Annexure – I

CENTRAL UNIVERSITY OF SOUTH BIHAR

Master of Science in Biotechnology (M.Sc. Biotechnology) Programme Syllabus

(Effective from Academic Session 2022-2023)

Department of Biotechnology
School of Earth, Biological and Environmental Sciences

August 5, 2022

Central University of South Bihar
Department of Biotechnology
Proposed Course Structure for M. Sc. Biotechnology as per NEP 2020
Course Duration: 2 years [4 Semesters] (80 Credits)

The Department of Biotechnology is currently offering M.Sc. Degree in Biotechnology. The programme includes well-designed theory and practical courses. Innovation-based training is the key to train students with a special emphasis on understanding the basic as well as modern concepts in biological processes for pursuing research in frontier areas of Biological Sciences. The Programme equip the students with deep theoretical as well as practical understanding of different aspects of biological processes and promote them to take on an integrative approach for their studies and research.

Biotechnology has emerged as a major thrust area in the field of science and technology having potential to boost the economy of several countries including India. The voice of global Biotechnology in 21st century is to transfer the bio-based technology from "Lab to Land and from Bench to Business" to bring the cost of bio-based commodities within the reach of common man. The courses in Biotechnology program are mainly related to recent and emerging trends in Biology but the students are also taught Research Methodology which enables them to analyse their data, draw meaningful conclusions and publishing in reputed journals. The Programme equally gives emphasis on integrated approaches to human health, recombinant DNA technology, transgenic development, infection and immunity and bioinformatics. Students work directly with faculty on real-time projects, gaining hands-on skills necessary to solve emerging problems.

Department of Biotechnology is equipped with state-of-the-art equipment and continue to upgrade its infrastructure that provide a stimulating environment for teaching and research.

Degree in Biotechnology

M. Sc. Degree in Biotechnology

The two year (four semesters) Post-Graduate Programme in Biotechnology has interdisciplinary approach with participation of faculty and researchers across the University based on NEP2020 pattern with an option of exit after one year leading to Post Graduate diploma in Biotechnology. Hands-on training with professional and management skills are keys to our teaching pedagogy. This programme focuses on to build the students a responsible educator/researcher and follow ethics in research and policy. We are equally giving emphasis on integrated approaches to human health, transgenic crop development, environmental sciences, skill development and bioinformatics. The course also comprised of project dissertation, presentation and comprehensive viva-voce as part of evaluation system. There is option of entry in the second year M.Sc program (3rd semester) provided the student fulfill the eligibility criteria completing the 4-year Bachelor degree in Research subject to availability of the seat in the department. Students are also visiting major research institutions in the form of educational/excursion tour and Biotechnology industries to provide them opportunity to learn various aspects of process and product developments. One of the major goals of the Biotechnology programme is to engage the students by actively involving them in cutting-edge research and development.

Currently, departmental research is mainly focused in the areas of Antimicrobial Resistance, Biofilm, Behavioral Neuroscience, Cancer Biology, Fabrication of Bioplastics, Genetic Engineering, Genesis of Secondary Metabolites, Immunology, Molecular Marker Development, Molecular Diagnostics, Microbial Diversity, Stem Cell Therapy, Signal Transduction, and Transcription Factors. Apart from the above activities, M.Sc. Biotechnology Programme prepares the students to be the leaders in research, policy writing and business entrepreneur.

Biotechnology Laboratory

Biotechnology laboratory is equipped with state of the art technology and equipment that provide a stimulating environment for teaching and research. The list includes Biosafety Cabinets, Laminar Air Flow, Autoclave, Water bath, Low temperature circulatory water bath, Dry Heating Block, Rotatory

Shaker, Stackable Incubator Shaker, Sonicator, Compound, Fluorescence, and Inverted Microscopes, refrigerated centrifuges, microcentrifuge, Nano Drop UV/VIS Spectrophotometer, ELISA Plate Reader, Spectrophotometer, Gradient Thermal Cycler, Real-Time PCR, UV/VIS Transilluminator, Gel Documentation Systems, Horizontal and Vertical gel electrophoresis, Trans-Blot System, Hybridization oven, Deep Freezers (-20^0 C and -86^0 C), Flow cytometer, HPLC, Ice-Flake Machine, Cryo-Can, Lyophilizer, Milli-Q Water System. Animal, plant and microbial culture are also available but need upgradation to BSL2/BSL3 level and other infrastructures.

Discipline Based Core Course (DBCC)

Course Code	Courses	Credits		
		L	T	P
	Semester I			
BTN 8 1 DC 001 04	Cell & Molecular Biology	**3**	**0**	**1**
BTN 8 1 DC 002 04	Biochemistry	**3**	**0**	**1**
BTN 8 1 DC 003 04	Tools & Techniques in Biotechnology	**3**	**0**	**1**
BTN 8 1 DC 004 04	Introductory Course on Research Methodology (Including Bioinformatics and Biostatistics) (Research Methodology, compulsory in 1st Semester instead of 2nd Semester)	**3**	**1**	**0**
DBCC Credit		**16**		
	Semester II			
BTN 8 2 DC 005 04	Microbiology (**Indian Knowledge System)**	**3**	**1**	**0**
BTN 8 2 DC 006 04	Immunology & Immunotechniques (**Vocational Course)**	**3**	**1**	**0**
BTN 8 2 DC 007 04	Enzymology & Enzyme technology	**3**	**0**	**1**
BTN 8 2 DC 008 02	Practicals in Microbiology	**0**	**0**	**2**
BTN 8 2 DC 009 02	Practicals in Immunology & Immunotechniques	**0**	**0**	**2**
DBCC Credit		**16**		
	Semester III			
BTN 9 1 DC 001 04	Recombinant DNA Technology	**3**	**0**	**1**
BTN 9 1 DC 002 04	Bioprocess Engineering	**3**	**0**	**1**
BTN 9 1 DC 003 04	Animal Biotechnology **(Value addition)**	**3**	**0**	**1**
BTN 9 1 DC 004 04	Plant Biotechnology (**Skill Enhancement)**	**3**	**0**	**1**
DBCC Credit		**16**		
	Semester IV			
BTN 9 2 DC 005 20	Project Dissertation[#]	**0**	**0**	**20**
DBCC Credit		**20**		
Total Credit for Discipline Based Core Course		**68**		

[#] *The student shall carry out the dissertation work outside CUSB or within CUSB as recommended by DC. Department will provide the recommendation letters for the same. However, they have to follow the academic calendar of the CUSB.*

Discipline Based Core Elective (DBCE), Open Elective Interdisciplinary Course (OEIC)

Course Code	Code	Courses	Credits		
			L	T	P
Elective Course		**Any three electives in one and half years of M.Sc Program to be chosen. (i) One from parent Department i.e., DBCE and (ii) Two from Other Department/School (OEIC)**			
		Semester I			
BTN 8 1 OE 010 04	OEIC	Biodiversity, Conservation and Environmental Biotechnology	**3**	**1**	**0**
BTN 8 1 DE 011 04	DBCE	Developmental Biology	**3**	**1**	**0**
		Semester II			
BTN 8 2 OE 012 04	OEIC	Neuroscience	**3**	**1**	**0**
BTN 8 2 DE 013 04	DBCE	Cancer Biology	**3**	**1**	**0**
		Semester III			
BTN 9 1 DE 006 04	DBCE	Molecular Diagnostics and Stem Cell Technology	**3**	**0**	**1**
		Semester IV			
BTN 9 2 OE 007 04	OEIC	IPR, Bioethics and Biosafety	**3**	**1**	**0**
DBCE taken by student			**4**		
OEIC taken by student			**8**		
Total Credit for Elective Course (DBCE and OEIC)			**12**		

Mandatory Elective Noncredit Course (MENC)

	MENC designed by Department	**L**	**T**	**P**
BTN 8 1 ME 014 00	*Drosophila* as a Research Model	**1**	**0**	**1**
BTN 8 2 ME 015 00	Summer Training* (for 2nd Semester students during summer vacation)	**0**	**0**	**2**
BTN 9 1 ME 008 00	Village Based Skills (Whole Department)	**0**	**0**	**2**
BTN 9 1 ME 009 00	Field and Excursion Tour (Whole Department)	**0**	**0**	**2**
	MENC on Swayam			
	Introductory Mathematical Methods for Biologists			
	Bio-energetics of Life Processes			
	Principles of Downstream Techniques in Bioprocess			
	Human Molecular Genetics			

Note: *Swayam based courses are updated regularly and students can select any other updated courses even if it is not mentioned in the list given above. But they should follow the criteria of 2 non-credit course either alone or in combination of two courses. * Summer Training will be under MENC category for 2nd Semester only.*

DISCIPLINE BASED CORE COURSE
Semester I

Course Details			
Course Title: Cell and Molecular Biology			
Course Code	BTN 8 1 DC 001 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course *(if applicable)*	Not Applicable		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To teach students about basic concepts and methodology in Cell and Molecular Biology.
- ✧ To gain knowledge in scientific progress, investigation, interpretation, empirical evidence, logical interpretation using inductive and deductive reasoning in cell biology.

Course Learning Outcomes:

- ➢ To know about discoveries and concept in cell and molecular biology that will open an era of understanding, both of ourselves and around us.
- ➢ To give insight into development in molecular biology, and to explore exciting scientific applications benefiting all of society.

Course Contents (Theory):

UNIT I: Diversity of cells (25% Weightage; 15 lectures)
Structure and functions: prokaryotic, eukaryotic cells; The structural and functional organizations of cell membrane, ionic transport (passive and active transport), the extra-cellular matrix of eukaryotes, cell wall. Structure and functions of endoplasmic reticulum, golgi complex, ribosome lysosomes, peroxisomes (glyoxysomes), plastids and mitochondria. Nucleus and nuclear ingredients, proteins associated with nuclei. packaging of genetic material: nucleosome model, Organization of chromatin: chromosome structure.

UNIT II: Cell-cycle and regulation (17% Weightage; 10 lectures)
Steps in cell cycle, yeast as a model system, cell division control and regulation: yeast *cdc* gene, role of cyclins and cdk. Cell signaling: exocrine, endocrine, paracrine and surface receptor mediated transduction (DAG, Ca^{+2}, c-AMP, G-proteins). Cell motility: microtubules, microfilaments and intermediate element.

UNIT III: Structure and function of nucleic acids (8% Weightage; 5 lectures)
Structure, properties and functions of DNA and RNA, secondary and tertiary level organization, Various DNA forms, super coiling, melting of DNA, thermal denaturation and renaturation kinetics, $C_o t$ Curve, DNA Replication.

UNIT IV: Gene expression of prokaryotes & eukaryotes (12% Weightage; 7 lectures)

Structure of bacterial RNA polymerase, transcription events, and sigma factor cycle, eukaryotic RNA polymerase, promoter sequences, TATA box, Hogness Box, CAAT box, enhancers, upstream activating sequences, initiation and termination of transcription factor, RNA processing in prokaryotes vs eukaryotes, spliceosome. transcriptomics.

UNIT V: Translation and gene regulation (13% Weightage; 8 lectures)
Prokaryotic and eukaryotic translation, the translation machinery, mechanisms of initiation, elongation and termination, post-translational modifications and intracellular proteins transport. Gene regulation: control of gene expression in prokaryotes, operon model: *lac* operon and *trp* operon.

UNIT VI: Methods in cell and molecular biology (Practicum) (25 % weightage)
Practicum (Experiment 1 to 10).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: Diversity of cells	
1	Structure and functions, prokaryotic, eukaryotic cells
2-3	The structural and functional organizations of cell membrane, ionic transport (Passive and active transport)
4-5	The extra-cellular matrix of eukaryotes, cell wall
6	Structure and functions of endoplasmic reticulum
7	Golgi complex
8	Ribosome lysosomes, peroxisomes (glyoxysomes)
9-10	Plastids and mitochondria
11	Nucleus and nuclear ingredients
12	Proteins associated with nuclei
13-14	Packaging of genetic material: nucleosome model
15	Organization of chromatin.: chromosome structure
UNIT II: Cell cycle and regulation	
16-18	Steps in cell cycle, yeast as a model system, cell division control and regulation: yeast *cdc* gene, role of cyclins and cdk
19-22	Cell signaling: exocrine, endocrine, paracrine and surface receptor mediated transduction (DAG, Ca^{+2}, c-AMP, G-Proteins)
23-24	Cell motility: microtubules, microfilaments
25	Intermediate element
Unit III: Structure and function of nucleic acids	
26	Nucleic acids: structure, properties and functions of DNA and RNA
27	DNA forms, super coiling, melting of DNA, thermal denaturation
28	Renaturation kinetics, Cot curve
29-30	DNA replication
Unit IV: Gene expression of prokaryotes & eukaryotes	
31	Structure of bacterial RNA polymerase, transcription events, and sigma factor cycle, eukaryotic RNA polymerase
32-34	Promoter sequences, TATA box, Hogness Box, CAAT box, enhancers, upstream activating sequences, initiation and termination of transcription factor
35-36	RNA processing in prokaryotes vs eukaryotes, spliceosome
37	Transcriptomics
Unit V:Translation and regulation	
38-40	Prokaryotic and eukaryotic translation, the translation machinery, mechanisms of initiation, elongation and termination
41-42	Post-translational modifications
43	Intracellular proteins transport
44-45	Gene regulation: control of gene expression in prokaryotes, operon model: *lac* operon and *trp* operon.
Unit VI: Methods in Cell and Molecular Biology	

1-30	Practicum (Experiment 1 to 10)

Suggested Readings:

1. Watson, J. D. (2017). *Molecular Biology of the Gene* (7th ed.). Pearson press.
2. Lodish, H. et. al., (2021). *Molecular Cellular Biology*. Macmillan Press.
3. Karp, G. (2017). *Cell and Molecular Biology* (9th ed.), Willey press.
4. DeRoberties, E. D. P. (2017). *Cell and Molecular Biology* (8th ed.). South Asian Edition.

UNIT VI: Methods in Cell and Molecular Biology (Practicum) (25 % weightage)

Course Content:

Experiment 1	Determination of Blood group of given Blood sample
Experiment 2	Mitosis/Meiosis in onion root tips and flower
Experiment 3	Osmosis demonstration in Tradescantia leaf
Experiment 4	Isolation of chloroplast/mitochondria from Plant/animal tissues
Experiment 5	Analysis on subcellular fractionations : Exploring Cells through Centrifugation
Experiment 6	Competent cells preparation of *E.coli* cells
Experiment 7	Transformation of plasmid DNA into competent *E.coli* cells
Experiment 8	Transformation efficiency calculation of competent Cells
Experiment 9	Restriction digestion of plasmid DNA
Experiment 10	Agarose gel electrophoresis for visualization of restriction digested DNA

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/Experiment**
1-2	Experiment 1: Determination of Blood group of given Blood sample
2-4	Experiment 2: Mitosis/Meiosis in onion root tips and flower
5-7	Experiment 3: Osmosis demonstration in Tradescantia leaf
8-10	Experiment 4: Isolation of chloroplast/mitochondria from Plant/animal tissues
11-12	Experiment 5: Subcellular fractionation by differential centrifugation
13-15	Experiment 6: Competent cells preparation of *E.coli* cells
16-20	Experiment 7: Transformation of plasmid DNA into competent *E.coli* cells
21-25	Experiment 8: Transformation efficiency calculation of competent cells
26-28	Experiment 9: Restriction digestion of plasmid DNA
29-30	Experiment 10: Agarose gel electrophoresis for visualization of restriction digested DNA

Course Details			
Course Title: Biochemistry			
Course Code	BTN 8 1 DC 002 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course *(if applicable)*	Skill Enhancement		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To train students to understand about different biomolecules, their structure and function.
- ✧ To acquaint the students with the chemistry of biological systems and to unravel the chemistry of the living state.
- ✧ To help the students unravel the importance of biomolecules in medical and clinical problems.
- ✧ To develop the ability to understand and do research on different biochemical problems up to molecular level.
- ✧ To give training covering both classical and applied aspects of biochemistry including basic techniques like qualitative and quantitative analysis of various biomolecules.

Course Learning Outcomes:

- ➢ Understanding about different biomolecules of life.
- ➢ Analyze different biochemical processes and their significance.
- ➢ Plan different biochemical tests in order to know about diseases.

Course Contents (Theory):

Unit I: Biophysical chemistry (10% Weightage; 7 lectures)
Details of various bonds and forces in biomolecules, pH, pK, buffers, acid base theories, ionization of weak acids and bases, Henderson Hasselbalch equation, Titration curves and buffering action. Laws of thermodynamics, colligative properties, Gibb's free energy, biosensor.

Unit II: Amino acids and proteins (20% Weightage; 12 lectures)
Structure, properties, classification and functions, naturally occurring modifications of amino acids in proteins, non-protein amino acids. Secondary structure, domains, motif and folds, Ramachandran plots, protein folding and chaperones.

Unit III: Structure and function of carbohydrates (18% Weightage; 10 lectures)
Classification, types, optical isomerism, mutarotation, basic structure and functions of monosaccharides, oligosaccharides, polysaccharides, proteoglycans, glycoproteins, peptidoglycans and bacterial cell walls.

