

**Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS),
PUNE**

Syllabus

for

S. Y. M. Sc. (Biotechnology)

[Pattern 2019]

(M.Sc. Semester-III and Semester-IV)

From Academic Year

2020-21

F.Y.M.Sc.				
Particulars		Course Code	Course Title	No. of Credits
Sem-I	Theory Paper - 1	BTH4101	Molecular Biology	04
	Theory Paper - 2	BTH4102	Cell Biology	04
	Theory Paper - 3	BTH4103	Biological Chemistry and Bacteriology	04
	Theory Paper - 4	BTH4104	Developmental Biology and Human Population Genetics	04
	Practical Paper - 1	BTH4105	Practicals in Biotechnology-I	04
	Practical Paper - 2	BTH4106	Practicals in Biotechnology-II	04
Sem-II	Theory Paper - 5	BTH4201	Genetic Engineering and Industrial Biotechnology-I	04
	Theory Paper - 6	BTH4202	Animal and Plant Biotechnology	04
	Theory Paper - 7	BTH4203	Virology and Immunology	04
	Practical Paper -3	BTH4204	Practicals in Biotechnology-III	04
	Practical Paper -4	BTH4205	Practicals in Biotechnology-IV	04
	Elective Paper -1	BTH4206	D: Critical Reading of Primary Scientific Literature OR	02
	Elective Paper -1	BTH4207	D: Agricultural Biotechnology OR	02
	Elective Paper -1	BTH4208	G: Environmental Biotechnology OR	02
	Elective Paper -1	BTH4209	D: Microbial Genetics OR	02
	Elective Paper -1	BTH4210	M: MOOCS-I	02
	Elective Paper -2	BTH4211	D: Clinical Research OR	02
	Elective Paper -2	BTH4212	D: Bioethics and Biosafety OR	02
	Elective Paper -2	BTH4213	G: Research Methodology OR	02
	Elective Paper -2	BTH4214	M: MOOCS-II	02
S.Y.M.Sc.				
Sem-III	Theory Paper - 1	BTH5301	Genomics and Proteomics	04
	Theory Paper - 2	BTH5302	Stem Cell Biology, Regenerative Medicine and Applied Biotechnology	04
	Theory Paper - 3	BTH5303	Industrial Biotechnology-II and Bioinformatics	04
	Practical Paper -5	BTH5304	Practicals in Biotechnology –V	04
	Practical Paper -6	BTH5305	Practicals in Biotechnology –VI	04
	Elective Paper -1	BTH5306	D: Analytical Techniques OR	02
	Elective Paper -1	BTH5307	D: Food technology OR	02
	Elective Paper -1	BTH5308	G: Nanotechnology OR	02
	Elective Paper -1	BTH5309	M: MOOCS-III	02
	Elective Paper -2	BTH5310	G: Bioentrepreneurship OR	02
	Elective Paper -2	BTH5311	D: Biostatics OR	02
	Elective Paper -2	BTH5312	G: Computational tools in Research OR	02
	Elective Paper -2	BTH5313	D: Emerging Trends and Technologies OR	02
	Elective Paper -2	BTH5314	M: MOOCS-IV	02
Sem-IV		BTH5401	Dissertation Project	08
			Total for the course	80

Abbreviations:

D: Departmental

G: General M: MOOC's

S.Y. M.Sc. Semester III
Biotechnology Paper -1 (BTH 5301) Genomics and Proteomics

[Credits-4]

Course Outcomes

At the end of this course, students will be able to

- CO1** • Analyze whole genomes, sequencing strategies, comparing genomes and understand its applications in drug efficacy and disease association
- CO2** • Understand genome expression and analysis tools
- CO3** • Analyze whole proteomes and to understand protein networks and protein-protein interactions

Unit	Details	Lectures
I	Genomics: Genomics and Proteomics overview, omes and omics: Concepts and applications. Transition from a single gene to genomics. Genome overview at the level of Chromosome (with model organisms example). Strategies for large-scale DNA sequencing- Whole genome analysis techniques, Next generation sequencing methods; Organization, structure and mapping of genomes. Genome Annotation, Comparative Genomics, Structural and functional Genomics. Databases and tools for DNA sequencing and analysis. Reading of current research publications.	15
II	Transcriptomics and Microarray: Introduction to transcriptomics and expression profiling. DNA and RNA Microarray-Preparation, working and analysis. Microarray databases and bioinformatics tools. Investigative techniques – EST, SAGE, SNP.	10
III	Applications: Metagenomics, Toxicogenomics, Pharmacogenomics, Gene disease association, Microbiome: Concept, Microbiome and Human health (examples), Human Microbiome Project (HMP): Goals, Significance, potential applications and challenges.	10
IV	Proteomics: Proteomics –Introduction, Concept, application. Advantages and limitations of Structural and Functional Proteomics. Reading of current research publications	10
V	Techniques in Proteomics: Protein separation techniques, Strategies in protein identification, 2D Gel electrophoresis, Isoelectric Focusing (IEF). Mass spectrometry in proteomics –Principle, techniques, components and variations (HPLC, ESI, MALDITOF, FT-MS, MS/MS, Quadrupole) and analysis, applications. Protein- Protein interactions- experimental and computational- two hybrid, Phage display; Protein Microarray- Preparation, working and analysis. Proteomics and Microarray databases and allied bioinformatics tools. Reading of current research publications.	10
VI	Applications: Peptidomics/Drug discovery, Toxicoproteomics, Biomarkers in disease diagnosis, Identification and characterization of novel proteins. Reading of current research publications	5

Books:

