelearningin molecular diagnostics.<br>• Ethical,legal,andsocialimplications(ELSI)inmedical biotechnology.<br>• Regulatoryaspects,qualitycontrol,andbiosafetyin diagnostic laboratories. | **15** |

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**SuggestiveReadingBooks:**


- *Glick,B.R.&Pasternak,J.J.(2017).MolecularBiotechnology:Principlesand Applications of Recombinant DNA. Springer.*
- *Primrose,S.B.&Twyman,R.M.(2014).PrinciplesofGeneManipulationandGenomics. Wiley.*
- *Butler,J.M.(2015).ForensicDNATyping:Biology,Technology,andGeneticsofSTR Markers. Elsevier.*
- *Freshney,R.I.(2016).CultureofAnimalCells:AManualofBasicTechniqueand Specialized Applications. Wiley-Blackwell.*
- *Willey,J.M.etal.(2023).Prescott'sMicrobiology(12thEd.).McGraw-Hill.*
- *Kues,W.A.&Niemann,H.(2004).AdvancesinGeneTransferforAnimalBiotechnology and Biomedicine. Springer.*


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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**SECOND(II) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:**M-DIS-TARB | **CourseTitle:THRUSTAREAOFRESEARCHIN BIOTECHNOLOGY** | |

**CourseOutcomes (COs)**

- Toacquaintstudentswithcurrentandemergingresearchareasinbiotechnology.
- Tounderstandmoderntoolsandapplicationsinhealthcare,agriculture,environment,and industry.
- Toencourageinnovation,criticalthinking,andproblem-solvingskillsforresearch-oriented careers.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| **Unit** | **Topics** | **No.ofLectures** |
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|---|---|---|
| **I** | **FrontierAreasinBiotechnology**<br>• IntroductiontoResearchFrontiersinBiotechnology– Scope, global trends, and future perspectives.<br>• GenomicsandProteomics:Advancesingenome sequencing,functionalgenomics,proteomeanalysis,and bioinformatics applications.<br>• MolecularDiagnosticsandTherapeutics:CRISPR-Cas9, RNAinterference,genetherapy,andpersonalized medicine.<br>• StemCellandRegenerativeMedicine:Typesofstem cells,tissueengineering,andorganoidculture. | **15** |
| | • SyntheticBiologyandSystemsBiology:Designing biological circuits, metabolic engineering, and computationalmodeling. | |
| **II** | **AppliedandEnvironmental Biotechnology**<br>• IndustrialandEnzymeBiotechnology:Biocatalysts, enzyme engineering, fermentation technology, and bioprocess optimization.<br>• AgriculturalBiotechnology:Geneticallymodifiedcrops, biofertilizers, biopesticides, plant tissue culture, and stresstolerance.<br>• EnvironmentalBiotechnology:Bioremediation, bioleaching,biosensors,andwaste-to-energyconversion.<br>• MarineandMicrobialBiotechnology: Marine bioresources,extremophiles,andnovel biomolecules.<br>• ClimateChangeandBiotechnology:Carboncapture, algal biofuels, and sustainable bioproducts. | **10** |

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| **III** | • Nanobiotechnology:Nanomaterials,biosensors,targeted drug delivery, and bioimaging.<br>• BioinformaticsandComputationalBiology:Bigdata analysis, AI/ML in life sciences, and molecular modeling.<br>• VaccineResearchandImmunotechnology:DNA/RNA vaccines, monoclonal antibodies, and adjuvants.<br>• IntellectualPropertyRights(IPR)andBioethics:Patents, biosafety, biopiracy, and regulatory frameworks | 15 |

**SuggestiveReadingBooks:**

- *Primrose,S.B. &Twyman,R.M.PrinciplesofGeneManipulationandGenomics. Wiley.*
- *Glick,B.R. &Pasternak,J.J.MolecularBiotechnology:PrinciplesandApplicationsof Recombinant DNA. ASM Press.*
- *Jogdand,S.N.AdvancesinBiotechnology.HimalayaPublishing House.*
- *RecentresearcharticlesfromNatureBiotechnology,TrendsinBiotechnology, Biotechnology Advances.*
- *NITIAayog &DBTReportson"EmergingAreasofBiotechnologyResearchinIndia".*