Unit IV: Structure and function of lipids (17% Weightage; 9 lectures)
Classification, structure, properties and function of fatty acids and lipids, phospholipids, glycolipids, sphingolipids, cerebrosides, steroids, prostaglandins, lipids as signals, cofactors and pigments.

Unit V: Bioenergetics and metabolic pathways (10% Weightage; 7 lectures)
Glycolysis, gluconeogenesis, Krebs cycle, oxidative phosphorylation, high energy compounds, degradation of lipids, biosynthesis of purines and pyrimidines, *de Novo* and salvage pathway, Vitamins.

Unit VI: Methods in Biochemistry (25% Weightage)
Practicum (Experiment 1 to 9).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	**Unit/Topic/Sub-Topic**
Unit I: Biophysical chemistry	
1	Details of various bonds and forces in biomolecules
2	pH, pK, buffers
3	Acid base theories, ionization of weak acids and bases
4	Henderson Hasselbalch equation, titration curves and buffering action
5	Laws of thermodynamics

6	Colligative properties
7	Gibb's free energy, biosensos
Unit II: Amino acids and proteins	
8-14	Structure, properties, classification and functions
15	Naturally occurring modifications of amino acids in proteins
16	Non-protein amino acids
17	Secondary structure, domains, motif and folds
18	Ramachandran plots
19	Protein folding and chaperones
Unit III: Structure and function of carbohydrates	
20-23	Classification, types
24	Optical isomerism, mutarotation
25-27	Basic structure and functions of monosaccharides, oligosaccharides, polysaccharides
28	Proteoglycans, glycoproteins
29	Peptidoglycans and bacterial cell walls
Unit IV Structure and function of lipids	
30-33	Classification, structure, properties and function of fatty acids and lipids
34	Phospholipids
35	Glycolipids, sphingolipids
36	Cerebrosides
37	Steroids, prostaglandins
38	Lipids as signals, cofactors and pigments
Unit V: Bioenergetics and metabolic pathways	
39-40	Glycolysis, gluconeogenesis, Krebs cycle
41-42	High energy compounds, degradation of lipids
43	Oxidative phosphorylation
44	Biosynthesis of purines and pyrimidines, *de Novo* and salvage pathway
45	Vitamins
Unit VI: Methods in Biochemistry	
1-30	Practicum (Experiment 1 to 9)
Suggested Readings:	
1. Ferrier, D. R. (2014). *Biochemistry (Lippincott's Illustrated Reviews Series)*. Wolter Kluwer. 2. Garrett, R. H., & Grisham, C. M. (2012). *Biochemistry.* Wadsworth Publishing Co Inc. 3. Lehninger, A., Nelson, D. L., & Cox, M. M. (2017). *Principles of Biochemistry*. WH Freeman. 4. Plummer, D. T. (2017). *An introduction to Practical Biochemistry*. McGraw Hill Education.	

Unit VI: Methods in Biochemistry (Practicum) (25% Weightage)

Course Content:

Experiment 1	Qualitative analysis of lipids by Acrolein test.
Experiment 2	Qualitative/ quantitative analysis of cholesterol by Salkowski test.
Experiment 3	Qualitative analysis of amino acids by Ninhydrin test.
Experiment 4	Qualitative analysis of proteins by Biuret test.
Experiment 5	Qualitative/ quantitative analysis of carbohydrates by Molisch's test.
Experiment 6	Qualitative analysis of reducing and non-reducing carbohydrates by Fehling's test and Bradford's test.
Experiment 7	Preparation of standard curve for quantitative estimation of proteins using BSA by Lowry's method.
Experiment 8	Methylene blue reductase test.
Experiment 9	Tests for food adulterations.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session	**Methods/Practicum/Experiment**

of 2 Hours)	
1-3	Experiment 1: Qualitative analysis of lipids by Acrolein test.
3-6	Experiment 2: Qualitative/quantitative analysis of cholesterol by Salkowski test.
7-9	Experiment 3: Qualitative analysis of amino acids by Ninhydrin test.
10-12	Experiment 4: Qualitative analysis of proteins by Biuret test.
13-15	Experiment 5: Qualitative/quantitative analysis of carbohydrates by Molisch's test.
16-18	Experiment 6: Qualitative analysis of reducing and non-reducing carbohydrates by Fehling's test and Bradford's test.
19-24	Experiment 7: Preparation of standard curve for quantitative estimation of proteins using BSA by Lowry's method.
25-27	Experiment 8: Methylene blue reductase test.
28-30	Experiment 9: Tests for food adulterations.

Course Details			
Course Title: Tools & Techniques in Biotechnology			
Course Code	BTN 8 1 DC 003 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P)
Course type	Discipline Based Core Course (DBCC)		
Nature of course	Theory cum Practicum		
Special Nature/ Category of the Course (*if applicable*)	Not Applicable		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To aware students with the basic concept, principle and application of various instruments commonly used to conduct experiments in biotechnology.
- ✧ To orient the students with tools and techniques used in Biotechnology for performing experiments, analysis of data and obtained results.
- ✧ To make the students understand how to measure, evaluate, interpret and record the result.
- ✧ To develop skills and competencies in conducting and standardizing a test/experiment.

Course Learning Outcomes:

- ➢ Understanding the basic principle and application of different Instruments used in Biotechnology.
- ➢ Differentiate among measurement, assessment and evaluation.

Course Contents (Theory):

UNIT I: Microscopic and centrifugation techniques (18% Weightage; 11 lectures)
Microscopic techniques: Principles and applications of simple, compound, phase-contrast and fluorescence microscopes, confocal microscopy electron microscopy - scanning electron microscopy and transmission electron microscopy. Centrifugation techniques: Principles and application of different types of centrifugation; differential and density gradient centrifugation of biomolecules and their applications.

UNIT II: Spectrophotometric techniques (17% Weightage; 10 lectures)

Spectrophotometric techniques: Electromagnetic spectrum, Beer Lambert's Law, UV/VIS spectrophotometer, fluorescent spectroscopy, spectrophotometry, infrared spectroscopy, atomic absorption spectroscopy, ESR and NMR spectroscopy, mass spectroscopy, circular dichroism.

UNIT III: Chromatographic techniques (12% Weightage; 7 lectures)
Types of chromatography, paper, thin layer, gas, gel permeation, ion-exchange, high performance liquid chromatography, and affinity chromatography, and their applications in biology.

UNIT IV: Electrophoretic techniques (20% Weightage; 12 lectures)
Horizontal and vertical gel electrophoretic system, agarose gel electrophoresis (DNA and RNA), pulsed field gel electrophoresis (PFGE), polyacrylamide gel electrophoresis (native and SDS), Immunolectrophoresis, isoelectric focusing and 2-dimension gel electrophoresis, two dimensional differential gel electrophoresis (DIGE), capillary electrophoresis, microchip electrophoresis.

UNIT V: Radiotechniques (8% Weightage; 5 lectures)
Radioactivity and its decay, Geiger-Müller counter**,** Scintillation counter, autoradiography and safety measures in handling radioisotopes.

UNIT VI: Methods in Tools & Techniques in Biotechnology (Practicum) (25% Weightage)
Practicum (Experiment 1 to 8).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	**Unit/Topic/Sub-Topic**
Unit I: Microscopic and centrifugation techniques	
1-2	Principles and applications: simple, compound microscope
3-4	Phase-contrast & Dark-field microscope
5	Fluorescence microscopes.
6	Confocal microscope
7	Electron microscopy: SEM and TEM
8-9	Principles of different types of centrifugation
10-11	Differential and density gradient centrifugation and ultracentrifugation of biomolecules and their applications
Unit II: Spectrophotometric techniques	
12-13	Electromagnetic spectrum, spectrophotometry, Beer Lambert's Law
14	UV/VIS spectrophotometer
15	Fluorescent spectroscopy
16	Infrared spectroscopy
17	Atomic absorption spectroscopy
18	NMR spectroscopy
19-20	ESR and Mass spectroscopy
21	Circular Dichroism
UNIT III: Chromatographic techniques	
22	Types of chromatography, Paper, thin layer chromatography
23-24	Gas chromatography, Gel permeation
25-26	Ion-exchange, affinity chromatography
27-28	HPLC, Applications of Chromatographic techniques in Biology
UNIT IV: Electrophoretic techniques	
29	Horizontal and vertical gel Electrophoretic system
30-31	Agarose gel electrophoresis (DNA, RNA)
32	Polyacrylamide gel (native gel electrophoresis and SDS-PAGE)
33	Pulsed field gel electrophoresis (PFGE)
34-35	Two dimensional differential gel electrophoresis (DIGE)
36-37	Isoelectric focusing and 2-Dimension gel electrophoresis
38-39	Immunolectrophoresis, capillary electrophoresis

40	Microchip electrophoresis
UNIT V: Radiotechniques	
41	Radioactivity and its decay
42	Geiger-Müller counter
43	Scintillation counter
44	Autoradiography
45	Safety measures in handling radioisotopes
Unit-VI: Methods in Tools and Techniques in Biotechnology	
1-30	Practicum (Experiment 1 to 8)

Suggested Readings:

1. White, R. (1990). *Biochemical Techniques Theory and Practice*. Waveland Press.
2. Christion, G. D. (2003). *Analytical Chemistry* (6th ed.), Wiley.
3. Wilson, K., & Walker, J. (2010). *Principles & Techniques of Biochemistry & Molecular Biology* (7th ed.). Cambridge University Press, UK.
4. Plummer, D. T. (2007). *An Introduction to Practical Biochemistry* (3rd ed.). Tata McGraw-Hill Education Pvt. Ltd.
5. Skoog, D. A. F., Holler J., & Crouch S.R. (2007). *Principles of Instrumental Analysis* (6th ed.), Cengage Learning, USA.

UNIT VI: Tools & Techniques in Biotechnology (Practicum) (25% Weightage)

Course Content:

Experiment 1	Locate a protein expression in the cell using fluorescence microscopy.
Experiment 2	Calculation of cell numbers of the given microbial cell by haemocytometer and spectrophotometer.
Experiment 3	Quantitative estimation of purified DNA by UV/VIS spectrophotometer.
Experiment 4	Determination of molecular weight of the given DNA sample using agarose gel electrophoresis and visualization by gel documentation system.
Experiment 5	SDS-PAGE for separation of proteins in a given sample/ western blot.
Experiment 6	To perform size exclusion/Ion exchange chromatography for protein purification.
Experiment 7	Determination of the molar extinction coefficient (ε) of the given sample.
Experiment 8	Determination of substrate concentration of the given unknown solution by Lambert's Beer's Law.

Course Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/Experiment**
1-6	Experiment 1: Locate a protein expression in the cell using fluorescence microscopy.
7-9	Experiment 2: Calculation of cell numbers of the given microbial cell by haemocytometer and spectrophotometer.
10-12	Experiment 3: Quantitative estimation of purified DNA by UV/VIS spectrophotometer.
13-15	Experiment 4: Determination of molecular weight of the given DNA sample using agarose gel electrophoresis and visualization by gel documentation system.
16-20	Experiment 5: SDS-PAGE for separation of proteins in a given sample/ blot.
21-23	Experiment 6: To perform size exclusion/Ion exchange chromatography for protein purification.
24-26	Experiment 7: Determination of the molar extinction coefficient (ε) of the given sample.
27-30	Experiment 8: Determination of substrate concentration of the given unknown solution by Lambert's Beer's Law.

Course Details			
Course Title: Introductory Course on Research Methodology			
Course Code	BTN 8 1 DC 004 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T)
Course Type	Discipline Based Core Courses (DBCC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Introductory course on Research Methodology		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To provide an overview on fundamentals of doing research including scientific terminology, literature, methods, analysis and interpretation of data, preparation of report, presentation, future aspects of research, importance and applications of scientific research to the society.
- ✧ An introduction to bioinformatics and a practical guide to the analysis of genes and proteins. It covers computational tools and databases widely used in bioinformatics.
- ✧ To provide a broad overview of biostatistics methods and commonly used application in bioscience research. Topics include measurement and categorizing variables, use and misuse of descriptive statistics, testing hypotheses, and applying statistical tests.

Course Learning Outcomes:

- ➢ Students will develop core research skills relevant to a wide spectrum of biological research, including written and oral communication, skills in making scientific observations, and recording and analysis of data by participating in discussions or through presentations or group research project associated with a discipline of interest to them.
- ➢ Students will learn about biological databases, computational tools to analyse biological data, microarray analysis, proteomics and role of Bioinformatics in drug discovery.
- ➢ How to choose and apply statistical tools to data sources, when and how statistical tools can be used to analyze data, and how to interpret others' quantitative studies.

Course Contents (Theory):

UNIT I: Perspectives and getting started with scientific research (20% Weightage; 9 lectures)
Science and technology, meaning and characteristic of research, importance and types of research activities, principles of quality research work, problems encountered in research, scientific attitude and temper, qualities of good researcher, contribution of indian scientists in global research planning and designing of research, criteria and validity of good research, reliability in research, artefacts and bias, managerialism and scientific research, leadership in scientific research.

UNIT II: Research in practice and science communication (14% Weightage; 6 lectures)
Literature review, journals, conference proceedings, journal impact factor, citation index, research index, reading a scientific paper, seminar, conference and workshops, scientific paper, writing a scientific paper, communicating to a journal, writing a grant for funding, preparation of research presentation, presenting in power point, open presentation.

UNIT III: Ethics in research (14% Weightage; 6 lectures)

Research ethics, importance of ethics in research, ethics: values and principles, codes of ethics, research misconduct, dealing with research misconduct, research ethics committees, general ethics and ethical issues.

UNIT IV: Introduction to bioinformatics and data analysis (26% Weightage; 12 lectures)
Biological databases- uses –sequence databases-nucleic acid (NCBI, EMBL, DDBJ), proteins-(SWISSPROT), structural databases- PDB, specialized databases – KEGG, OMIM, PubMed. Global and Local alignment, pairwise and multiple sequence alignment, database similarity searches: BLAST, bioinformatics in pharmaceutical industry: drug discovery and pharmacogenomics. Microarray data analysis methods. SAGE (Serial analysis of gene expression).

UNIT V: Descriptive data analysis and inferential statistics (26% Weightage; 12 lectures)
Introduction to biostatistics, concept of variables in biological systems. Data representation and summary measures for central tendency, dispersion, skewness and kurtosis of a frequency distribution. Concepts of population and sample, making inference about population from sample, framing hypothesis and possible errors. Testing hypothesis about mean: one sample and two sample cases. ANOVA and regression analysis, chi test.

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	**Unit/Topic/Sub-Topic**
UNIT I: *Perspectives of scientific research and getting started with research*	
1-9	
UNIT II: *Research in practice and scientific writing and scientific presentation*	
10-15	
UNIT III: *Ethics in Research*	
16-21	
UNIT IV: *Introduction to bioinformatics and data analysis*	
22-33	
UNIT V: *Descriptive data analysis and inferential statistics*	
34-45	
15 Hours	***Tutorials***

Suggested Readings:

1. Mount, D. (2004). Bioinformatics: Sequence and Genome Analysis (2nd ed.). Cold Spring Harbor Laboratory Press,U.S.
2. Lesk, A. (2008). *Introduction to Bioinformatics* (3rd ed.). OUP Oxford.
3. Attwood, T., & Parry-Smith, D. (2001). *Introduction to Bioinformatics*. Prentice Hall.
4. Krawetz, S. A. & Womble, D. D. (2003). *Introduction to Bioinformatics: A Theoretical and Practical Approach* (3rd ed.), Humana.
5. Abhilash, M. (2010). *Introduction to Bioinformatics and Microarray Technology*. CBS.
6. Baxevanis, A. D., & Francis Ouellette, B. F. (2004). *Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins* (3rd ed.). Wiley Interscience.
7. Knudsen, S., (2004). *Guide to Analysis of DNA Microarray Data* (2nd ed.). Wiley-Liss. Schena, M., (2002). *Microarray Analysis* (1st ed.). Wiley-Liss.
8. Jagota, A. (2001). *Microarray Data Analysis and Visualization*. The Bay Press.
9. Daniel, W. W. (2009). *Biostatistics: A Foundation for Analysis in the Health Sciences*. Wiley.
10. Das, N. G. (2008). *Statistical methods.* Tata McGraw Hill Education Private Limited.
11. Das, K. K. (2010). *An introduction to probability theory*. Asian Books Pvt Ltd.
12. Pal, N., & Sarkar, S. (2005). *Statistics: Concepts and Applications*. Prentice-Hall of India Pvt.Ltd.
13. Rosner, B. (2010). *Fundamentals of Biostatistics* (7th ed.). Cengage Learning, Inc.
14. Stephenson, G., & Radmore, P. M. (1990). *Advanced Mathematical Methods for Engineering and Science Students*. Cambridge University Press.
15. Kothari, C. R. (2019). *Research Methodology: Methods and Techniques*. New Age International Publishers.