1. David W Mount. *Bioinformatics-Sequence and Genome Analysis*. 2nd ed. USA: Cold Spring Harbor Laboratory Press, 2004
2. Graham, David R M et al. "Broad-based proteomic strategies: a practical guide to proteomics and functional screening." *The Journal of physiology* vol. 563, Pt 1 2005: 1-9. doi:10.1113/jphysiol.2004.080341
3. Miller, Webb et al. "Comparative genomics." *Annual review of genomics and human genetics* vol. 5, 2004: 15-56. doi:10.1146/annurev.genom.5.061903.180057.
4. Malcolm Campbell, and Laurie J. Heyer, *Discovering genomics, Proteomics and Bioinformatics*. 2nd ed. USA: Benjamin Cummings, 2006.
5. Pierre Baldi, and G. Wesley Hatfield. *DNA Microarrays and Gene Expression: From Experiments to Data Analysis and Modeling*. Cambridge: Cambridge UP, 2002.
6. Xiong, Jin. *Essential Bioinformatics*. 1st ed. Cambridge: Cambridge UP, 2006.
7. Michael J., Brownstein. *Functional Genomics: Methods and Protocols*. Humana Press, 2003.
8. Reeves, Gabrielle A., et al. "Genome and Proteome Annotation: Organization, Interpretation and Integration." *Journal of the Royal Society, Interface*, vol. 6, no. 31, Feb. 2009, pp. 129–47. doi:10.1098/rsif.2008.0341.
9. Anthony JF Griffiths, Jeffrey H Miller, David T Suzuki, Richard C Lewontin, and William M Gelbart. *Introduction to genetic analysis*. 7th ed. New York, USA: W. H. Freeman, 2008
10. Arthur M. Lesk. *Introduction to genomics*. UK: OUP Oxford, 2007.
11. Richard Twyman. *Principles of Proteomics*. 1st ed. London: Taylor & Francis, 2004
12. Terence Brown. *Genomes*. 4th ed. Oxford: Wiley-Liss; 2017

eResources

1. <https://www.ncbi.nlm.nih.gov/geo/info/overview.html>
2. <https://www.ncbi.nlm.nih.gov/genbank/tsa/>
3. <https://www.pharmgkb.org>
4. <https://www.nlm.nih.gov/toxnet/index.html>
5. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2792171/>
6. <https://www.hmpdacc.org/>
7. https://depts.washington.edu/ceeh/downloads/FF_Microbiome.pdf
8. <https://www.sciencedirect.com/topics/immunology-and-microbiology/microbiome>

S.Y. M.Sc. Semester III
Biotechnology Paper -2 (BTH 5302) Stem Cell Biology, Regenerative Medicine and Applied Biotechnology

[Credits-4]

Section –I Stem Cell Biology and Regenerative Medicine

Course Outcomes

At the end of this course, students will be able to

- CO1** • Concept of differentiation, plasticity & trans differentiation
CO2 • Properties of stem cells and their application in regenerative medicine

Unit	Details	Lectures
I	<ul style="list-style-type: none"> Cellular basis of differentiation, trans-differentiation, metaplasia and regeneration, cell lineages. Stem cell self-renewal and pluripotency: molecular mechanisms Cell cycle regulation in stem cells. Embryonic, Adult and Induced Pleuripotent Stem cell niches 	8
II	<ul style="list-style-type: none"> Isolation, characterization and maintenance of embryonic stem cells, adult stem cells, embryonic germ cells, embryonic carcinoma cells 	5
III	<ul style="list-style-type: none"> Stem Cell Therapy: Research Expansion of stem cells <p>Applications of Stem cells in</p> <ul style="list-style-type: none"> Neurodegenerative disorders, spinal cord injury, Wound healing, burns, diabetes, Orthopedic applications Infertility HIV/AIDS 	7
IV	<ul style="list-style-type: none"> Genetic Manipulation of stem cells: Overview of different methods of introduction of a viz. micronuclear injection method, transduction with recombinant retroviruses, targeted gene insertion, cre-LoxP recombination and production of transgenic animals. Mouse models to study human disorders 	8
V	Limitations, Controversies and Criticism of stem cell research and therapy	2
	Seminars/ group discussion/journal club for various current and relevant topics.	

Books:

- 13.Scot F Gilbert, *Development Biology*, 9th ed. Sinauer Associates, USA. 2010.
 14.Lewis Wolpert, Cheryll Tickle and Alfonso Martinez Arias, *Principles of Development*, 6th ed OUP Oxford, 2019.
 15.Robert Lanza, *Essentials of Stem Cell Biology*, 2nd ed, Elsevier Academic Press, USA, 2009.

Research Articles:

1. Mahla, Ranjeet Singh. "Stem cells application in regenerative medicine and disease therapeutics". *International Journal of Cell Biology*, issue. 7, 2016, pp. 1–24. doi:10.1155/2016/6940283. PMC 4969512. PMID 27516776.
2. Rosemann, Achim. "Why regenerative stem cell medicine progresses slower than expected". *Journal of Cellular Biochemistry*, vol. 115, issue no. 12, December 2014, pp. 2073–76. doi:10.1002/jcb.24894. PMID 25079695.
3. Zhang, Bin; Yeo, Ronne Wee Yeh; Tan, Kok Hian; Lim, Sai Kiang. "Focus on Extracellular Vesicles: Therapeutic Potential of Stem Cell-Derived Extracellular Vesicles". *International Journal of Molecular Sciences*, vol. 17, issue no. 2, February 2016.
4. Shi Yanhong, Inoue Haruhisa, Wu Joseph C and Yamanaka Shinya. "Induced Pluripotent Stem Cell Technology: A Decade of Progress". *Nature Reviews Drug Discovery*, vol. 16, issue no. 2, pp. 115-130. doi: 10.1038/nrd.2016.245

Section-II Applied Biotechnology

Course Outcomes

At the end of this course, students will be able to understand

- CO1** • Current application in Tissue Engineering and Biopharmaceuticals.
CO2 • Regulations, Controversies and Market development in Applied Biotechnology

Unit	Details	Lectures
I	Tissue Engineering <ul style="list-style-type: none"> • Introduction to tissue engineering • Overview of <i>in vivo</i> tissue organization, tissue dynamics and homeostasis • Cells as building blocks: types and extraction methods. ECM, cell-cell/ cell-ECM interactions • Scaffolding: Concept, Different materials used for scaffold synthesis, their advantages and drawbacks • Assembly of engineered tissues: Self assembly, organ printing etc. • Examples of Engineered tissues • Bioartificial skin, liver, cartilage etc. • Artificial meat • Tissue engineering of heart valves • Tissue Engineering Regulations, Controversies and Market 	15
II	Biopharmaceuticals: <ul style="list-style-type: none"> • Antibody drug conjugates, Monoclonal antibodies etc • Different methods of production • Direct Extraction, Semisynthesis, Biosimilars • Applications • Regulations • Toxicity Screening using cell lines 	8
III	Applications of Biotechnology in Cancer <ul style="list-style-type: none"> • Overview • Biotechnology applications in Cancer Detection • Biotechnology applications in Cancer Treatment • Current research 	7
	Seminars/ group discussion/journal club for various current and relevant topics.	

