DR. HARISINGH GOUR VISHWAVIDYALAYA, SAGAR
(A CENTRAL UNIVERSITY)

M.Sc. Biotechnology: 04 Semester Course
Curriculum: 2019 - 2021 Onwards

A) General:

1. Name of the Program: **M. Sc. Biotechnology**
2. Duration of the Program:
    a) Minimum duration: 2 years
    b) Maximum duration: 4 years
3. Structure of the Program:
    a) Number of core courses: 16 (60 credits)
    b) Minimum number of Elective courses to be opted by the student: 5 (18 credits)
    (Note: 4 elective course of 4 credits each and one elective of 2 credits)
    c) Minimum number of Open elective courses to be opted by the student: 1 (2 credits)
4. Scheme of Examination:
    a) Mid Semester Examination: 20 marks
    b) Internal Assessment: 20 marks
    [15 marks: Assignment/presentation/group discussion; 05 marks: Attendance]
        i) 75% and below : 00 marks
        ii) >75% and upto 80% : 01 marks
        iii) >80% and upto 85% : 02 marks
        iv) >85% and upto 90% : 02 marks
        v) >90% and upto 95% : 04 marks
        vi) >95% : 05 marks
    c) End Semester Examination* : 60 marks

* To appear in the End Semester Examination the student must appear in I Mid Semester Examination and Internal Assessment.

End semester Examination for Practical course (60 Marks)
    a) Assessment of performance in the experiment : 50 marks
    b) Viva-voce of experiment : 10 marks

Biotechnology: M. Sc. Program Structure and Scheme

Semester	Paper Code	Title of the Paper	Credit			
			L	T	P	C
I	BIT CC 121	Cell Biology	4	0	0	4
	BIT CC 122	Biochemistry	4	0	0	4
	BIT CC 123	Microbiology	4	0	0	4
	BIT CC 124	Lab Course 1	0	0	2	2
	BITCC 125	Lab Course 2	0	0	2	2
	BIT OE 126	Scientific Writing and Presentation	0	0	2	2
	BIT SE 127	Bioentrepreneurship	0	0	4	4
II	BIT CC 221	Molecular Biology	4	0	0	4
	BIT CC 222	Bioinstrumentation & Bioinformatics	4	0	0	4
	BIT CC 223	Immunology	4	0	0	4
	BIT CC 224	Lab Course 3	0	0	2	2
	BIT CC 225	Lab Course 4	0	0	2	2
	BIT SE 226	Critical analysis of classical research papers	0	0	4	4
	BIT SE 227	Basic virology	4	0	0	4
III	BIT CC 321	Animal Biotechnology	4	0	0	4
	BIT CC 322	Plant Biotechnology & Genetic Engineering	4	0	0	4
	BIT CC 323	Bioprocess Engineering and Technology	4	0	0	4
	BIT CC 324	Lab Course 5	0	0	2	2
	BIT CC 325	Lab Course 6	0	0	2	2
	BIT SE 326	Lab based Project Work	0	0	4	4
	BIT SE 327	Biostatistics	3	0	1	4
IV	BIT CC 421	Semester Long Dissertation/Project Work/Practical Training/Field Work, and Technical Writing.	12 Credits			

BIT: Biotechnology **CC:** Core Course **OE:** Open Elective
SE: Self Elective **L:** Lecture **T:** Tutorial
P: Practical **C:** Credits

Semester-I

Course code: **BIT CC 121**	L	T	P	C
Course name: **Cell Biology**	4	0	0	4

Objectives: To provide basic information about structure and functions of various cell organelles.

Outcome: Students will learn basic of cell structure and functions along with basic techniques.

UNIT	Content	Contact Hours
I	**Cell organelles: Structure & Function:** Structure of Prokaryotic and Eukaryotic cell, Plasma membrane, Cell wall, Nucleus, Mitochondria, Golgi bodies, Lysosomes, Endoplasmic Reticulum, Peroxisomes, Plastids, Vacuoles and Chloroplast. Cell motility- cilia and flagella.	12
II	**Techniques in cell biology:** Sub-cellular fractionation, microscopic techniques (light microscopy, electron microscopy, fluorescence and confocal microscopy, flow cytometry), cytochemical methods	12
III	**Cellular Energy Transactions:** Glycolysis, Kreb's cycle and respiration (role of mitochondria and chloroplast), Protein localization: synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes	12
IV	**Cell signaling:** mechanisms of signal transduction, types of signal molecules and response, cell surface and intracellular receptors, classes of cell surface receptors. Signal transduction via GPCRs. Receptor mediated endocytosis	12
V	**Cell division:** mitosis and meiosis, homologous recombination. Cell cycle- steps and control of cell cycle. Cancer and cell cycle. Development in drosophila: spatial and temporary regulation of gene expression.	12

Essential Readings:

1) B. Alberts et. al., Molecular Biology of Cell, Garland Science, 2014, 6th edition
2) H. Lodish et.al., Molecular Cell Biology, W H Freeman & Co (Sd), 2016, 8th edition
3) E. D. P De Robertis, Cell and Molecular biology, Wolter Kluwer, 2011.
4) G. Karp, Cell Biology, Wiley, 2013, 7th edition
5) Bakers, The world of the Cell, Jeff Hardin, Pearson Education, 8th

Suggested Reading:

1) S. F. Gillbert, Developmental Biology, Sinauer, 2016, 11th edition
2) B. Lewin, Cells, Jones & Bartlett Pub, 2006, 1st edition

Course code: **BIT CC 122**

L	T	P	C
4	0	0	4

Course name: **Biochemistry**

Objectives: To build upon master level knowledge of biochemical principles with specific emphasis on different metabolic pathways.

