Course Curriculum
for
M. Sc. Biotechnology
for
2024, 2025 and 2026

M. Sc. BIOTECHNOLOGY SYLLABUS

SUMMARY OF CREDIT DISTRIBUTION AND MARKS AS PER CBCS

Semester	Courses						Total credits	Marks
	Core				Elective			
	Theory (core)	Practical (core)	Seminar / journal club (core)	Dissertation	Open (OE)	Discipline centric (DCE)		
Semester-1	16	8					24	600
Semester-2	10	8	2		4		24	600
Semester-3	14	8				2	24	600
Semester-4				24			24	600
	Total						96	2400

M. Sc. BIOTECHNOLOGY SYLLABUS

LIST OF PAPERS ALONG WITH CREDIT DISTRIBUTION AND MARKS AS PER CBCS

SEMESTER I

PAPER					CREDITS	MARKS		
S. No.	Code	Title	Category	Duration [Hours]		Internal Assessment	University Examination	Total Marks
1	Bio-101	Cell Biology	Core	72	4	40	60	100
2	Bio-102	Molecular Biology	Core	72	4	40	60	100
3	Bio-103	Biomolecules	Core	36	2	20	30	50
4	Bio-104	Microbiology	Core	72	4	40	60	100
5	Bio-105	Genetics	Core	36	2	20	30	50
6	Bio-106	**Lab Course I based on:** Cell Biology and Molecular Biology	Core	72	4	50	50	100
7	Bio-107	**Lab Course II based on:** Biomolecules, Microbiology and Genetics	Core	72	4	50	50	100
Sub-total			**Core**	Theory	**16**	**160**	**240**	**400**
				Practical	**8**	**100**	**100**	**200**
TOTAL					**24**	**260**	**340**	**600**

SEMESTER II

PAPER					CREDITS	MARKS		
S. No.	Code	Title	Category	Duration [Hours]		Internal Assessment	University Examination	Total Marks
1	Bio-201	Enzymology and Metabolism	Core	72	4	40	60	100
2	Bio-202	Bioinformatics and Biostatistics	Core	36	2	20	30	50
3	Bio-203	Genomics and Proteomics	Core	36	2	20	30	50
4	Bio-204	Analytical Techniques	Core	36	2	20	30	50
		Open Elective (OE)*						
5	Bio-205	Fundamentals of Biotechnology[@]	Elective	36	4	40	60	100
6	Bio-206	Seminar/Journal Club (JC)	Core	36	2	50		50
7	Bio-207	**Lab Course III based on:** Enzymology and Metabolism, Bioinformatics and Biostatistics	Core	72	4	50	50	100
8	Bio-208	**Lab Course IV based on:** Genomics and Proteomics, Analytical Techniques	Core	72	4	50	50	100
Sub-total			**Core**	Theory	**10**	**100**	**150**	**250**
				Practical	**8**	**100**	**100**	**200**
				Seminar/JC	**2**	**50**		**50**
			Elective (Open)		**4**	**40**	**60**	**100**
TOTAL					**24**	**290**	**310**	**600**

* **Open Elective Course:** Candidate has to opt 1 course out of 14 courses offered. The courses are listed separately.

[@] **Open Elective Course:** For students other than Biotechnology.

SEMESTER III

PAPER					CREDITS	MARKS		
S. No.	Code	Title	Category	Duration [Hours]		Internal Assessment	University Examination	Total Marks
1	Bio-301	Plant Biotechnology	Core	36	2	20	30	50
2	Bio-302	Animal Biotechnology	Core	36	2	20	30	50
3	Bio-303	Genetic Engineering	Core	72	4	40	60	100
4	Bio-304	Industrial Biotechnology	Core	36	2	20	30	50
5	Bio-305	Immunology	Core	72	4	40	60	100
6	**Discipline Centric Elective (DCE)#**		**Elective**	**36**	**2**	**20**	**30**	**50**
	Bio-306	Crop Biotechnology#	DCE	36	2	20	30	50
	Bio-307	Human Genetic Disorders#	DCE	36	2	20	30	50
	Bio-308	Signal Transduction and Cancer Biology#	DCE	36	2	20	30	50
	Bio-309	Protein Engineering#	DCE	36	2	20	30	50
8	Bio-310	**Lab Course V based on:** Plant Biotechnology, Animal Biotechnology and Industrial Biotechnology	Core	72	4	50	50	100
9	Bio-311	**Lab Course VI based on:** Genetic Engineering, Immunology and Discipline centric elective	Core	72	4	50	50	100
Sub-total			**Core**	Theory	**14**	**140**	**210**	**350**
				Practical	**8**	**100**	**100**	**200**
			Elective (DCE) Theory		**2**	**20**	**30**	**50**
TOTAL					**24**	**260**	**340**	**600**

Discipline Centric Elective: Candidate has to opt 1 course out of 4 courses offered. The courses are separately listed.

SEMESTER IV

PAPER					CREDITS	MARKS		
S. No.	Code	Title	Category	Duration [Hours]		Internal Assessment	University Examination	Total Marks
1	Bio-401	Dissertation	Core	864	24		600	600
TOTAL					**24**		**600**	**600**

LIST OF OPEN ELECTIVES

SECOND SEMESTER			
S. No.	**Paper Code**	**Paper Title**	**Course Type**
1	Math-201	Mathematical Tools for Real World Problems	OE
2	IT-202	Soft Skills in Information Technology	OE
3	Comp-203	Computer Applications and Operations	OE
4	Bot-235	Mushroom Cultivation	OE
5	Bot-206	Botany in Rural Development	OE
6	Zol-207	Nutrition, Health and Hygiene	OE
7	Arab-208	Fundamentals of Arabic Language	OE
8	Eng-209	Applied English	OE
9	Edu-210	Higher Education	OE
10	Eco-211	Principles of Banking	OE
11	HT-212	Basics of Tourism and Travel Agencies	OE
12	HT-213	Tourism Resources of J&K	OE
13	Mgt-214	Business Communication and Soft Skills	OE
14	Edu-215	Instructional Technology	OE

LIST OF DISCIPLINE CENTRIC ELECTIVES

THIRD SEMESTER			
S. No.	**Paper Code**	**Paper Title**	**Course Type**
1	Bio-306	Crop Biotechnology	DCE
2	Bio-307	Human Genetic Disorders	DCE
3	Bio-308	Signal Transduction and Cancer Biology	DCE
4	Bio-309	Protein Engineering	DCE

Programme Outcome:

- **Deeper understanding**

  To have deeper understanding of a subject for its application in addressing social and scientific issues

- **Research and development**

  To prepare students for research and development in respective areas

- **Problem solution**

  Problem solving by applying reasoning and technical inputs

- **Environment and sustainable development**

  To study and understand the impact of development on environment safety and its significance for sustainable ways of development.

- **Lifelong learning**

  Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

- **Leadership and self-reliance**

  Impact leadership abilities to the students to lead and excel in their respective fields. Also, the training will make students self-reliant.

Programme specific outcomes:

Upon successful completion of the M.Sc. Biotechnology programme, the students will be able to:

- Use the scientific methods, and critical thinking skills to ask questions and solve problems
- Follow a protocol independently, including locating materials and equipment, practicing good lab procedures and accurately performing all experimental procedures.
- Analyze experimental results, differentiating between expected and unexpected results, trouble shooting, interpreting results and making conclusions.
- Demonstrate proficiency in maintaining a safe work place, including observation of lab safety procedures, use of personal protective equipment, identification hazards and proper disposal of commonly used chemicals and biohazardous materials.
- Demonstrate improvement in communication skills, including maintenance of laboratory notebooks, oral presentations and written reports.
- Identify carriers in biotechnology and skills required for landing a job.

SEMESTER- I

Course Code: Bio-101
Course Title: Cell Biology
Credits: 04

Maximum Marks: 100
Internal Assessment: 40
University Examinations: 60
Duration of Exam: 3 hours

Unit 1: Structural organization of cells

1.1 Overview of the structure of cell, cell theory and biochemical composition of cytosol.

1.2 Study and observation of cells: preparation and staining of cell specimens, selective staining of different components of cells.

1.3 Structure of prokaryotic cells: *E. coli* as an example, size, shape and arrangement, composition of prokaryotic cell wall.

1.4 Structure of Eukaryotic cells: plant and animal cell structure, size, shape and components.

Unit 2: Cell membrane: structure and functions

2.1 Basic structural elements of membrane- lipid bilayer, micelles and vesicles characteristics and composition of cell membrane.

2.2 Membrane structure and assembly: fluid mosaic model; membrane proteins- integral, peripheral and lipid anchored; membrane lipids- structure and asymmetry.

2.3 Membrane dynamics: ordering of acyl group in bilayer; transbilayer movement of lipids-catalysed and uncataysed movement.

2.4 Membrane transport: passive mediated- ionophores, porins, ion channels, aquaporins; active transport- Na^+-K^+ ATPase, Ca_2^+ ATPase, and ABC transporters.

Unit 3: Structure of cellular organelles

3.1 Structure and function of endoplasmic reticulum and transport of proteins.

3.2 Structure and functions of mitochondria, chloroplast, vacuoles, lysosomes and microbodies.

3.3 Nucleus: nucleoplasm, nuclear envelope, nuclear lamina, nuclear bodies-nucleolus.

3.4 Cytoskeleton: structure, composition and functions of microtubules, microfilaments and intermediate filaments (cilia and flagella).

Unit 4: Cell signaling

4.1 Overview of cell signaling, concept of signaling molecules and receptors, role of effector proteins and secondary messengers in signaling.

4.2 Structure of G-protein coupled receptors (GPCR), trimeric G-protein; classes and functions

4.3 Signaling pathway that regulate ion channels: Rhodopsin signaling pathway in Rod cells of the eye.

4.4 Gene controlling signaling pathways: tyrosine kinase pathway and Ras/MAP kinase pathway.

Unit 5: Eukaryotic cell cycle

5.1 Cell cycle: overview, CDK-cyclin dependent control of cell cycle, regulation of CDKs by different proteins (kinases, phosphatases, inhibitory proteins and ubiquitin-protein ligases).

5.2 Events of interphase, entry into M phase of cell cycle: Stages of mitosis and exit of mitosis, stages of meiosis (generalized idea).

5.3 Cell cycle regulation (surveillance): the DNA damage checkpoints and their role in regulation of cell cycle.

5.4 Cellular death and its regulation: apoptosis; extrinsic and intrinsic pathways.

Note for Paper Setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks.

Course Outcome:

- The present course has been devised to familiarize students with the structural and functional aspects of cell, the basic unit of life, and its different organelles. Knowing the components of cells and how they work is fundamental to all biological sciences.
- Students will understand structure and function of different cell organelles.
- Students will be able to understand the cyclic events of cell division and types of cell division.
- Will understand cell signalling and processes of cell death and cellular aging.