Books:

1. Scoot F Gilbert, *Development Biology*, 9th ed. Sinauer Associates, USA. 2010.
2. Lewis Wolpert, Cheryll Tickle and Alfonso Martinez Arias, *Principles of Development*, 6th ed OUP Oxford, 2019.
3. Ulrich Meyer Jörg, Handschel Hans Peter, Wiesmann Thomas Meyer, *Fundamentals of Tissue Engineering and Regenerative Medicine*, Springer, 2009.
4. Bernard R. Glick, Jack J. Pasternak and Cheryl L. Patten, *Molecular Biotechnology*, 4th ed, ASM press, USA, 2010.

e-Resources:

1. <https://pubmed.ncbi.nlm.nih.gov/6349488/>
2. Screening of toxic compounds in tissue culture. Ekwall B. Toxicology. 1980;17(2):127-42. doi: 10.1016/0300-483x(80)90085-2. PMID: 7209994

S.Y. M.Sc. Semester III**Biotechnology Paper -3 (BTH 5303) Industrial Biotechnology-II and Bioinformatics**

[Credits-4]

Course Outcomes

At the end of this course, students will be able to understand

- CO1** • The production process of fermentation products in various sectors
- CO2** • Functioning of Quality control and Quality Assurance department
- CO3** • Concepts in fermentation economics
- CO4** • IPR in Biotechnology. Importance and process of patenting
- CO5** • Various bioinformatics tools and techniques and how to use those for the analysis of the biological experimental data.
- CO6** • Concepts of various databases and various methods for the data retrieval, data storage, and data mining and use that data for the further analysis.
- CO7** • *In-silico* approach for the protein modeling and drug discovery process.

Unit	Details	Lectures
Industrial Biotechnology		
I	<p>a. General Lay out of a Fermentation Unit</p> <p>b. Upstream, Fermentation and Downstream Processing for Industrial Products:</p> <ul style="list-style-type: none"> • Antibiotics: Rifamycin, Streptomycin • Vitamins: Ascorbic Acid, B12 • Alcohol and Alcoholic Beverages: Ethanol, Wine and Beer • Amino Acids: Glutamic Acid, Lysine • Organic Acid: Lactic Acid • Food and Dairy products: Sauerkraut, Cheese, Probiotics • Microbial Cells as Products: Microbial Insecticides, Yeast as food and food supplement, Mushroom Cultivation • Enzymes: Proteases, Restriction Enzymes, Immobilized enzymes (Commercial Applications) • Bio based Polymers: Bioplastics, Xanthan Gum • Microbial Flavors and Nutraceuticals • Recombinant products: Vaccines, Mammalian Proteins • Bio renewable fuels 	16
II	<ul style="list-style-type: none"> • Roles and Responsibilities of Quality Assurance (QA) and Quality Control (QC) Departments in Biotechnology Industry, Quality Control Tests (AMES, LAL, Pyrogen, Sterility and other), Process Validation • Fermentation Economics • Biotech Companies and Sectors, New Challenges and Opportunities 	6

IPR in Biotechnology		
IV	<ul style="list-style-type: none"> Intellectual Property Rights: Overview and Historical Perspectives; TRIPS (Trade Related Intellectual Property Rights) Agreement and International Treaties related to IPR 	1
	Patents: Criteria of Patentability; <ul style="list-style-type: none"> Procedure for Filing Patent Applications, Patent Granting Procedure; Revocation, Patent Infringement and Remedies; Plant, Animal, Microbial Patents: Indian and International Perspective; Patenting Biosimilars. 	7
V	<ul style="list-style-type: none"> Copyright and Neighboring Rights - Conceptual Framework, Copyrightworks, Ownership, transfer and duration of Copyright, Renewal and Termination of Copyright, Neighboring Rights, Infringement of copyrights and remedies; Examples and Case study; Geographical Indications - Concept of Appellations of Origin, Indication of Source and Geographical Indication, Examples and case studies; Protection of Plant Varieties and Plant Breeders' Rights - Protection of Plant Varieties and Farmers Rights, Authority and Registry, Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing; Examples and Case study; Industrial Design - Need for Protection of Industrial Designs, Subject Matter of Protection and Requirements, Examples and Case Study. 	5
Bioinformatics		
VI	Bioinformatics- Introduction and definition, History and Scope, Applications of Bioinformatics in various fields. Nucleic Acid Sequence Databases : Nucleic acid sequence databases (GenBank, EMBL, DDBJ), Keyword-based search at Entrez Search Engine at NCBI. Sequence Submission tools at NCBI, EMBL etc. Protein sequence database: UniProtKB(SwissProt, TrEMBL). Open Access Bibliographic Resources and Literature Databases: PubMed, MEDLINE, PubMedCentral at NCBI Derived Databases: Sequence: InterPro, Prosite, Pfam, ProDom, Gene Ontology Structure classification database: CATH, SCOP, FSSP Protein-Protein interaction database: STRING	7
VII	Sequence Analysis: Various File Formats for Biomolecular Sequences: GenBank FASTA Basic concepts of sequence analysis: Global Pairwise Sequence Alignment Local Pairwise Sequence Alignment Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, gap penalties, use of pairwise alignments for analysis of Nucleic acid and Protein sequences and interpretation of results.	10