16. Chaddah, P. (2018). *Ethics in Competitive Research: Do not get scooped; do not get plagiarized*, India.
17. Muralidhar, K., Ghosh, A., Singhvi, A. K. (2019). *Ethics in Science Education, Research and Governance*. Indian National Science Academy (INSA), New Delhi.

Semester II

Course Details			
Course Title: Microbiology			
Course Code	BTN 8 2 DC 005 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course type	Discipline Based Core Course (DBCC)		
Nature of course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Indian Knowledge System (partly)		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The course is designed to cover Indian Knowledge system, scope and history of microbiology, characteristics, molecular taxonomy, structure, metabolism and physiology of microorganisms and how microbes live, divide and causes diseases.
- ✧ Teaching on isolation, identification, antibiotic resistance, genetic recombination and their significance, pathogenesis, microbial growth control methods will be a part of the course.
- ✧ This course also includes bacterial, viral and protozoan pathogen, epidemiology, microbial flora and host pathogen interaction.

Course Learning Outcomes:

- ➢ Importance of microorganism in real world.
- ➢ Concept how different types of microorganism survive, divide, and causes disease.
- ➢ To learn the techniques involving isolation and identification of microbes and their controls.
- ➢ To get an idea about epidemiology, host pathogen interaction, microflora and their importance in health.

Course Contents (Theory):

UNIT I: Microbes and taxonomy (22% Weightage; 10 lectures)
Sukshmajeev in Vedas and their application, history and scope of microbiology, structure of bacteria, archaebacteria, cyanobacteria, fungi and their cell wall organization, viruses (plant and animal virus) and bacteriophages, culture media and their types, pure culture techniques, serial dilution methods, spread plate, pour plate, streak plate technique, numerical and molecular taxonomy, polyphasic taxonomy and identification of microorganisms.

UNIT II: Microbial growth and control (18% Weightage; 8 lectures)
Microbial growth and nutrition, growth kinetics, growth measurement and its regulation, batch, fed-batch and continuous culture, extremophiles, thermophiles, and their applications, methane oxidizing and methanogenic bacteria, physical and chemical control of microbes, antibiotics and other chemotherapeutic agents.

UNIT III: Microbial metabolism (27% Weightage; 12 lectures)
Metabolic pathways of microbes, aerobic and anaerobic carbon metabolism, glycolysis, ED pathway, pentose phosphate pathway, fermentation, TCA cycle and ETC; photophosphorylation; bacterial motility and transport of nutrients, synthesis of amino acids and other molecules, structure and synthesis of peptidoglycan and other cell wall material, carbon cycle, sulfur cycle, and nitrogen cycles, nitrate reduction, ammonia assimilation, nitrogen fixation and its regulation

UNIT IV: Genetic recombination in microbes (11% Weightage; 5 lectures)
Inheritance characters and variability, phenotypes, genotypes and mutation, conjugation, transformation, and transduction (generalized & specialized).

UNIT V: Host-pathogen Interactions (22% Weightage; 10 lectures)
Microbial flora and health, host pathogen interaction, epidemiology of infectious diseases-microbial agents, human pathogenic viruses and bacteria, drug-resistant bacteria, biofilms, life cycle of malarial parasite, leishmania (Kala-Azar), tuberculosis, hepatitis-B virus and AIDS virus.

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Microbes and taxonomy	
1	Sukshmajeev in Vedas and their application
2	History and scope of microbiology
3	Structure and cell wall organization of bacteria
4	Structure and cell wall organization of archaebacteria
5	Structure and cell wall organization of cyanobacteria
6	Structure and cell wall organization of fungi
7	Viruses and bacteriophage
8	Culture media and their types
9	Pure culture techniques-serial dilution methods
10	Numerical, molecular and polyphasic taxonomy and identification of microorganisms
Unit II: Microbial growth and control	
11	Microbial growth and population kinetics
12	Mode of nutrition & nutritional requirements of microorganisms
13	Measurement of growth and growth regulation
14	Extremophiles, thermophiles and their applications
15	Methane oxidizing and methanogenic bacteria
16	Physical control of microbe
17	Chemical control of microbes
18	Antibiotics and other chemotherapeutic agents
Unit III: Microbial metabolism	
19	Metabolic pathways of microbes, electron transport chain,
20-21	Anaerobic carbon metabolism - glycolysis, Entner Doudor0ff pathway, pentose phosphate pathway, fermentation
22	Aerobic carbon metabolism - TCA cycle and glyoxalate cycle
23	Photophosphorylation
24	Catabolism of lipids and proteins
25	Bacterial motility and transport of nutrients
26	Synthesis of amino acids and other molecules
27	Structure and synthesis of peptidoglycan
28-30	Carbon cycle and sulfur cycle, nitrogen cycle, nitrogen fixation and its regulation
Unit IV: Genetic recombination in microbes	
31	Inheritance characters, variability and mutation
32	Conjugation
33	Transformation
34-35	Transduction, generalized and specialized transduction
Unit V: Host-pathogen interactions	
36	Microbial flora and health
37	Host pathogen interaction
38	Epidemiology of infectious diseases-microbial agents
39	Human pathogenic viruses and bacteria
40	Antibiotic resistant bacteria and biofilm

41-42	Life cycle of Malarial parasite and Leishmania (Kala-Azar)
43	Life cycle of Tuberculosis
44-45	Life cycle of Hepatitis-B virus and AIDS virus
15 Hours	***Tutorials***

Suggested Readings:

1. Pommerville, J. C. (2013). *Alcano's Fundamentals of Microbiology* (10th ed.) Jones and Bartlett Publishers, Inc
2. Atlas, R. M. (1996). *Principles of Microbiology* (2nd ed.). McGraw-Hill: Boston, MA.
3. Chan, E. C. S., Pelczar, M. J., & Krieg, N. R. Jr. (2001). *Microbiology* (5th ed.). McGraw-Hill: India.
4. Gornity, G. M. (2012). *Bergey's Manual of Systematic Bacteriology* (2nd ed.). ASM Press.
5. Madigan, M. T., Martinko, J., & Parker, J. (2002). *Brock Biology of Micro-organism* (10th ed.). Prentice Hall College Div.
6. Willey, J. M., Sherwood, L., & Woolverton, C. J. (2016). *Prescott's Microbiology* (10th ed.). McGraw Hill.
7. Talaro, K. P., & Chess, B. (2014). *Talaro,s Foundations in Microbiology* (9th ed.). McGraw Hill Education Pvt. Ltd.
8. Hogg, S. (2013). *Essential Microbiology* (2nd ed.) John Wiley and Sons Ltd.
9. Schlegel, H. G. (2008). *General Microbiology* (7th ed.). Cambridge University Press.
10. Hurst, C. J., Crawford, R. L., Knudsen, G. R., McInerney, M. J. & Stetzenbach, L. D. (2007). *Manual of Environmental Microbiology* (3rd ed.). Wiley-Blackwell.
11. Schlossberg, D. (2015). *Clinical Infectious Disease* (2nd ed.), Cambridge University Press.
12. Spice, W. J.. (2007). *Clinical Microbiology and Infectious Diseases* (2nd ed.). Churchill Livingstone.
13. Mandell, G. L., Bennett, J. E. & Dolin, R. (1995). *Principles and Practice of Infectious Diseases* (4th ed.). Churchill Livingstone.
14. Rupp, S., & Sohn, K. (2009). *Host-pathogen Interactions: Methods and Protocols*. Humana Press.
15. Francisco, M. S., & Francisco, B. S. (2016). *Host-Microbe Interactions, Series Progress in Molecular Biology and Translational Science* (1st ed.). Volume 142, Elsevier Inc.
16. Salyers, A. A., & Whitt, D. D. (2005). *Revenge of the microbes: how bacterial resistance is undermining the antibiotic miracle*. ASM.
17. Mascaretti, O. A. (2003). *Bacteria verses antibacterial agents: an integrated approach*. ASM.
18. Costerton, J. W., & Lappin-Scott, H (1995). *Microbial Biofilm.* Cambridge University Press.

Course Details			
Course Title: Immunology & Immunotechniques			
Course Code	BTN 8 2 DC 006 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course type	Discipline Based Core Course (DBCC)		
Nature of course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Vocational Course		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To introduce students about the exciting and challenging field of immunology with theoretical and practical applications.
- ✧ To provide basic and advanced academic training in cellular and molecular immunology.

- ✧ To train students with emphasis on the interface between the basic and clinical aspects of the subject, developing investigative and presentational skills as well.
- ✧ The students get exposed to a wide range of immunological topics during lectures and assignments.

Course Learning Outcomes:

- ➢ To understand basics of immunology, and various immune cells.
- ➢ To gain knowledge about different immunological diseases with their causes.
- ➢ To understand cytokine biology and how their network interferes with the immune system.
- ➢ To know about different therapeutic approaches for combating variety of immunological diseases.
- ➢ To know about different aspects of applied immunology.

Course Contents (Theory):

Unit I: Basics of immune system (24% Weightage; 11 lectures)
Phylogeny of immune system**, i**nnate and acquired immunity, clonal nature of immune response, structure of lymphoid organs. nature and biology of antigens, immunogenicity, antigenicity, haptens, toxins-toxiods, hapten carrier system super antigens, mitogens. structure and function of antibody, generation of antibody diversity, antibody engineering, complement system.

Unit II: Immunotechnology (20% Weightage; 9 lectures)
Antibody generation (polyclonal and monoclonal), antigen-antibody interactions, antibody-antigen binding: affinity, avidity, cross reactivity, agglutination, hemagglutination, precipitation reactions in solution and in gels, immunoassays: detection of molecules using ELISA, ELISPOT, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

Unit III: Cells of immune system and its function (18% Weightage; 8 lectures)
Lymphocyte trafficking, B-lymphocyte, BCR, B cell development, T-lymphocytes, TCR, γδ TCR, dendritic cells, natural killer and lymphokine activated killer cells, eosinophils, basophils, neutrophils and mast cells, monocytes, macrophages. Generation of humoral and cell mediated immunity, activation of B and T- lymphocytes, cell mediated cytotoxicity.

Unit IV: Immune responses (20% Weightage; 9 lectures)
Major histocompatibility complex - general organization, inheritance, polymorphism and regulation, antigen processing and presentation, cytokines and their role in immune regulation, immunological tolerance, hypersensitivity, autoimmunity, immonosenescence, transplantation.

Unit V: Applied immunology (18% Weightage; 8 lectures)
Tumor immunology, AIDS and other immunodeficiencies, animal models and transgenic animals and their use in immunology. Vaccinology: active and passive immunization; live, killed, attenuated, sub unit vaccines. Vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology, peptide vaccines, Conjugate vaccines: cell based vaccines, rational vaccine design based on clinical requirement.

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	**Unit/Topic/Sub-Topic**
Unit I: Basics of immune system	
1	Phylogeny of immune system
2-3	Innate and acquired immunity
4	Clonal nature of immune response
5	Organization and structure of lymphoid organs
6	Nature and biology of antigens and super antigens
7	Immunogenicity, antigenicity, haptens,

8	Toxins-toxiods, super antigens, mitogens
9	Structure and function of antibody, generation of antibody diversity
10	Antibody engineering,
11	Complement system
Unit II: Immunotechnology	
12-13	Antibody generation (polyclonal and monoclonal)
14	Antigen-antibody interactions, Antibody-antigen binding: affinity, avidity, cross reactivity
15	Agglutination, hemagglutination, Precipitation reactions in solution and in gels
16	Immunoassays: detection of molecules using ELISA, ELISPOT, RIA
17	Immuno electrophoresis, Western blot, immune-precipitation
18	Flow cytometry,
19	Immunofluorescence microscopy,
20	Detection of molecules in living cells. in situ localization by techniques such as FISH and GISH
Unit III: Cells of immune system and its function	
21	Lymphocyte trafficking
22	B-lymphocyte, T-lymphocytes and its development
23-24	Activation of B and T- lymphocytes, BCR, TCR, γδ TCR,
25	Cell mediated cytotoxicity: mechanism of T cell and antibody dependent cell mediated cytotoxicity
26	Monocytes, macrophages, dendritic cells, macrophage mediated cytotoxicity
27	Natural killer and lymphokine activated killer cells, NK cell mediated lysis,
28	Eosinophils, basophils, neutrophils and mast cells
Unit IV: Immune responses	
29	Major histocompatibility complex
30	MHC inheritance, polymorphism and regulation,
31-32	Antigen processing and presentation
33	Cytokines and their role in immune regulation
34	Immunological tolerance
35	Hypersensitivity
36	Autoimmunity
37	Immonosenescence
Unit V: Applied immunology	
38	Transplantation
39-40	AIDS and other immunodeficiencies
41	Tumor Immunology
42	Animal models and transgenic animals and their use in immunology
43	Vaccinology: active and passive immunization, live, killed, attenuated, sub unit vaccines; peptide vaccines, conjugate vaccines
44-45	Vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Cell based vaccines, Rational vaccine design based on clinical requirements
15 Hours	***Tutorials***

Suggested Readings:

1. Kindt, T. J., Osborne, B. A., & Goldby, R. A. (2013). *Kuby Immunology* (7th ed.). W.H. Freeman.
2. Delves, P., Martin, S., Burton, D., & Roitt, I. (2011). *Roitt's Essential Immunology* (12th ed.). Wiley Blakwell publication.
3. Murphy, K. (2011). *Janeway's Immunobiology* (8th Edition). New York: Garland Science.
4. Price, C. P., & Newman, D. J. (1997). *Principles and Practice of Immunoassay* (7th sub ed.). SpringerLink.
5. Abbas, A., Lichtman, A., & Pillai, S. (2014). *Cellular and Molecular Immunology* (8th ed.). Elsevier.
6. Khan, F. A. (2104). *Biotechnology in Medical Sciences* (1st ed.). CRC Press.
7. Pongracz, J., & Keen, M. (2008). *Medical Biotechnology* (1st ed.). Churchill Livingstone.

Course Detail			
Course Title: Enzymology & Enzyme technology			
Course Code	BTN 8 2 DC 007 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course (*if applicable*)	Not Applicable		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The course is designed in such a way that covers topics on enzyme technology, including those related to animals, microbes, human health, agriculture and the environment. The instructor will introduce each topic and lead the subsequent class discussions.
- ✧ The course is also to teach concepts and principles of various experiments commonly conducted for Enzymology. This course covers methods for the isolation, purification, optimization and characterization of proteins, enzyme kinetics; and production conditions.

Course Learning Outcomes:

- ➢ To understand working principle of enzymes and their uses in the human life.
- ➢ Developing skill for purification and characterization of enzyme, determining its catalytic activity with respect to other important factors responsible for its stabilization and function.
- ➢ Planning and execution of various types of assessments as a teacher in their classes.
- ➢ To examine a quality of enzymes by establishing reliability and validity, and checking other requirements in our daily life.
- ➢ To teach various practicals related to enzymology and enzyme technology.
- ➢ They will be able to learn various methods used in enzyme kinetics.

Course Contents (Theory):

UNIT I: Introduction to enzymes (8% Weightage; 5 lectures)
Classification and nomenclature, isolation and purification of enzymes, enzyme activity, specific activity and turnover number, marker enzymes.

UNIT II: Enzyme kinetics (15% Weightage; 9 lectures)
Enzyme Kinetics: rate of reaction, product and substrate kinetics, steady state, pre-steady state, equilibrium kinetics, Michaelis and Menten Equation and its derivation, different methods to calculate the K_m and V_{max} and their significance.

UNIT III: Enzyme regulation (22% Weightage; 13 lectures)
Factor affecting enzyme activity and catalysis: pH, substrate and enzyme concentration, temperature, coenzyme and cofactors, catalytic mechanism of the enzyme. Enzyme inhibition, different types of inhibitors and activators.

UNIT IV: Structure and function of enzymes (23% Weightage; 14 lectures)
Structure and function of enzymes: lysozyme, chymotrypsin, RNase. Introduction to allosteric enzymes and isozymes. Industrial enzymes: lipase, protease and pectinase, protein crystallization.

UNIT V: Enzyme technology (7% Weightage; 4 lectures)
Immobilization of enzymes and their application, RNA-catalysis, catalytic antibodies - abzymes.