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| **Programme/Class:**B.Sc. | **Year:**SECOND (II) | **Semester:**THIRD(III) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:**M-DIS-PB | **CourseTitle:PHARMACEUTICAL BIOTECHNOLOGY** | |

**CourseOutcomes (COs)**

- Tounderstandtheprinciples and applicationsof biotechnologyindrugdevelopment.
- Togainknowledgeaboutbiopharmaceuticals,vaccines,andrecombinanttherapeutic proteins.
- Tostudyproduction, formulation, andqualitycontrol of biotechnological drugs.

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| **Credits:**3 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| **Unit** | **Topics** | **No.ofLectures** |
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| **I** | **IntroductiontoPharmaceuticalBiotechnologyand Biopharmaceuticals**<br>• **OverviewofPharmaceuticalBiotechnology**: Definition, scope, and importance; historical developments.<br>• **Classification of Biopharmaceuticals**: Recombinant proteins,peptides,vaccines,monoclonalantibodies,and nucleic acid-based drugs.<br>• **Drug Discovery and Development Process**: Pre-clinicalandclinicalstudies;phasesofclinicaltrials; regulatory aspects (FDA, CDSCO).<br>• **GoodManufacturingPractices(GMP)andQuality Control**: Concept of GLP, GMP, and validation processes. | **15** |
| **II** | **MicrobialandAnimalCellCulturesinBiopharmaceutical Production**<br>• Expressionsystems:E.coli,yeast,mammaliancells.<br>• Upstreamanddownstream processing.<br>**RecombinantProteinProduction**:Insulin,humangrowth hormone, interferons, erythropoietin, monoclonal antibodies.<br>**Vaccines**:<br>• Types: Conventional (live, killed), recombinant, subunit, DNA and mRNA vaccines.<br>• Examples:HepatitisB,HPV,COVID-19vaccines.<br>**AdjuvantsandDeliverySystems**:Liposomes,nanoparticles, viral vectors. | **10** |
| **III** | **GeneTherapyandNucleicAcid-basedTherapeutics**:<br>• Conceptandstrategies (invivo,exvivo).<br>• siRNA,antisenseoligonucleotides,CRISPR-based therapeutics.<br>**DrugDeliverySystems**:Targetedandcontrolled release | **15** |

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| | systems;nanobiotechnologyin drugdelivery.<br>**TissueEngineeringandRegenerativeMedicine**:Artificial organs, stem cell-based therapy.<br>**Ethical,LegalandSocialIssues(ELSI)**:Biosafety,bioethics, intellectual property rights (IPR) in pharmaceutical biotechnology. | |

**SuggestiveReadingBooks:**

- *Walsh,G.(2018).PharmaceuticalBiotechnology:ConceptsandApplications.Wiley.*
- *Crommelin,D.J.A.,Sindelar,R.D.,Meibohm,B.(2019).PharmaceuticalBiotechnology: Fundamentals and Applications. Springer.*
- *Smith,J.E.(2020).Biotechnology.CambridgeUniversityPress.*
- *Prescot,L.M.,Harley,J.P.&Klein,D.A.Microbiology(LatestEd.)–Relevantsections on biopharmaceuticals.*
- *Rang,H.P.,Dale,M.M.Pharmacology(LatestEdition).*

## SKILLENHANCEMENTCOURSESYLLABUS

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**FIRST(I) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:SEC-QAPI** | **CourseTitle:QUALITYASSURANCEOFFOODAND PHARMACEUTICAL INDUSTRIES** | |

**CourseOutcomes (COs)**

- UnderstandQA/QCprinciples,regulatoryguidelines,anddocumentationsystems followed in food & pharma industries.
- Identifyqualityparameters,contaminants,andsafetystandardsinfoodproductsasper national and international norms.
- DemonstrateknowledgeofGMP,validation,andqualitycontroltestsusedin pharmaceutical industries.
- Performbasicanalytical andmicrobiologicaltechniquesforensuringqualityandsafety offoodand drugproducts.