	<p>Databases Searches: BLAST FASTA</p> <p>Multiple Sequence Alignment: The need for MSA Basic concepts of various approaches for MSA (e.g. progressive, hierarchical, iterative etc.).</p> <p>Concept of Phylogeny: Molecular Phylogeny Various Methods of Phylogenetic Tree Construction</p> <p>Scoring matrices: Basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSSUM series.</p>	
VIII	<p>Structure Databases: PDB, NDB, PubChem</p> <p>Molecular visualization: Protein conformation and visualization tool (RASMOL, SPDBViewer, Cn3D and Jmol).</p> <p>Computational Methods for Protein Structure Prediction:</p> <ul style="list-style-type: none"> • Energy- and fragment-based methods • Evolutionary covariation to predict 3D contacts • Comparative protein modeling • Homology modeling • Protein threading • Side-chain geometry prediction <p>Molecular Modeling :</p> <ul style="list-style-type: none"> • Introduction to modelling protein ligand interactions • Pose Prediction Strategies in molecular Docking: Rigid body docking flexible ligand docking (Conformational search method, Fragmentation method, Database method) • Scoring Functions: Force field-based, Empirical, Knowledge-based • Application in Structure Based Drug Designing 	8

Books:

1. E. M. T. El-Mansi., Jens Nielsen, David Mousdale and Ross P. Carlson. *Fermentation Microbiology and Biotechnology*. 4th ed. London : CRC press, 2019.
2. BIOTOL series, Bioreactor *Design and Product Yield*. UK: Butterworth-Heinemann, 1992
3. Casida, L. E., *Industrial Microbiology*. 2nd ed. New Delhi: New age International, 2019.
4. Indian Pharmacopia and British Pharmacopia (Latest Edn).
5. Pepler, H. J., D. Perlman. *Microbial Technology*, Vol I and II, 2nd ed. New York: Academic Press, 1979
6. Peter F. Stanbury., A. Whittaker and S. Hall. *Principles of Fermentation Technology*. 3rd ed., Springer 2016.
7. Prescott, S.C. and Dunn, C. G. *Industrial Microbiology*. 4th ed.: New Delhi., CBS Publishers, 2004.
8. Crueger, W. and Crueger, A. *A Text Book of Industrial Biotechnology*. New Delhi, Panima, 2005.

9. Daham I. Alan, Murray Moo-Young. *Perspectives in Biotechnology and Applied Microbiology*,: Dordrecht:Springer,1986.
10. Wiseman A. *Topics in Enzyme and Fermentation - Biotechnology*, Vol. 1 and 2. New York: John Wiley and Sons,1985.
11. Aydin Berenjian. *Essentials in Fermentation Technology*. Kindle ed.,Springer,2019
12. Patel, A.H. *Industrial Microbiology*.2nd ed. Macmillan India Ltd,2011.
13. David Mount, *Bioinformatics Sequence and Genome Analysis* 2nded.,University of Arizona, Tucson, 2004
14. JinXiong, *Essentials Bioinformatics*, 1st ed., Cambridge University Press, New York 2006
15. H. wood, T.K. Parry smith DJ, *Introduction to Bioinformatics*, Pearson education Asia 2001.
16. Nithyananda, K V. *Intellectual Property Rights: Protection and Management*. India, IN: Cengage Learning India Private Limited 2019.
17. Neeraj, P., & Khusdeep, D. *Intellectual Property Rights*. India, IN: PHI learning Private Limited 2014.
18. Ahuja, V K. (2017). *Law relating to Intellectual Property Rights*. India, IN: Lexis Nexis.
19. A.D. Baxevanis & BFF *Bioinformatics: A practical guide to the analysis of genes and proteins*. Ouellette – Wiley Interscience – New York 2001
20. Stephen Misener & Stephen A. Krawetz, *Bioinformatics: Methods and Protocols Humana Press*, New Jersey 2000
21. Des Higgins Willie Taylor *Bioinformatics: Sequence, structure and databanks* Oxford University Press 2000
22. Stephen Misener., Stephen A. *Bioinformatics: Sequence Bioinformatics: Methods and Protocols*, Krawetz, Humana Press, New Jersey, 2000
23. Journal of Intellectual Property Rights (JIPR): NISCAIR

eResources:

<https://www.sciencedirect.com/science/article/pii/S1045105684710219>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1927659/>
<https://www.europeanpharmaceuticalreview.com/article/78981/quality-assurance-quality-systems-making-medicinal-products/>
<https://www.ijpsr.com/sites/default/files/articles/IJIPSRMN-61.pdf>
<https://www.pharmaguideline.com/p/sop-for-quality-control.html>
<https://www.researchgate.net/>
<http://www.bdu.ac.in/cells/ipr/docs/ipr-eng-ebook.pdf>
https://www.wipo.int/edocs/pubdocs/en/intproperty/489/wipo_pub489.pdf
<http://cipam.gov.in/>
<https://www.wipo.int/about-ip/en/>
<http://www.ipindia.nic.in/>
<https://www.edx.org/learn/bioinformatics>
<https://www.coursera.org/specializations/bioinformatics>
<https://www.ebi.ac.uk/>
<https://www.expasy.org/>
<https://www.rcsb.org>
<https://www.uniprot.org/>

**Exercises in Stem Cell Biology, Regenerative Medicine,
Applied Biotechnology and IPR****[Credits-4]****Course Outcomes**

At the end of this course, students will be able to

- CO1** • Initiate and maintain primary culture from chick embryo
- CO2** • Follow aseptic techniques and subculture avoiding contamination
- CO3** • Perform cytotoxicity assay
- CO4** • Analyze the Indian Scenario in Tissue Engineering
- CO5** • Patent: Prior art search and specification drafting.

Sr.No	List of Practicals	Practicals (15P X 4H)
1	Initiation of primary cell culture from chick embryo	3
2	Subculture and observation of the cell line established from the chick embryo	2
3	Cytotoxicity analysis of various compound on cells in culture	2
4	Analysis and report writing on current tissue engineering application in India	2
5	Conduct survey on various topics related to cancer treatment and epidemiology.	1
6	Visit to a stem cell facility	1
7	Patent – Prior Art Search Exercise	2
8	Patent Specification Drafting Exercise	2

S.Y. M.Sc. Semester III
Biotechnology Practical Paper -6 (BTH 5305) Biotechnology Practical- VI

Exercises in Industrial Biotechnology-II and Bioinformatics

[Credits-4]

Course Outcomes

At the end of this course, students will be able learn the techniques involved in :

- CO1** • Laboratory scale and Lab bench scale production process of fermentation products
- CO2** • Use of immobilized cells for production.
- CO3** • Solid state Fermentation
- CO4** • Quality Control test
- CO5** • Data Retrieval from the Biological Databases and its analysis
- CO6** • Molecular Modeling, Docking, Structure based drug discovery