Recommended Textbooks and References:

1. Albert B; Bray D; Raff M; Roberts K and Watson JD. (2004). *Molecular Biology of the Cell*, Garland Publishing Inc., New York. 6th Ed.
2. Cooper, G. M. and Hausman R.E. (2006). *The Cell: A Molecular Approach*, ASM Press, Washington DC. 4th Ed.
3. Evans, J. and Manson, A. L. (2008). *Cell Biology and Genetics*. Mosby Publishers.
4. Karp, G. (2007). *Cell and Molecular Biology*, John Wiley and Sons Inc. 5th Ed.
5. Kleinsmith L. J. and Kish V. M. (1995). *Principles of Cell and Molecular Biology*, Harper Collins College Publishers, New York, USA. 2nd Ed.
6. Lodish H; Berk A; ZipurskySl; Matsudaira P; Baltimore D and Darnell J. (2004). *Molecular Cell Biology*, W. H. Freeman and Company, 5th Ed
7. Nelson, D. D. L., Lehninger, A. L. and Cox, M. M. (2013). *Lehninger Principles of Biochemistry*. W.H. Freeman Publishers.
8. Sako, Yasushi, Ueda, Masahiro (Eds.) (2011). *Cell Signaling Reactions*. Springer.

SEMESTER- I

Course code: Bio-102
Course Title: Molecular Biology
Credits: 04

Maximum Marks: 100
Sessional Assessment: 40
University Examination: 60
Duration of Exam: 3 hours

Unit 1: Nucleic acid structure and functions

1.1 Nucleic acid as genetic information carriers; experimental evidence, chemical and molecular structure of nucleic acids, types of DNA and RNA.

1.2 Denaturation and Renaturation: hyper and hypo-chromic effect, Denaturation curve, Tm, analysis of denaturation curve.

1.3 DNA supercoiling; underwinding of DNA, linking number of DNA, role of topoisomerases in changing the linking number of DNA.

1.4 Fundamental organizational units of chromatin: nucleosomes- structure and higher level of organization.

Unit 2: DNA replication

2.1 Need for replication of DNA, Conservative, semi-conservative and dispersive; semi-discontinuous DNA replication; bidirectional mode of replication.

2.2 Mechanism of DNA replication; enzymes and accessory proteins required in DNA replication of *E. coli*.

2.3 Sigma and rolling circle mode of replication with examples from M13 and lamda phage.

2.4 Replication of DNA in eukaryotes; enzymes and accessory proteins involved, end replication of linear genomes; role of telomerase in the formation of telomers.

Unit 3: DNA damage, repair and recombination

3.1 Physical and chemical DNA damaging agents; spontaneous hydrolysis and deamination of DNA bases; Alkylating agents and radiation; Base analogs and intercalating agents.

3.2 DNA repair mechanism; mismatch repair, base excision, nucleotide excision and direct repair.

3.3 Recombination: homologous recombination; Holiday junction; Proteins involved in recombination; Site specific recombination.

3.4 Transposable genetic elements in prokaryotes and eukaryotes; essential parts, insertional sequences, complex transposons, composite transposons.

Unit 4: Transcription

4.1 Transcription in prokaryotes; factors involved in transcription, mechanism (initiation, elongation and termination), antibiotic inhibitors of transcription in prokaryotes.

4.2 Operon concept; lactose, tryptophan and arabinose operons, bacteriophage lambda as an example of transcriptional riboswitches.

4.3 Transcription in eukaryotes; general and specific transcription factors, mechanism, enhancers and silencers and DNA binding motifs, antibiotic inhibitors of transcription in eukaryotes.

4.4 Post-transcriptional modifications in eukaryotes: 5' capping and polyadenylation, splicing; spliceosome machinery, alternate splicing, exon shuffling and RNA editing, Post-transcriptional gene control.

Unit 5: Translation

5.1 Genetic code- concept, degeneracy, triplet nature, deviation from universality and Wobble hypothesis.

5.2 Translation in prokaryotes; mechanism of initiation, elongation and termination, importance of co-transcriptional translation in prokaryotes.

5.3 Translation in eukaryotes; mechanism of initiation, elongation and termination, inhibitors of translation; antibiotics and toxins.

5.4 Post-translational modification of proteins; chemical modification and proteolytic cleavage, ubiquitin mediated protein degradation.

Note for Paper Setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks.

Course outcome:

- The course has been devised to familiarize students with Molecular Biology which chiefly deals with interactions among various systems of the cell, including those between DNA, RNA and proteins and learning how these are regulated.
- To gain an understanding of chemical and molecular processes that occurs in and between cells.
- To gain insight into the most significant molecular and cell-based methods used today to expand our understanding of biology.
- Will be able to design and implement experimental procedures using relevant techniques.

Books recommended

1. Albert, B., Bray, D., Raff, M., Roberts, K and Watson, J. D. (2004). Molecular Biology of the Cell, Garland Publishing Inc., New York. 6th Ed.
2. Benjamin, Lewin, Krebs, J. E., Goldstein, E., and Kilpatrick (2009) Lewin's Gene X, ST Jones and Bartlett publishers Ltd USA.
3. Brown, T.A (2000). Molecular Biology. Bios Scientific Publishers Ltd., Oxford.
4. Burton E. Tropp & David Freifelder (2012). Molecular Biology, 4th edition, Jones and Bartlett India Pvt. Ltd. New Delhi
5. David P. Clark & Nanette J. Pazdernik (2013). Molecular Biology. Elsevier Academic Press, UK. 2nd Ed.
6. Friefelder, D. (1990). Molecular Biology. Narosa Publishing House, Delhi. 2nd Ed.

7. James, D. Watson, Baker and Bell. (2013): Molecular Biology of the Gene,Cold Spring Harbor Laboratory Press, New York. 7th Ed.
8. Karp, G. (2007). Cell and Molecular Biology, John Wiley and Sons Inc. 5th Ed.
9. Kornberg, A. and Baker, A.T. (1992). DNA Replication, W.H. Freeman & Company. 2nd Ed.
10. Krebs E, J., Goldstein S, E., Kilpatrick T. S. (2011). Lewin's Gens X, Jones and Bartlett publishers, Inc.
11. Krebs E, J., Goldstein S, E., Kilpatrick T. S. (2013). Lewins Gene XI, Jones and Bartlett publishers, Inc.
12. Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon, Scott (2013). Molecular cell Biology, W. H. Freeman; 7th Ed.

SEMESTER- I

Course Code: Bio-103
Course Title: Biomolecules
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2hours

Unit 1: Introduction to biomolecules and proteins

1.1 Water: structure and properties, ion product, dipolar structure and dielectric constant; concentration of solution- Molarity, Normality, Molality and Strength.

1.2 Chemical foundations of biology: pH, pK, acids, bases, buffers- composition, preparation, Henderson-Hasselbalch, buffer capacity and strength.

1.3 Amino acids: structure and classification; Proteins: characteristics of peptide bond and Ramachandran map; Hierarchy in structure: primary, secondary, tertiary and quaternary structures.

1.4 Protein folding- Anfinsen's experiment, Levinthal paradox, chaperons, protein sequencing (N-terminal sequencing, C-terminal sequencing, Edmann degradation).

Unit 2: Carbohydrates and lipids

1.5 Carbohydrates: classification, basic chemical structure, monosaccharides – aldoses and ketoses; Configuration and conformation of monosaccharides (pyranose and furanose), stereoisomerism, anomers, epimers and mutarotation.

1.6 Polysaccharides: structural polysaccharides - cellulose and chitin; storage polysaccharides - starch and glycogen; glycoproteins: N- and O-glycosylation; glycosaminoglycans; glycoproteins.

1.7 Lipids – classification of lipids: oils, fats, and waxes, occurrence and properties of fatty acids, esters of fatty acids, phosopholipids, glycolipids, sphingolipids, cerebrosides and gangliosides.

1.8 Lipoproteins, steroids and cholesterol; Eicosanoids, prostaglandins and leukotriene's.

Unit 3: Nucleic acids, vitamins and pigments

3.1 Nucleic acids: purines, pyrimidines, nucleosides, nucleotides: structure of DNA and RNA.

3.2 Vitamins and Co-enzymes: classification, water-soluble and fat-soluble vitamins, dietary requirements, deficiency conditions, coenzyme forms.

3.3 Porphyrins and porphyrin ring system: chlorophyll, hemoglobin and myoglobin.

3.4 Secondary metabolites: isoprenoids, polyphenols and flavonoids.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

14

Course Outcome:

- The course is designed to make students appreciate the structure and importance of various biomolecules involved in sustenance and perpetuation of living organisms.
- Learn the elements that are present in biomolecules and different monomers and polymers.
- To acquaint students with the shape, structure, function and importance of proteins.
- Students will understand chemical properties, structure and function of Lipids and Proteins.

Books recommended:

1. Cox Michael M. and Nelson. D. L. (2008): Principles of Biochemistry, 5th Edition, W. H. Freeman and Company, New York.
2. Heldt Hans-Walter and Piechulla Birgit (2010): Plant Biochemistry, 4th Edition, Academic Press.
3. Plummer, T. David, (2004): An Introduction to Practical Biochemistry, 4th Edition, Tata McGraw-Hill Publishing Co.
4. Stryer. L. (2005): Biochemistry, 6th Edition, W.H. Freeman and Company, San Francisco.
5. Voet. Donald, Voet Judith., W. Pratt. Charlotte. (2008): Fundamentals of Biochemistry, 3rd Edition John Wiley, New York.
6. Wilson K., and J. Walker, (2010): Principles and Techniques of Biochemistry and Molecular Biology Techniques, 7th Edition, Cambridge Univ. Press.

SEMESTER- I

Course Code: Bio-104
Course Title: Microbiology
Credits: 04

Maximum Marks: 100
Sessional Assessment: 40
University Examination: 60
Duration of Exam: 3 hours

Unit 1: Introduction to microbiology and microscopy

1.1 Introduction, history and scope of microbiology. Discovery of microscope and microbes, Theory of abiogenesis & biogenesis, Koch's postulates, River's postulate, concept of kingdom- prokaryote and eukaryotes.

1.2 Classification of Microorganisms: Haekel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese.

1.2 Microscopy: Principle and working (Bright field; Phase contrast and Electron microscopy); specimen preparation

1.3 Microbiological stains and staining techniques: Types of stains and principles of staining; Stains for bacteria, fungi, algae and protozoa, spirochetes, stains for mycoplasma.

Unit 2: Prokaryotic cell structure and function

2.1 An overview of prokaryotic cell structure; Morphology and ultrastructure of bacteria: size, shape, and arrangement of bacteria, ultra-structure of eubacteria and archeabacteria. Protoplast and spheroplast formation.

2.2 Components external to cell wall: Structure and function of flagella, fimbriae and pilli, capsule- types, composition and function, slime layers, S-layers.

2.3 Prokaryotic cell membrane and cytoplasmic matrix – cell membrane structure and function of bacteria and archeabacteria, mesosomes, ribosomes, cytoplasmic inclusion bodies (polyhydroxy butyrate, polyphosphate granules, oil droplets, cyanophycin granules) and Prokaryotic genome.

2.4 Protein secretion in prokaryotes; Microbial response to external stimulus: Chemotaxis and phototaxis; formation and germination of bacterial endospore.