Outcome: Students would be able to analyse and interpret various biochemical pathways of the cell and their significance in metabolism.

UNIT	**Content**	**Contact Hours**
I	Nucleotides, DNA: Structure, types and functions. RNA: Structure, types and functions. Molecular structure of Ribosome structure & function. Chromosome organization & histone proteins.	12
II	Carbohydrates- classification and reactions. Carbohydrates metabolism, Lipids- classification, structure and functions. Glycolipids and phospholipids, structure and function plasma membrane	12
III	Amino acids and peptides- classification, chemical reactions and physical properties. Proteins- classification and separation, protein primary, secondary, Tertiary and quaternary structure. Concept of protein folding & denaturation, Ramachandran plot	12
IV	Enzymes: Structure and classification. Enzymes as biological catalysts. Isozymes, Vitamins and cofactors, Ribozymes: structure and function, Mechanism of enzyme action, Enzyme inhibition: competitive, non-competitive, allosteric inhibition.	12
V	Concept of Photosynthesis, Light reaction of photosynthesis, Biochemistry of C3 and C4 cycle, pentose phosphate pathway and its regulation, Glycogen metabolism: synthesis and metabolism	12

Essential Readings:

1) D. Voet and J. G. Voet, Biochemistry, J. Wiley & Sons, 2011, 4th edition
2) L. Pauling, General Chemistry, www.bnpublishing.com, 2011
3) D. L. Nelson and M. Cox, Lehninger Principles of Biochemistry, WH Freeman, 2017, 7th edition
4) J. M. Berg, et. al., Biochemistry, WH Freeman, 2015, 8th edition

Suggested Readings:

1) H. Lodish, et.al., Molecular Cell Biology, W H Freeman & Co (Sd), 2016, 8th edition
2) E. D. P De Robertis, Cell and Molecular biology, Wolter Kluwer, 2011.

L	T	P	C
4	0	0	4

Course code: **BIT CC 123**
Course name: Microbiology

Objectives: The students will understand the significance and importance of microorganisms. The course is designed to introduce students to the basics of microbial growth, nutrition, structure and classification. The course will introduce students to microbial genetics, diseases caused by microbes and their treatment.
Outcomes: The student would be able to: articulate the importance of microbes in various aspects of human life and environment; Identification and classify microorganisms; demonstrate to culture and control the growth of microorganisms; analyze the transfer of genetics of microorganisms.

UNIT	Content	Contact Hours
I	The history and development of Microbiology, contribution of Leeuwenhoek, Pasture, Jenner, Koch. Microbial nutrition, Microbial growth: Culture media (Synthetic and complex), batch and continuous culture, Factors affecting microbial growth. Growth curve. Physical and chemical control of microorganisms.	12
II	Morphology and structure of bacteria, Berger's manual classification of microorganisms, three domain system, Scientific nomenclature, phylogenic and taxonomic hierarchy, morphological, biochemical and molecular identification methods.	12
III	Gene structure, mutation and mutagenesis: UV and chemical mutagens; types of mutations, methods of genetic analysis. Bacterial Genetic System: transposable elements, plasmids, transformation, conjugation, transduction, bacterial genetic map with reference to *E. C coli.*	12
IV	Etiology, prevention and cure of Microbial diseases: Tuberculosis, AIDS and Malaria. Antimicrobial agents, Antibiotics, Sulfa drugs, Antifungal drugs.	12
V	Applied microbiology: Microbiology of fermented food, probiotics, microorganisms used in industrial microbiology, major products of industrial microbiology	12

Essential Readings:
1) J. Willey, et. al., Prescott's Microbiology, McGraw Hill Education, 2011, 8th edition
2) M. J. Pelczar, et. al., Microbiology, McGraw Hill Education, 2001, 5th edition
3) R. Ananthanarayan, A & P Textbook of Microbiology, Orient Blackswan, 2013, 9th edition
4) G. J. Tortora, et. al., Microbiology, Pearson Education India, 2016, 11th edition
Suggested Readings:
1) D. Anderson, Nester's Microbiology: A Human Prespective, McGraw Hill Education, 2016, 8th edition

Course code: **BIT CC 124**
Course name: **Lab Course 1**

L	T	P	C
0	0	2	2

Objectives: To provide the principles of various cell biology and microbiology techniques. To provide an opportunity for hands of training of these techniques.

Outcomes: Able to observe cells and various organelles of cells. Students should be able to isolate and grow pure cultures of microorganism and identify the morphological features of the bacteria by staining.