Sr.No	List of Practicals	Practicals (20P X 3H)
Industrial Biotechnology		
1.	Laboratory Scale Production, Recovery of an enzyme/antibiotic/organic acid (any one) Scale up to Lab Bench Fermenter	2
2.	Assay of fermentation product: Ascorbic acid/Vitamin B12	1
3.	Solid state fermentation : Lab scale production, recovery and estimation of a product	2
4.	Microbial Cells as Products: Mushroom Cultivation/ Yeast/ Probiotic organisms (any one)	1
5.	Ethanol /Enzyme production by immobilized yeast cells	1
6.	Sterility testing of injectable	1
7.	Laboratory Scale Preparation of Sauerkraut	1
8.	Visit to Food/Dairy/Fermentation Industry	1
Bioinformatics		
9.	Using online resources like NCBI, PubMed (GenBank, UniProtKB, PDB) Sequence alignment using BLAST/Database Similarity searching using BLAST	3
10.	Phylogenetic analysis using Phylip or Mega	1
11.	Basic Structure visualization using Deep View (Performing basic tasks like Selecting and Displaying structures, Colouring, Measuring distances and labeling)	2
12.	Prediction of protein tertiary structure using any method (CPH, MODELLER, SWISS Model, Easy Modeller)	2
13.	Molecular Docking using AutoDock and Molecular visualization of docked complexes (using Pymol or Chimera)	2

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -1(BTH 5306) Analytical Techniques

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

- CO1** • Principle and instrumentation of spectroscopic and chromatographic techniques.
CO2 • Applications of these techniques.

Unit	Details	Lectures
I	Spectroscopic techniques: Principle, instrumentation and applications of: UV-Vis spectroscopy, Fluorescence spectroscopy, Circular dichroism spectroscopy, Infra red spectroscopy, Electron paramagnetic resonance (ESR) spectroscopy, Nuclear magnetic resonance (NMR) spectroscopy, X-ray diffraction	12
II	Chromatographic techniques: HPLC (High Performance Liquid Chromatography): Fundamentals and Principles of HPLC, Instrumentation, Types; Normal phase HPLC, Reverse Phase HPLC, Ion Exchange Chromatography (IEC), Size exclusion chromatography. Mobile phases, sample preparation, pumps, injectors, columns, detectors (UV-Visible, fluorescence, PDA, RI), Elution systems-Isocratic and Gradient, Applications. Liquid Chromatography–Mass Spectrometry (LC–MS): Fundamentals and Principles, Instrumentation, Ionization, MS analysis, Applications. Gas Chromatography (GC): Principle, Instrumentation, Sample preparation, Carrier gases, Injectors, Columns, Detectors (TCD, FID, ECD, NPD), Applications. Gas chromatography–mass spectrometry (GC-MS): Fundamentals and Principles, Instrumentation, Ionization, Detectors, Applications.	16
III	Visit to instrumentation facility center	02

Books:

1. Keith Wilson and John Walker. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th ed. Cambridge, UK: Cambridge University Press, 2010.
2. Rodney Boyer. *Modern experimental biochemistry*. 3rd ed. San Francisco, USA: Benjamin Cummings, 2000.
3. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath. *Biophysical Chemistry (Principles and Techniques)*. 4th ed. New Delhi, India: Himalaya Publishing House, 2016.

E-resources:

1. <https://nptel.ac.in/courses/102/103/102103044>
2. <https://www.cell.com/trends/biotechnology/newarticles>

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -1(BTH 5307) Food Technology

[Credits-2]

Course Outcomes

At the end of this course, students will be able to understand:

- CO1** • Methods of analyzing foods, adulterants and toxicants.
- CO2** • Factors affecting growth of Microorganisms in food and food borne diseases and intoxications.
- CO3** • Detection of microbial food spoilage
- CO4** • Food Processing and packaging methods
- CO5** • Concept of Specialty foods, Nutraceuticals, health foods, functional foods
- CO6** • Food laws and legislations, HACCP.

Unit	Details	Lectures
I	Classification of food: Health food, ethnic food, organic food functional food, nutraceuticals, fabricated foods, convenience foods, GM foods, space foods	1
II	Compositional Analysis of Foods: Physical, Chemical properties, Characteristics of foods, Sensory evaluation Food adulterants, toxicants Types and methods of detecting food adulterants and toxicants	4
III	Food Microbiology: Sources of microorganisms in foods; microbial growth, growth curve; factors affecting growth-intrinsic and extrinsic, factors controlling growth of microorganisms, microbiological criteria of foods and their significance Foods microbiology and public health GRAS foods, Food poisoning, types of food poisonings, important features etc; bacterial agents of food borne illness, food poisoning by <i>Clostridium</i> , <i>Salmonella</i> , <i>E. coli</i> , <i>Staphylococcus</i> etc.; non-bacterial agents of food borne illness, mycotoxins Food spoilage Methods of isolation and detection of microorganisms or their products in food; conventional methods; rapid methods (newer techniques) -immunological methods; fluorescent, antibody	5
IV	Food processing and Packaging Scope and importance of food processing- Preparation of foods before processing cleaning, sorting, grading, peeling .etc. Thermal. Low temperature and Dehydration methods Canning, Introduction to Food Packaging: definition, factors involved in the evolution and selection of a food package, functions of food packaging (containment, protection, convenience and communication). Paper and paper based packaging materials, Plastic packaging materials Metal packaging materials Glass packaging materials Aseptic packaging of foods Modern packaging techniques	5