Unit 3: Microbial nutrition and growth

3.1 Microbial nutrition: Basic nutritional requirements, growth factors, nutritional categories, physical requirements of bacterial growth.

3.2 Microbial media: types (complex, synthetic, differential, enrichment and selective media) and their uses, culture characteristics of bacteria on different media.

3.3 Cultivation of microbes: aerobic and anaerobic culture, pure culture techniques, shaker and still culture, maintenance and preservation of microbial culture.

3.4 Microbial growth: growth kinetics, growth curve. Batch, continuous and synchronous culture. Measurement of growth and influence of environmental factors affecting growth.

Unit 4: Control of microorganisms by physical and chemical agents

4.1 Control of microorganisms: Microbial death curve, concept of bio-burden, thermal death time and decimal reduction time. Factors influencing the effectiveness of antimicrobial agents.

4.2 Control of microorganisms by physical agents: heat (moist and dry), filtration and radiation.

4.3 Chemical control of microorganisms: Halogens, phenol and other phenolic compounds, heavy metals, alcohols, ethylene oxide and aldehydes.

4.4 Antibiotics: classification, mode of action and development of antibiotic resistance in bacteria.

Unit 5: General features of archaea, fungi, viruses and acellular infectious agents

5.1 General features of Archaea: Halophiles, Methanogens, Hyperthermophilic archaea, Thermoplasm.

5.2 Fungi - Distinguished characteristics of fungi, general account on morphology, reproduction, physiology and classification.

5.3 Viruses - General properties, morphology, and reproduction mechanisms of viruses. General characteristic features of plant, animal and bacterial viruses.

5.4 Acellular Infectious agents: Viroid and Prions.

Course outcome:

- General introduction to the history and scope of microbiology, microbial classification and nomenclature.
- To acquaint students with the concepts of cellular classification (prokaryotes and Eukaryotes), their structure and function.
- To provide a detailed understanding about infectious agents (cellular and acellular).
- Development of understanding among the students about bacterial growth and control methods

Note for paper setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks.

Books Recommended.

1. Prescott, Harley and Klein's (2013). Microbiology, 6th edition The McGraw–Hill Publishing Co Ltd.
2. Pommerville, J. C. (2012). Alcamo's Fundamentals of Microbiology. Jones and Bartlett Publishers, Boston.

17

3. Schlegel, H.G. (2012). General Microbiology. Cambridge University Press.
4. Pelczer, M. J., Chan, E. C. S., Kries, N. R. (2008). A text book of microbiology, 5th edition. Tata McGraw Hill publishing Co Ltd.
5. Maloy, S.R., Cronan Jr, J.E. and Freifelder, D (2006). Microbial Genetics. Narosa Publishing House.
6. Atlas R.M. (1998). Microbiology, Fundamentals and applications 2nd Edition, Milan Publishing Co.
7. Holt J.S. Kreig N.R., Sneath P.H.A and Williams S.T (1994). Bergey"s Manual of Systemic Bacteriology 9th Edition. William and Wilkins, Baltimore.
8. Brock T.D. and Madigan M.T (1992). Biology of Microorganisms 6th Edition. Prentice Hall, Eagle wood cliffs.
9. Alexander M (1977). Introduction to soil microbiology, John Wiley and Sons Inc.N.Y.

SEMESTER- I

Course code: Bio-105
Course Title: Genetics
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Introduction to genetics

1.1. Basic mechanisms of inheritance: Mendel's Laws of Inheritance, extensions to Mendelism- dominance, co-dominance and incomplete dominance

1.2. Alleles and Gene Interactions: Multiple alleles, pleiotropic effects, partial penetrance & variable expressivity, lethal alleles

1.3. Linkage and Recombination: Recombination as the basis of gene mapping, linkage mapping, tetrad analysis

1.4. Extra-nuclear Inheritance: cytoplasmic inheritance and maternal effects.

Unit 2: Human genetics

2.1. Pedigrees: gathering family history, pedigree symbols, construction of pedigrees, and presentation of molecular genetic data in pedigrees.

2.2. Autosomal inheritance: dominant, recessive, consanguinity and its effects.

2.3. Sex-linked inheritance, sex-limited and sex-influenced traits, genomic imprinting.

2.4. Genetic disorders caused by a single gene: Tay-Sachs disease, haemophilia, cystic fibrosis, muscular dystrophy.

Unit 3: Mutation and its effects

3.1 Types of mutations, causes, detection & application.

3.2 Mutant types: lethal, conditional, spontaneous verses induced mutations.

3.3 Phenotypic effects of mutation, somatic vs germinal mutation, suppressor mutation, biochemical loss of function and gain of function.

3.4 Molecular basis of mutation: radiation and chemical induced mutations.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The objectives of this course are to take students through basics of genetics and classical genetics covering prokaryotic/ phage genetics to yeast and higher eukaryotic domains.
- On covering all classical concepts of Mendelian genetics across these life-forms, students will be exposed to concepts of population genetics.

19

- Students will also be exposed to quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.
- To understand the genetics of model animal Drosophila.

Recommended Textbooks and References:

1. Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis.* Sudbury, MA: Jones and Bartlett.
2. Pierce, B. A. (2005). *Genetics: A Conceptual Approach.* New York: W.H. Freeman.
3. Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics.* Dubuque, IA: Wm. C. Brown.
4. Smith, J. M. (1989). *Evolutionary Genetics.* Oxford: Oxford University Press.
5. Gardner, M. J., Simmons D. P. Snustad*Principles of Genetics* 8thEdn. John Wiley and Sons.

SEMESTER- I

Course code: Bio-106
Course Title: Lab courses I based on Cell Biology and Molecular Biology

Maximum Marks: 100
University Examination: 50
Sessional Assessment: 50

Cell Biology

1. Lab demonstration of light and fluorescence microscopic techniques.
2. Study the process of somatic cell division in root tips of *Allium sativum* (garlic)/ *Aillum cepa* (onion)/*Aillum tuberosum.*
3. Study the structure of somatic chromosomes of *Allium cepa/ Vicea faba,* describe the salient features of the karyotype and preparation of ideogram.
4. Study meiotic behaviour of chromosomes of *Phlox drumondii, Allium sp or Eremurus persicus.*
5. Lab demonstration of microtomy technique.
6. Preparation of plant and animal tissue sections for microtomy and their staining.
7. Isolate chloroplasts from leaf tissues of spinach; study the variation in chloroplast shape in spinach, *Ulothrix* and *Spirogyra.*
8. Study the diversity in cell structure in a given sample of plant and animal tissue. (Onion peel, pulp of banana, xylem cells, liver of sheep)
9. Study transport across the semi permeable membrane by using potato osmoscope.
   *Depending upon the availability, only one material will be used.

Molecular Biology

1. Isolation of plant, animal and bacterial genomic DNA (*Brassica*sp, humans, *E. coli)*
2. Isolation of RNA from the leaves of *Catharanth usroseus, Valleriana wallichii* and *Brassica* sp. by using Trizol method.
3. Isolation of plasmid DNA from *E. coli.*
4. Agarose gel electrophoresis of plasmid/genomic DNA
5. Restriction digestion of total genomic DNA
6. Preparation of restriction maps from gel pictures.
7. Elution of target DNA fragments from agarose gel.
8. Demonstration of Southern Blotting technique.

Course Outcome:

- The objective of this laboratory course is to provide the students practical skills in basic and cell biology and molecular biology
- Students will learn different techniques of cell biology.
- Enable students to acquire expertise in the field of molecular biology.
- Demonstrate practical skills in different laboratory equipment's and their handling.

SEMESTER- I

Course code: Bio-107
Course Title: Lab courses II based on Biomolecules, Microbiology and Genetics

Maximum Marks: 100
University Examination: 50
Sessional Assessment: 50

Biomolecules

1. Biochemical calculation and reagent preparation.
2. Estimation of pH using pH meter.
3. Estimation of proteins by Lowery's method.
4. Estimation of proteins by Biuretic method.
5. Colorimetric determination of pKa.
6. Amino acid titration.
7. Study reactions of amino acids, sugars and lipids.
    - Tests for sugars:
      Molish's test, Fehling's test, Seliwanoff's test, Nylander's test, Barrfoed's test
    - Tests for amino acids:
      Ninhydrin test, Xanthoproteic test, Morner's test, Lead sulphide test, Hopkin's test
    - Test for lipids:
      solubility test, Emulsification test, Saponification test, Unsaturation test
8. Quantification of proteins from hen's eggs and sugars from potato.
9. Analysis of oils – iodine number, saponification value and acid number.
10. Use of spectro fluro photometer.
11. Undertake separation techniques - Centrifugation, Chromatography (TLC and paper chromatography).

Microbiology

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria.
3. Isolation and identification of bacteria from soil/water samples.
4. Isolation of bacteria in pure culture by streak plate method.
5. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.
6. Study of colony and growth characteristics of some common bacteria: *Bacillus, E. coli, Staphylococcus, Streptococcus, etc.*
7. Preparation of bacterial smear and Gram's staining.
8. Enumeration of bacteria: standard plate count.
9. Antimicrobial sensitivity test and demonstration of drug resistance.
10. Determination of Minimum Inhibitory Concentration (MIC).

Genetics

1. Mounting of polytene chromosomes
2. Mounting of Barr bodies

3. Study of Karyotyping in onion, humans (normal and abnormal)
4. Study of mutation in *E. coli* by UV light
5. Demonstration of multiple alleles by blood group in humans
6. Mounting of imaginal discs of drosophila
7. Study of Drossophila mutant type
8. Problems on (a) law of segregation (b) Independent assortment (c) Sex linked inheritance (d) population genetics

Course Outcome:

- The objective of this laboratory course is to provide the students with practical skills in basic biochemical calculations, identification of biomolecules and certain cell biology techniques.
- Enable students to acquire expertise in the field of microbiology.
- Demonstrate practical skills in different laboratory equipment's and their handling

SEMESTER- II

Course Code: Bio-201
Course Title: Enzymology and Metabolism
Credits: 04

Maximum Marks: 100
Sessional Assessment: 40
University Examination: 60
Duration of Exam: 3 hours

Unit 1: Enzyme kinetics

1.1 Nomenclature and classification of enzymes: Enzyme Commission's system of classification, seven classes of enzymes; co-factors and coenzyme.

1.2 Factors affecting enzyme activity: pH, temperature, substrate and enzyme concentration; ribozymes and abzymes.

1.3 Reaction kinetics: chemical kinetics- Michaelis-Menten equation using steady-state kinetics, significance of K_{cat}, K_m and K_{cat}/K_m.

1.4 Enzyme inhibition: competitive, noncompetitive, uncompetitive and mixed inhibitions; allostery of enzyme action: MWC model, KNF model.

Unit 2: Enzyme catalysis

2.1 Mechanism of catalysis: acid-base catalysis and covalent catalysis (examples of enzyme catalysis using chymotrypsin, lysozyme and ribonuclease).