UNIT VI: Methods in Enzymology & Enzyme Technology (Practicum) (25% Weightage)
Practicum (Experiments 1-7).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Introduction to enzymes	
1-2	Classification and nomenclature
3	Isolation and purification of enzymes
4	Enzyme activity
5	Specific activity and turnover number, marker enzymes
Unit II: Enzyme kinetics	
6	Rate of reaction
7	Product and substrate kinetics
8-9	Steady state, pre-steady state, equilibrium kinetics
10-12	Michaelis and Menten Equation and its derivation
13-14	Different methods to calculate the K_m and V_{max} and their significance
Unit III: Enzyme regulation	
15-17	Factor affecting enzyme activity and catalysis: pH, substrate and enzyme concentration, temperature
18-19	Coenzyme and cofactors
20-21	Catalytic mechanism of the enzyme and different types of inhibitors and activators
22-27	Enzyme inhibition (competitive, noncompetitive, uncompetitive, mixed, substrate and partial)
Unit IV: Structure and function of enzymes	
28-32	Structure and function of enzymes: lysozyme, chymotrypsin, RNase
33-35	Introduction to allosteric enzymes and its kinetics
36-37	Isozymes
38-40	Industrial enzymes: lipase, protease and pectinase
41	Protein crystallization
Unit V: Enzyme technology	
42-43	Immobilization of enzymes and their application
44	RNA-catalysis
45	Catalytic antibodies - abzymes
UNIT VI: Methods in Enzymology & Enzyme Technology (Practicum)	
1-30	Practicum (Experiments 1-7)

Suggested Readings:

1. Copeland, R. A. (2000). *Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis* (2nd ed.). Wiley-VCH.
2. Kulkarni & Deshpande. (2016). *General Enzymology.* Himalya Publishing House.
3. Marangoni, A.G. (2008). *Enzyme Kinetics- A modern Approach*. Wiley-VCH.
4. Palmer, T., & Bonner, T. L. (2008). *Enzymes- Biochemistry, Biotechnology and Clinical Chemistry* (2nd ed.). Woodhead Publishing.
5. Reymond, J-L. (2006). *Enzyme Assays: High-throughput Screening, Genetic Selection and Fingerprinting.* Wiley-VCH.

UNIT VI: Methods in Enzymology & Enzyme Technology (Practicum) (25% Weightage)

Course Content:

Experiment 1	To determine the presence of catalase enzyme in green peas.
Experiment 2	To study the effect of salivary enzyme (papain) on starch.

Experiment 3	Preparation of ion exchange column to perform ion exchange chromatography.
Experiment 4	Extraction of lysozyme from egg white by ion exchange chromatography.
Experiment 5	To immobilize the given enzyme using sodium alginate method.
Experiment 6	To study the effect of inhibitors on enzyme activity.
Experiment 7	To study the effect of lysozyme on the degradation of cell wall.

Course Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/ Experiment**
1-4	Experiment 1: To determine the presence of catalase enzyme in green peas.
5-6	Experiment 2: To study the effect of salivary enzyme (papain) on starch.
7-8	Experiment 3: Preparation of ion exchange column to perform ion exchange chromatography.
9-14	Experiment 4: Extraction of lysozyme from egg white by ion exchange chromatography.
15-18	Experiment 5: To immobilize the given enzyme using sodium alginate method.
19-26	Experiment 6: To study the effect of inhibitors on enzyme activity.
27-30	Experiment 7: To study the effect of lysozyme on the degradation of cell wall.

Course Details			
Course Title: Methods in Microbiology			
Course Code	BTN 8 2 DC 008 02	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	60 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Practical		
Special Nature/ Category of the Course (*if applicable*)	Vocational course		
Methods of Content Interaction	Tutorials, practicals, individual and group performance of experiment, self-study, assignment, seminar and presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The main aim of this practical course is to train students to a variety of microbiological techniques, all of which are currently used in biotechnology research.
- ✧ The practicals have been designed to complement the vocational course and fit in with their sequence as far as possible.
- ✧ The hands-on experience should link to the mental framework provided by the tutorial, and give students a deeper understanding and more realistic perspective of the topics discussed.

Course Learning Outcomes:

- ➢ Students will be able to handle and analyze the microbiological experimental data effectively, and to extract the information contents from the data.
- ➢ This course will introduce students with hands on training for the cultivation of bacteria/sterile technique, growth of bacteria, pure culture technique, antibiotic susceptibility,

biofilm estimation and finally identification of an unknown microorganism by using advanced molecular biology techniques.

Course Content:

Experiment 1	Preparation of nutrient agar and culture of bacteria.
Experiment 2	Isolation of bacteria from soil or water sample.
Experiment 3	Growth curves and preservation of the bacteria.
Experiment 4	Biochemical tests & Gram staining of bacteria.
Experiment 5	Antibiotic susceptibility assays (Disc diffusion).
Experiment 6	Determination of minimum inhibitory concentration
Experiment 7	Quantitative determination of bacterial bioflim.
Experiment 8	Isolation and quantification of bacterial genomic DNA.
Experiment 9	PCR amplification of 16S rDNA/virulence gene from bacterial DNA and sequencing.
Experiment 10	Sequence analysis of 16S rDNA using chromatogram and identification of bacteria.

Course Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/ Experiment**
1-6	Experiment 1: Preparation of nutrient agar and culture of bacteria.
7-12	Experiment 2: Growth curves and preservation of the bacteria.
13-18	Experiment 3: Isolation of bacteria from soil or water sample.
19-24	Experiment 4: Biochemical tests & Gram staining of bacteria.
25-30	Experiment 5: Antibiotic susceptibility assays (Disc diffusion).
31-36	Experiment 6: Determination of minimum inhibitory concentration
37-42	Experiment 7: Quantitative determination of bacterial bioflim.
43-48	Experiment 8: Isolation and quantification of bacterial genomic DNA.
49-54	Experiment 9: PCR amplification of 16S rDNA from bacterial DNA and sequencing.
55-60	Experiment 10: Sequence analysis of 16S rDNA using chromatogram and identification of bacteria.

Suggested Readings:

1. Bauer, A., Kirby, W. M. M., Sherris, J. C. & Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disc diffusion method. *Am J Clin Pathol* 45, 493–496.
2. Clinical and Laboratory Standard Institute. (2010). Performance standard for antimicrobial susceptibility testing; twentieth informational supplement. CLSI document M100-S20; Vol. 30 No. 1, Wayne, PA. http://www.clsi.org/source/orders/free/m100-s20.pdf
3. Cruickshank, R., Duguid, J. P., Marmion, B. P., & Swain, R. H. A. (1975). *Medical Microbiology: The Practice of Medical Mcirobiology*. Churchill Livingstone.
4. Fredheim, E. G. A., Klingenberg, C., Rohde, H., Frankenberger, S., Gaustad, P., Flægstad, T., & Sollid, J. E. (2009). Biofilm formation by *Staphylococcus haemolyticus*. *Journal of Clinical Microbiology*, *47*(4), 1172-1180.
5. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual* (4th ed.). Cold Spring Harbor Laboratory.

Course Details			
Course Title: Methods in Immunology & Immunotechniques			
Course Code	BTN 8 2 DC 009 02	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	60 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Practical		
Special Nature/ Category of the Course (*if applicable*)	Vocational Course		
Methods of Content Interaction	Tutorials, practicals, individual and group performance of experiment, self-study, assignment, seminar and presentations by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The aims of this applied immunology laboratory course is to equip students with a good understanding of major immunological laboratory techniques (including safety) and their applications to both clinical analysis and experimental research.
- ✧ Research principles, quantitative reasoning, and understanding of immunological research methodologies will be highlighted within the course.
- ✧ Special attention is given to the experimental approaches that led to the general principles of immunology.

Course Learning Outcomes:

- ➢ This practical course will teach the students various practicals related to Immunology & immunological techniques.
- ➢ They will be able to learn various methods of immunodiagnostic techniques.
- ➢ The students will develop skills to distinguishing different characteristics of a variety of techniques used in clinical Immunology

Course Content:

Experiment 1	Separation of plasma and serum from blood.
Experiment 2	Identification and estimation of the percentage of live and dead cells in the blood sample using trypan blue.
Experiment 3	Lysis of RBC in the blood sample and estimation of the percentage of live and dead WBCs in the blood sample after RBC lysis using Trypan Blue.
Experiment 4	Counting of RBCs and WBCs using haemocytometer.
Experiment 5	Isolation of lymphocytes using histopaque and counting using haemocytometer.
Experiment 6	Differential staining of cells in the blood sample using Wright-Giemsa staining method.
Experiment 7	Determination of antigen or antibody by Radial immunodiffusion and Ouchterlony Double Diffusion method
Experiment 8	Determination of antibody/antigen/cytokine by ELISA/Dot ELISA.
Experiment 9	To observe the phagocytosis process in macrophages and WBC/T cell culture work
Experiment 10	Demonstration of dissection to show different lymphoid organs in mouse (Computer technology).

Course Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/ Experiment**
1-6	Experiment 1: Separation of plasma and serum from blood.
7-12	Experiment 2: Identification and estimation of the percentage of live and dead cells in the blood sample using Trypan Blue.
13-18	Experiment 3: Lysis of RBC in the blood sample and estimation of the percentage of live and dead WBCs in the blood sample after RBC lysis using trypan blue.
19-24	Experiment 4: Counting of RBCs and WBCs using haemocytometer.
25-30	Experiment 5: Isolation of lymphocytes using histopaque and counting using haemocytometer.
31-36	Experiment 6: Differential staining of cells in the blood sample using Wright-Giemsa staining method.
37-42	Experiment 7: Determination of antigen or antibody by Radial immunodiffusion and Ouchterlony double diffusion method.
43-48	Experiment 8: Determination of antibody/antigen/cytokine by ELISA/Dot ELISA.
49-54	Experiment 9: To observe the phagocytosis process in macrophages and WBC/T cell culture work
55-60	Experiment 10: Demonstration of dissection to show different lymphoid organs in mouse (Computer technology).

Suggested Readings:

1. Hay, F. C., Westwood, O. M. R. (2002). *Practical Immunology* (4th Edition). Wiley-Blackwell.
2. Stevens, C. D. (2003). *Clinical Immunology and Serology: A Laboratory Perspective*. F.A. Davis Company.

Semester III

Course Details			
Course Title: Recombinant DNA Technology			
Course Code	BTN 9 1 DC 001 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course (if applicable)	Skill Enhancement		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To present an in-depth understanding of recombinant DNA technology as the foundation of modern biotechnology and to show how these tools can be employed in guiding for quality research say production of biological molecules and providing sequencing services.
- ✧ Outlining the process of molecular cloning of a gene or segment of DNA, choosing the most appropriate technique for cloning eukaryotic genes, comparing and contrasting the vectors and methods used for creating genetically modified bacteria, plants and animals.

Course Learning Outcomes:

- ➢ To illustrate creative use of modern tools and techniques for manipulation and analysis of genomic sequences.
- ➢ To expose students to application of recombinant DNA technology in biotechnological research.

Course Contents (Theory):

Unit I: **Restriction-modification system** **(10% Weightage; 6 lectures)**
Types of restriction endonucleases, classification and their application. DNA modifying enzymes: nucleases, polymerases, phosphatases, DNA ligases, kinases, and other relevant enzymes, cutting and joining of DNA fragments, cohesive and blunt end ligation, adaptors, linkers, polylinkers and homo polymer tailing.

Unit II: **Nucleic acid labelling and sequencing** **(15% Weightage; 9 lectures)**
Isolation of DNA and RNA, quantification of nucleic acids. Radiolabeling and non-radiolabelling of nucleic acids: end labelling, nick translation, labelling by primer extension, non-radioactive labelling of Probe. DNA sequencing: Maxam-Gilbert and Sanger-Nicolson sequencing methods, pyrosequencing, automated gene sequencing, protein sequencing.

Unit III: **Vectors in cloning and gene expression** **(10% Weightage; 6 lectures)**
Properties and construction of cosmid and artificial plasmids, bacteriophage λ as cloning vector, other prokaryotic vectors, expression vectors, difference in cloning and expression vectors, and use of strong promoters.

Unit IV: **Cloning strategies** **(15% Weightage; 9 lectures)**
Construction of genomic and cDNA libraries, selection, screening and analysis of recombinants. Principle of hybridization- Southern blotting, Northern blotting, Western blotting, polymerase chain reaction and their applications.

Unit V: **Methods of nucleic acid transfer** **(25% Weightage; 15 lectures)**
Methods used to transfer rDNA in host: application of RDT in medicine and agriculture, site directed mutagenesis, DNA fingerprinting, DNA microarray, CRISPR Cas9 technology, genome mapping and codon optimization.

Unit VI: Methods in Recombinant DNA Technology (Practicum) **(25% Weightage)**
Practicum (Experiments 1 to 7).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: Restriction-modification System	
1	Types of restriction endonucleases, classification and their application
2-3	DNA modifying enzymes: nucleases, polymerases phosphatases and DNA ligases, kinases and other relevant enzymes
4-5	Cutting and joining of DNA fragments, cohesive and blunt end ligation, adaptors
6	Linkers, polylinkers and homo polymer tailing
UNIT II: Nucleic acid labelling and sequencing	
7-8	Isolation of DNA and RNA, quantification of nucleic acids
9-10	Radiolabeling and non-radiolabelling of nucleic acids: end labelling, nick translation, labelling by primer extension, DNA sequencing
11	Non-radioactive labelling of probe
12-13	Maxam-Gilbert and Sanger- Nicolson sequencing methods
14	Automated gene sequencing, pyrosequencing
15	Protein sequencing
Unit III: Vectors in cloning and gene expression	
16-17	Properties and construction of cosmid and artificial plasmids
18-19	Bacteriophage λ as cloning vector, other prokaryotic vectors, expression vectors
20-21	Difference in cloning and expression vectors, use of strong promoters
Unit IV: Cloning strategies	
22-23	Construction of genomic and cDNA libraries
24-25	Selection, screening and analysis of recombinants
26-27	Principle of hybridization. Southern blotting, Northern blotting
28	Western blotting
29-30	Polymerase chain reaction and their applications
Unit V: Methods of nucleic acid transfer	
31-33	Application of RDT in medicine
34-36	Application of RDT in agriculture
37	Site directed mutagenesis
38	DNA finger Printing
39	DNA microarray
40	CRISPR-Cas9 technology
41-43	Genome Mapping
44-45	Codon Optimization
Unit-IV: Methods in Recombinant DNA Technology (Practicum)	
1-30	Experiment 1 to 6

Suggested Readings:

1. Primrose, S. B., & Twyman, R. M. (2006). *Principles of Gene manipulation and Genomics* (7th ed.). Willey Blackwell press.
2. Winnaeker, E.L. (2010). *From Genes to Clones* (4th ed.). VCH publisher.
3. Glick B.R., Pasternak, J. J., & Patten, C. L. (2002). *Molecular Biotechnology: Principle and Application of Recombinant DNA* (4th ed.). ASM.
4. Prakash, K. (2020). *Fundamentals of Gene Cloning* (1st ed.). Sara publication.
5. Brown, T. A. (2016). *Gene Cloning and DNA analysis* (7th ed.). Willey Blackwell.

Unit VI: Methods in Recombinant DNA Technology (Practicum) (25% Weightage)

Course Contents:

Experiment 1	Isolation of total RNA from cell line/tissue.
Experiment 2	Preparation of cDNA using mRNA isolated from cell line/tissue.
Experiment 3	Polymerase chain reaction used for amplification of a gene.
Experiment 4	Ligation reaction setup for recombinant DNA generation
Experiment 5	Transformation of ligation mix in competent *E.coli* cells
Experiment 6	Identification of protein expressed in *E. coli/* cell line.
Experiment 7	Western blot for confirmation of recombinant protein expression in *E.coli*

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hour)	**Methods/Practicum/Experiment**
1-5	Experiment 1: Isolation of total RNA from cell line/tissue.
6-11	Experiment 2: Preparation of cDNA using mRNA isolated from cell line/tissue. Experiment 3: Polymerase chain reaction used for amplification of a gene.
12-17	Experiment 4: Ligation reaction setup for recombinant DNA generation
18-19	Experiment 5: Transformation of ligation mix in competent *E.coli* cells
20-25	Experiment 6: Identification of protein expressed in *E. coli/* cell line.
26-30	Experiment 7: Western Blot for confirmation of recombinant protein expression in *E.coli*

Course Details			
Course Title: Bioprocess Engineering			
Course Code	BTN 9 1 DC 002 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course (*if applicable*)	Not Applicable		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To get a thorough knowledge of all the unit operations of upstream and downstream processing involved in fermentation process.
- ✧ To introduce the basic concepts of process engineering, including fluid flow, heat and mass transfer and their applications in various process development.
- ✧ To design appropriate sterilization method, choosing a proper enzyme system and corresponding bioreactor.
- ✧ This course also covers the concepts and principles of various experiments commonly conducted for Bioprocessing Engineering such as growth curve leading to the calculation of various parameters. Also the experiments related to the isolation of protein and secondary metabolite will be carried out.

Course Learning Outcomes:

- Students will learn the importance of engineering in the bioprocess and concept of scaling up from lab to industry.
- They will know the techniques involved to get the purified products after fermentation.
- Student will get the idea about the production of drugs, antibiotics and factors affecting the production of these products.
- In bioprocess experiment, the student will learn how to calculate different bioprocess parameters from growth curve.
- They will also learn the death kinetics of microbes as well as downstream processing.

Course Contents (Theory):

UNIT I: Kinetics of microbial growth (15% Weightage; 9 lectures)
Introduction to bioprocess engineering, microbial growth and products formation, media formulation for industrial fermentation, media optimization and sterilization, mass balance in biotechnology.

UNIT II: Aeration and agitation (15% Weightage; 9 lectures)
Oxygen requirement, volumetric oxygen transfer rate, oxygen uptake rate, degree of oxygen satisfaction, types of impellers and spargers, foam formation and control.