V	<p>Specialty foods: Nutraceuticals, Functional foods, Nutrigenomics Scope, importance and renewed emphasis on specialty foods, health foods, functional foods. Nutraceuticals, infant and baby foods, adolescent/ teen age foods, foods for pregnant ladies and nursing mothers, geriatric foods. Concept of nutrigenomics Food recommended and restricted in metabolic disorders and disturbances, gastrointestinal disorders; fever and infection; liver, gall, bladder and pancreatic disturbances; blood, circulatory and cardiac diseases; urinary and musculoskeletal diseases; allergies. Health benefits/ mode of action of PUFA/ gamma linoleic acids, antioxidants, dietary fiber, oligosaccharides, sugar alcohols, peptides and proteins, glycosides, alcohols, isoprenoids and vitamins, choline, LAB, phenolic, flavonols, minerals and other minor food constituents Genetically modified foods : health claims and concerns</p>	6
VI	<p>Food legislation: Food Laws and Standards, National and International, FSSAI, Duties and responsibilities of Food Safety Authorities HACCP system and food safety used in controlling microbiological hazards Concept of QA, QC, ISO. Industrial Visit to Food Industry</p>	2

Practicals [0.5 C]		
Sr. No.	Title	No. of Practical
1.	Compositional Analysis of Foods (Physical, Chemical and Microbial)	1
2.	Detection of Food Adulterants in various food samples	1
3.	Visit to Food Industry/Food testing Laboratory	1

Books:

1. De Sukumar., *Outlines of Dairy Technology* : Oxford University Press, 2007.
2. Coles R, McDowell D and Kirwan MJ, *Food Packaging Technology*: CRC Press, 2003.
3. Deman JM, *Principles of Food Chemistry*, 2nd ed. :Van Nostrand Reinhold, NY 1990
4. Frazier WC and Westhoff DC, *Food Microbiology* : TMH Publication, New Delhi, 2004.
5. Jenkins WA and Harrington JP, *Packaging Foods with Plastics*: Technomic Publishing Company Inc., USA, 1991.
6. Manay NS and Shadaksharaswamy M, *Food-Facts and Principles*, New Age: International (P) Ltd. Publishers, New Delhi, 1987
7. Ramaswamy H and Marcott M, *Food Processing Principles and Applications*:CRC Press, 2006
8. Ranganna S, *Handbook of Analysis and Quality Control for Fruits and Vegetable Products*, 2nd ed.: TMH Education Pvt. Ltd, 1986
9. Bamji MS, Krishnaswamy K, Brahmam GNV (2009). *Textbook of Human Nutrition*, 3rd ed. :Oxford and IBH Publishing Co. Pvt. Ltd.
10. Desrosier, Norman W. and Desrosier., James N., *The technology of food preservation* , 4th Ed., Westport, Conn. : AVI Pub. Co., 1977.
11. Whitehurst and Law, *Enzymes in Food Technology*: CRC Press, Canada, 2002
12. Fuller, Gordon W, *New Product Development From Concept to Marketplace* : CRC Press, 2004
13. Ramesh C. Gupta , *Nutraceuticals: Efficacy, Safety and Toxicity* 1sted.,USA: Elsevier, 2016
14. Dhiraj A. Vatterm , Vatsala Maitin , *Functional Foods, Nutraceuticals and Natural Products: Concepts and Applications*: DEStech Publications, Inc 2016.

15. Codex Guidelines on Nutrition Labelling (CAC/GL 2_1985) (Rev.1_1993). Rome, Food and Agriculture Organisation of the United Nations / World Health Organisation, 1993.
16. Food Safety and Standards Authority of India portal, Government of India

e-Resources

1. <https://www.cdr.wisc.edu/>
2. <http://www.agr.gc.ca/eng/science-and-innovation/?id=1360882179814>
3. <https://www.centerforfoodsafety.org/>
4. <https://www.ifst.org/>
5. <https://www.who.int/health-topics/food-safety/>
6. <https://www.fda.gov/food/laboratory-methods-food/about-bacteriological-analytical-manual-bam>

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -1(BTH 5308) Nanotechnology

[Credits-2]

Course Outcomes

At the end of this course, students will be able to have a knowledge of :

- CO1** • Fundamentals of nanotechnology
CO2 • Synthesis and characterization of nanoparticles
CO3 • Applications of nanomaterials in various fields
CO4 • Techniques in synthesis and activity of nanoparticles

Unit	Details	Lectures
I	Introduction to Nanoworld, Nanoscience and Nanotechnology: <ul style="list-style-type: none"> • Introduction to Nanobiotechnology, Concepts, historical perspective • Types of nanoparticles and their Properties: Quantum dots, Polymeric nanoparticles, Metal nanoparticles, metal oxide nanoparticles, Dendrimers, Composites • Nanofilms, Nanoparticles 	5
II	Synthesis of Nanoparticles: <ul style="list-style-type: none"> • Physical methods - mechanical methods, methods based on evaporation sputter deposition, chemical vapour deposition (CVD), electric arc deposition. • Chemical methods - Synthesis of nanoparticles by colloidal route, microemulsion, sol-gel method, chemical precipitation, pyrolysis. • Biological methods - Synthesis using microorganism, synthesis using plant extracts, use of proteins and template like DNA. 	5
III	Properties and Characterization of Nanomaterials: Optical (UV-Vis / Fluorescence), X-ray diffraction, Imaging and size (Electron microscopy TEM, SEM), Light scattering- DLS NTA, Zeta potential.	3
IV	Applications of Nanomaterials in/as: <ul style="list-style-type: none"> • Medicine: Drug Delivery, Nanomedicines, diagnostics and imaging • Food Science:(Food Processing, Food Packaging, detection of pathogens) • Nanosensors • Water remediation and purification, • Agriculture. • Green Nanotechnology 	5
Practicals [0.5C]		
Sr. No.	Title	No. of Practicals
1	Synthesis of metal/metal oxide Nanoparticles by: (any 2) a. Chemical b. Microbial c. Plant based method	2
2	Biological activities of nanoparticles: 1. Antimicrobial activities of synthesized nanoparticles (MIC/MBC determination) 2. Cytotoxicity testing of nanoparticles using MTT/Tryphan blue assay	2

Books:

1. Kulkarni, S. K. *Nanotechnology: Principals and Practices*. Revised ed., New Delhi:Capital Publishing company, 2009.
2. Michael Stroschio and Mitra Dutta. *Biological Nanostructures and Application of Nanostructures in Biology*. 2nd ed., Springer, 2013.
3. Elizabeth Papazoglou, and Aravind Parthasarathy. *BioNanotechnology*, 1sted.,Morgan & Claypool Publishers' series, 2007
4. David Goodsell. *Bionanotechnology*. 1st ed., New Jersey: John Wiley & Sons, Inc, Publication, 2004.
5. C. N. R. Rao, Achim Müller, Anthony K. Cheetham (Eds). *The Chemistry of Nanomaterials: Synthesis, Properties and Applications*, 2 Volume Set. Wiley VCH, 2004.
6. Christof M. Niemeyer and Chad A. Mirkin (Eds). *Nanobiotechnology: Concepts, Applications and Perspectives*, Wiley Publishers, April 2004.