1. Observation of cells by light microscopy.
2. Staining of mitochondria
3. Staining of DNA and RNA
4. Cytochemical techniques
5. Observation of mitosis and meiosis.
6. Development of Drosophila
7. Sub cellular fractionation.
8. Preparation of liquid and solid media for growth of microorganisms.
9. Isolation of pure culture from soil by serial dilution method.
10. Maintenance of organisms by plating, streaking, slants and stab cultures.
12. Preparation of glycerol stocks.
13. Gram staining

Essential Readings:

1) J. Davey and J.M. Lord, Essential Cell Biology Vol 1: Cell Structure (A practical approach), Oxford University Press, 2003
2) J. Davey and J.M. Lord, Essential Cell Biology Vol 2: Cell Function (A practical approach), Oxford University Press, 2003
3) J. P. Harley, Laboratory exercises in Microbiology, McGraw-Hill Higher Education, 2004, 6th edition

Suggested Readings:

1) J. E. Celis, Cell Biology: A laboratory handbook (Vol 1-4), Elsevier Academic Press, 2008, 3rd edition
2) E. Goldman and L. H. Green, Practical Handbook of Microbiology, CRC press, 2015, 3rd edition

	L	T	P	C
Course code: **BIT CC 125**	0	0	2	2
Course name: **Lab Course 2**				

Objective: To introduce and train students in various techniques used for biochemical analysis of biomolecules.

Outcomes: The students would be able to analyze biomolecules qualitatively and quantitatively.

1. Preparation of different buffers in biochemistry buffers and pH measurement
2. Isolation and quantization of protein by spectrophotometric method.
3. Enzyme isolation, quantification and kinetic analysis.
4. Reactions of amino acids, sugars including diagnostic tests
5. Isolation, purity & quantization of DNA and RNA.
6. Electrophoresis of proteins-native and under-denaturing conditions.
7. Methods for immobilization of enzymes.
8. Enzyme isolation from various tissues, precipitation methods for purification of enzyme proteins

Essential Reading:

1) H. Miller, et al., Molecular Biology Techniques, Elsevier Academic Press, 2011, 3rd edition
2) W. Ream and K. G. Field, Molecular Biology Techniques: An Intensive Laboratory Course, Elsevirer Academic Press, 1998, 1st edition
3) David Plummer, An Introduction To Practical Biochemistry, Tata McGraw Hill Education; 3rd edition (2006)

Suggested Reading:

1) M. R. Green and J. Smbrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cols Spring Harbor Laboratory Press, 2012, 4th edition

Course code: **BIT OE 126**	L	T	P	C
Course name: **Scientific Writing and Presentation**	0	0	2	2

Objectives: Students will be able to understand the techniques for scientific literature searching and scientific writing as well as PowerPoint presentation.

Outcomes: The students should be able to read, interpret and present scientific data.

UNIT	**Content**	**Contact Hours**
I	Searching and reviewing scientific articles. Publishing in scientific journals. Plagiarism	6
II	Art of scientific presentations. PowerPoint presentations, animations. Do's and Don'ts of presentations. Efficient speech.	6
III	Making Posters. Presenting a poster in record time. Do's and Don'ts of posters.	6
IV	Dissertation writing. Thesis writing. Article writing. Fellowship/scholarship application writing.	6
V	Reading - understand scientific texts in science.	6

Mode of End semester examination: Internal only

Practicals:
1) Prepare a PowerPoint Presentation
2) Deliver a scientific seminar.
3) Write a given assignment.

Essential Readings:
1) M. Davis, et al., Scientific Papers and Presentations, Elsevier Academic Press, 2012, 3rd edition
2) J. Giba and R. Ribes, Preparing and Delivering Scientific Presentations: A Complete Guide for International Medical Scientists, Springer, 2011

Suggested Readings:
1) Recent research and review articles from reputed impact journals.

Course code: BIT SE 127

L	T	P	C
0	0	4	4

Course name: **Bioentrepreneurship**

Objectives: To teach students about concepts of entrepreneurship including identifying a business opportunity in the area of biotechnology through resource generation and launching a biotech business, growing and nurturing the organization as well as harvesting the rewards.

Outcomes: The students should be able to visualize and consider bioenterpreneurship as a viable career option.

UNIT	Content	Contact Hours
I	Introduction to bioentrepreneurship – biotechnology in a global scale; Importance of entrepreneurship; advantages of being entrepreneur - freedom to operate; types of bio-industries – bioservices bioindustrial, agribio and biopharma; business incubators	12
II	Innovation – types, out of box thinking; skills for successful entrepreneur – creativity, leadership, managerial, team building, decision making.; R&D for technology development and up-gradation; assessment of technology development	12
III	Industry visits to successful biotech-enterprises, regulations for transfer of profitable technologies; quality control; technology transfer agencies; Understanding of regulatory compliances and procedures.	12
IV	Business Strategy; Entry and exit strategy; pricing strategy; negotiation with financiers, bankers, government and law enforcement authoritie dispute resolution skills; global thinking; mergers & acquisitions.	12
V	Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/support from Government agencies like MSME/banks and private agencies like venture capitalists, business plan proposal for virtual startup, statutory and legal requirements for starting a company/venture.	12

Essential readings:

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for life scientists: Developing innovation and entrepreneurship in the biosciences. Bloxham: Scion.

2. Shimasaki, C. D. (2014). Biotechnology entrepreneurship: Starting, managing, and leading biotech companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.

3. Onetti, A., & Zucchella, A. (n.d.). Business modeling for life science and biotech companies: Creating value and competitive advantage with the milestone bridge. Routledge.

Suggested Reading:

1. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.

2. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Semester-II

Course code: **BIT CC 221**

Course name: **Molecular Biology**	L	T	P	C
	4	0	0	4

Objectives: To teach students the fundamentals of central dogma, gene expression and regulation.

Outcomes: The students would be able to understand each step of gene expression and regulation.