UNIT III: Fermentation techniques (20% Weightage; 12 lectures)
Types and modes of cultivation (batch, fed batch and continuous bioreactions), measurement and control of bioprocess parameters, microbial and plant bioreactors, different types of bioreactors- CSTR, airlift bioreactor, packed bed, fluidized, photobioreactors, enzyme reactors, design, stability and analysis of reactors, microbes in food and industry- lactic acid, vinegar and penicillin production.

UNIT IV: Scale up techniques (10% Weightage; 6 lectures)
Introduction, bases of scale-up, physical concept and biological concept, scale-up methods in use, examples of scale-up, power per unit volume of liquid and volumetric oxygen transfer coefficient, introductory comments on non-Newtonian fluids.

UNIT V: Downstream processing (15% Weightage; 9 lectures)
Introduction, removal of microbial cells and solid matters, foam separation, precipitation, filtration, centrifugation, cell disruption, liquid-liquid extraction, chromatography, membrane process, crystallization and drying.

UNIT VI: Methods in Bioprocess Engineering (Practicum) (25% Weightage)
Practicum (Experiment 1 to 6).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Kinetics of microbial growth	
1	Introduction to bioprocess engineering
2-3	Kinetics of microbial growth
4-5	Kinetics of products formation
6	Media formulation for industrial fermentation and media optimization
7-8	Media sterilization and kinetics of thermal death, design criteria
9	Mass balance and stoichiometric calculation
Unit II: Aeration and agitation	
10	Oxygen transfer from gas bubble to cell
11-12	Volumetric oxygen transfer rate and K_La
13	Oxygen uptake rate and critical value of dissolved oxygen concentration (degree

	of oxygen satisfaction)
14-15	Dynamic and static method for K_La and parameters on which K_La depend
16	Types of impellers and spargers, foam formation and control
17-18	Stirrer power requirement (ungassed and gassed Newtonian liquid)
Unit III: Fermentation techniques	
19	Introduction to batch, fed batch and continuous bioreactors
20	Concept of chemostat and turbidostat
21-22	Steady state continuous cultivation theory for substrate, cell mass and product
23-24	Design criteria with concept of wash-out phenomenon
25	Concept of fed batch operation
26	Design, stability and analysis of reactors, measurement and control of bioprocess parameters
27	Microbial and plant bioreactors, different types of bioreactors-CSTR, airlift bioreactor, packed bed, fluidized, photobioreactors, enzyme reactors,
28-30	Microbes in food and industry- lactic acid, vinegar and penicillin production
Unit IV: Scale up techniques	
31	Bases of scale-up, physical concept and biological concept
32-33	Scale-up methods in use, power per unit volume of liquid
34-35	Volumetric oxygen transfer coefficient
36	Introductory comments on non-Newtonian fluids
Unit V: Downstream processing	
37	Introduction, removal of microbial cells and solid matters, foam separation
38-39	Filtration
40	Centrifugation
41	Cell disruption,
42	Liquid-liquid extraction
43	Precipitation
44	Membrane process (dialysis, reverse osmosis and ultra-filtration)
45	Chromatography, crystallization and drying
Unit VI: Methods in Bioprocess Engineering (Practicum)	
1-30	Experiment 1 to 6

Suggested Readings:

1. Bailey, J. E., & Ollis, D. F. (2010). *Biochemical Engineering Fundamentals* (2nd ed.). Tata McGraw Hill Education.
2. Board, B. (2007). *Product Recovery in Bioprocess Technology* (3rd ed.). Butterworth-Heinemann.
3. Crueger, W., & Crueger, A. (2017). *A text of Industrial Microbiology* (2nd ed.). Medtech.
4. Doran, P. M. (2010). *Bioprocess Engineering Principles* (2nd ed.). Academic Press.
5. Glaser, A. N., & Nilaido, H. (2011). *Microbial Biotechnology* (2nd ed.). W.H Freeman and Co.
6. Shuler, M. L., & Kargi, F. (2009). *Bioprocess Engineering Basic Concepts* (2nd ed.). Pearson.
7. Stanbury, P. F., Ehitaker, H. & Hall S. J. (2006). *Principles of Fermentation Technology* (3rd ed.). Butterworth-Heinemann.
8. Sullia, S. B., & Shantharam, S. (2010). *General Microbiology* (2nd ed.). Oxford and IBH Publishing Co. Pvt.Ltd.
9. Vogel, H. C., & Todaro, C. L, (2008), *Fermentation and Biochemical Engineering Handbook* (2nd ed.). Wiley Publishing, Hoboken.

Unit VI: Methods in Bioprocess Engineering (Practicum) (25% Weightage)

Course Contents:

Experiment 1	Bacterial growth curve and different phases of growth curve.
Experiment 2	Specific growth rate from the growth curve.
Experiment 3	Determination of doubling time from the growth curve.

Experiment 4	Thermal death of constant and thermal reduction time of bacteria.
Experiment 5	Extraction of soy protein from soy flour.
Experiment 6	Microbial degradation of aromatic compounds.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/Experiment**
1-8	Experiment 1: Bacterial growth curve and different phases of growth curve.
9-10	Experiment 2: Specific growth rate from the growth curve.
11-12	Experiment 3: Determination of doubling time from the growth curve.
13-18	Experiment 4: Thermal death of constant and thermal reduction time of bacteria.
19-20	Experiment 5: Extraction of soy protein from soy flour.
21-30	Experiment 6: Microbial degradation of aromatic compounds.

Course Details			
Course Title: Animal Biotechnology			
Course Code	BTN 9 1 DC 003 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course type	Discipline Based Core Course (DBCC)		
Nature of course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Value addition		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To develop competence in the areas of animal biotechnology to improve animal growth and reproduction.
- ✧ To have a comprehensive understanding of animal tissue culture, Stem cell research, transgenic techniques and biotechnological applications.
- ✧ To understand the use of biotechnological applications in health, medicine and industries.
- ✧ To promote transferable skills, such as critical thinking and systematic problem solving skills.
- ✧ To familiarize the students with all practical tools and techniques required for practical applications of the exciting field of animal biotechnology.
- ✧ To develop interest in this upcoming area useful in health and academics research and future entrepreneurship.

Course Learning Outcomes:

- ➢ To make an association between animal and human health with development of technology.
- ➢ To understand how to modify physiological processes to obtain biotechnological products to be applied to agricultural, social and medical areas.
- ➢ To develop career in biotechnology research relevant to animal health and medicine.
- ➢ To understand the methods used in routine animal cell culture practices in biological, and pharma industries.
- ➢ Student would be able to carry out future research involving animal tissue culture.

- To be able to compete in various training based programmes providing financial support e.g. Biotech Consortium of India Limited (BCIL).
- Take up independent career in the field of biotechnology.

Course Contents (Theory):

UNIT I: Introduction to animal tissue/cell culture (20% Weightage; 12 lectures)
History of animal cell culture, cell culture laboratory setup and instrumentation, cell culture media-media composition, serum, antibiotics, supplements, physicochemical properties, trypsinization, cryopreservation. cell senescence, common cell culture contaminants, different types of cell cultures-development of cell lines primary and continuous cell cultures, characterization and maintenance of cell lines, immortalisation of cell lines, cell growth curve, Good Laboratory Practices.

UNIT II: Cell culture techniques (17% Weightage; 10 lectures)
Experimental applications- cell proliferation assays, study of cell cycle, cell synchronization, mitosis in growing cells, measurement of viability and cytotoxicity. specialized culture techniques such as 3-D cultures and spheroid formation, applications of 3D culture, organ explant and utility of organ culture, histotypic and organotypic cultures, organ transplants, tissue engineering.

UNIT III: Gene transfer technology in animals (23% Weightage; 14 lectures)
Viral and non-viral methods of gene delivery (retro- and adeno- virus mediated gene transfer, liposome and nanoparticles mediated gen delivery), gene silencing technology- antisense therapy, siRNA, CRISPR Cas-9, tissue and organ transplantation, transgenics and their uses, production and status of transgenic animals, molecular pharming, animal and human cloning, ethical issues, animal imaging, molecular medicine.

UNIT IV: Application of cell culture technology (15% Weightage; 9 lectures)
Somatic cell nuclear transfer (SCNT), recombinant therapy- recombinant human growth hormone, streptokinase and urokinase in thrombosis- recombinant coagulation factors, cell culture technology in production of human and animal vaccines and pharmaceutical proteins, pharmacogenomics and its relevance in personalized medicine, gene therapy, strategies and vectors used in gene therapy, enzyme therapy.

Unit V: Methods in Animal Biotechnology (Practicum) (25% Weightage)
Practicum (Experiment 1 to 8).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 hour)	**Unit/Topic/Sub-Topic**
UNIT I: Animal Tissue/Cell Culture	
1-2	History of animal cell culture, cell culture laboratory setup and instrumentation, different types of cell cultures
3-6	Development of cell lines primary and continuous cell cultures, characterization and maintenance of cell lines, immortalization of cell lines, cellular growth curve
7-10	Cell culture media: media composition, serum, antibiotics, supplements, physiochemical properties
10-12	Trypsinization, cryopreservation. cell senescence, common cell culture contaminants, Good Laboratory Practices
UNIT II: Cell culture techniques	
13	Cell proliferation assays, study of cell cycle
14	Cell synchronization, mitosis in growing cells
15-16	Measurement of viability and cytotoxicity
17-18	Specialized culture techniques such as 3-D cultures and spheroid formation, applications of 3D culture
19-20	Organ explant and utility of organ culture, histotypic and organotypic cultures
21	Organ transplants
22	Tissue engineering

UNIT III: Gene transfer technology in animals	
23-27	Viral and non-viral methods of gene delivery (retro- and adeno- virus mediated gene transfer, liposome and nanoparticles mediated gen delivery)
28-30	Gene silencing technology- antisense therapy; siRNA; CRISPR
31	Tissue and organ transplantation
32	Transgenics and their uses, production and status of transgenic animals
33	Molecular pharming
34	Animal and human cloning, ethical issues
35	Animal imaging
36	Molecular medicine
UNIT IV: Application of cell culture technology	
37	Somatic cell nuclear transfer (SCNT)
38	Artificial Blood
39	Cell culture technology in production of human and animal vaccines
40	Cell culture technology in production of pharmaceutical proteins
41	Recombinant therapy- recombinant human growth hormone, streptokinase and urokinase in thrombosis; recombinant coagulation factors
42	Pharmacogenomics and its relevance in personalized medicine
43	Gene therapy, strategies and vectors used in gene therapy
44-45	Antibody and enzyme therapy
Unit V: Methods in Animal Biotechnology (Practicum)	
1-30	Practicum (Experiment 1 to 8)

Suggested Readings:

1. Freshney, I. R. (2010). *Culture of Animal Cells* (5th ed.). Wiley-Liss.
2. Masters, J.R.W. (2000). *Animal Cell Culture - Practical Approach* (3rd ed.). OUP.
3. Clynes, M. (2008). *Animal Cell Culture Techniques*. Springer.
4. Hafez, B., & Hafez, E.S.E. (2010) *Reproduction in Farm Animals* (7th ed.). Wiley- Blackwell.
5. Turksen, K. (2004). *Adult Stem Cells*. Humana Press, Inc.
6. Thomson, J., et al. (2004). *Handbook of Stem Cells: Embryonic/ Adult and Fetal Stem cells* (Vol. 1 & 2). Academic Press.
7. Twyman, R. M. (2005). *Gene Transfer to Animal Cells* (1st ed.). Taylor & Francis ,USA.
8. Glick, B.R., Pasternak J.J., & Patten C. L. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). ASM.
9. Emery, A. E. H. (1995). *Recombinant DNA Technology*. Wiley.
10. Emery, A. E. H. (2006). *Principles and Practice of Medical Genetics*, I, II, III Volumes (5th ed.). Churchill Livingstone.
11. Nallari, P., & Rao, V. V. (2010). *Medical Biotechnology*. OUP.
12. Pongracz, Keen. (2008). *Medical Biotechnology* (1st Edition). Elsevier Health – UK.

Unit V: Methods in Animal Biotechnology (Practicum) (25% Weightage)

Course Contents:

Experiment 1	Adherent and non-adherent animal cell culture.
Experiment 2	Cell trypsinization, sub culturing, cryopreservation.
Experiment 3	Live and dead cell assay by trypan blue method.
Experiment 4	Cellular proliferation and cytotoxicity assay by MTT method.
Experiment 5	To study the cell death by apoptotic assay.
Experiment 6	To study the effect of oxidative stress on viability of cell lines.
Experiment 7	Transfection of animal cell line (optional).
Experiment 8	Analysis of expressed proteins through western blotting/microscopy.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/Experiment**
1-3	Experiment 1: Adherent and non-adherent animal cell culture.

4-6	Experiment 2: Cell trypsinization, sub culturing, cryopreservation.
7-9	Experiment 3: Live and dead cell assay by trypan blue method.
10-12	Experiment 4: Cellular proliferation and cytotoxicity assay by MTT method.
13-15	Experiment 5: To study the cell death by apoptotic assay.
16-18	Experiment 6: To study the effect of oxidative stress on viability of cell line animal cell line.
19-24	Experiment 7: Transfection of animal cell line (optional)
25-30	Experiment 8: Analysis of expressed proteins through western blotting/microscopy.

Course Details			
Course Title: Plant Biotechnology			
Course Code	BTN 9 1 DC 004 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course Type	Discipline Based Core Course (DBCC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course (*if applicable*)	Skill Enhancement		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The main objectives of this course is to introduce students to the principles, practices and applications of plant tissue culture, transgenic technology, molecular marker development for crop improvement, and secondary metabolites production from plants.
- ✧ The students will also be exposed to the issues and challenges encountered in the area of plant biotechnology.

Course Learning Outcomes:

- ➢ Students will learn the importance of plant tissue culture, genetic transformation and molecular marker development.
- ➢ Students will have the concept of development of transgenic plant.
- ➢ They will know the techniques involved in molecular marker development.

Course Contents (Theory):

UNIT I: Introduction to plant tissue culture techniques (17% Weightage; 10 lectures)
Introduction to the techniques of plant tissue culture, media composition and sterilization techniques, concept of cellular totipotency, plant propagation: regeneration through meristem and callus cultures, somatic embryogenesis, embryo culture, haploid plant production, protoplast culture, somatic hybridization, somaclonal variation, artificial seeds.

UNIT II: Principle of plant transformation (22% Weightage; 13 lectures)
Basis of tumor formation, hairy root, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri as vectors, binary vectors, use of 35S and other promoters, methods of nuclear transformation, direct and Indirect DNA transfer, particle bombardment, electroporation, microinjection, chloroplast transformation.

UNIT III: Application of transgenic technology (8% Weightage; 5 lectures)
Insect resistance, fungal diseases resistance, bacterial diseases resistance, herbicide resistance, drought and salt resistance and Golden rice.

UNIT IV: Molecular markers in plant genome analysis (17% Weightage; 10 lectures)
Introduction to the principle of molecular marker, types of molecular markers and its application-RAPD, RFLP, AFLP, QTL, microsatellites, simple sequence repeats (SSR's), sequence-tagged sites (STSs), sequence characterized amplified regions (SCAR), single strand conformational polymorphism (SSCP), cleaved amplified polymorphic sequences (CAPs).

UNIT V: Bioactive compounds from plants (11% Weightage; 7 lectures)
Introduction and importance of plant secondary metabolites, different types of secondary metabolite, strategies to enhance secondary metabolites production, edible vaccines.

UNIT VI: Methods in Plant Biotechnology (Practicum) (25% Weightage)
Practicum (Experiments 1-5).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: Introduction to plant tissue culture techniques	
1-2	Introduction to the techniques of plant tissue culture, concept of cellular totipotency
3	Media composition and sterilization techniques
4-5	Plant propagation: Regeneration through meristem and callus cultures
6	Somatic embryogenesis, embryo culture
7	Haploid plant production
8	Protoplast culture, somatic hybridization
9	Somaclonal variation
10	Artificial Seeds
UNIT II: Plant transformation techniques	
11-12	Basis of tumor formation; hairy root
13-14	Features of Ti and Ri plasmids
15-16	Mechanisms of DNA transfer
17-20	Role of virulence genes, use of Ti and Ri as vectors; Binary vectors; Use of 35S and other promoters
21-22	Methods of nuclear transformation; Direct and Indirect DNA transfer; Particle bombardment, electroporation, microinjection
23	Chloroplast transformation
UNIT III: Application of transgenic technology in crop improvement	
24	Insect resistance
25	Fungal diseases resistance
26	Bacterial diseases resistance
27	Herbicide Resistance,
28	Drought and salt resistance, golden rice
UNIT IV: Molecular markers in plant genome analysis	
29-30	Introduction to the principle of Molecular marker
31-32	Types of molecular markers and its application: RAPD, RFLP
33-35	AFLP, QTL, microsatellites, simple sequence repeats (SSR's), sequence-tagged sites (STSs), sequence characterized amplified regions (SCAR)
36-38	single strand conformational polymorphism (SSCP), cleaved amplified polymorphic sequences (CAPs)
UNIT V: Bioactive compounds from plants	
39	Introduction and importance of plant secondary metabolites
40-42	Different types of Secondary metabolite
43-44	Strategies to enhance secondary metabolites production

45	Edible vaccines
UNIT VI: Methods in Plant Biotechnology (Practicum)	
1-30	Experiment 1-5.

Suggested Readings:

1. Chawla, H. S. (2020). *Introduction to Plant Biotechnology* (3rd ed.). Oxford & IBH publishing.
2. Singh, P. (2013). *Principles of Plant Biotechnology*. Kalyani Publishers.
3. Aneja, K. R. (2017). *Experiment in Microbiology, Plant pathology and Tissue Culture* (5th ed.). New Age International Publishers.
4. Singh, B. D. (2015). *Plant Biotechnology*. Kalyani Publishers.
5. Razdan M. K. (2019). *Introduction to Plant Tissue Culture* (3rd ed.). Oxford & IBH publishing.
6. Stewart, C. N., Touraev, A., Citovsky, V., & Tzfira, T. (2010). *Plant Transformation Technology.*
7. Dunwell, J. M. & Andy, C. (2010). *Transgenic Plants*. Wiley.