2.2 Multi-enzyme complex: fatty acid synthase, allosteric regulation of aspartate transcarbamylase.

2.3 Mapping of active site: Affinity labeling and chemical modification methods of active site determination.

2.4 Immobilization of enzymes, properties and application of immobilized enzymes. Isoenzymes- application and significance.

Unit 3: Bioenergetics and carbohydrate metabolism

3.1 Principles of bioenergetics: Energy transformation, laws of thermodynamics, spontaneity of a process, life and thermodynamics.

3.2 Carbohydrate metabolism: aerobic and anaerobic pathways, glycolysis, citric acid cycle, oxidative phosphorylation and electron transport chain.

3.3 Alternate pathways of glucose metabolism-pentose phosphate pathway, glyoxalate cycle, and glucuronic acid cycle.

3.4 Gluconeogenesis, glycogen synthesis and breakdown.

Unit 4: Lipid metabolism

4.1 Oxidation of lipids: β- oxidation, oxidation of unsaturated and odd chain fatty acids and formation of ketone bodies.

4.2 Biosynthesis of fatty acids: carbon sources, acetyl-CoA carboxylase and reactions of fatty acid synthase complex, synthesis of odd chain and unsaturated fatty acids.

4.3 Lipoproteins: Low density lipoproteins (LDL), Very low density lipoproteins (VLDL), High density lipoproteins (HDL) and Chylomicrons.

4.4 Biosynthetic pathway of cholesterol.

Unit 5: Nitrogen metabolism

5.1 Oxidative degradation of amino acids: transamination, oxidative deamination and urea cycle.

5.2 Biosynthesis of essential (leucine, isoleucine and valine) and non-essential (alanine, asparagine and glutamine) amino acids.

5.3 Regulation of amino acid biosynthesis, genetic defects in amino acid metabolism.

5.4 Biosynthesis of purine and pyrimidine nucleotides, regulation of nucleotide synthesis.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks

Course Outcome:

- The course is designed to make students learn and appreciate the importance of enzymes and enzyme catalyzed reactions.
- Students will acquaint with mechanism and regulation of various biochemical reactions taking place in living systems.
- Students will understand the laws of thermodynamics and conceptual knowledge of aerobic and anaerobic pathways.
- Students will be able to understand different processes involved in nitrogen metabolism.

Recommended Textbooks and References:

1. Lansing M Prescott, John P. Harley, Donald A Klein, *Microbiology;* Sixth edition, Mc Graw Hill Higher education.
2. Price & Stevens. (1999). *Fundamentals of Enzymology*
3. Palmer, T. (2001). *Enzyme; Biochemistry, Biotechnology*, Clinical Chemistry. Horwood Ltd.
4. Alcomo, I.E. 2001. *Fundamentals of Microbiology*. VI Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts.
5. Stryer, L. (2015). *Biochemistry* (8th ed.). New York: Freeman.
6. Lehninger, A. L. (2012). *Principles of Biochemistry*(6th ed.). New York, NY: Worth.

Voet, D., &Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons

SEMESTER- II

Course Code: Bio-202
Course Title: Bioinformatics and Biostatistics
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Biological databases

1.1. Bioinformatics: Concept and applications.
1.2. Biological databases: Types of biological databases, data representation and storage, information retrieval from biological databases.
1.3. Nucleotide Sequence databases: NCBI, EMBL, DDBJ, and ESTs.
1.4. Protein sequence databases: Swiss Port, PIR, SCOP and CATH.

Unit 2: Sequence analysis and phylogeny

2.1 Sequence Alignments: introduction and significance; Pairwise sequence alignment; Scoring matrices: PAM and BLOSUM; Global and Local Sequence alignment; FASTA and BLAST.
2.2 Multiple Sequence alignment: introduction; databases of multiple sequence alignment; pfam, Smart, Conserved domain databases and Prints
2.3 Phylogeny: introduction, molecular phylogeny; Representation of molecular phylogeny, MEGA –X.
2.4 Tree building methods; Types of trees; Phylogenetic software's.

Unit 3: Basics of biostatistics

3.1 Statistics: definition, history, applications and limitations; concept of Biometry, population and sample.
3.2 Data collection and tabulation, primary and secondary data, methods of collecting primary data, sources of secondary data, editing of primary and secondary data, rule of tabulation, parts and types of tables and role of tabulation of data.
3.3 Frequency distribution: classification of data, histogram, frequency polygon, cumulative frequency curves, designs and limitations of graph.
3.4 Measures of central tendency: arithmetic mean, median, mode; measures of dispersion: standard deviation, standard error and coefficient of variation, tests of significance: t-test, F-test and X^2 test and Correlation (types, methods; Karl Pearson's coefficient) and regression (linear) analysis and their uses, ANOVA.

Note for paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit.

Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The objective of this course is to define and explain key terms and concepts in bioinformatics.
- Demonstrate comprehension of the interdisciplinary nature of bioinformatics.
- Navigate and retrieve information from major biological databases.
- Apply various bioinformatics tools for sequence analysis, structure prediction, and functional annotation.
- Analyze genomic data using bioinformatics approaches.
- Predict protein structures using homology modeling and ab initio methods.
- Understand the principles of biostatistics. Define basic statistical terms and concepts.
- Recognize the role of biostatistics in experimental design and data analysis.
- Perform hypothesis testing and interpret the results.
- Analyze and interpret data using statistical software:
- Understand and apply regression and correlation methods in biological data analysis.
- Evaluate and critique statistical methods used in published research.

Books recommended

1. Bioinformatics Principles and Applications. Zhumar Ghosh and Bibekanand Mallick (2008). ISBN; 0195692306, 978-0195692303. Oxford University Press.
2. Gupta, S.P. (2005). Statistical Methods, Sultan Chand and Sons, New Delhi.
3. Gupta, C.B. and Gupta, V. (2005). An Introduction to Statistical Methods, Vikas Publishing House Pvt Ltd, New Delhi.
4. Gun, A.M., Gupta, M.K. and Dasgupta, B (2005). Fundamentals of Statistics, The World Press Pvt. Ltd, Kolkata.
5. Sinha, P.K. and Sinha, P. (2005). Computer Fundamentals, BPB Publication.
6. Rajaraman, V. (2004). Fundamentals of Computers, Prentice-Hall of India Pvt. Ltd., New Delhi.

SEMESTER- II

Course Code: Bio-203
Course Title: Genomics and Proteomics
Credits: 02

Maximum Marks: 50
Sessional Assessment:20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Introduction to genomics

1.1 Introduction to omes and omics; Application of genomics.
1.2 Gene location by sequence inspection; locating genes for functional RNA. Computational prediction of miRNA target gene.
1.3 Gene expression: reporter genes for monitoring gene expression, deletion analysis of the upstream regions.
1.4 Human Genome Project: Background, features and Strategic issues.

Unit 2: Genome analysis

2.1 DNA sequencing technologies: Sanger sequencing, pyro- sequencing and next generation sequencing.
2.2 Sequencing and assembling of genomes: whole genome shotgun sequencing and hierarchical shotgun sequencing; DNA microarray technology
2.3 Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs., DNA barcoding.
2.4 Locating protein-binding sites in the upstream region: Gel retardation assay, DNA footprinting and Chromatin Immunoprecipitation (ChIP).

Unit 3: Proteomics

3.1 Separation of proteins from proteome (SDS-PAGE, 2-D PAGE), antibodies for proteomics, western blotting.
3.2 Identification of proteins from proteome (Mass spectrophotometry & tandem mass spectrometry).
3.3 Protein - protein interaction by phage display and yeast two hybrid system.
3.4 Chemical modifications of histones: acetylation and deacetylation; influence of nucleosome remodelling on genome expression.

Note for paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The objective of this course is to provide introductory knowledge concerning genomics, proteomics and their applications.
- To know the basic concept of genomics and functional genomics.
- Elucidate different techniques involved in Genomics and Functional Genomics.
- Students will acquaint with different methods of genome sequencing and assembly.

Books Recommended

1. Brown, T. A. 2007. Genomes 3. Garland Science, Taylor & Francis Group, New York
2. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ISBN: 1555816126, 9781555816124. ASM press. 4th Ed.
3. Hunt, P. Stephen and R. Livesey (eds). 2000. Functional Genomics: A Practical Approach. Oxford University Press.
4. Jonathan Pevsner (2013). Bioinformatics and Functional Genomics. Wilwy India Pvt. Ltd. 2nd ed.
5. Primrose, S. B. and R. M. Twyman. 2007. Principles of Gene Manipulation and Genomics. Blackwell Publishing, Oxford, UK.
6. Schlena, Mark (ed). 2000. DNA Microarrays: A Practical Approach. Oxford University Press

SEMESTER- II

Course Code: Bio-204
Course Title: Analytical Techniques
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Centrifugation and chromatographic techniques

1.1 Centrifugation: Basic principle of centrifugation; Types, care and safety aspect during centrifugation.

1.2 Preparative and Analytical Centrifugation and their applications.

1.3 Chromatographic techniques: Principle and applications of Adsorption, Partition, Ion-exchange, Size exclusion and Affinity chromatography.

1.4 HPLC, FPLC Gas chromatography. Dialysis, Ultrafiltration and other membrane techniques.

Unit 2: Spectroscopic and immune techniques

2.1. Ultraviolet and visible light spectroscopy, Fluorescence spectroscopy and Light Scattering and Circular dichroism spectroscopy.

2.2. Overview and Applications of Surface Plasmon Resonance, NMR and X-ray diffraction.

2.3. Principle of Mass Spectrometry: MALDI-TOF; ESI-MS; Structural Analysis by Tandem mass spectrometry; Usage in Proteomics.

2.4. Immunochemical techniques: Production of Antibodies; Immunoassay and Immunoelectrophoresis formats; Immunomicroscopy; Epitope mapping; Immunoblotting, Chromatin Immuno precipitation (ChIP) and Fluorescence Activated Cell Sorting (FACS).

Unit 3: Protein Isolation, purification and Electrophoretic Techniques

3.1 Protein Isolation and Purification: Methods of cell disintegration

3.2 Protein sequencing methods; detection of post translation modification of proteins

3.3 Electrophoretic Techniques: General Principle; Support media used in Electrophoresis; Electrophoresis of proteins and nucleic acids.

3.4 Capillary electrophoresis and Microchip electrophoresis.

Note for the paper setter:

The question paper will have, two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The objective of this course is to familiarize students with the basic concepts and applications of modern techniques used in Biochemistry, Biophysics, Cell and Molecular Biology.
- The students will be able to understand the principle and working of different chromatography techniques.
- The students will be able to understand the principle and working of different centrifugation techniques.
- The students will be able to understand the principle and working of different Electrophoretic techniques.

Recommended Textbooks and References:

1. E. H. Segel. *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd Edition, John Wiley Publications.
2. Branden, C. and Tooze, J. (1999). *Introduction to Protein Structure*. Garland Publishing New York.
3. Tanford, C. (1961). *Physical Chemistry of Macromalocules*. John Wiley and Sons.
4. Wilson, K and Walker, J. (2011). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University press.
5. Friefilder, D. (1987). *Essentials of Molecular Biology*. Jones and Bartlett Publications.
6. Clark, D. P. (2005). *Molecular Biology: Understanding the Genetic Revolution*. Academic Press.
7. Nelson, D. D. L., Lehninger, A. L. and Cox, M. M. (2013). *Lehninger Principles of Biochemistry*. W.H. Freeman Publishers.