UNIT	Content	Contact Hours
I	Introduction to Molecular Biology and Genetics. Flow of genetic information. Anatomy of gene, gene structure of prokaryotes and eukaryotes. Genome organization.	12
II	DNA Replication: Prokaryotic and Eukaryotic DNA replication, enzymes and accessory proteins involved in DNA replication. DNA repair and recombination.	12
III	Transcription: Prokaryotic and Eukaryotic transcription, RNA polymerase. Transcription factors, regulatory elements and mechanisms of transcriptional regulation. Alternative splicing. Modification in RNA: 5'-Cap formation, transcription termination, 3-end processing and polyadenylation, splicing, editing, nuclear export of mRNA, mRNA stability.	12
IV	Translation: Prokaryotic and Eukaryotic translation, translation machinery, mechanisms of initiation, elongation and termination, regulation of translation. Co-and post-translation modification in proteins.	12
V	Control of gene expression in Prokaryotes: DNA binding proteins, posttranscriptional control of gene expression. Control of gene expression in Eukaryotes: enhancers, chromatin remodeling, posttranscriptional control of gene expression. Antisense RNA, role of epigenetics in regulation of gene expression.	12

Essential Reading:

1) J. E. Kerb's, Lewin's Gene XII , Jones and Barlett.
2) H. Lodish, et.al., Molecular Cell Biology, W H Freeman & Co (Sd), 2016, 8th edition
3) G. Karp, Cell Biology, Wiley, 2013, 7th edition
4) D. Voet and J. G. Voet, Biochemistry, J. Wiley & Sons, 2011, 4th edition
5) P. J. Russel, Genetics: A Molecular Approach, Pearson Education, 3rd Edition.
6) D. P. Snustad and M. J. Simmons, Principles of Genetics, John Wiley, 5th Ed.

Suggested Reading:

1) J. M. Berg, et. al., Biochemistry, WH Freeman, 2015, 8th edition
2) B. Alberts and A, Johnson, Molecular Biology of Cell, Garland Sciences, 2014, 2014.

Course code: **BIT CC 222**

Course name: **Bioinstrumentation & Bioinformatics**

L	T	P	C
4	0	0	4

Objectives: To provide students with the theory and practical experience of various instruments used in the Biotechnology and also the use of common computational tools and databases which facilitate investigation of molecular biology.

Outcomes: The student would be able to operate the sophisticated instruments and use online bioinformatic tools.

UNIT	Content	Contact Hours
I	Microscopy: Light and compound microscopy, confocal microscopy, electron microscopy; Atomic Force Microscopy	12
II	Principle of centrifugation, preparative and analytical centrifugation, Principle of Chromatography, planar and column chromatography, paper chromatography, Thin layer chromatography, High performance liquid chromatography and Gas Chromatography	12
III	Spectroscopic techniques: Principle of spectroscopy (emission and absorbance), Visible, UV, fluorescence spectroscopy and NMR spectroscopy.	12
IV	Introduction of biostatistics. Types of data, types of variables, tabulation of data and its graphical representation. Measures of central tendency and dispersion: Mean median, model range, standard deviation and variance.	12
V	Tools for sequence alignment through NCBI database; Alignment of pairs of sequence; Alignment of multiple sequences; Primer designing tools and characteristics of primers; Accessing and retrieving genome project information for microbes, plants and animals from database-case study	12

Essential Reading:

1) K. Wilson and J. Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2013.
2) B Sivasankar, Instrumental Methods of Analysis, Oxford University Press, 2012
3) Sharma, Munjal and Shanker, Text book of Bioinformatics: Rastogi publisher, India 2017
4) Attood, Parry-Smith and Phukan, Introduction to Bioinformatics, Fourth edition, Pearson Publisher

Suggested Reading:

1) B. Williams and S. Sawyer, using information technology: a practical introductino to computers & communications, McGraw Hill Education, 2005, 6th edition
2) R. Greenlaw, inline/online: fundamentals of the internet & the world wide web, McGraw Hill Education, 2005, 2nd edition

Course code: BIT CC 223
Course name: Immunology

L	T	P	C
4	0	0	4

Objectives: To introduce the students to the basics of immunology. The course will provide an overview of coordinated functioning of immune organs, cells and cytokines to protect the body from infections. The course also introduces student to the basics of immune tolerance and autoimmunity.
Outcomes: The student would be able to analyze and connect the collective ability of various organs, cells, macromolecules and pathways to protect and eliminate human body from infectious agents.

UNIT	Content	Contact Hours
I	Introduction to immune system, features of innate and adaptive immunity, Cells, tissues and organs of the immune system. Innate immunity: recognition of microbe by innate immunity, properties and components of innate immunity, innate immune cells and mechanism.	12
II	Antigen capture and presentation: major histocompatibility complex (MHC), classification: MHC Class I and Class II, structure, genes, antigen peptides binding to MHC complex, processing and presentation of antigen proteins.	12
III	Antigen recognition: Antibody structure, T cell receptor complex (TCR complex) structure, types of antibodies and function, monoclonal antibodies, production of diverse antigen receptors: antibodies and T cell receptors, B cell maturation process and T cell maturation process.	12
IV	T-cell activation mechanism, clonal expansion and development of memory T cells, functions of helper T cells and cytotoxic T cells, B cell activation mechanism, primary and secondary immune response, T cell dependent antibody response, antibody mediate effecter functions.	12
V	Immune regulation: significance and mechanisms, T cell tolerance and B cell tolerance, autoimmunity: Pathogenesis, genetic factors and role of infection and environment, hypersensitive response.	12