Unit VI: Methods in Plant Biotechnology (Practicum) (25% Weightage)

Course Contents:

Experiment 1	Preparation of stock solutions of MS (Murashige & Skoog, 1962) basal medium.
Experiment 2	To prepare MS media with different concentration and combination of plant growth regulators for micropropagation or regeneration.
Experiment 3	Surface sterilization and inoculation of explants on MS medium for micropropagation or regeneration.
Experiment 4	Isolation and visualization of plant genomic DNA by CTAB method.
Experiment 5	To perform DNA fingerprinting by random amplification of polymorphic DNA (RAPD) technique by PCR.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hour)	**Methods/Practicum/Experiment**
UNIT I: Introduction to plant tissue culture techniques	
1-4	Experiment 1: Preparation of stock solutions of MS (Murashige & Skoog, 1962) basal medium.
5-10	Experiment 2: To prepare MS media with different concentration and combination of plant growth regulators for micropropagation or regeneration.
10-15	Experiment 3: Surface sterilization and inoculation of explants on MS medium for micropropagation or regeneration.
15-25	Experiment 4: Isolation and visualization of plant genomic DNA by CTAB method.
25-30	Experiment 5: To perform DNA fingerprinting by random amplification of polymorphic DNA (RAPD) technique by PCR.

Semester IV

Course Details			
Course Title: Project Dissertation			
Course Code	BTN 9 2 DC 005 20	**Credits**	20
L + T + P	0 + 0 + 20	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	640 (P)
Course Type	Discipline Based Core Courses		
Nature of the Course	Dissertation		
Special Nature/ Category of the Course (*if applicable*)	Not Applicable		
Methods of Content Interaction	Literature review, gap area, methodology, laboratory work, dissertation writing, results and discussion, seminar, presentation and viva voce.		
Assessment and Evaluation	• 30% - Continuous Internal/ External Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

 # The student has the option to carry out the dissertation work outside the university provided he gets it on his own. However, they have to follow the academic calendar of the Central University of South Bihar. They will be accommodated in the Dept. of Biotechnology, if failed to get option outside the University. Students will be allotted as per the system so as to maintain uniformity and non-biasness.

Course Objectives:

As per requirement for the Award of M.Sc. Degree in Biotechnology, a project culminating in the submission of a dissertation must be carried out by students in their final year of study. The project-dissertation is a component that provides the students an opportunity to design, undertake an independent research under the guidance of a supervisor. A 'Project' leads to a 'dissertation' is assessed by supervisor and departmental committee members. The 'Dissertation' is comprised of the aims and objectives, a review of the literature, gap area, methodology, results and discussion, concrete recommendations and conclusions. Every student will submit a comprehensive report of the project work carried out in previous semesters in the form of dissertation, duly certified by the supervisor appointed by the Head of the Department. The project work will be presented by the students and evaluated by external/internal experts at the end of the semester. The students shall be present themselves for a comprehensive viva-voce examination before completion of the course.

- ✧ A 'Project' is an investigation driven undertaking, a structured and organized experiential learning includes designing the work, field work or other placement learning.
- ✧ The dissertation is a major document that reflects the skill to investigate the relevant topic/problem, ability to gather and analyze the result and discuss it concisely and clearly.
- ✧ Student will be a self-motivated and personally responsible for their action and learning.
- ✧ They will apply standard and advance techniques to solve a range of identified problems.
- ✧ Students will be proficient in the recording, storage, management and reporting data.

Course Learning Outcomes:

- ➢ To gain expertise in specific area of research and ability to conduct research work.
- ➢ To learn the process of evaluation of useful and non-useful information.
- ➢ To learn the ways how to write the thesis, and made a clear, detailed and logical arguments.
- ➢ To gain an idea how to asses the experimental results and present data.
- ➢ Developing skill to present and defend their research work in front of panel of experts.
- ➢ Developing the ability to publish their research output in high impact journals, present in national/ international conferences/proceedings and in the form of patents.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hours)	**Methods/Practicum/Experiment**
640 Hours	Student will devote 40 h in one week on experimental work. A total of 16 weeks or 640 hours will be given to them to complete the dissertation work.

DISCIPLINE BASED ELECTIVE COURSE & OPEN ELECTIVE INTERDISCIPLINARY COURSE

Semester I

Course Details			
Course Title: Biodiversity, Conservation and Environmental Biotechnology			
Course Code	BTN 8 1 OE 010 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory and Tutorial		
Special Nature/ Category of the Course (*if applicable*)	Skill Enhancement		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ This course is an introduction to biodiversity and its conservation strategies, environment and types of pollution present in the universe.
- ✧ It focuses on the utilization of microbial processes in waste and water treatment, biodegradation of petroleum products and bioremediation.

Course Learning Outcomes:

- ➢ Students will learn the importance of biodiversity and its conservation strategies
- ➢ Students will have the concept and importance of ecology.
- ➢ They will know the biotechnological techniques involved biodiversity conservation and remediation of toxic compounds in the environment.
- ➢ Student will know the importance of microbial diversity in environmental systems, processes and biotechnology as well as the importance of molecular approaches in environmental microbiology and biotechnology.

Course Contents (Theory):

UNIT I: Biodiversity –concept and introduction (24% Weightage; 11 lectures)
Concept and principle- history of the earth and biodiversity patterns through geological times; reasons of biodiversity, component of biodiversity, centers of biodiversity; primary and secondary center of diversity, microcenters, concepts of species and speciation, different types of species diversity; biological nomenclature, classical & quantitative methods of taxonomy of plants.

UNIT II: Conservation strategies (16% Weightage; 7 lectures)
Concept and principle of conservation strategies, reasons of loss of biodiversity, causes of endangerment, ex-situ and in situ conservation strategies, selection criteria for protection of species – species quality, IUCN guidelines for red list categories and criteria, red list of indian flora and fauna, selection criteria for protection of habitats – hotspots, conservation indices.

UNIT III: **Basics of ecobiotechnology (24% Weightage; 11 lectures)**
Composition of atmosphere, lithosphere, hydrosphere; atmospheric layers, ecosystem structure- air, water, soil, primary producers, consumers and decomposers, component of ecosystem, types of ecosystem; ecosystem function- energy flow, food chains, food webs, ecological pyramids & biotic interaction, concepts of sustainable development.

UNIT IV: Environmental pollution (18% Weightage; 8 lectures)

Air pollution, major sources and effects of air pollutants, water pollution, major sources and effects of water pollutants, soil pollution, major sources and effects of soil pollutants, noise pollution, major sources and effect of of noise pollution, radioactive pollution, major sources and effects of radioactive pollutants, micro-plastics and E-waste.

UNIT V: Remediation strategies of pollutants (18% Weightage; 8 lectures)

Waste water and sewage treatment, treatment through chemical, microbial and biotech techniques, bioremediation of contaminated soils, phytoremediation of soil metals, xenobiotic compounds, genetically engineered microbes and environmental risk.

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: Biodiversity –concept and introduction	
1	Concept and principle
2	History of the earth and biodiversity patterns through geological times
3-4	Reasons of biodiversity, component of biodiversity
5	Centers of biodiversity
6	Primary and secondary center of diversity, microcenters
7	Concepts of species and speciation
8	Different types of species diversity
9	Biological nomenclature
10-11	Classical and quantitative methods of taxonomy of plants and animals
UNIT II: Conservation strategies	
12	Concept and principle of conservation strategies
13	Reasons of loss of biodiversity, causes of endangerment
14	Ex-situ and in situ conservation strategies
15	Selection criteria for protection of species – species quality
16	IUCN guidelines for red list categories and criteria
17	Red list of indian flora and fauna.
18	Selection criteria for protection of habitats – hotspots, conservation indices
UNIT III: Basics of ecobiotechnology	
19	Composition of atmosphere, lithosphere, hydrosphere
20	Atmospheric layers
21-22	Ecosystem structure- air, water, soil, primary producers, consumers and decomposers
23	Component of ecosystem
24-26	Types of ecosystem
27-28	Ecosystem function- energy flow, food chains, food webs, ecological pyramids & biotic interaction
29	Concepts of sustainable development
UNIT IV: Environmental pollution	
30-31	Air pollution, major sources and effects of air pollutants
32-33	Water pollution, micro-plastics, major sources and effects of water pollutants
34-35	Soil pollution, E-waste, major sources and effects of soil pollutants
36	Noise pollution, major sources and effect of noise pollution
37	Radioactive pollution, major sources and effects of radioactive pollutants
UNIT V: Remediation strategies of pollutants	
38-39	Waste water and sewage treatment, treatment through chemical, microbial and biotech techniques
40	Bioremediation of contaminated soils
41	Phytoremediation of soil metals
42	Xenobiotic compounds
43-45	Genetically engineered microbes and environmental risk
15 Hours	***Tutorials***

Suggested Readings:

1. Dyke, F. V. (2011). *Study guide for Conservation Biology: Foundations, Concepts, Applications*. Springer Nature.
2. Dyke, F. V., & Lamb, R. L. (2020). *Conservation Biology: Foundations, Concepts, Applications*. Springer Nature.
3. Groom, M. J., Meffe, G. K., & Ronald, C (2005). *Principles of Conservation Biology*. Sinauer Associates, Inc.
4. Krishnamurthy, K. V. (2018). *An Advanced Textbook On Biodiversity: Principles And Practice*. Oxford & IBH Publishing.
5. Primack, R. B. (2014). *Essentials of Conservation Biology*. OUP USA.
6. Tchobanoglous, G., Burton, F., & Stensel, H. D (2017). *Wastewater Engineering: Treatment and Reuse*. McGraw Hill Education.
7. Bhattacharyya. B. C., & Banerjee, R. (2007). *Environmental Biotechnology*. OUP.
8. Thakur, I. S. (2017) *Environmental Biotechnology: Basic Concepts and Applications* (2nd ed.). I K International Publishing House Pvt. Ltd.

Course Details			
Course Title: Developmental Biology			
Course Code	BTN 8 1 DE 011 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course *(if applicable)*	Not Applicable		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ This course introduces to the molecular and cellular principles how a single cell becomes a multicellular organism with specialized tissues and organs.
- ✧ Introduction to molecular and cellular mechanisms involved in development of organisms.
- ✧ The focus will be on the genes and proteins involved in controlling the behavior of cells in the processes of differentiation, morphogenesis and growth.
- ✧ The developmental mechanisms and processes will be examined using genetic model organisms as examples.

Course Learning Outcomes:

- ➢ To understand how cells communicate in promoting the development of a multicellular organism,
- ➢ Appreciate the conservation of the molecular and cellular principles across different species.
- ➢ To learn the basic understandings of developmental biology providing an invaluable foundation for other aspects of biology as well as medicine, especially as many health issues can be related back to early developmental defects during embryogenesis.

Course Contents (Theory) :

Unit I: Introduction to developmental biology (10% Weightage; 5 lectures)

Introduction, history and concepts of developmental biology, phases of development, introduction to evolutionary developmental biology (Evo-Devo).

Unit II: Concepts of development (20% Weightage; 8 lectures)
Cell-cell interaction, cell fate and cell lineages, potency, commitment, specification, induction, competence, determination and differentiation, morphogenetic gradients, adhesion, migration, pattern formation, genomic equivalence and cytoplasmic determinants, sexual reproduction including meiosis, germ cells and fertilization, asymmetric cell division, imprinting, mutants and transgenics in analysis of development.

Unit III: Development process in animals (35% Weightage; 16 lectures)
Gametogenesis, cell surface molecules in sperm-egg recognition in animals, fertilization, zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals, embryogenesis, neurulation, cell aggregation and differentiation in *Dictyostelium*, axes and pattern formation in *Caenorhabditis elegans*, *Drosophila*, zebra fish, amphibian, chick and mammals, somitogenesis and organogenesis, vulva formation in *C. elegans*, eye lens induction, limb development and regeneration in vertebrates, differentiation of neurons, neurulation and CNS development, neural crest cells, post embryonic development- larval formation, metamorphosis and hormonal regulation, environmental regulation of normal development, sex determination.

Unit IV: Development process in plants (25% Weightage; 11 lectures)
Sporogenesis, gametogenesis, fertilization, embryonic and post-embryonic development, embryo sac development and double fertilization in plants, embryogenesis, developmental regulators, establishment of symmetry in plants, growth and tissue differentiation in plants, organization and maintenance of shoot and root apical meristem, organogenesis and organ polarity, shoot and root development, leaf development and phyllotaxy, floral transition, floral meristems and floral development in *Arabidopsis* and *Antirrhinum,* seed formation and germination, genetic manipulation of plant for studying development, fundamental differences between animal and plant development.

Unit V: Implications of developmental biology (10% Weightage; 5 lectures)
Teratogenesis: Teratogenic agents and their effects on embryonic development, *In vitro* fertilization, embryonic and adult stem cells, tissue homeostasis, amniocentesis, ageing.

Content Interaction Plan (Theory) :

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Introduction to developmental biology	
1-3	Introduction, history and concepts of developmental biology
4	Phases of development
5	Introduction to evolutionary developmental biology (Evo-Devo)
Unit II: Concepts of development	
6	Cell-cell interaction, cell fate and cell lineages
7-8	Potency, commitment, specification, induction, competence
9	Determination and differentiation, morphogenetic gradients, adhesion, migration
10	Pattern formation, genomic equivalence and cytoplasmic determinants
11	Sexual reproduction including meiosis, germ cells and fertilization, asymmetric cell division
12	Imprinting
13	Mutants and transgenics in analysis of development.
Unit III: Development process in animals	
14-15	Gametogenesis, cell surface molecules in sperm-egg recognition in animals, fertilization, zygote formation
16	Cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals
17	Embryogenesis, neurulation
18	Cell aggregation and differentiation in *Dictyostelium*
19-22	Axes and pattern formation in *Caenorhabditis elegans*, *Drosophila*, zebra fish, amphibian, chick and mammals
23-24	Somitogenesis and organogenesis, vulva formation in *C. elegans*, eye lens

	induction, limb development and regeneration in vertebrates
25-26	Differentiation of neurons, neurulation and CNS development, neural crest cells
27-28	Post embryonic development- larval formation, metamorphosis and hormonal regulation
29	Environmental regulation of normal development, sex determination
Unit IV: Development process in plants	
30	Sporogenesis, gametogenesis, fertilization, embryonic and post-embryonic development
31	Embryo sac development and double fertilization in plants, embryogenesis
32	Developmental regulators, establishment of symmetry in plants, growth and tissue differentiation in plants,
33	Organization and maintenance of shoot and root apical meristem,
34-35	Organogenesis and organ polarity, shoot and root development, leaf development and phyllotaxy,
36-37	Floral transition, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*
38	Seed formation and germination
39	Genetic manipulation of plant for studying development
40	Fundamental differences between animal and plant development.
Unit V: Implications of Developmental Biology	
41	Teratogenesis: Teratogenic agents and their effects on embryonic development
42	*In vitro* fertilization
43	Embryonic and adult stem cells
44	Tissue homeostasis, amniocentesis
45	Ageing
15 Hours	***Tutorials***

Suggested Readings:

1. Wolpert, L., & Tickle, C. (2019). *Principles Of Development*. OUP.
2. Gilbert, S. F. (2000). *Developmental Biology*. Sinauer Associates, Inc.
3. Slack, J. M. W. (2012). *Essential Developmental Biology*. John Wiley & Sons.
4. Leyser, O., & Day, S. (2002). *Mechanisms in Plant Development*. Willey-Blackwell.

Semester II

Course Details			
Course Title: Neuroscience			
Course Code	BTN 8 2 OE 012 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course *(if applicable)*	Skill Enhancement		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To give students a basic understanding of how our nervous system is organized and functions.
- ✧ To acquaint the students with different sense organs and their functions.
- ✧ To promote students for integrative thinking about the brain, behaviour, learning & memory and how disorders of the brain impact us at different levels.
- ✧ To help students understand about different neurological disorders at different levels.