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| • PrepareSOPsand applyconceptsofindustrialdocumentationandaudits. | | |
| **Credits:**2 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |
| **Unit** | **Topics** | **No.ofLectures** |
| **I** | **FundamentalsofQuality Assurance**<br>**ConceptsofQuality:**Quality,QualityControl(QC),Quality Assurance (QA), Good Laboratory Practices (GLP).<br>**Regulatory Framework:**<br>• Nationalstandards:FSSAI,BIS,AYUSH parameters.<br>• Internationalstandards:WHO,FAO,Codex Alimentarius.<br>**QualityManagementSystems(QMS):**ISO9001,ISO22000 (Food Safety), GxP (Good Practices).<br>**Documentation:**SOPs,batchmanufacturingrecords,audit trails, traceability, deviation reports.<br>**RiskAnalysis:**HACCP(HazardAnalysisandCriticalControl Points) – principles and applications. | **10** |
| **II** | **QualityAssurancein FoodIndustries**<br>**FoodSafety&Sanitation:**Foodhygiene,GMPsinfood processing, sanitation standard operating procedures.<br>**Food QualityParameters:** Physical, chemical, microbiological indicators of food quality; adulteration testing.<br>**FoodPackaging&Labelling:**Packagingmaterials,safetyconsider ations, labelling requirements as per FSSAI.<br>**Food ProductTesting:** Shelf-lifeassessment,sensoryevaluation techniques, nutrient profiling.<br>**Contaminants & Residues:** Heavy metals, pesticides, mycotoxins—testingand permissiblelimits. | **10** |

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| **III** | **Quality Assurance in Pharmaceutical Industries**<br>**RegulatoryBodies:**CDSCO,USFDA,EMA,WHO-GMP norms.<br>**Good Manufacturing Practices (GMP):** Facility design, personnelhygiene,cleanrooms,environmentalmonitoring.<br>**Quality Control Tests:**<br>• Tablets:hardness,friability,disintegration, dissolution. | **10** |
| | • Capsules:uniformity,weightvariation.<br>• Syrups/injectables: sterility, clarity, pyrogen testing.<br>**ValidationProcesses:**Processvalidation,methodvalidation, equipment calibration.<br>**PharmaceuticalDocumentation:**Batchrecords,change control,CAPA(Corrective&PreventiveAction), audits. | |
| **SuggestiveReadingBooks:**<br>• *FSSAIManualsforFoodSafetyTesting*<br>• *WHOTechnicalReportSeries(GMPguidelines)*<br>• *"QualityAssuranceinPharmaceuticals"–WHO*<br>• *"FoodQualityAssurance"– Ronald Schmidt&Gary Rodrick*<br>• *"PharmaceuticalQualityAssurance"–Dipankar SenGupta* | | |

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**SECOND(II) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:SEC-PMM** | **CourseTitle:PRODUCTIONOFMICROGREENSAND MUSHROOM** | |
| **CourseOutcomes (COs)** | | |

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- Understandthebasicsofmicrogreenandmushroombiology,productionrequirements, and market importance.
- Demonstratetheabilitytocultivatemicrogreensandmushroomsusingappropriate substrates and environmental conditions.
- Acquireskillsinharvesting,post-harvesthandling,andpackagingtomaintainquality and safety.
- Developentrepreneurial skillsforsmall-scalecommercialproductionand valueaddition.
- Prepare,manage,andevaluateamicro-scaleproductionunitfollowingNEPskill-oriented learning goals.