Essential Reading:
1) A. K. Abbas, et. al., Basic Immunology: Functions and Disorders of the Immune System, Elsevier, 2015, 5th edition
2) A. K. Abbas, et. al., Cellular and Molecular Immunology, Elsevier, 2017, 9th edition
3) J. A. Owen, et. al., Kuby Immunology, W H Freeman & Co, 2013, 7th edition
4) I. Tizard, Immunology: An Introduction, Cengage Learning, 2005
5) M. A. Khan, Elements of Immunology, Pearson Education.
Suggested Reading:
1) P. J. Delves, Roitt's Essential Immunology, Wiley-Blackwell, 2017, 13th edition
2) W. E. Paul, Fundamental Immunology, Lippincott Williams & Wilkins, 2012, 7th edition

Course code: **BIT CC 224**	L	T	P	C
Course name: **Lab Course 3**	0	0	2	2

Objective: To train students in various basic techniques of molecular biology. To introduce students to basic immunological techniques.

Outcome: The student should be able to isolate, manipulate, visualize and quantify nucleic acids and proteins. Able to qualitatively analyze blood cells and serum components.

Practicals:

1. Plasmid DNA isolation.
2. Visualization of DNA using EtBr.
3. Restriction digestion of genomic DNA.
4. Isolation of genomic DNA.
5. Electrophoresis of DNA- linear, circular and super coiled plasmid.
6. Plasmid restriction map.
7. RFLP and RAPD
8. Western blotting.
9. Blood film preparation and identification of cells.
10. Isolation of WBCs using density gradient centrifugation
11. Radial immunodiffusion
12. Immuno-electrophoresis.
13. Immunodiagnostics (demonstration using commercial kits).

Essential Reading:

1) T. Brown, Essential Molecular Biology: Volume I: (Practical Approach Series), Oxford University Press, 2000, 2nd edition
2) T. Brown, Essential Molecular Biology: Volume II: (Practical Approach Series), Oxford University Press, 2000, 2nd edition
3) F. C. Hay and O. M. R. Westwood, Practical Immunology, Wiley-Backwell, 2002, 4th edition

Suggested Reading:

1) M. R. Green and J. Smbrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cols Spring Harbor Laboratory Press, 2012, 4th edition

Course code: **BIT CC 225**
Course name: **Lab course 4**

L	T	P	C
0	0	2	2

Objective: To introduce and train students in various techniques used in computer operation and bioinformatics.

Outcomes: The students would be able to operate computer and instruments.

Practicals:

1. Operating system commands.
2. Document preparation and formatting.
3. Power point presentation.
4. Web development using front page.
5. Website surfing on the basis of Unit V.
6. Sequence analysis, BLAST, NCBI search methods
7. Separation by Chromatography.
8. Analysis of DNA and protein by electrophoresis.
9. Experimental demonstration of TEM, SEM and Confocal Microscopy
10. Measurement of bacterial population by turbidometry and photometry.

Essential Reading:

1) K. M. Mooring, Computer Fundamentals: A Practical Guide, Kendall Hunt Pub Co, 2009
2) J. J. Parsons and D. Oja, Practical Microsoft Office 2013, South-Western College Publishing, 2013
3) M. Agostino, Practical Bioinformatics, Garland Sciences, 2012, 1st edition
4) M. R. Green and J. Smbrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cold Spring Harbor Laboratory Press, 2012, 4th edition

Suggested Reading:

1) J. Pevsner, Bioinformatics and Functional Genomics, Wiley-Backwell, 2015, 3rd edition
2) K. Wilson and J. Walker, Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2013, 7th edition

Course code: BIT SE 226

Course name: **Critical Analysis of Classical Papers**

L	T	P	C
4	0	0	4

Objectives: to familiarize the students with classic literature to make them appreciate how ground-breaking discoveries were made without, necessarily, use of high-end technologies.

Outcomes: Students should be able to appreciate the techniques and thought process in design experiments that have made seminal contribution to field of basic biological sciences.

Syllabus: How does the Course Module work? There are sixteen (or more) classical papers. Students will be divided in to groups and each group will be responsible for two papers. There will be three hour presentation cum discussion for each of the papers. At the end of the semester, each student will be asked to write a mini-review on any of the sixteen papers, other than the one he/she has presented/discussed.

A list of seventeen classic papers and some suggested reference materials: The research paper may also be decided by the course coordinator but the paper must be a classical paper with outstanding recognition.

Suggested classical research paper

Molecular Biology	
1	Avery OT, Macleod CM, McCarty M (1944) Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from Pneumococcus type III. J Exp Med. 79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith
2	Hershey AD and Chase M (1952) Independent functions of viral protein and nucleic acid in growth of bacteriophage. J Gen Physiol. 1952 May;36(1):39-56. Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.
3	Watson JD and Crick FH (153) Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid; Nature. 25;171(4356):737-8 Note: In this one page paper Watson and Crick first described the structure of DNA double helix
4	James Hicks, Jeffrey N. Strathern & Amar J.S. Klar (1979) Transposable mating type genes in *Saccharomyces cerevisiae*. Nature 282, 478-483, Note: This paper provided evidence for „cassette hypothesis" of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae) occurs by DNA rearrangement.
5	Meselson M and Stahl FW (1958) Messelson and Stahl experiment demonstrating semi-conservative replication of DNA. Proc Natl Acad Sci U S A; 15;44(7):67182 Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"
6	Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn (1990) In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs. Nature 344, 126-132, Note: This paper demonstrates that the telomerase contains the template for telomere synthesis.