Course Learning Outcomes:

- ➢ Learning about anatomy and functioning of the central and peripheral nervous system.
- ➢ To gain knowledge about various type of cells found in the nervous system.
- ➢ To understand different types of learning and memory and senses.
- ➢ Students will think about therapies for various neurological disorders.
- ➢ Help to eradicate social stigma and superstitions associated with neurological disorders.

Course Contents (Theory) :

Unit I: Organization of the nervous system (30% Weightage; 14 lectures)
Basics about the nervous system, different types of the nervous system, anatomy and functions of the Central Nervous System and Peripheral Nervous System, different parts of the brain and their functions, structure, functions and types of glial cells in the nervous system, blood brain barrier.

Unit II: Neural signaling (10% Weightage; 5 lectures)
Ion transport, resting potential, action potential, synaptic and vesicular transmission at excitatory and inhibitory synapses, neurotransmitters.

Unit III: Sensory systems (20% Weightage; 8 lectures)
Anatomy, biochemistry and functioning of vision, olfaction, taste, auditory, tactile, motor system and nocireceptors.

Unit IV: Behaviour, learning and memory (15% Weightage; 7 lectures)
Basics of learning and memory, types of learning and memory, long-term potentiation and depression, different behavioural training paradigms, associative and non-associative learning, reward and punishment learning, fear conditioning, stages of memory, sensory memory, short-term and long-term memory, forgetting, brain systems in memories.

Unit V: Neuro-psychiatric disorders (25% Weightage; 11 lectures)

Chemical control of brain, mental disorders like anxiety, mood disorders, depression, bipolar disorder, PTSD, schizophrenia, dementia, neurodegenerative diseases like Alzheimer's, Parkinson's, Huntington's, multiple sclerosis, amyelotrophic lateral sclerosis, ageing, neurotechnology.

Content Interaction Plan (Theory) :

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Organization of the nervous system	
1	Basics about the nervous system
2	Different types of the nervous system
3-4	Anatomy and functions of the Central Nervous System and Peripheral Nervous System
5-10	Different parts of the brain and their functions
11-12	Structure, functions and types of Neurons
13	Glial cells in the nervous system
14	Blood brain barrier
Unit II: Neural signalling	
15	Ion transport
16-17	Resting potential, action potential
18	Synaptic and vesicular transmission at excitatory and inhibitory synapses
19	Neurotransmitters
Unit III: Sensory systems	
20	Anatomy, biochemistry and functioning of vision
21	Olfaction
22	Taste
23-24	Auditory
25	Tactile
26-27	Motor system, nocireceptors
Unit IV: Behaviour, learning and memory	
28-29	Basics of learning and memory, types of learning and memory
30	Long-term potentiation and depression
31	Different behavioural training paradigms
32	Associative and non-associative learning, reward and punishment learning, fear conditioning
33	Stages of memory, sensory memory, short-term and long-term memory
34	Forgetting, brain systems in memories
Unit V: Neuro-psychiatric disorders	
35	Chemical control of brain
36-37	Mental disorders like anxiety, mood disorders
38	Depression, bipolar disorder
39	PTSD, Schizophrenia
40	Dementia, neurodegenerative diseases like Alzheimer's
41	Parkinson's, Huntington's
42	Multiple sclerosis, amyelotrophic lateral sclerosis
43	Ageing
44-45	Neurotechnology
15 Hours	***Tutorials***

Suggested Readings:

1. Kandel, E. R. (2021). *Principles of Neural Science*. McGraw-Hill, New York.
2. Purves, D., Augustine G. J. & Hall W. C. (2001). *Neuroscience.* Sinauer Associates, Inc.
3. Nicholls, J. G., & Martin A. R. (2011). *From Neuron to Brain*. Sinauer Associates, Inc.

Course Details			
Course Title: Cancer Biology			
Course Code	BTN 8 2 DE 013 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Discipline Based Core Elective (DBCE)		
Nature of the Course	Theory		
Special Nature/ Category of the Course *(if applicable)*	Skill Enhancement		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ The course is designed to provide students with a conceptual understanding of the development of cancer at the cellular and molecular levels and appreciate the complexity of cancer development.
- ✧ To provide students with an understanding of regulatory network involved in growth control and tissue organization with special emphasis on studying the mechanisms of tumorigenesis, metastasis, and angiogenesis.
- ✧ In addition, the course will investigate the development and clinical use of therapies based on the major discoveries in cancer biology research.
- ✧ This course is textbook based but will involve the substantial use of the related primary literature to understand the cellular and molecular basis of current strategies for cancer prevention and treatment.

Course Learning Outcomes:

- ➢ To understand the cellular and molecular basis of cancer.
- ➢ Current strategies for cancer prevention and treatment.
- ➢ To take up the research in the frontier area of cancer biology.

Course Contents (Theory):

Unit I: Basics of cancer biology (20% Weightage; 8 lectures)
Basics of Cancer Biology, cancer incidence and mortality; origin of neoplastic cells; cancer as cellular disease; oncogenes, tumour suppressor genes, multistep process of carcinogenesis. Tumor cell growth kinetics, types of cancer, different stages of cancer. Cancer detection and diagnosis.

Unit II: Viral oncogenesis and cancer signaling (35% Weightage; 17 lectures)
Viral carcinogenesis mechanism, oncogenes such as *Ras*, *Src*, etc., tumor suppressor genes such as p53, and Rb-E2F interaction, chemical carcinogenesis; initiation, promotion and progression, CDK-Cyclin-CDKI and CDC regulation in cancer progression, IGFR signaling, heredity and cancer; genetic basis of carcinogenesis (e.g. APC mutation and colon cancer), immunological aspects of cancer; leukemia.

Unit III: Epigenetic mechanism and cancer models (20% Weightage; 8 lectures)
Epigenetic mechanisms: DNA and histone modification, and micro RNA in cancer, animal models of cancer research, athymic nude mice model, syngeneic mouse model, transgenic mouse model etc, tumor angiogenesis and its molecular mechanisms, mechanisms of cancer invasion and metastasis and cancer stem cells.

Unit IV: Cell death and cancer therapeutics (25% Weightage; 12 lectures)

Apoptosis, death receptors, mitochondrial proteins, caspases, cancer therapeutics: surgery, radiation and chemotherapy. autophagy, mitophagy, adjuvant therapy, drug resistance, regenerative medicine, identification of new targets for cancer.

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: Basics of cancer biology	
1-2	Cancer incidence and mortality; origin of neoplastic cells
3	Cancer as cellular disease; oncogenes, tumour suppressor genes
4-5	Multistep process of carcinogenesis. tumor cell growth kinetics
6-7	Types of cancer, Different stages of cancer
8	Cancer detection and diagnosis
UNIT II: Viral oncogenesis and cancer signaling	
9-11	Viral carcinogenesis mechanism
12-14	Oncogenes such as Ras, Src, etc.
15-16	Tumor suppressor genes such as p53, and Rb-E2F interaction,
17-19	Chemical carcinogenesis; initiation, promotion and progression,
20-21	CDK-Cyclin-CDKI and CDC regulation in cancer progression,
22-24	IGFR signaling, heredity and cancer; genetic basis of carcinogenesis (e.g. APC mutation and colon cancer)
25	Immunological aspects of cancer; leukemia
UNIT III: Epigenetic mechanism and cancer models	
26	DNA and histone modification
27	micro RNA in cancer
28-29	Animal models of cancer research; athymic nude mice model
30-31	Syngeneic mouse model, transgenic mouse model etc
32-33	Tumor angiogenesis and its molecular mechanisms, mechanisms of cancer invasion and metastasis and cancer stem cells
UNIT IV: Cell death and cancer therapeutics	
34-35	Apoptosis, (death receptors, mitochondrial proteins, caspases)
36-37	Autophagy, mitophagy
38-39	Cancer therapeutics: surgery, radiation and chemotherapy
40-41	Adjuvant therapy, drug resistance
42-43	Regenerative medicine
44-45	Identification of new targets for cancer
15 Hours	***Tutorials***

Suggested Readings:

1. Wolfgang, A. S. (2007). *Molecular Biology of Human Cancers* (2nd ed.). Springer.
2. Weinberg, R. A. (2013). *Biology of Cancer* (2nd ed.). Garland Science
3. Knasmuller, S., DeMarini, D. M., Johnson, I, & Gerhauser, C. (2009). *Chemoprevention of Cancer and DNA Damage by Dietary Factors* (1st ed.). Willey-Blackwell Publisher.

Semester III

Course Details			
Course Title: Molecular Diagnostics and Stem Cell Technology			
Course Code	BTN 9 1 DE 006 04	**Credits**	4
L + T + P	3 + 0 + 1	**Course Duration**	One Semester
Semester	Odd	**Contact Hours**	45 (L) + 30 (P) Hours
Course type	Discipline Based Core Elective (DBCE)		
Nature of course	Theory cum Practicum		
Special Nature/ Category of the Course (*if applicable*)	Vocational Course		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, individual and group drills, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To provide a comprehensive understanding of the basic principles of the rapidly growing field of molecular diagnostics applicable to clinical laboratories, research, food, dairy and pharma industries.
- ✧ With an overview of essentials the course includes various molecular biology methods related to isolation and quantification of DNA, RNA and proteins.
- ✧ It will provide an preliminary training in the essential and common tools/ techniques that are used to isolate, culture, and expand stem cells, manipulate/engineer stem cells, characterize differentiation, and control microenvironments for elucidation of mechanisms and translation for specific applications.
- ✧ Hands on experiments of the most commonly used techniques that include to develop skills relevant to molecular diagnostic laboratory for future entrepreneurships and start-ups.

Course Learning Outcomes:

- ➢ Understanding of the basic principle used in molecular diagnostics.
- ➢ To gain thinking and analysis skills to understand new diagnostic methods.
- ➢ Student will develop an ability to collect new information to design new diagnostic kits.
- ➢ To gain knowledge for important parameters in designing the laboratory, quality system for molecular analyses and to use common molecular diagnostic procedures.
- ➢ Become proficient with the techniques required to perform the most commonly used molecular diagnostics protocols.
- ➢ Identify the components of a well-controlled diagnostic test.
- ➢ Gaining knowledge for critical thinking skills to trouble shoot problems as they occur and determine possible causes.
- ➢ Student will learn how stem cells are currently being used in the clinics and what kinds of future treatments lie on the horizon.

Course Contents (Theory):

UNIT I: DNA and RNA based molecular diagnostics (22% Weightage; 13 lectures)

Principles and techniques: Nucleic acid isolation and quantification methods, primer designing, fidelity of thermostable enzymes (Taq & Pfu polymerases), DNA polymerases. Principle and types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products. PCR in gene recombination: DNA & RNA hybridization techniques, Flourescence in-situ hybridization (FISH), microarrays, detection of microbial pathogens through PCR, ERIC- and REP-PCR, PFGE and AFLP. Application of these techniques in forensics, paternity identification, sex determination and detecting genetic disorders.

UNIT II: Clinical proteomics (18% Weightage; 12 lectures)

Overview of immune system, antibody based diagnostics, Monoclonal antibodies as diagnostic reagents, diagnosis of bacterial, viral and parasitic diseases by using, ELISA, ELISPOT, RIA, Western blot and immunofluorescence techniques. Immunohistochemistry- principle and techniques, application in diseases diagnosis. Proteomics based diagnosis- Protein profiling for disease diagnosis, 2D analysis of isolated proteins associated with disease by sequencing individual spots by Mass Spectrometry, Protein Micro array, present methods for diagnosis of Specific diseases like Tuberculosis, Malaria and AIDS.

UNIT III: Stem cell culture (16% Weightage; 9 lectures)

Stem cells, stem cell classification and location, stem cell development and differentiation, signaling pathways associated with stem cell development and induced pluripotent stem cells. Reprogramming, transcription factors, trans-differentiation, germ line epithelial and epidermal and neural niches, muscle and cardiac stem cells. Differentiation status of cells, primordial germ cell, skin cell, gastrointestinal cells. Autophagy in cell differentiation and embryonic development, principles and techniques of stem cell culture. Single-cell PCR methods for studying stem cells.

UNIT IV: Application of stem cell technologies (19% Weightage; 11 lectures)

Concept of tissue engineering, role of scaffolds, role of growth factors, potential uses of stem cells in cell based therapies. Molecular diagnostics for detection of tumor. Cancer stem cells, bioartificial organs- liver, heart auricles, blood vessels and skin. Animal models of regeneration, uses of stem cells - human stem cells, embryonic stem cells and gene therapy, SCNT and IVF techniques, therapeutic cloning, ethical issues.

UNIT V: Methods in Molecular Diagnostics and Stem Cell Technology (Practicum) (25% Weightage)

Practicum (Experiments 1-4).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
UNIT I: DNA and RNA based molecular diagnostics	
1-6	Principles and techniques, nucleic acid isolation, quantification methods, primer designing, types of PCRs. DNA & RNA hybridization techniques, in-situ (FISH), microarrays
6-13	Detection of microbial pathogens through PCR, REP and ERIC-PCR, AFLP, RAPD for animal and plants. Application of these techniques in forensics, paternity identification, sex determination and detecting genetic disorders
UNIT II: Clinical proteomics	
14-15	Overview of immune system, antibody based diagnosis, monoclonal antibodies as diagnostic reagents
16-18	Diagnosis of bacterial, viral and parasitic diseases by using ELISA, ELIPSOT, RIA, Western blot and immunofluorescence techniques
19	Immunohistochemistry – principle and techniques, application in diseases diagnosis
20-22	Proteomics based diagnosis: protein profiling for disease diagnosis, 2D analysis of isolated proteins associated with disease by sequencing individual spots by Mass spectrometry
23	Protein microarray
24-25	Present methods for diagnosis of specific diseases like Tuberculosis, Malaria and AIDS
UNIT III: Stem cell culture	
26	Stem cells, stem cell classification and location, stem cell development and differentiation
27	Signaling pathways associated with stem cell development

28-29	Induced pluripotent stem cells, reprogramming, transcription factors, trans-differentiation
30-31	Germ line epithelial and epidermal and neural niches, muscle and cardiac stem cells, differentiation status of cells, primordial germ cell, skin cell, gastrointestinal cells
32	Autophagy in cell differentiation and embryonic development
33-34	Principles and techniques of stem cell culture, single-cell PCR methods for studying stem cells
UNIT IV: Application of stem cell technologies	
35	Concept of tissue engineering, role of scaffolds, role of growth factors
36-37	Potential uses of stem cells in cell based therapies, Ethical issues
38-39	Molecular diagnostics for detection of tumor, cancer stem cells
40-41	Bioartificial organs- liver, heart auricles, blood vessels and skin
42-43	Animal models of regeneration, uses of Stem cells - human stem cells, embryonic stem cells and gene therapy
44-45	SCNT and IVF techniques, therapeutic cloning
UNIT V: Methods in Molecular Diagnostics and Stem Cell Technology (Practicum)	
1-30	Practicum (Experiment 1 to 4)

Suggested Readings:

1. Griffiths, J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart. (2000). *An Introduction to Genetic Analysis*. W.H. Freeman, New York.
2. Malacinski and Friefelder. (1998). *Essentials of Molecular Biology*. Jones & Bartlett Publishers.
3. Kumar, Weatherall. (2008). *Genomics and Clinical Medicine*. Oxford University Press. (ISBN 13: 978019518834)
4. Bruns, Dennis Lo, & Wittwer. (2003). *Molecular Testing in Laboratory Medicine: Selections from Clinical Chemistry 1998-2001*. AACC Press. (ISBN: 1890883603).
5. Kindt, T. J., Osborne, B. A., & Goldsby, R. A. (2013). *Kuby Immunology* (7th ed.). W. H. Freeman.
6. Newman, P. (1997). *Principles and Practice of Immunoassay* (2nd Sub ed.). NPG.
7. Freshney. (2010). *Culture of Animal Cells* (5th ed.).Wiley-Liss.
8. Lanza, Gearhart. *Essentials of Stem Cell Biology* (2nd ed.). Academic Press.
9. Gilbert, S.F. (2006). *Developmental Biology*. Sinauer Associates.
10. Turksen, K. (2004). *Adult Stem Cells*. Humana Press, Inc.
11. Thomson, J. et al. (2004). *Handbook of Stem Cells: Embryonic/ Adult and Fetal Stem cells* (Vol. 1 & 2). Academic Press.

Unit V: Methods in Molecular Diagnostics and Stem Cell Technology (Practicum)
(25% Weightage)

Course Contents:

Experiment 1	DNA and RNA Methods • Isolation of DNA/RNA from microbe (E. coli)/ Plant/ mammalian cell lines/ Human (Peripheral Blood).. • Quality / Quantity checking of Nucleic acids by a) UV Spectrophotometer and Agarose Gel Electrophoresis. • Polymerase Chain Reaction (PCR)
Experiment 2	Protein methods • Protein isolation, quantitation, and resolution by SDS-PAGE • Western blotting and ELISA
Experiment 3	Immunological methods • Blood typing (ABO determination) • Precipitation, Immunodiffusion, Immunoelectrophoresis
Experiment 4	Animal/stem cell culture experiments • Isolation of stem cells and maintenance of animal/stem cells, trypsinization, sub-culturing and cryopreservation • Viability analysis.