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| **Credits:**2 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **Introduction & Basics of Microgreens**<br>**ProductionConceptofMicrogreens:**Definition,differencefromsprouts and baby greens; importance and market demand.<br>**Nutritional&FunctionalProperties:**Vitamins,minerals, antioxidants, phytochemicals.<br>**GrowingRequirements:**<br>• Cropselection—mustard,radish,basil,fenugreek,beet, broccoli, sunflower, pea shoots. | **10** |
| | • Growthmedia—soil,cocopeat,jutemats,hydroponic pads.<br>• Light,temperature,humidityneeds.<br>**ProductionTechnology:**<br>• Seeddensity,soaking,sowing,misting,watering schedule.<br>• Use of trays, shelves, vertical farming setups.<br>**Harvesting&Post-harvestHandling:**Cutting,washing, drying, packing, storage, shelf-life.<br>**Quality&Safety:**Hygieneprotocols,microbialrisk reduction, food safetystandards. | |

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| **II** | **Basicsof MushroomCultivation**<br>**Introduction to Edible Mushrooms:** Button mushroom, oyster mushroom, shiitake, milky mushroom.<br>**Biology of Mushrooms:** Mycelium growth, substrate colonization, fruiting body development.<br>**SubstratePreparation:**Wheatstraw,paddystraw,sawdust; pasteurization, sterilization methods.<br>**SpawnProduction&Handling:**Typesofspawn,motherspawn, commercial spawn, inoculation techniques.<br>**Cultivation Technology:**<br>• Bagmethod,traymethod,shelfmethod.<br>• Environmental management—humidity, temperature, aeration, light.<br>**Pest&DiseaseManagement:**Greenmould,bacterialblotch, insects,mites—preventionandcontrol. | **10** |
| **III** | Entrepreneurship,Value Addition&Marketing<br>**Small-ScaleMicrogreensBusiness:**Start-uprequirements,cost analysis, space optimization (balcony/indoor/greenhouse).<br>**Small-ScaleMushroomBusiness:**Unitsetup,substrate procurement, production cycle cost, yield estimation.<br>**Value-Added Products:**<br>• Microgreens:powders,mixes,saladkits,ready-to-eat packs.<br>• Mushrooms:dehydratedmushrooms,mushroompickles, powders, snacks.<br>**Packaging&Branding:**Labellingrequirements,shelf-life extension, eco-friendly packaging.<br>**MarketingStrategies:** Localmarkets, supermarkets, restaurants,onlinedirect-to-consumer(D2C) models. | **10** |

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| | **GovernmentSchemes&TrainingSupport:**Agri-start-ups, MSMEsupport,NABARD,KrishiVigyanKendra(KVK) programs. | |

**SuggestiveReadingBooks:**

- *"Microgreens:AGuidetoGrowingNutrient-DenseFoods"–EricFranks*
- *"HandbookofMushroomCultivation"–SatishBhatt*
- *ICAR/KVKMushroomCultivationManuals*
- *FAOManualsonSmall-ScaleAgricultureProduction*

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**SECOND (II) | **Semester:**THIRD(III) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:SEC-OF** | **CourseTitle:ORGANICFARMING** | |

**CourseOutcomes (COs)**

Understand the principles, concepts, and regulatory framework of organic farming.
Applyorganicinputs,nutrientmanagement,andbiologicalcontroltechniquesforcrop production.
Analyze soil health and implement eco-friendly agronomic practices.
Demonstratepracticalskillsinorganicinputpreparationandcropcultivation.
Developentrepreneurshipskillsandknowledgeofcertificationandmarketingoforganic produce.

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| **Credits:**2 | **CoreCompulsory** |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms |

| **Unit** | **Topics** | **No.ofLectures** |
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|---|---|---|
| **I** | Principles and Concepts of Organic Farming<br>**IntroductiontoOrganicAgriculture:**Definition,scope, importance, and history.<br>**PrinciplesofOrganicFarming:**Health,ecology,fairness,care (IFOAM standards).<br>**SoilHealth Management:**<br>• Soilphysical,chemical,andbiological properties.<br>• Soilorganicmatter,humusformation,carbon sequestration.<br>**OrganicManures&Soil Amendments:**<br>• Farmyardmanure(FYM),compost,greenmanure, vermicompost.<br>• Biofertilizers:Rhizobium,Azotobacter,Azospirillum, PSB, VAM fungi.<br>**SustainableFarmingSystems:**Croprotation, intercropping, mixedfarming,mulching,conservation practices. | **10** |
| | **CertificationSystems:**NPOP,FSSAIorganicstandards,PGS-India. | |