SEMESTER- II

Open Elective

Course Code: Bio-205
Course Title: Fundamentals of Biotechnology
Credits: 04

Maximum Marks: 50
Sessional Assessment:40
University Examination: 60
Duration of Exam: 3 hours

Unit 1: Biotechnological perspective

1.1 Scope of biotechnology, conventional and modern biotechnology, goals of biotechnology.

1.2 Basic structure of prokaryotic and eukaryotic cell; Central dogma of molecular biology.

1.3 Genetic engineering: Basics of gene cloning; Restriction endonucleases.

1.4 Application of gene transfer in plants and animals.

Unit 2: Plant and Animal Biotechnology

2.1 Concept of plant tissue culture, micropropagation and transgenic plants.

2.2 Crop improvement: Bt cotton, Bt brinjal and Golden rice.

2.3 Transgenic animals and concept of bio-pharming.

2.4 IVF technology for livestock improvement and pharmaceutical products.

Unit 3: Industrial and Environmental Biotechnology

3.1 Basic Design of Fermenter; Batch, Fed-batch and Continuous fermentation methods.

3.2 Food Processing, Food and Beverages Fermentation, Probiotics and Antibiotics.

3.3 Bioremediation of Soil and Water, Vermicomposting and Biopesticides.

3.4 Impact and Biotechnological Approaches for management of environment.

Unit 4: Biotechnology and Social Welfare – I

4.1 Microbial Diseases of Humans: AIDS, Hepatitis B, TB and Malaria.

4.2 Genetic Disorders: Cancer, Cystic Fibrosis and Alzheimer's disease.

4.3 Therapeutics: Stem Cells and Gene Therapy.

4.4 Drug and Gene Delivery, Development of vaccines.

Unit 5: Biotechnology and Social Welfare – II

5.1 Bio-safety: Definition, Requirement, Bio-safety Containment Facilities and Biohazards.

5.2 Genetically Modified Organisms (GMOs), Environmental Safety of GMO's.

5.3 Intellectual Property Rights, Patentability of Life Forms with reference to microorganisms and biodiversity.

5.4 Human genome project: applications and benefits.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks

Course Outcome:

- The objective of this course is to familiarize students of other disciplines with principles and applications of modern biotechnology.
- To give students basic concept of different branches of Biotechnology.
- To acquaint students with basic principles of plant and animal biotechnology.
- To familiarize students with some important genetic disorders, genetically modified organisms and bio-safety measures.

Recommended Textbooks and References:

1. Albert B; Bray D; Raff M; Roberts K and Watson JD. (2004). *Molecular Biology of the Cell*, Garland Publishing Inc., New York. 6th Ed.
2. Bhohwani, S. S. (1990) *Plant Tissue Culture: Applications and Limitations,* Elsevier, Amsterdam.
3. Clark, D. P (2005). *Molecular Biology: Understanding the Genetic Revolution.* Academic press
4. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 4th Ed. ASM press.
5. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), *Principles of Gene Manipulation and Genomics,* Blackwell Publishing Limited; 7th Edition
6. Tara Satyavathi, C.,Bharadwaj, S. K., Srivastwa, G., *et al.* (2014), *Biotechnology,* Agri Books.
7. Das, H.K. (2010) *Textbook of Biotechnology* Wiley India.
8. Correa, Carlos Mo. (2000), *Intellectual Property Rights, The WHO and Developing Countries: The TRIPS Agreement and Policy Options.* Zed Books, New York.
9. Kumaresan, V., Arumugam N. (2016) *Fundamentals of Biotechnology*, Saras Publications.

SEMESTER- II

Course Code: Bio-206
Course Title: Journal Club/Seminar
Credits: 02

Maximum Marks: 50
Sessional Assessment:20
University Examination: 30
Duration of Exam: 2 hours

- Topics of Seminar/Research Article be allotted to every student along with a supervisor / mentor.
- Students have to make 30 min. PowerPoint presentation of the same, which all the faculty of the department and students should attend.
- Following the seminar, there will be a short quiz consisting of 5 multiple-choice questions, prepared by the relevant faculty on the topic, which all students are required to attempt.
- Student assessment will be based on their seminar presentation (25%), evaluated individually by all faculty members, and their average performance on the quiz (75%).

Course Outcome:

- The main objective of this course is to prepare students for PowerPoint presentation.
- Students will be able to review the literature.
- To acquaint students with recent developments in the concerned subject
- To enhance their orientation skills.

SEMESTER- II

Lab courses V

Course code: Bio-207 **Maximum Marks: 100**
Course Title: Lab courses III based on Enzymology and Metabolism, and Bioinformatics and Biostatistics **University Examination: 50**
Sessional Assessment: 50

Enzymology and Metabolism

1. Effect of pH and temperature on enzyme activity.
2. Assay of acid phosphatase from potato.
3. Assay of beta-amylase from sweat potato.
4. Assay of serum alkaline phosphatase.
5. Assay of serum ALT and AST.
6. Estimation of glucose.
7. Estimation of urea.
8. Nitrogen estimation from animal tissue.
9. Cholesterol estimation.
10. Isolation and estimation of starch from potato using iodine test.
11. Isolation of glycogen from animal tissue.

Bioinformatics and Biostatistics

1. Retrieval of protein and nucleotide sequences from suitable databanks.
2. Similarity searches using BLAST.
3. Online tools for PCR primer generation and restriction analysis.
4. Visualization of genome maps-usage of Mapviewer from NCBI resource.
5. Study particular gene using TAIR database.
6. Study alignment of DNA and protein sequences by using bioinformatics tools.
7. Study phylogenetic analysis by using NTSYs.
8. Construct dendogram of available data (protein and DNA sequences) using cladistic methods.
9. Construct dendogram of available data (protein and DNA sequences) using distance methods.
10. Calculate central tendencies: mean, median and mode from the data provided.
11. Draw frequency distribution curve and frequency polygons from the data provided.
12. Calculate Standard Deviation and Standard Error from given data.
13. Subject the available data to χ^2 analysis and compare the mean values by applying t-test.

Course Outcome:

- The objective of this laboratory course is to provide some practical skills pertaining to enzymology.

- Students will receive hands on experience of various biochemical assays to estimate some biomolecules and activities of various enzymes.
- Students will learn different techniques pertaining to enzymology and metabolism.
- Demonstrate practical skills in different laboratory equipment's and their handling.

Lab courses IV

Course code: Bio-208
Course Title: Lab courses IV based on Genomics and Proteomics and Analytical Techniques

Maximum Marks: 100
University Examination: 50
Sessional Assessment: 50

Genomics

1. Protein profiling by PAGE and SDS PAGE.
2. Primer designing for gene cloning using bioinformatics.
3. Transfer of DNA fragments from Agarose gel to Nitrocellulose membrane (Southern blotting).

Analytical Techniques

1. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
2. Preparation of TLC plates and separation of amino acids using Thin Layer Chromatography.
3. Separation of carbohydrates through Thin Layer Chromatography (nectar of flowers).
4. Separation of amino acids by Paper Chromatography.
5. Use of UV-Visible spectroscopy for the estimation of protein and DNA concentration.
6. Monitoring structure perturbation by solvent using UV-Visible spectroscopy.
7. Separation of Plasmids using Agarose gel electrophoresis.
8. Separation of Proteins by PAGE.
9. Gene amplification by PCR.

SEMESTER- III

Course Code: Bio-301
Course Title: Plant Biotechnology
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Plant tissue culture

1.1 Plant tissue culture- history; totipotency of plant cells; Principles for aseptic culture techniques, culture media, plant growth regulators.

1.2 Plant regeneration: somatic embryogenesis, importance of haploid production through pollen and anther culture; triploid production through endosperm.

1.3 Micropropagation, stages and methods; production of virus free plants; Synthetic seeds and their importance.

1.4 Initiation and maintenance of callus and suspension culture, Single cell clones; Basis, applications & control of Somaclonal variation.

Unit 2: Plant transformation techniques

2.1 Structure and features of *Agrobacterium tumefaciens*; Ti and Ri plasmids, role of virulence genes, mechanism of T-DNA transfer; Factors influencing binding of Agrobacterium to plant, Mechanism of T-DNA transfer & Role of virulent proteins in (Formation of T-DNA strand, movement of T-Complex & Integration of T-DNA into Plant genome).

2.2 Methods of gene transfer- Agrobacterium mediated, particle bombardment and electroporation.

2.3 Vectors based on Ti and Ri plasmids – cointegrate and binary vectors, technique and factors affecting Agrobacterium mediated transformation of plants; Use of reporter genes (Opine synthase, CAT, GUS, LUX, GFP) and selectable markers (antibiotic & herbicide resistant genes).

2.4 Plant transformation for productivity and performance with special example of Herbicide resistance (Glyphosate & Phosphinothricin resistance), Insect resistance (Bt based plants), Disease resistance (Role of R-proteins & other molecules).

Unit 3: Plant biotechnology for improving crop yield and quality (value addition)

3.1 Plant biotechnology in improving fruit ripening and enhancing resistance against fungal and viral pathogens.

3.2 Golden rice- nutritionally improved rice through biotechnology; Plant biotechnology in enhancing various abiotic stresses (like drought, salinity, temperature).

3.3 Modification of food, plant taste and appearance- Sweetness, Starch and preventing discoloration.

3.4 Bioplastics- biodegradable plastic from plants through biotechnological intervention; Production of antibodies, vaccines and other medically related proteins in plants.

Note for paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- To impart theoretical knowledge on various techniques of plant biotechnology like tissue culture, plant genetic transformation and their application in industries.
- To develop concepts, principles and processes in plant biotechnology.
- Students will know about different types of plant tissue culture.
- Elucidation of different methods for the improvement of plants, including plant taste, texture, fruit ripening, sweetness etc.

Books recommended:

1. Bhojwani, S. S. (1990). Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam.
2. Brown, T. A (2007). Genomes. BIOS Scientific Publishers Ltd.
3. Clark, D. P (2005). Molecular Biology: Understanding the Genetic Revolution. Academic press.
4. Malacinski, G. M (2006). Essentials of Molecular Biology. Narosa Publishing House. (4^{th}
5. edition).
6. Primrose, S. B and Twyman, R. M (2007). Principles of Gene Manipulation and Genomics.
7. Blackwell Publishing, Oxford, UK.
8. Singh, B. D. (2007). Biotechnology: Expanding Horizons. Kalyani Publishers.
9. Slater, A., Scott, N and Fowler, M (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press.
10. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ISBN: 1555816126, 9781555816124. ASM press. 4^{th} Ed.
11. H. S. Chawla (2013) Introduction to Plant Biotechnology Science Publishers, Recent Edition.