Cell Biology	
1	Simon SM AND Blobel G (1991) A protein-conducting channel in the endoplasmic reticulum. Cell 3;65(3):371-80 Note: This paper demonstrates the existence of a protein conducting channel
2	Novick P, Field C, Schekman R (1980) Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway. Cell. 21(1):205-15 Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion
3	Deshaies RJ and Schekman R (1987) A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum. J Cell Biol. 105(2):633-45 Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC)
4	Balch WE, Dunphy WG, Braell WA, Rothman JE (1984) Reconstitution of the Transport of Protein between Successive Compartments of the Golgi. Cell. 39(2 Pt 1):405-16 Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.
5	Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S (1978) A complete immunoglobulin gene is created by somatic recombination. Cell. 15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.
6	Buck L and Axel R (1991) A novel multigene family may encode odorant receptors: a molecular basis for odor recognition. Cell. 5;65(1):175-87 Note: This paper suggests that different chemical odorants associate with different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.
7	Yildiz A, Tomishige M, Vale RD, Selvin PR (2004) Kinesin walks hand-over-hand. Science. 30;303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.
8	Lowry OH, Rosenbough NJ, Fasr AL and Randall RJ (1951). Protein measurement with the folin-phenol reagent. Journal of Biological Chemistry. 193: 265-275.
Developmental Biology/ Genetics	
1	Nusslein-Volhard and Eric Weischaus (1980) Mutations affecting segment number and polarity in Drosophila Christiane. Nature 287, 795-801 Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well

2	Anderson KV and Nüsslein-Volhard C (1984) Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA Nature. 311(5983):223-7 Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes
3	Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV (2003) Hedgehog signalling in the mouse requires intraflagellar transport proteins. 6;426(6962):83-7 Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it

Mode of Assessment:

At the end of the course, assessment will be done. Student will write a mini-review on any of the sixteen papers, other than the one paper the student have to presented/discussed in the class.

Mode of end semester examination: Internal only

Course code: BIT SE 227
Course name: Basic Virology

L	T	P	C
4	0	0	4

Objectives: To introduce the students to basic aspect of virology such as virological techniques, viral life cycle, antiviral response, oncogenic viruses and vaccination against viral infection.

Outcomes: General understanding of virology with ability to understand various aspect of viral life cycle and importance of studying viruses.

UNIT	**Content**	**Contact Hours**
I	History and introduction: Significance, characteristics and morphology, classification: Shape, Size genome and Baltimore, virology techniques.	12
II	Viral life cycle: Entry, uncoating, Viral replication (of various types of viruses), Assembly and release	12
III	Virus host interaction: Interferon response and adaptive immune response	12
IV	Vaccination: Types of vaccines, Antiviral vaccines, small pox vaccine, vaccine production.	12
V	Oncogenic virus: Study of molecular mechanisms of DNA and RNA oncogenic viruses.	12

Essential Reading:
1) E. K. Wagner, et al., Basic Virology, Wiley, 2007, 3rd edition
2) T. Shores, Understanding Viruses, Jones and Bartlett, 2009, 1st edition
3) J. S. Flint, et al., Principles of Virology: Molecular Biology, Pathogenesis, and Control, American Society for Microbiology, 2009

Suggested Reading:
1) D. M. Knipe and P. M. Howley, Fields Virology, Lippincott Williams & Wilkins, 2013, 6th edition

Semester-III

L	T	P	C
4	0	0	4

Course code: BIT CC 321

Course name: Animal Biotechnology

Objective: Animal Biotechnology is fast growing area, therefore knowledge of DNA technology, cell, tissue, organ and embryo culture, transgenic animals, knock-out, knock-in and gene editing, functional genomics will help students for future endeavour.

Outcomes: The students should be able to analyze and comprehend the requirement and principles of animal cell and tissue culture.

UNIT	Content	Contact Hours
I	Animal cell and tissue culture, Equipments and materials for animal cell culture technology. Balanced Salt Solutions (BSS), Culture medium. Chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide, serum and supplements. Serum and protein-free media and their applications. Scaling up of monolayer and suspension cultures.	12
II	Primary culture, Subculture. Disaggregation of tissue in primary culture, Cell lines, their maintenance, large scale cell culture and their applications, Stem cells: Types and applications Biology of cultured cells: cell adhesion, proliferation, differentiation, signaling, metabolism and origin. Characterization of cultured cells: parameters of growth. Cell transformation and immortalization.	12
III	Organ culture, Whole embryo culture, *In-vitro* fertilization, artificial insemination and embryo transfer, Animal cloning: Methods and applications. Transfection methods	12
IV	Transgenic animals: Production methods and their commercial applications,. Regulation of GE animals, Vaccines and Cell culture based vaccines, Diagnostics and Forensic applications	12
V	Gene therapy, Vectors and other delivery systems, *ex-vivo* and *in-vivo* therapy, application for genetic diseases, Aquaculture: Types, methods and prospects, Animal biodiversity and Animal Genetic Resources (AnGR), National Biodiversity Authority (NBA), Intellectual Property Rights (IPR), Patents, Trade secrets, Copy right, Trade Mark,	12