e-Resources:

1. <https://www.nanowerk.com/nanotechnology-applications.php>
2. <https://www.frontiersin.org/articles/10.3389/fmicb.2017.01501/full>
3. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5766453/>
4. <https://www.nanotech-now.com/current-uses.htm>

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -2 (BTH 5310) Bio-entrepreneurship

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

- CO1** • How to gain entrepreneurial skills
- CO2** • Various operations involved in venture creation
- CO3** • Scope for entrepreneurship in biosciences
- CO4** • How to utilize the schemes promoted through knowledge centres and various agencies.

Unit	Details	Lectures
I	<p>Basics of Entrepreneurship:</p> <ul style="list-style-type: none"> • Importance of entrepreneurship; advantages of being entrepreneur - freedom to operate; introduction to bio entrepreneurship – biotechnology in a global scale; • Scope in bio entrepreneurship; types of bio-industries biopharma, bioagri, bio services and bio industrial; innovation types, out of box thinking; skills for successful entrepreneur creativity, leadership, managerial, team building, decision making; • Opportunities for bio entrepreneurship - Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Start-up& Make in India); patent landscape, IP protection & commercialization strategies. 	6
II	<p>Accounting and Finance:</p> <ul style="list-style-type: none"> • Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from Government agencies like MSME/banks and private agencies like venture capitalists:/angel investors for bio-entrepreneurship; • Business plan proposal for „virtual startup company“; statutory and legal requirements for starting a company/venture; basics in accounting practices: concepts of balance sheet, profit and loss statement, double entrybookkeeping; • Collaborations & partnerships; information technology for business administration and expansion. 	6
III	<p>Business Strategy</p> <ul style="list-style-type: none"> • Entry and exit strategy; pricing strategy; negotiations with financiers, bankers, government and law enforcement authorities; dispute resolution skills; • External environment/ changes; avoiding/managing crisis; broader vision– global thinking; mergers & acquisitions. 	6
IV	<p>Marketing</p> <ul style="list-style-type: none"> • Market conditions, segments, prediction of market changes; • Identifying needs of customers; • Market linkages, branding issues; • Developing distribution channels - franchising; policies, promotion, advertising; • Branding and market linkages for virtual startup company 	6
V	<p>Knowledge Centre and R&D</p> <ul style="list-style-type: none"> • Knowledge centres e.g., in universities, innovation centres, research institutions (public & private) and business incubators; 	6

<ul style="list-style-type: none">• R&D for technology development and upgradation; assessment of technology development;• Managing technology transfer; industry visits to successful bio-enterprises, regulations for transfer of foreign technologies;• Quality control; technology transfer agencies; Understanding of regulatory compliances and procedures (CDSCO, NBA, GLP, GCP, GMP)	
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References:

1. Ram Chandran, *'Entrepreneurial Development'*, Tata McGraw Hill, New Delhi.
2. Saini, J. S., *'Entrepreneurial Development Programmes and Practices'*, Deep & Deep Publications (P), Ltd.
3. Khanka, S S. *'Entrepreneurial Development'*, S Chand & Company Ltd. New Delhi
4. Badhai, B *'Entrepreneurship for Engineers'*, Dhanpat Rai & co. (p) Ltd.
5. Desai, Vasant, *'Project Management and Entrepreneurship'*, Himalayan Publishing House, Mumbai, 2002.
6. Gupta and Srinivasan, *'Entrepreneurial Development'*, S Chand & Sons, New Delhi.
7. Adams, D. J., & Sparrow, J. C. , *Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences 2008*
8. Bloxham: Scion Shimasaki, C. D., *Biotechnology entrepreneurship: Starting, managing, and leading biotech companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier 2014.
9. Onetti, A., & Zucchella, A. Routledge.Jordan, J. F..*Business modeling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge 2014*.
10. Desai, V. *Innovation, Commercialization, and Start-Ups in Life Sciences*. London: CRC Press (2009).
11. *The Dynamics of Entrepreneurial Development and Management*. New Delhi: Himalaya Pub. House.

eResources:

1. <https://library.stanford.edu/guides/entrepreneurship-resources>
2. <https://ocw.mit.edu/courses/entrepreneurship/>
3. <https://unimelb.libguides.com/c.php?g=849410&p=6079235>
4. <https://entrepreneurship.wharton.upenn.edu/>

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -2(BTH 5311) Biostatistics

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

- CO1** • Collect, present and analyze data
CO2 • Design experiments and trials
CO3 • Ask the statistical questions, test hypotheses, draw logical inferences

Unit	Details	Lectures
I	Descriptive statistics: Biological variables, frequency distributions, graphical visualization of data Measures of central tendency, measures of dispersion, skewness, kurtosis Sampling, sampling distributions and sampling strategies	7
II	Probability & Sample Basic probabilities – addition, multiplication, independence of events. Probability Distributions: binomial distribution and Poisson distribution Normal Distributions and applications Properties of Gaussian distributions Central Limit theorem Std. error and confidence limits	10
III	Research Methodologies Design of research, formulation of questions and the hypotheses. Design of experiments – randomization, replication, control, samples size	3
IV	Hypothesis Testing (with biological examples) Principles of hypothesis testing, significance level, null hypothesis Type I and Type II errors Examples of hypothesis testing: comparison of means, t-test, Chi-square test Regression Correlation	10

Books:

1. Robert Bartle ., and Donald Sherbert. *Introduction to real analysis*.4th ed. Illinois, USA: John Wiley& Sons, Inc., USA, 2011.
2. Chap T. Le. *Introductory Biostatistics*. 1st ed. New Jersey, USA: John Wiley& Sons, Inc., USA, 2003.
3. Antony N Glaser. *High-Yield™ Biostatistics*. Maryland, USA: Lippincott Williams and Wilkins, USA, 2005.
4. Edward Batschelet. *Introduction to Mathematics for Life Scientists*. 3rd ed. Berlin, Germany: Springer-Verlag Berlin Heidelberg, Germany, 1979.