SEMESTER- III

Course Code: Bio-302
Course Title: Animal Biotechnology
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Animal cell culture and scaling up

1.1 Primary and established cell line cultures.

1.2 Cell culture-suspension cultures, culture media, natural and artificial media, initiation of cell cultures, evolution of continuous cell lines.

1.3 Measurement of viability and cytotoxicity of cultured cells.

1.4 Scaling up of animal cell cultures.

Unit 2: Animal tissue culture and hybridoma technology

2.1 Organ culture- techniques, advantages, limitations and applications.

2.2 Stem cell lines: origin and types; stem cell therapy and its applications

2.3 Somatic cell fusion, techniques and importance.

2.4 Hybridoma technology and its importance in medicine, cell cloning and manipulation and cell synchronization.

Unit 3: Animal cell culture products and transfection techniques

3.1 Cell culture products: viral vaccines, interferons, recombinant proteins, hybrid antibodies.

3.2 *In-vitro* fertilization in humans, embryo transfer in cattle, applications of embryo transfer technology, (the story of Noori)

3.3 Transfection methods- Ca^{2+} phosphate precipitation, DEAE-Dextran mediated transfection, lipofection, fusion with bacterial protoplasts, electroporation; targeted gene transfer- gene disruption and gene replacement.

3.4 Production of transgenic animals with special reference to transgenic mice, cow and sheep; identification and transfer of genes influencing milk quality and disease resistance; production of pharmaceuticals.

Note for paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- To impart theoretical knowledge on various techniques of animal biotechnology and their application in industries.
- To develop concepts, principles and processes in animal biotechnology.
- Students will know about different techniques for in vitro fertilization.
- Elucidation of different methods for the improvement of animals, including poultry production, milk quality, disease resistance etc.

Books recommended:

1. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). Molecular Biotechnology
2. Principles and Applications of Recombinant DNA. ISBN: 1555816126, 9781555816124. ASM press. 4th Ed.
3. Brown, T. A (2007). Genomes. BIOS Scientific Publishers Ltd.
4. Clark, D. P (2005). Molecular Biology: Understanding the Genetic Revolution. Academic press.
5. Das, H. K (2010). Textbook of Biotechnology. Wiley India Pvt. Ltd.
6. Freshney, R. I (2010). Culture of Animal Cells. John Wiley and Sons Inc.
7. Malacinski, G. M (2006). Essentials of Molecular Biology. Narosa Publishing House. 4th Ed.
8. Primrose, S. B and Twyman, R. M (2007). Principles of Gene Manipulation and Genomics. Blackwell Publishing, Oxford, UK.
9. Singh, B. D. (2007). Biotechnology: Expanding Horizons. Kalyani Publishers.
10. Ralf Portner (2007). Animal Cell Biotechnology, Methods and Protocols, 2nd Edition, Humana Press.

SEMESTER- III

Course Code: Bio-303
Course Title: Genetic Engineering
Credits: 04

Maximum Marks: 100
Sessional Assessment: 40
University Examination: 60

Unit 1: Introduction and tools for genetic engineering

1.1 Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment.
1.2 Restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase.
1.3 Cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labeling of DNA: nick translation, random priming, radioactive and non-radioactive probes.
1.4 Hybridization techniques: northern, southern, western, south-western, far-western, colony hybridization, fluorescence *in situ* hybridization.

Unit 2: Different types of vectors

2.1 Plasmids; Bacteriophages (Lambda and M13 vectors); pUC19 and Bluescript vectors, phagemids.
2.2 Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); expression vectors (pET-based vectors).
2.3 Protein purification: His-tagged/GST-tagged proteins, Inclusion bodies; methodologies to reduce formation of inclusion bodies.
2.4 Mammalian expression and replicating vectors; Baculovirus and Pichia pastoris expression system, plant based vectors (Ti and Ri plasmids), yeast vectors, shuttle vectors.

Unit 3:Different types of PCR techniques

3.1 Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; proof reading enzymes.
3.2 Types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, hot start PCR, colony PCR, asymmetric PCR, and RACE.
3.3 Cloning of PCR products; TA cloning vectors; site-specific mutagenesis; PCR in molecular diagnostics.
3.4 Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; Pyrosequencing; Next-generation sequencing technologies.

Unit 4:Genomic and cDNA library construction

4.1 Insertion of foreign DNA into host cells; transformation, electroporation, transfection.

4.2 Construction of cDNA library; isolation of mRNA and total RNA; reverse transcriptase, cDNA synthesis and screening.

4.3 Construction of Genomic DNA library: DNA isolation, gDNA library synthesis, screening,

4.4 Applications of cDNA and genomic libraries.

Unit 5:Gene silencing and genome editing technologies

5.1 Gene silencing techniques; mechanism of siRNA and miRNA

5.2 Principle and application of gene silencing; creation of transgenic plants (Bt Cotton, Flavr savr tomato and Golden rice); debate over GM crops.

5.3 Gene expression analysis by microarray using fluorescent dyes.

5.4 Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; gene therapy and its types; concept of genome editing by CRISPR-CAS.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks

Course Outcome:

- The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries.
- Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.
- To know the basics and concepts of various genetic engineering terms.
- Elucidate different techniques involved in genetic engineering.

Recommended Textbooks and References:

1. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub
2. Brown, T. A (2010) Gene cloning and DNA Analysis: An Introduction, Wiley-Blackwell Publication
3. Clark, D. P (2005). Molecular Biology: Understanding the Genetic Revolution. Academic press
4. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Ed. ASM press.
5. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006), Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited; 7th Edition
6. Green, M. R., &Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

7. Selected papers from Scientific Journals, particularly Nature & Science.
8. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

SEMESTER- III

Course Code: Bio-304
Course Title: Industrial Biotechnology
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30

Unit 1: Basic principles of biochemical engineering

1.1. General concept of microbial fermentation; Definition of primary and secondary metabolites, and screening of new metabolites. Substrates used as carbon and nitrogen source in industrial fermentation.

1.2. Isolation, screening and maintenance of industrially important microbes; Methods of Strain improvement for industrial purposes: mutation, recombination, protoplast fusion, regulation and gene technology.

1.3. Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations.

1.4. Design and functioning of Continuously Stirred Tank Reactor (CSTR); Bioreactors for immobilized cell systems; animal and plant cell cultivation. Conventional fermentation v/s biotransformation.

Unit 2: Downstream processing, product recovery and fermentation economics

2.1 Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation, Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation.

2.2 Product purification using chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

2.3 Effluent treatment: B.O.D and C.O.D treatment and disposal of effluents.

2.4 Fermentation Economics: Isolation of microorganisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs. Media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit 3: Applications of enzyme and microbial technology in food process operations and production, biofuels

3.1 Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.*, starch and sugar conversion processes; Glucose syrup, Maltose syrup, high-fructose corn syrup.

3.2 Industrially Important Enzymes and their usage: Amylase, Lipase, Protease, Glucose Isomerase. Microbial Production of Alcoholic beverages: (Wine and Beer) and Dairy Products (Cheese, Yoghurt and Buttermilk).

3.3 Fermented foods and beverages; Microbial fermentation as a method of preparing and preserving foods; producing colours, flavours (production of organic acids) and vitamins.

3.4 Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The objectives of this course are to educate students about fundamental concepts of bioprocess technology and its related applications, thus, preparing them to meet challenges of new and emerging areas of biotechnology industry.
- Students will be able to understand fermentative productions of representative biomolecules like enzymes, antibodies, vitamins etc.
- Understanding recovery and purification of biomolecules.
- Quality control procedures like sterility, toxicity and carcinogenicity testing.

Recommended Textbooks and References:

1. Crueger, W. and Crueger, A. (2002) Biotechnology: *A Textbook of Industrial Microbiology*. Science Tech Inc. Publishers.
2. Shuler, M. L., &Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.
3. Stanbury, P. F., & Whitaker, A. (1984). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
4. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering*. New York: M. Dekker.
5. Bailey, J. E., &Ollis, D. F. (1986). Biochemical *Engineering Fundamentals*. New York: McGraw-Hill.
6. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

SEMESTER- III

Course Code: Bio-305
Course Title: Immunology
Credits: 04

Maximum Marks: 100
Sessional Assessment: 40
University Examination: 60
Duration of Exam: 3 hours

Unit 1: Introduction to immunology

1.1 Types of immunity, innate and adaptive, features of immune response memory; recognition of self and non-self, hematopoiesis.

1.2 Cells and organs of immune system: B and T cells, macrophages, dendritic cells, NK cells, eosinophils, neutrophills and mast cells, organs; thymus, bursa of fabricus, spleen, lymph nodes and lymphatic system.

1.3 Immunoglobulin: structure, classes and subclasses.

1.4 Nature and biology of antigens, immunogenicity versus antigenicity, epitopes, antigen- antibody interactions and heptans.

Unit 2: Humoral and cell mediated immunity

2.1 Generation of humoral and cell mediated immune responses, Antigen processing and presentation.

2.2 Complement fixing antibodies and complement pathways.

2.3 Major histo-compatibility complex and HLA system, recognition of antigens by T-cells and role of MHC.

2.4 Cytokines, types and functions, cell adhesion molecules, cytokine related diseases; therapeutic uses of cytokines.

Unit 3: Immunological disorders

3.1 Type I, type II, type III and type IV hypersensitivity reactions.

3.2 Autoimmune disorders: Systemic lupus erythematosus (SLE), Multiple sclerosis (MS) and Rheumatoid arthritis.

3.3 Cancer: oncogenes and proto-oncogenes, tumor antigens, tumor evasion of immune system.

3.4 AIDS, HIV infection of Target Cells and Activation of Provirus.

Unit 4: Immunodiagnostic procedures

4.1 Techniques: flow cytometry, ELISA, RIA (principles, properties and applications).

4.2 Fluorescent immunoassay, agglutination of pathogenic bacteria, haemagglutination and its inhibition.

4.3 Immunodiffusion: Mancini and Ouchterlony methods, immune electrophoresis.

4.4 Separation of immunoglobulin from serum.

Unit 5: Immunobiotechnology

5.1 Monoclonal antibodies: production, detection and applications.

5.2 Organ transplantation: immunological basis of graft rejection and immunosuppressive therapy.

5.3 Vaccines: conventional vaccines, peptide vaccines, genetically engineered vaccines.

5.4 Stem cells: overview of stem cells, functions and medical applications.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 10 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 10 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 10 marks

Course Outcome:

- The objectives of this course are to make students learn about the structural features of the components of the immune system as well as their function.
- The major emphasis of this course will be on the development of the immune system and mechanisms by which our body elicit the immune response. This will be imperative for the students as it will help them to think like an immunologist and predict about the nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.
- Students are able to understand basic concepts of Immunology, properties of immune system and types of immunity.
- Elucidation of immunodiagnostic procedures and monoclonal antibodies.