Content Interaction Plan (Practicum):

Practicum cum Discussion (Each Session of 2 Hour)	**Methods/Practicum/Experiment**
1-9	Experiment 1: DNA and RNA Methods • Isolation of DNA/RNA from microbe (E. coli)/ Plant/ mammalian cell lines/ Human (Peripheral Blood).. • Quality / Quantity checking of Nucleic acids by a) UV Spectrophotometer and Agarose Gel Electrophoresis. • Polymerase Chain Reaction (PCR)
10-15	Experiment 2: Protein methods • Protein isolation, quantitation, and resolution by SDS-PAGE • Western blotting and ELISA
16-21	Experiment 3: Immunological methods • Blood typing (ABO determination) • Precipitation, Immunodiffusion, Immunoelectrophoresis
21-30	Experiment 4: Animal/stem cell culture experiments • Isolation of stem cells and maintenance of animal/stem cells, trypsinization, sub-culturing and cryopreservation • Viability analysis.

Semester IV

Course Details			
Course Title: Intellectual Property Rights (IPR), Bioethics and Biosafety			
Course Code	BTN 9 2 OE 007 04	**Credits**	4
L + T + P	3 + 1 + 0	**Course Duration**	One Semester
Semester	Even	**Contact Hours**	45 (L) + 15 (T) Hours
Course Type	Open Elective Interdisciplinary Course (OEIC)		
Nature of the Course	Theory		
Special Nature/ Category of the Course (*if applicable*)	Not Applicable		
Methods of Content Interaction	Lecture, tutorials, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ This course explores all the intellectual properties such as patents, copyright, trademark and others in the present context. The course discusses about different national and international IPR issues and various international agreements and treaties.
- ✧ Biotechnology and allied fields like Molecular Biology, Biochemistry and Microbiology are promising research-oriented and fast-growing interdisciplinary fields having applications in every sphere of life. Due to growing concerns arising from Genetically-Modified-Organisms (GMOs) it is necessary to understand various national and international biosafety guidelines and bioethics regulations to assess and control the related potential risks.
- ✧ This course consists of teachings like good laboratory procedure and practices, standard operating procedures for biotechnology research, legal and institutional framework for biosafety, international agreements and protocols for biosafety.

Course Learning Outcomes:

- ➢ The students will learn about the intellectual property rights and their usages to protect work created by human mind that has commercial value.
- ➢ The students will have an idea of biosafety guidelines and bioethics regulations so that they can apply while working in laboratory.

Course Contents:

Unit I: Intellectual property rights (30% Weightage; 14 lectures)
Basic concepts of intellectual property: introduction to intellectual property rights; intellectual property laws; trade related aspects of intellectual property rights. Forms of IPR like patent, design and copyright, trademark, IPR laws.

Unit II: Biosafety (25% Weightage; 11 lectures)
Definition of biosafety, risk group categorization of organisms, biosafety levels, biosafety for human and environment, general guidelines for rDNA research activity, containment facilities and biosafety practices, guidelines for research in transgenic plants and animals with applications, structure and functions of committees, DBT guidelines on biosafety in conducting research in biology/biotechnology.

Unit III: Bioethics (25% Weightage; 11 lectures)
General ethics and ethical issues, animal rights, necessity of bioethics, different paradigms of bioethics- national and international, ethical issues against molecular technologies, regulations of genetically modified organisms (GMOs), environmental safety of GMOs, labelling of GM foods, human cloning, bioethics for the future.

Unit IV: Case studies **(20% Weightage; 9 lectures)**

Case studies related to patents, copyright, geographical indication and trademark. Issues related to bioethics and biosafety.

Content Interaction Plan:

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Intellectual property rights	
1-3	Basic concepts of intellectual property: introduction to intellectual property rights
4-8	Intellectual property laws
9-12	Trade related aspects of intellectual property rights
13-14	Forms of IPR like patent, design and copyright trademark, IPR laws
Unit II: Biosafety	
15-16	Definition of biosafety, risk group categorization of organisms, biosafety levels
17	Biosafety for human and environment
18	General guidelines for rDNA research activity
19-20	Containment facilities and Biosafety practices
21-22	Guidelines for research in transgenic plants and animals with applications
23	Structure and functions of Biosafety Committees
24-25	DBT guidelines on biosafety in conducting research in biology/biotechnology
Unit III: Bioethics	
26-27	General ethics and ethical issues
28-29	Animal rights, necessity of bioethics
30	Different paradigms of bioethics- national and international
31-32	Ethical issues against molecular technologies
33	Regulations of genetically modified organisms (GMOs),
34	Environmental safety of GMOs, labelling of GM foods,
35	Ethics in human cloning
36	Bioethics for the future
Unit IV: Case studies	
37-38	Case studies related to patents
39-40	Case studies related to copyright
41-42	Case studies related to geographical indication and trademark
43	Issues related to bioethics
44-45	Issues related to biosafety
15 Hours	***Tutorials***

Suggested Readings:

1. Vaughn, L. (2012). *Bioethics: Principles, Issues, and Cases* (2nd ed.). Oxford University Press.
2. Singer, P. A., & Viens, A. M. (2008). *The Cambridge Textbook of Bioethics* (1st ed.). Cambridge University Press.
3. Shannon, T.A., & Kockler, N.J. (2009). *An Introduction to Bioethics* (4th ed.). Paulist Press.
4. Sateesh, M. K. (2008). *Bioethics and Biosafety*. I.K. International Publication House Pvt Ltd.
5. Joshi, R. M. (2006). *Biosafety and Bioethics*,.Isha Books, New Delhi
6. Gupta, K., Karihaloo J. L., & Ketarpal R. K. (2008). *Biosafety Regulations of Asia-Pacific Countries*. Wiley.
7. Richard, W. S. (2001). *Intellectual Property: Patents, Trademarks, and Copyrights* (2nd ed.). Cengage Learning.

Mandatory Elective Non-Credit Course

Course Details			
Course Title: *Drosophila* as a Research Model			
Course Code	BTN 8 1 ME 014 00	**Credits**	2
L + T + P	1 + 0 + 1	**Course Duration**	One Semester
Semester	Any	**Contact Hours**	15 (L) + 30 (P) Hours
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Theory cum Practicum		
Special Nature/ Category of the Course *(if applicable)*	Skill Enhancement		
Methods of Content Interaction	Lecture, practicals, group discussion, self-study, seminar, assignments and presentation by students.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To make the students familiar with the *Drosophila* model system, its importance and significance.
- ✧ To train the students for working with *Drosophila* (fruit flies), identification of sexes, and their life cycle.
- ✧ To train the students for using different behavioural paradigms to measure olfactory learning and memory, basic genetics and molecular biology using flies.

Course Learning Outcomes:

- ➢ Student will understand the fly model system, how to work with this model to solve different biological problems.
- ➢ Plan and do research on various neurological problems using fly model.
- ➢ Can develop a fly lab themselves.

Course Contents (Theory):

Unit I: Culturing the flies (10% Weightage; 3 lectures)
Different types of culturing media used for rearing flies, learning techniques to keep the flies healthy.

Unit II: Life cycle of flies (7% Weightage; 2 lectures)
An understanding of the life cycle of *D. melanogaster*, an insect which exhibits complete metamorphosis

Unit III: Setting up genetic crosses (10% Weightage; 4 lectures)
Identification of male and female flies, virgin flies, collection of virgin flies and setting up genetic crosses and observe the effects in the next generation.

Unit IV: Behavioural experiments (13% Weightage; 4 lectures)
Measuring olfaction, learning and memory in larvae and adult of flies.

Unit V: Molecular biology with flies (10% Weightage; 3 lectures)
Extraction of genomic DNA, RNA and protein from flies and determination of marker gene by PCR.

Unit VI: Methods in Drosophila Techniques (Practicum) (50% Weightage)
Practicum (Experiments 1-6).

Content Interaction Plan (Theory):

Lecture cum Discussion (Each Session of 1 Hour)	Unit/Topic/Sub-Topic
Unit I: Culturing the flies	
1-2	Different types of culturing media used for rearing flies.
3	Learning techniques to keep the flies healthy.
Unit II: Life cycle of flies	
4-5	Gain an understanding of the life cycle of D. *melanogaster*, an insect which exhibits complete metamorphosis.
Unit III: Setting up genetic crosses	
6	Identification of male and female flies, virgin flies.
7-8	Collection of virgin flies and setting up genetic crosses and observe the effects in the next generation.
Unit IV: Behavioural experiments	
9-10	Measuring olfaction.
11-12	Learning and memory in larvae and adult of flies.
Unit V: Molecular Biology with flies	
13	Extraction of genomic DNA from flies.
14	Extraction of RNA from flies
15	Extraction of Protein from flies
Unit VI: Methods in Drosophila Techniques	
1-30	Practicum (Experiment 1 to 6)
Suggested Readings: 1. Dahmann, C. (2008). Drosophila Methods and Protocols. Springer-Verlag New York, LLC ***2.*** Sullivan, W., Ashburner, M., & Hawley, R. S. (2000). Drosophila Protocols. Cold Spring Harbor Laboratory, USA. ***3.*** Greenspan, R. J. (2004). Fly Pushing: The Theory and Practice of Drosophila Genetics, Second Edition. Cold Spring Harbor Laboratory, USA.	

Unit VI: Methods in *Drosophila* as a Research Model (Practicum) (50% Weightage)

Course Contents:

Experiment 1	Preparation of corn meal agar media for culturing flies, transfer of flies.
Experiment 2	Identification of different stages of flies in their life cycle.
Experiment 3	Identification of male and female flies, collection of virgin female flies and setting up genetic crosses with males.
Experiment 4	Setting up two-choice assay for measuring olfaction in adult flies.
Experiment 5	Training and measuring learning and memory in larvae and adults of flies.
Experiment 6	Extraction of genomic DNA, RNA and protein from flies.

Content Interaction Plan (Practicum):

Practical cum Discussion (Each Session of 2 Hours)	Methods/Practicum/Experiment
1-6	Experiment 1: Preparation of corn meal agar media for culturing flies, transfer of flies
7-12	Experiment 2: Identification of different stages of flies in their life cycle.
13-18	Experiment 3: Identification of male and female flies, Collection of virgin female flies and setting up genetic crosses with males.
19-21	Experiment 4: Setting up two-choice assay for measuring olfaction in adult flies.
22-24	Experiment 5: Training and measuring learning and memory in larvae and adults of flies.
25-30	Experiment 6: Extraction of genomic DNA, RNA and protein from flies.

Course Details			
Course Title: Summer Training			
Course Code	BTN 8 2 ME 015 00	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Any	**Contact Hours**	60 (P) Hours
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Practical		
Special Nature/ Category of the Course *(if applicable)*	Skill based		
Methods of Content Interaction	Literature review, methodology, laboratory work, dissertation writing and presentation.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ An investigation driven small project, designing the work, performing experiments and learn techniques associated with the project.

Course Learning Outcomes:

- ➢ To gain training how to use techniques and perform experiments.
- ➢ To learn writing the thesis, asses the experimental results and present the data.

Course Details			
Course Title: Village Based Skills			
Course Code	BTN 9 1 ME 008 00	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Any	**Contact Hours**	60 (P) Hours
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Practical		
Special Nature/ Category of the Course *(if applicable)*	Skill based		
Methods of Content Interaction	Group discussion, visiting nearby village to learn skills relevant to villages.		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

For Village based skills, the Department should contact Mukhiya and Sarpanch of the particular village for their visit. Financial support for this course should be provided by the University. After the visit student should submit the excursion report.

Course Objectives:

- ✧ To make the students familiar with the skills such as pottery making, natural fiber roof etc. prevalent in villages.
- ✧ Village population and health.
- ✧ To show the students the way villagers lead their life.

Course Learning Outcomes:

- ➢ Learn about several small level skill developments.
- ➢ They will understand about the ways the villagers adopt for their healthy and good life.

Course Details			
Course Title: Field and Excursion Tour			
Course Code	BTN 9 1 ME 009 00	**Credits**	2
L + T + P	0 + 0 + 2	**Course Duration**	One Semester
Semester	Any	**Contact Hours**	60 (P) Hours
Course Type	Mandatory Elective Non-Credit Course (MENC)		
Nature of the Course	Practical		
Special Nature/ Category of the Course *(if applicable)*	Skill based		
Methods of Content Interaction	Visiting Biotechnology Based Industries		
Assessment and Evaluation	• 30% - Continuous Internal Assessment (Formative in nature but also contributing to the final grades) • 70% - End Term External Examination (University Examination)		

Course Objectives:

- ✧ To make the students familiar with the Biotechnology Based Industries/Institutes involved in the production of drugs / biological / pharmaceuticals / vaccines / food processing.
- ✧ To show the students the process of fermentation/pharmaceuticals/plant tissue culture.
- ✧ To show the students R &D related to stem cell research and other high end research.

Course Learning Outcomes:

- ➢ Learn about optimization process involved in the industries.
- ➢ They will understand about the ways for scaling up the production of the products from lab to industry.

Equivalence of Previous Syllabus vs. Proposed New Syllabus as Per NEP2020

Code & Course title of Previous Syllabus	Code & Equivalent Course title of New Syllabus
Discipline Based Core Course (DBCC)	
Semester-I	
MSBTN1001C04 & Cell Biology and Genetics	BTN 8 1 DC 001 04 & Cell and Molecular Biology
MSBTN1002C04 & Biomolecules & Biochemistry	BTN 8 1 DC 002 04 & Biochemistry
MSBTN1003C04 & Instrumentation: Tools and Techniques in Biotechnology	BTN 8 1 DC 003 04 & Tools and Techniques in Biotechnology
MSBTN1004C04 & Bioinformatics and Biostatistics	BTN 8 1 DC 004 04 & Introductory Course on Research Methodology
MSBTN1005C04 & Lab 1 (MSBTN1001C04 + MSBTN1002C04 + MSBTN1003C04)	None
Semester-II	
MSBTN2001C04 & Molecular Biology & Genomics	None
MSBTN2002C04 & Microbiology	BTN 8 2 DC 005 04 & Microbiology
MSBTN2003C04 & Enzymology	BTN 8 2 DC 006 04 & Immunology & Immunotechniques
MSBTN2004C02 & Biology of Immune System	BTN 8 2 DC 007 04 & Enzymology & Enzyme Technology
MSBTN2005C02 & Lab 3 (2001C04 + 2002C04)	BTN 8 2 DC 008 02 & Practical in Microbiology
MSBTN2006C02 & Lab 4 (2003C04 + 2004C04)	BTN 8 2 DC 09 02 & Practicals in Immunology Immunotechniques
Semester-III	
MSBTN3001C04 & Recombinant DNA Technology	BTN 9 1 DC 001 04 & Recombinant DNA Technology
MSBTN3002C04 & Bioprocess Engineering	BTN 9 1 DC 002 04 & Bioprocess Engineering
MSBTN3003C04 & Animal Biotechnology	BTN 9 1 DC 003 04 & Animal Biotechnology
MSBTN3004C04 & Plant Biotechnology	BTN 9 1 DC 004 04 & Plant Biotechnology
MSBTN3005C04 & Lab 5 (3001C04 + 3002C04)	None
MSBTN3006C04 & Lab 6 (3003C04 + 3004C04)	None
Semester-IV	
MSBTN4001C16 & Project Dissertation	BTN 9 2 DC 005 20 & Project Dissertation
Discipline Based Core Elective (DBCE)/ Open Elective Interdisciplinary Course (OEIC)	
Semester-I	
MSBTN1001E04 & Biodiversity & Ecobiotechnology	BTN 8 1 OE 010 04 & Biodiversity, Conservation and Environmental Biotechnology
MSBTN1002E04 & Metabolism & Metabolic Eng.	BTN 8 1 DE 011 04 & Developmental Biology
Semester-II	
MSBTN2001E04 & Cancer Biology	BTN 8 2 OE 012 04 & Cancer Biology
MSBTN2002E04 & IPR, Bioethics & Biosafety	**Moved to 4th semester**
MSBTN2002E04 & Neuroscience	BTN 8 2 DE 013 04 & Neuroscience
Semester-III	
MSBTN3001E04 & Neurological Diseases & Techniques	**Deleted**
MSBTN3002E04 & Techniques in Molecular Diagnostics and Stem Cell Technology	BTN 9 1 DE 006 04 & Molecular Diagnostics and Stem Cell Technology
Semester-IV	
	BTN 9 2 OE 007 04 & IPR, Bioethics and Biosafety
Mandatory Elective Noncredit Course (MENC)	
Drosophila Techniques	BTN 8 1 ME 014 00 - *Drosophila* as a Research Model
	BTN 8 2 ME 015 00 - Summer Training
Village Based Skills	BTN 9 1 ME 008 00 - Village Based Skills
Field and Excursion Tour	BTN 9 1 ME 009 00 - Field and Excursion Tour