Essential Reading:

1) R. I. Freshney, Culture of Animal Cells A Manual of Basic Technique and Specialized Applications, Wiley-Blackwell, 2016, 7th edition
2) B. Singh, et. al., Textbook of Animal Biotechnology, TERI, 2013
3) A. Verma and A. Singh, Animal Biotechnology: Models in Discovery and Translation, Elsevier Academic Press, 2014

Suggested Reading:

1) M. M. Ranga, Animal Biotechnology, Agrobios India, 2007, 3rd edition
2) P.K.Gupta, Animal Biotechnology, Rastogi Publication, Meerut, 2018

Course code: BIT CC 322
Course name: Plant Biotechnology & Genetic Engineering

L	T	P	C
4	0	0	4

Objectives: To teach students the fundamentals of plant biotechnology and their applications with various approaches to conduct plant genetic engineering will help for future career in biological research as well as in biotechnology industries.

Outcome: The students would be able to make changes at the genetic level of organisms for the development of novel genetically modified organisms.

UNIT	Content	Contact Hours
I	historical perspective; totipotency; organogenesis; Somatic embryogenesis; establishment of cultures – callus culture, cell suspension culture, media preparation – nutrients and plant hormones; sterilization techniques; applications of tissue culture - micropropagation; germplasm conservation and cryopreservation; synthetic seed production; protoplast isolation- culture and usage; somatic hybridization - methods and applications	12
II	Various types of cloning vectors, Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; hybridization techniques: northern, southern and western	12
III	Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries, reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; Gene silencing techniques; principle and application of gene silencing;	12
IV	Genetic engineering: *Agrobacterium*-plant interaction; virulence; Ti and Ri plasmids; opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - *Agrobacterium*-mediated gene delivery; binary vectors and their utility; direct gene transfer-electroporation, particle bombardment and alternative methods.	12
V	Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; NGS; Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, Intellectual property management and patent	12

Essential Reading:

1) D. S. T. Nicholl, Introduction to Genetic Engineering, Cambridge University Press, 2008 3rd edition
2) T. A. Brown, Gene Cloning and DNA Analysis, Wiley-Backwell, 2016, 7th edition
3) J. Hammond, Plant Biotechnology: New products and applications, Springer, 2000

Suggested Reading:

1) M. R. Green and J. Smbrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cold Spring Harbor Laboratory Press, 2012, 4th edition

Course code: BIT CC 323

Course name: Bioprocess Engineering and Technology

L	T	P	C
4	0	0	4

Objectives: The course is designed to introduce students to Bioprocessing with emphasis on importance of microbes in bioprocessing, growth of these microbes, fermentation, downstream processing, applications of bioprocessing and effluent treatment.

Outcomes: The student would be able to demonstrate the ability to conceptualize various aspects that are involved in bioprocessing. The ability to understand important aspects of bioprocessing such as isolation of industrially important microbes and their preservation, fermentation, product isolation, effluent treatment, scope and economics of bioprocessing plant.

UNIT	Content	Contact Hours
I	Introduction to bioprocess engineering. Isolation, preservation and maintenance of industrial microorganisms. Kinetics of microbial growth. Media for industrial fermentation. Media sterilization. Thermal death kinetics of microorganisms	12
II	Fermentation: General introduction, Range of fermentation, Design and construction of fermenter, Aerobic and anaerobic fermentation processes, Solid and submerged fermentations and Types of bioreactors.	12
III	Downstream processing: Introduction, removal of microbial cells and solid matter foam separation, precipitation, filtration, centrifugation, cell disruptions, liquid-liquid extraction. Chromatography, membrane process, drying and crystallization.	12
IV	Enzyme immobilization and their industrial applications. Protein engineering: native and fusion proteins, strategies to maximize protein expression, industrial production of ethanol, citric acid, antibiotics and glutamic acid.	12
V	Effluent Treatment: Need for effluent treatment, Physical, chemical and biological methods of effluent treatment. Plant design and economics, Cost of production.	12

Essential Reading:

1) D. G. Rao, Introduction to Biochemical Engineering, Tata McGra-Hill Education, 2010, 2nd edition

2) P. F. Stanbury, et. al., Principles of Fermentation Technology Butterworth-Heinemann, 2016, 3rd edition

3) D. S. Kompala, Bioprocess Engineering: Fundamentals and Applications, CRC press, 2012

Suggested Reading:

1) P. Doran, Bioprocess Engineering Principles, Elsevier Academic Press, 2012, 2nd edition

2) M. L. Shuler and F. Kargi, Bioprocess Engineering: Basic Concepts, Pearson, 2002, 2nd edition

Course code: **BIT CC 324**
Course name: **Lab Course 05**

L	T	P	C
0	0	2	2

Objective: To introduce and train students in various techniques used for genetic engineering, plant and animal biotechnology.

Outcomes: The students would be able to analyze perform DNA recombination and cloning.

Practicals:

1. Bacterial culture and antibiotic selection media, preparation of competent cells.
2. Isolation of plasmid DNA and quantification
3. Preparation of media & Surface sterilization and organ culture with suitable explants.
4. Cloning in plasmid and screening.
5. RNA isolation and synthesis of c-DNA
6. Construction of restriction map of plasmid DNA.
7. PCR and DNA sequencing.
8. Agrobacterium culture, transformation method, reporter gene (GUS) assays.