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| **II** | **OrganicCropProductionPractices**<br>**Seed and Planting Material:** Organic seed production, seed treatment methods.<br>**Nutrient Management in Organic Systems:** Nutrient cycles, preparation and application of organic formulations (jeevamrut, panchagavya).<br>**Pest&DiseaseManagement:**<br>• Biologicalcontrolagents:Trichoderma,Pseudomonas, Bacillus.<br>• Botanicalpesticides:neem,cowurineextract,chilli- garlic extract.<br>• Cultural&mechanicalcontrolmethods.<br>**WaterManagementinOrganicFarming:**Micro-irrigation, rainwater harvesting, moisture conservation.<br>**Weed Management:** Manual, mechanical, mulching, biological methods.<br>**OrganicFarmingModels:**<br>• Naturalfarming(SubhashPalekarmodel).<br>• IntegratedOrganicFarmingSystem (IOFS).<br>• Kitchengardens/terracegardens. | **10** |

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| **III** | OrganicCertification,Marketing&Entrepreneurship<br>**CertificationProcedures:**<br>• StepsforNPOPandPGS-Indiacertification.<br>• Farmdocumentation,fieldhistorysheets,inspection,and audit.<br>**Standards&Regulations:**Nationalandinternational(NPOP, USDA Organic, EU organic standards).<br>**Post-HarvestManagement:**Cleaning,grading,processing, packaging, and storage of organic produce.<br>**ValueAddition:**Organicfoods—millets,herbalteas,spices, fruits, vegetables, processed products.<br>**SupplyChain &Marketing:**<br>• Farmers'markets,e-commerce,farm-to-table models.<br>• Brandingandlabellingrequirementsfororganic products.<br>**EntrepreneurshipOpportunities:** | **10** |

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| | • Organicinputproduction(vermicompost,biofertilizers, biopesticides).<br>• Organicvegetable/fruitscultivation,nichemarkets, community-supported agriculture (CSA).<br>• Governmentsupport—NABARD,APEDA,PKVY,FPO formation. | |

**SuggestiveReadingBooks:**

- *IFOAM–PrinciplesofOrganicAgriculture*
- *NPOP(NationalProgrammeforOrganicProduction)Guidelines*
- *"OrganicFarmingforSustainableAgriculture"–R.Bhavadas*
- *ICAROrganicFarming Manuals*
- *FAO SustainableAgricultureGuides*

## VALUEADDEDCOURSESYLLABUS

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|---|---|---|
| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**FIRST(I) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:VAC-FTBT** | **CourseTitle:**FERMENTATIONTECHNOLOGYAND BIOPROCESSTRAINING | |
| **CourseOutcomes (COs)** | | |
| Explaintheprinciplesoffermentation,typesofbioprocesses,andindustrialapplications. Demonstrate basic skills in handling fermenters and maintaining aseptic conditions. Describemediumformulation,sterilization,andprocessparametersinfluencingmicrobial growth. Performsmall-scalebatchfermentationand analyzekeybioprocess parameters. Understanddownstreamprocessingtechniquesusedinbioproduct recovery. | | |
| **Credits:**1 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