Books recommended:

1. Eli Benjamin, Rechard Coico, Geoffrey: Immunlogy, A Short Course, Sunshine (Wiley-Liss). 4th Ed.
2. Goldsby, R. A. Kindt, T. J., and Osborne, B. A. (2000): Kuby Immunology, W/H/Freeman and Company, New York, 5th Ed.
3. Roitt I., Brostoff. J., and Male, D., (1999): Immunology, Hartcourt Brace and Company ASI Pte. Ltd. 7th Ed.
4. Warren, Levinson. (2010): Review of Medical Microbiology and Immunology, LANGE Basic Science. 11th Ed.

48

SEMESTER- III

Course Code: Bio-306, 307, 308 and 309
Course Title: Discipline Centric Electives (DCE)
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

LIST OF DISCIPLINE CENTRIC ELECTIVES (DCE)

S. No.	Paper Code	Paper Title	Course Type	Credits
1	Bio-306	Crop Biotechnology	DCE	2
2	Bio-307	Human Genetic Disorders	DCE	2
3	Bio-308	Signal Transduction and Cancer Biology	DCE	2
4	Bio-309	Protein Engineering	DCE	2

Note: Candidate has to opt only 1 course out of the 4 courses offered.

SEMESTER- III

Course Code: Bio-306
Course Title: Crop Biotechnology
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Plant genome organization

1.1 Features of plant chromosomes: centromere, telomere, euchromatin, heterochromatin and nucleolus organizing region (NOR); karyotype (asymmetric and symmetric).

1.2 C-value paradox, range of interspecific and intraspecific variation, origin of quantitative DNA variation.

1.3 Estimation of various components of higher-plant genome: highly repetitive sequences, middle repetitive sequences, and unique DNA sequences.

1.4 Rice and maize genome sequencing projects; cereal genome databases.

Unit 2: Biotechnological approach for crop improvement

2.1 Biotechnological approaches for disease resistance, protection against fungal pathogens and drought tolerance.

2.2 Modification of crop-plant nutritional content (vitamins, amino acids and lipids).

2.3 Modification of crop-plant taste and appearance (sweetness, starch and preventing discoloration).

2.4 Polyploidy: induction of polyploidy by artificial methods; role of polyploidy in crop improvement.

Unit 3: Molecular markers and crop improvement

3.1 Types of molecular markers used in analyzing genetic diversity for crop improvement; molecular mapping and tagging of agronomically important traits.

3.2 Molecular cytogenetic markers: FISH and GISH, their application in crop improvement.

3.3 Transposable elements: mechanism of action and their role in crop improvement.

3.4 Quantitative trait loci (QTL) mapping: introduction, types of mapping populations; role in crop improvement.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The crops produced need to increase with ever increasing population. Conventional methods for crop improvement are not able to deliver fully. Therefore, high use of throughput technologies is need of the hour. This course is intended to give some idea to students how crop plants can be improved quantitatively and qualitatively using biotechnological approaches.
- Students are able to understand plant genome organization.
- To acquaint students with recent techniques for crop improvement
- Application of molecular markers for crop improvement.

Recommended Textbooks and References:

1. Clark, D. P. (2005). Molecular Biology: Understanding the Genetic Revolution. Academic Press.
2. Malacinski, G. M. (2006). Essentials of Molecular Biology. Narosa Publishing House. (4th edition).
3. Primrose, S. B and Twyman, R. M. (2007). Principles of Gene Manipulation and Genomics. Blackwell Publishing, Oxford, UK.
4. Slater, A., Scott, N. and Fowler, M. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press.
5. Bernard, R. G., Jack J. P., Cheryl, L. P. (2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. 4th Ed.
6. Chawla, H. S. (2013). Introduction to Plant Biotechnology Science Publishers, Recent Edition.

SEMESTER- III

Course Code: Bio-307
Course Title: Human Genetic Disorders
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30

Unit 1: Introduction to genetics

1.1 Basic mechanisms of inheritance: Mendel's Laws of Inheritance, extensions of Mendelism- dominance, co-dominance and incomplete dominance.

1.2 Alleles& gene interactions: multiple alleles, pleiotropic effects, partial penetrance & variable expressivity, lethal alleles.

1.3 Linkage and recombination: recombination as the basis of gene mapping, linkage mapping, tetrad analysis, genetic fine structure mapping.

1.4 Extra-nuclear inheritance: cytoplasmic inheritance and maternal effects.

Unit 2: Genetic disorders-I

2.1 History of human genetics.

2.2 Pedigrees: gathering family history, pedigree symbols, construction of pedigrees, presentation of molecular genetic data in pedigrees.

2.3 Autosomal inheritance: dominant, recessive, consanguinity and its effects.

2.4 Sex-linked inheritance, sex-limited and sex-influenced traits, genomic imprinting.

Unit 3: Genetic disorders-II

3.1 Genetic disorders caused by structural and numerical chromosomal abnormalities: Di- George Syndrome, Cry-du-chat syndrome, Down's Syndrome, Patau Syndrome, Edward Syndrome, Klinefelter Syndrome, Turner Syndrome.

3.2 Genetic disorders caused by a single gene: haemophilia, cystic fibrosis, and muscular dystrophy.

3.3 Polygenic diseases- diabetes mellitus, atherosclerosis; inborn errors of metabolism and their genetic bases- phenylketonuria, maple syrup urine syndrome.

3.4 Genetic counseling, pre-implantation, pre-natal, peri-natal, adult (for late on-set diseases) screening of genetic diseases.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The course deals with basic concepts of heredity and genetics. Students will be acquainted with genetics of single gene, polygenic and chromosomal disorders.
- Genetic counseling in common genetic disorders will also be dealt with.
- To understand the different types of genetic interaction, incomplete dominance, co-dominance, multiple alleles etc.
- To study genetic disorders caused by structural and numerical chromosomal abnormalities

Recommended Textbooks and References:

1. Benjamin A. Pierce. (2013): *Genetics: A Conceptual Approach*, 5th Edition, Freeman Press, USA.
2. John, Ringo. (2006): *Fundamental Genetics*. Cambridge University Press, UK.
3. Daniel, L. Hartl (2006). *Essential Genetics: A Genomics Perspective*. Boston: Jones and Bartlett Publishers
4. Gardner, Simmons, Snustad. (2006). *Principles of Genetics*, 8th Edition. John Wiley & Sons.
5. Thompson and Thompson. (2008). *Genetics in Medicine*, 8th Edition. Elseiver Press.
6. Peter, J. Russell. (2002). *Genetics*, 5th Edition. Benjamin / Cummings Publishing Inc.
7. Lynn B., Jorde*et al.* (2006). *Encyclopedia of Genetics, Genomics, Proteomics and Bioinformatics*. Wiley Publishers.

SEMESTER- III

Course Code: Bio-308
Course Title: Signal Transduction and Cancer Biology
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Signalling I- general properties and structural diversity

1.1 General principles of signalling: overview of recognition of signalling molecules by extracellular receptors, general overview of nuclear receptors.

1.2 Signalling molecules and their mode of transmission-autocrine, paracrine, juxtacrine and endocrine signalling, secondary messengers.

1.3 Signalling receptors: general structure of G-protein coupled receptors (GPCRs), types of G proteins- trimeric and monomeric G proteins.

1.4 General structure of Ion Channel receptors and enzyme linked receptors: overview of Receptor Tyrosine Kinases (RTKs) and Receptor serine/threonine kinase.

Unit 2: Signalling II- functional diversity

2.1 Mechanism of action of GPCRs: cAMP mediated signalling; IP3 mediated signalling and rhodopsin receptors in rod cells of eyes.

2.2 Signaling through enzyme coupled receptors: Ras/MAP kinase pathway and PI3-Akt Pathway.

2.3 Mechanism of action of signaling pathway mediated by protein cleavage and Ubiquitination: Notch/Delta pathway and Wnt pathway for control of gene expression.

2.4 Mechanism of Quorum sensing in bacteria: general account of chemotaxis in bacteria and two-component system in bacteria.

Unit 3: Cancer biology

3.1 General overview of cancer: benign and malignant cancers, their characteristics, properties of cancer cells.

3.2 Genetic basis of cancer cells: oncogenes, tumor suppressor genes, gain of function mutations and loss of function mutations, inherited mutations, concept of epigenetics and cancer induction by epigenetic changes.

3.3 Cancer induction by unregulated cell cycle phases: unregulated entry of cell cycle from G1 to S phase, loss of function of p53 in DNA damage checkpoints, role of Rb (Retinoblastoma) in cancer induction.

3.4 Programmed cell death- apoptosis: extrinsic pathway and intrinsic pathway, role of apoptotic proteins in apoptosis, general concept of carcinogens and caretaker genes.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The present course has been designed to expose the students to cell signaling, its components and relation with cancer.
- To understand general principles of signaling and nuclear receptors.
- To understand mechanism of action of signalling pathway mediated by protein cleavage.
- To understand genetic basis of cancer cells: oncogenes, tumor suppressor genes and gain of function mutations.

Recommended Textbooks and References:

1. Albert, B., Bray, D., Raff, M., Roberts, K. and Watson, J.D. (2004). *Molecular Biology of the Cell.* Garland Publishing Inc., New York. 6th Ed.
2. Cooper, G. M. and Hausman, R.E. (2006). *The Cell: A Molecular Approach.* ASM Press, Washington DC. 4th Ed.
3. Karp, G. (2007). *Cell and Molecular Biology*, John Wiley and Sons Inc. 5th Ed.
4. Kleinsmith, L. J. and Kish, V. M. (1995). *Principles of Cell and Molecular Biology.* Harper, Collins College Publishers, New York, USA. 2nd Ed.
5. Lodish, H., Berk, A., Zipursky, S.l., Matsudaira, P., Baltimore, D., and Darnell, J. (2004). *Molecular Cell Biology.* W. H. Freeman and Company, 5th Ed.
6. Raymond,W.Ruddon (2007). *Cancer Biology.* University of Michigan Medical School Ann Arbor, Michigan 4th Ed.

55

SEMESTER- III

Course Code: Bio-309
Course Title: Protein Engineering
Credits: 02

Maximum Marks: 50
Sessional Assessment: 20
University Examination: 30
Duration of Exam: 2 hours

Unit 1: Protein structure, purification and characterization

1.1 Basic structural concepts – Primary, secondary, tertiary and quaternary structures; Ramachandran plot, super secondary structures – motif and domain.

1.2 Protein folding; protein function and structure-function relationship; cloning, preparation of recombinant proteins, host organisms, Homologous and heterologous protein expression; Overexpression.

1.3 Protein purification: Cell disruption, Chromatographic techniques including Ion exchange, Gel filtration, Hydrophobic Interaction Chromatography, Metal chelation chromatography, Affinity chromatography.

1.4 Structural characterization of proteins by spectroscopic techniques: UV-Visible spectroscopy, Fluorescence spectroscopy, Circular Dichroism.

Unit 2: Protein engineering: targets and strategy

2.1 Industrially important enzymes, Proteases, Amylases, Lipases and Esterase, targets of protein engineering, Biosensors and Biomarkers (GFP and its variants).

2.2 Engineering therapeutically important proteins (e.g. Streptokinase), Antibodies and its fragments and artificial binding proteins.