Essential Reading:
1) K. Lindsey, Plant tissue culture manual, Springer, 2007
2) J. S. Vennison, Laboratory manual for Genetic Engineering, PHI Learning, 2010, 1st edition

Suggested Reading:
1) M. R. Green and J. Smbrook, Molecular Cloning: A Laboratory Manual (3 Volumes), Cold Spring Harbor Laboratory Press, 2012, 4th edition
2) R. H. Smith, Plant Tissue Culture: Techniques and Experiments, Elsevier Academic Press, 2012, 3rd edition

Course code: **BIT CC 325**
Course name: **Lab Course 06**

L	T	P	C
0	0	2	2

Objectives: To introduce students to various basic techniques of animal cell culture. To introduce students to bioprocessing and product isolation techniques.

Outcomes: The students should be able to demonstrate ability to isolate cells from animals and grow them. To isolate industrially important microbes and isolate commercially important components from raw materials.

Practicals:

1. Preparation of tissue culture medium and membrane filtration.
2. Preparation of single cell suspension from spleen and thymus.
3. Cell counting and cell viability.
4. Isolation of amylase producing bacteria and fungus.
5. Production of curd by fermentation/isolation of bacteria from curd.
6. Production of bread dough by yeast fermentation.
7. Crystal formation heating and cooling methods.
8. Extraction of essential oils from lemon grass/orange peel

Essential Reading:

1) R. I. Freshney, Culture of Animal Cells: A Manual of Basic Technique, Wiley-Backwell, 2000, 4th edition
2) J. Masters, Animal Cell Culture – Practical approach, Oxford University Press, 2000, 3rd edition
3) T. Palvannan, Laboratory Manual on Biochemistry, Bioprocess & Microbiology, Scitech publications, 2006

Suggested reading:

1) J. Davis, Basic Cell Culture, Oxford University Press, 2002, 2nd edition

Course code: **BIT SE 326**
Course name: **Lab Based Project Work**

L	T	P	C
0	0	4	4

The purpose of the course is to improve the student's ability to apply basic concepts and knowledge through laboratory based project work. The course will comprise of a mini project to solve or address a simple question or to improve/develop expertise of a particular technique through hands on experiments and generate data. The data will be interpreted and submitted as a project report and also be presented.

Evaluation:

a) First periodic assessment of the progress after 08 weeks : 20 marks
b) Second periodic assessment of the progress after 12 weeks : 20 marks
c) End semester examination will consist of
    i) Evaluation of project report/presentation : 50 marks
    ii) Viva-Voce of the project : 10 marks

Mode of end semester examination: Internal only

Course code: **BIT SE 327**
Course name: **Biostatistics**

L	T	P	C
3	0	1	4

Objectives: To provide the basic concepts of the statistics and their applications in the data analysis of the biological research.
Outcomes: The students should be able to perform statistical analysis of scientific data for drawing plausible conclusions.

UNIT	Content	Contact Hours
I	Introduction of biostatistics. Types of data, types of variables, tabulation of data and its graphical representation. Measures of central tendency and dispersion: Mean median, model range, standard deviation and variance.	12
II	Multiplicity of data, major bioinformatics databases, data integration, data analysis, Modern biology in bioinformatics. Molecular biology and Bioinformatics. Information molecules and information flow. Biological databases.	12
III	Two types of errors and level of significance, tests of significance (F and t test, chi- square tests). Simple linear regression and correlation. Use of linear regression in biological experiments.	12
IV	Computer- oriented statistical techniques: Frequency table of single discrete variable. Bubble sort through excel, computation of mean, variance and standard deviation; t- test, correlation coefficient, Annova analysis	12
V	Linear regression & goodness of curves, Significance of r2 value, Single and double side binding curves equations	12

Practicals
1) Tabulate and present graphs in excel.
2) Using excel to do simple maths on data tables.
3) Calculate descriptive statistics through excel.
4) Calculate regression and correlation through excel.
5) Statistical tests through excel (t-test)
6) How to download and install biostat softwares from internet.
7) Sorting lowest to highest and highest to lowest in excel (bubble sort).

Essential Reading:
1) P. K. Banerjee, Introduction to Bio-Statistics, S. Chand Publishing, 2006, 3rd edition
2) G. W. Snedecor and W. G. Cochran, Statistical Methods, Wiley India, 2014, 8th edition
3) T. J. Bailey, Statistical Methods in Biology, Cambridge University Press, 2000, 3rd edition

Suggested Reading:
1) R. N. S. Pillai, Statistics (Theory and Practice), S. Chand Publishing, 2010

Semester IV

Course code: **BIT CC 421**
Course name: **Semester Long Dissertation/Project Work/Practical Training/Field Work, and Technical Writing**:
Credits: **12**

Objective: To provide students to conceptualize, design, plan and performed a short term research project.

Outcome: The student should be able to a answer a research questions.

Course Instructors:
Prof. Subodh Kumar Jain
Dr. C. P. Upadhyaya
Dr. Rajaneesh Anupam

Evaluation:

a) First periodic assessment of the progress after 08 weeks : 20 marks

b) Second periodic assessment of the progress after 12 weeks : 20 marks

c) End semester examination will consist of

i) Evaluation of project report/presentation : 50 marks

ii) Viva-Voce of the project : 10 marks

Mode of end semester examination: Internal only