e-Resources

1. Online Statistics Education: A Multimedia Course of Study (<http://onlinestatbook.com/>).

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -2 (BTH 5312) Computational Tools in Research

[Credits-2]

Course Outcomes

At the end of this course, students will be able to

- | | |
|------------|--|
| CO1 | • Organize research content in file |
| CO2 | • Organize data in spreadsheets and use spreadsheets in the analysis of data |
| CO3 | • Make effective MS PowerPoint presentations |
| CO4 | • Write and review manuscripts and drafts |

Unit	Details	Lectures
I	Research content writing Creating, Organizing & Formatting Research Content using MS Word Merge, Insert, View, Edit, Track Mode etc. Organizing bibliography and formatting using Mendeley/Zotero	4
II	Technology – based Communication Netiquettes: effective e-mail messages, Video conferencing, preparing CV, Bio data.	4
III	Research data organization and analyses Creating, Analyzing, Formatting Data & Content using Spreadsheets Insert, View, Edit etc. Managing Workbooks, Data tabulation, Calculations, Equations and analyzing biological Data using statistical tools Data analysis using excel: Measures of Central Tendency, Measures of Dispersion, Equality of means, Independence of Attributes, Goodness of Fit, Correlation Coefficient	10
IV	Data Presentation Making effective PowerPoint presentations Organizing Presentation Material Use of audio visual aids in presentation Elements of presentation preparation: objective, subject, audience, duration of talk Managing & Delivering Presentations Brief overview of Prezi	6
V	Other modes of Presentation Poster Making, Model exhibits, Popular Science articles	6

Books:

1. Robert Barass. *Scientists Must Write: A Guide to Better Writing for Scientists, Engineers and Students*. 2nd ed. London and New York: Routledge, 2002.
2. Thomas Kuhn. *The Structure of Scientific Revolution: 50th Anniversary Edition*. 4th ed. Chicago, USA: The University of Chicago Press, 2012.
3. Martha Davis ., Kaaron Davis, and Marion Dunagan. *Scientific Papers And Presentations*. 3rd ed. Cambridge, USA: Academic Press, 2004.
4. John M. Smith. *The Problems Of Biology*. Oxford, United Kingdom: Oxford University Press, 1986.
5. Richard P. Feynman. *The Pleasure Of Finding Things Out: The Best Short Works Of Richard Feynman*. Cambridge, USA: Perseus Books, 1999.
6. Robert A. Day ., Barbara Gastel. *How to Write and Publish a Scientific Paper*. 4th ed.

Phoenix, Chicago, USA: Oryx Pres, 1994.

7. William Strunk Jr., and E. White. *The Elements of Style*. 4th ed. Boston, USA: Allyn & Bacon, 2000.

E-resource:

1. Online Statistics Education: A Multimedia Course of Study (<http://onlinestatbook.com>).
Project Leader: [David M. Lane](#), Rice University.

S.Y. M.Sc. Semester III
Biotechnology Elective Paper -2 (BTH 5313) Emerging Trends and Technologies

[Credits-2]

Course Outcomes

At the end of this course, students will be able to learn

- CO1** • History, theoretical basis and basic understanding of some of the latest technologies in the area of biotechnology.
- CO2** • Various applications of these technologies. They may learn one application in depth through an assignment and/or seminar.

Unit	Details	Lectures
I	Optical Microscopy Methods: Confocal Microscopy, Scanning-Tunneling Microscopy, Atomic Force Microscopy, Interfacial-Force Microscopy. Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Near-Field and Evanescent Waves, Total Internal Reflection Microscopy; Near-Field Microscopy; Beyond the Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM)	10
II	Mass Spectroscopy Ionization techniques: Mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho-proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.	7
III	CRISPR-CAS: History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for in vivo genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.	7
IV	Systems Biology: High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions.	6

Books:

4. Keith Wilson and John Walker. *Principles and Techniques of Biochemistry and Molecular Biology*. 7th ed. Cambridge, UK: Cambridge University Press, 2010.
5. Rodney Boyer. *Modern Experimental Biochemistry*. 3rd ed. San Francisco, USA: Benjamin Cummings, 2000.
6. Iain Campbell. *Biophysical techniques*. 1st ed. Oxford, UK: Oxford University Press, 2012.
7. V. Pattabhi and N. Gautham. *Biophysics*. 1st ed. New Delhi, India: Kluwer Academic Publishers and Narosa Publishing House, 2002.
8. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath. *Biophysical Chemistry (Principles and Techniques)*. 4th ed. New Delhi, India: Himalaya Publishing House, 2016.

E-resource:

1. <https://crispr.i2bc.paris-saclay.fr/>
2. <http://systems-biology.org/resources/>

**S.Y. M.Sc. Semester IV
Biotechnology Practical VII (BTH 5401) Dissertation/ Projects**

[Credits-8]

Course Outcomes

At the end of this course, students will be able to

- CO1** • Carry out a research project from conception of idea, plan of work, literature survey, Laboratory experimental work to completion of the project as per objectives of the project.
- CO2** • Prepare project report as per standard scientific guidelines
- CO3** • Prepare and Present the project findings

Project work, Thesis Submission & presentation Guidelines	
	<ul style="list-style-type: none"> • Project work / Thesis / Dissertation shall be carried out under the supervision of a qualified investigator in the concerned Department /Research Institute/Industry. In case of interdisciplinary project work, qualified supervisors from other departments will be permitted. • A co-guide from the parent department shall be appointed for all students. • Project work / Thesis / Dissertation shall be pursued during semester IV, following the preliminary plan of work carried out in during the previous semester. • Progress of the project work shall be submitted to the Department from time to time by all the students. • The Project Report/ Thesis / Dissertation report that will be submitted to the department shall be prepared as per standard scientific research methodology and then duly signed by the supervisor(s) and the Head of the Department. • The assessment (Internal and external) of the project work will be as per guidelines of Fergusson College (Autonomous).