2.3 Protein engineering by Rational design; Site directed mutagenesis, Site-saturation mutagenesis, evaluation of the effect of mutations on enzyme structure and function.

2.4 Directed evolution; Random mutagenesis by error prone PCR, DNA shuffling, screening and selection; Semi and High-throughput screening strategies; optimization of variants by recombination and/or site saturation mutagenesis.

Unit 3: *In Vitro* screening; display technologies and applications of protein engineering

3.1 Cell surface and phage display technologies; Cell-free protein engineering technologies; ribosome display technique.

3.2 Emulsion techniques including water in oil emulsion and oil in water emulsion. Use of FACS and microfluidics in screening.

3.3 Examples of application of protein engineering to improve enzyme catalytic efficiency and to improve protein stability.

3.4 Examples of application of protein engineering to improve protein thermostability; enzyme enantioselectivity and affinity of binding proteins.

Note for the paper setter:

The question paper will have two Sections. Section 'A' carrying 6 compulsory, objective-cum-short answer type questions, 2 from each unit. Each question will carry 1 mark. Section 'B' will have 6 descriptive answer questions, 2 from each unit. Students will be required to answer 1 question from each unit. Each question will carry 8 marks.

Course Outcome:

- The aim of this course is to introduce methods and strategies commonly used in protein engineering.
- At the end of the course, students should be able to understand and explain differences between rational design and directed evolution.
- Students will acquire knowledge about miscellaneous topics such as searches in bioinformatics databases, isolation, expression and purification of novel proteins.
- Students will also get an overview of several biophysical techniques used for analysis of secondary, tertiary and quaternary structure, as well as of screening methods used for selection of novel protein variants with improved properties.

Recommended Textbooks and References:

1. *Protein Engineering: Principles and Practice* by Jeffrey L. Cleland and Charles S. Craik, publisher-Wiley-Liss-A John Wiley & Sons, INC.
2. *Protein Design: Methods and Applications* by Raphael Guerois and Manuela Lopez de la Paz, publisher- Humana Press
3. *Protein Engineering and Design* by Sheldon J. Park and Jennifer R. Cochran, Publisher- CRC press.
4. *Protein Purification: Principle and Practice* by Robert K. Scopes, Publisher-Springer.
5. Carl Brandon & John Tooze, "Introduction *to Protein Structure,*" "2nd Edition" Garland Publishing, 1999
6. Paul R. Carey, "Protein *Engineering and Design,*" Academic Press, 1996.
7. *Protein engineering handbook.* Edited by Stefan Lutz - Uwe Bornscheuer. Weinheim: Wiley-VCH, 2009. xli, 409-9. ISBN 9783527318506.
8. *Directed evolution library creation: methods and protocols.* Edited by Frances Hamilton Arnold - George Georgiou. Totowa, N.J.: Humana Press, 2003. x, 224. ISBN 1588292851.
9. Fersht, Alan. *Structure and mechanism in protein science : a guide to enzyme catalysis and protein folding.* New York: W.H. Freeman, 1998. xxi, 631 s. ISBN 0-7167-3268-8.
10. Jennifer Cochran and Sheldon Park *Protein Engineering and Design,* eds., Taylor and Francis, 2009.
11. K. Dane Wittrup and Gregory L. Verdine, *Methods in Enzymology- Protein Engineering for Therapeutics, Parts A and B,* eds. Elsevier, 2012.

SEMESTER- III

Course code: Bio-310
Course Title: Lab courses V based on Plant Biotechnology, Animal Biotechnology and Industrial Biotechnology

Maximum Marks: 100
University Examination: 50
Sessional Assessment: 50

Plant Biotechnology

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Valeriana wallichii* for inoculation under aseptic conditions.
3. Attempt *in vitro* andro and gynogenesis in plants *(Datura stramonium).*
4. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
5. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
6. Generate an RAPD and ISSR profile of *Eremuruspersicus* and *Valleriana wallichii.*
7. Prepare karyotypes and study morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum* and compare them on the basis of karyotypes.
8. Pollen mother cell meiosis and recombination index of select species (one achiasmate, and the other chiasmata) and correlate with generation of variation.
9. Undertake plant genomic DNA isolation by CTAB method and its quantitation by visual as well as spectrophotometeric methods.
10. Perform PCR amplification of 'n' number of genotypes of a species for studying the genetic variation among the individuals of a species using random primers.
11. Study the genetic finger printing profiles of plants and calculate the polymorphic information content.
12. Protein profiling by PAGE and SDS PAGE.
13. Primer designing for gene cloning using bioinformatics.

Animal Biotechnology

1. Prepare culture media with various supplements for plant and animal tissue culture.
2. Prepare single cell suspension from spleen and thymus.
3. Count the cells of an animal tissue using Haemocytometer.
4. Monitor cell viability by using dye-exclusion test.
5. Monitor and measure doubling time of animal cells.
6. Chromosome preparations from cultured animal cells.
7. Isolate DNA from animal tissue by SDS method.
8. Attempt animal cell fusion using PEG.

Industrial Biotechnology

1. Basic Microbiology techniques: Streak plate and Pour Plate Techniques
2. Instrumentation: Microplate reader, Spectrophotometer, Light microscopy.
3. Scale up from frozen vial to agar plate to shake flask culture.
4. Preparation of Nutrient Broth and Agar, Starch Agar and Skimmed milk media.
5. Isolation of microorganisms from soil samples.

6. Screening bacterial and fungal isolates for Amylase, Lipase and Protease activity by plate array method.
7. Monitoring bacterial growth through measurement of turbidity in spectrophotometer and plotting of growth curve.
8. Determination of thermal death point of different bacteria.
9. Determination of thermal death time of different bacteria.

Course Outcome:

- The objective of this laboratory course is to provide the students practical skills in basic analytical techniques and genetics.
- To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.
- Students will also be acquainted with techniques in Animal Biotechnology.
- Further, it will give students a practical exposure to various techniques used in industries.
- It will provide training to students to isolate and manipulate industrially important microorganisms.
- Students will be able to know about different databases.

SEMESTER- III

Course code: Bio-311
Course Title: Lab courses VI based on Genetic Engeenering, Immunology and Discipline centric elective

Maximum Marks: 100
University Examination: 50
Sessional Assessment: 50

Genetic Engeenering

1. Concept of lac-operon:
    a. lactose induction of β-galactosidase.
    b. Glucose Repression.
    c. Diauxic growth curve of *E. coli*
2. UV mutagenesis to isolate amino acid auxotroph
3. Phage titer with λ phage/M13
4. Plasmid DNA isolation and DNA quantitation
5. Restriction Enzyme digestion of plasmid DNA
6. Agarose gel electrophoresis
7. Polymerase Chain Reaction and analysis by agarose gel electrophoresis
8. Vector and Insert Ligation
9. Preparation of competent cells
10. Transformation of *E. coli* with standard plasmids, Calculation of transformation efficiency.
11. Confirmation of the insert by Colony PCR and Restriction mapping
12. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E. coli*, SDS-PAGE analysis.
13. Purification of His-Tagged protein on Ni-NTA columns.

Immunology

1. To prepare soluble antigen by different methods.
2. To demonstrate various routes of immunization in mice.
3. To prepare serum and plasma from blood.
4. To precipitate immunoglobulins by ammonium sulphate and to determine total protein contents.
5. To determine Blood group and Rh factor by slide agglutination test.
6. To determine Total Leukocyte Count (TLC) for given blood sample.
7. To determine Differential Leukocyte Count (DLC) for given blood sample using Leishman stain.
8. To perform Widal agglutionation test (slide and tube) for diagnosis of typhoid.
9. To perform Ouchterlony double diffusion test for detection of antigen and antibody reaction and to demonstrate relationship between antigens.
10. To perform Redial immuno-diffusion test for detection of antigen and antibody reaction and for quantification of antigens.
11. To perform immune-electrophoresis for separation of antigens and for detection of antigen and antibody reaction

12. To perform Rocket immuno-electrophoresis for detection of antigen and antibody reaction
13. To perform ELISA for assay of antibodies in serum sample against given antigen.

Discipline centric elective

1. Count the cells of an animal tissue and check their viability.
2. Prepare culture media with various supplements for plant and animal tissue culture.
3. Prepare single cell suspension from spleen and thymus.
4. Monitor and measure doubling time of animal cells.
5. Chromosome preparations from cultured animal cells.
6. Isolate DNA from animal tissue by SDS method.
7. Attempt animal cell fusion using PEG.
8. Prepare culture media with various supplements for plant tissue culture.
9. Prepare explants of *Valleriana wallichii* for inoculation under aseptic conditions.
10. Attempt in vitro andro- and gynogenesis in plants (*Datura stramonium*).
11. Isolate plant protoplast by enzymatic and mechanical methods and attempt fusion by PEG (available material).
12. Culture *Agrobacterium tumefaciens* and attempt transformation of any dicot species.
13. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. tuberosum* and compare them on the basis of karyotypes.
14. Generate RAPD and ISSR profiles of *Valleriana wallichii* and *Zea mays*.
15. Pollen mother cell meiosis and recombination index of select species (one chiasmata, and the other chiasmata) and correlate with generation of variation.
16. Undertake plant genomic DNA isolation by CTAB method and its quantification by visual as well as spectrophotometeric methods.
17. Determination of density, abundance and frequency of species by quadrat method.
18. Determination of species diversity by using Shanon Wiener's information statistics and Simpson Index.
19. Analysis of SNP linked to a disease using PCR-RFLP.
20. To perform Southern Blotting procedure.
21. Analysis of pedigrees and patterns of inheritance.
22. To perform DNA Finger printing using RFLPs and VNTRs.
23. To perform Drumstick and Barr body identification.
24. Lab demonstration of fluorescence microscopic techniques.
25. To study chemotaxis in bacteria and Paramecium.
26. Model demonstration of cell signalling pathways.
27. To study Gramene database.
28. Study genetic diversity of the available plant material by using RAPD and ISSR markers.
29. Induction of polyploidy by using cotton swab method.
30. Study genetic diversity by using CAPS marker.
31. Demonstration of FISH and GISH techniques.
32. SDS PAGE

Course Outcome:

- The objective of this laboratory course is to provide practical skills on basic genetic engineering techniques.
- Train students with basic techniques in Genetic Engineering.
- Students will learn basic steps of cloning
- Demonstrate practical skills in different laboratory equipment's and their handling.
- The objectives of this laboratory course are to make students develop an understanding about practical aspects of the components of the immune system as well as their function.
- Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells etc. and how they can be used in respective research work.

SEMESTER- IV

Dissertation

Course code: Bio-401
Course Title: Dissertation

Maximum Marks: 600
University Examination: 600

PAPER					CREDITS	MARKS		
S. No.	Code	Title	Category	Duration [Hours]		Internal Assessment	University Examination	Total Marks
1	Bio-401	Dissertation	Core	864	24		600	600
TOTAL					**24**		**600**	**600**

Course Outcome:

- To give laboratory training to students.
- Students will be able to handle research problems independently.
- Vigorous laboratory training will help students to boost their research career.
- Dissertation work is important component for admission to the Ph.D course.