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| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **BasicsofFermentationTechnology**<br>• Definitionandscopeof fermentation<br>• Typesoffermentation:batch,fed-batch, continuous<br>• Microbialgrowth kinetics basics<br>• Industriallyimportantmicroorganisms<br>• Applicationsoffermentationinpharma,food,agriculture, biomolecules | **4** |
| II | **BioprocessEquipment&Operations**<br>• Designandcomponentsofa fermenter/bioreactor | **4** |
| | • Asepticoperation &sterilization ofmediaand bioreactor<br>• Aerationand agitation:oxygentransfer,foam control<br>• Sensorsandcontrols(pH,DO, temperature)<br>• Inoculumdevelopmentandscale-upbasics | |
| III | **LabHands-On Trainingin Fermentation**<br>• Preparationoffermentation media<br>• Sterilizationandaseptic techniques<br>• Inoculumpreparation<br>• Settingup asmall-scalebatch fermentation<br>• Monitoringgrowth byOD,pH, substrate utilization<br>• Plottinggrowthcurveandinterpretingfermentationdata | **4** |
| IV | **DownstreamProcessing&ProductRecovery**<br>• Cellseparation:centrifugation, filtration<br>• Celldisruption:physicalandchemical methods<br>• Purificationofmetabolites(precipitation,extraction)<br>• Overviewofchromatographyinbioprocessing<br>• Qualitycontrol of fermentation products | **3** |
| **SuggestiveReadingBooks:**<br>• *PrinciplesofFermentationTechnology–Stanbury,Whitaker&Hall*<br>• *BioprocessEngineering:BasicConcepts–Shuler&Kargi*<br>• *BiochemicalEngineering – Bailey&Ollis*<br>• *OnlinemodulesfromDBT,NPTEL&FSSAISkill Training* | | |

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| **Programme/Class:**B.Sc. | **Year:**FIRST(I) | **Semester:**SECOND(II) |
| **Subject:**BIOTECHNOLOGY | | |
| **CouseCode:VAC-EBSI** | **Course Title: ENTREPRENEURSHIP IN BIOTECHNOLOGY/STARTUPINCUBATION** | |
| **CourseOutcomes (COs)** | | |
| Describethefundamentalsofentrepreneurshipandopportunitiesinthebiotechnologysector. Identify biotechnological product ideas and assess feasibility for startups. Demonstrateunderstandingofregulatory,IP,andbiosafetyrequirementsinbiotech entrepreneurship. Developa basic businessmodel canvasfor abiotechnologystartup. | | |
| **Credits:**1 | **CoreCompulsory** | |
| **MaximumMarks:100** | **MinimumPassingMarks:** As perUniversitynorms | |

| Unit | Topics | No.ofLectures |
|---|---|---|
| I | **IntroductiontoBiotechnology Entrepreneurship**<br>• Conceptofentrepreneurship,intrapreneurship<br>• Characteristicsofbiotech entrepreneurs<br>• Overviewofbiotechindustries:pharma,agriculture,food, diagnostics, environmental<br>• Emergingtrendsandstartupopportunitiesin biotechnology<br>• RoleofNEP infosteringinnovation and skill development | **4** |
| II | **Innovation, Idea Generation & Product Development**<br>*Identifying*problemsandconvertingthemintoentrepreneurial opportunities<br>• Ideascreeningandfeasibilityanalysis<br>• Stagesofbiotechproductdevelopment<br>• MinimumViableProduct (MVP)conceptforbiotech<br>• Casestudiesofsuccessfulbiotechstartupsin India | **3** |

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| **III** | **Regulatory,IP,andBiosafetyRequirements**<br>• Introductiontobiosafetylevels,ethicalissuesinbiotech startups<br>• Overviewofregulatorybodies:DBT,CDSCO,FSSAI, GEAC, ICMR<br>• Qualitystandards:GLP,GMPbasics<br>• IntellectualPropertyRights(IPR):patents,copyrights, trademarks<br>• Processofpatentfilinginbiotech sector | **4** |
| **IV** | **StartupIncubation,Funding&BusinessModel Development**<br>• Roleofincubators,accelerators,andtechnologytransfer offices<br>• Governmentschemes:StartupIndia,BIRAC-BIG,DBT-BioNest, MSME<br>• Basicsofbusiness planning<br>• BusinessModelCanvas(BMC)forbiotechnology ventures<br>• Preparingasimple pitchdeckfor investors | **4** |

**SuggestiveReadingBooks:**

- *BiotechnologyEntrepreneurship:Starting,Managing,andLeadingBiotechCcompanies– Craig Shimasaki*
- *Bioentrepreneurship:ConceptsandCases–Prasad&Ramesh*
- *DBT&BIRACentrepreneurshipschemebooklets*
- *Startup India LearningModule*

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