ANNEXURE I A

M. Sc. BIOTECHNOLOGY SYLLABUS

SUMMARY OF CREDIT DISTRIBUTION AND MARKS AS PER CBCS

SEMESTER	COURSES								Total Credits	Marks
	CORE				ELECTIVE			FOUNDATION		
	Theory (Core)	Practical (Core)	Seminar / Journal Club (Core)	Dissertation	Open (OE)	Discipline Centric (DCE) (Theory)	Discipline Centric (DCE) (Lab)	Compulsory (CF)		
Semester-1	14	6						4	24	600
Semester-2	12	6	2		4				24	600
Semester-3	14	6				2	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

SEMESTERI

PAPER					CREDITS	MARKS		
S. No.	**Code**	**Title**	**Category**	**Duration [Hours]**		**Internal Assessment**	**University Examination**	**Total Marks**
1	Bio-1014	Foundation Course	Compulsory Foundation	72	4	40	60	100
2	Bio-1024	Molecular Biology	Core	72	4	40	60	100
3	Bio-1032	Microbial Bioresources	Core	36	2	20	30	50
4	Bio-1042	Plant Bioresources	Core	36	2	20	30	50
5	Bio-1052	Animal Bioresources	Core	36	2	20	30	50
6	Bio-1062	Cell Biology	Core	36	2	20	30	50
7	Bio-1072	Biomolecules	Core	36	2	20	30	50
8	Bio-1712	**Laboratory I:** Molecular Biology and Microbial Bioresources	Core	72	2	25	25	50
9	Bio-1722	**Laboratory II:** Plant and Animal Bioresources	Core	72	2	25	25	50
10	Bio-1732	**Laboratory III:** Biomolecules and Cell Biology	Core	72	2	25	25	50
Sub-total			**Core**	Theory	**14**	**140**	**210**	**350**
				Practical	**6**	**75**	**75**	**150**
			Foundation		**4**	**40**	**60**	**100**
TOTAL					**24**	**255**	**345**	**600**

SEMESTERII

PAPER					CREDITS	MARKS		
S. No.	**Code**	**Title**	**Category**	**Duration [Hours]**		**Internal Assessment**	**University Examination**	**Total Marks**
1	Bio-2014	Genetic Engineering	Core	72	4	40	60	100
2	Bio-2022	Genomics and Proteomics	Core	36	2	20	30	50
3	Bio-2034	Enzymology and Metabolism	Core	72	4	40	60	100
5		**Open Elective (OE)***						
	Bio-2514	Fundamentals of Biotechnology[@]	Elective	72	4	40	60	100
	Bio-2052	Plant Biotechnology	Core	36	2	20	30	50
6	Bio-2662	Seminar/Journal Club (JC)	Core	36	2	50		50
7	Bio-2712	**Laboratory IV:** Enzymology and Metabolism	Core	72	2	25	25	50
8	Bio-2722	**Laboratory V:** Plant Biotechnology and Genomics	Core	72	2	25	25	50
9	Bio-2732	**Laboratory VI:** Genetic Engineering	Core	72	2	25	25	50
Sub-total			**Core**	Theory	**12**	**120**	**180**	**300**
				Practical	**6**	**75**	**75**	**150**
				Seminar/JC	**2**	**50**		**50**
			Elective (Open)		**4**	**40**	**60**	**100**
TOTAL					**24**	**285**	**315**	**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.

SEMESTERIII

PAPER					CREDITS	MARKS		
S. No.	**Code**	**Title**	**Category**	**Duration [Hours]**		**Internal Assessment**	**University Examination**	**Total Marks**
1	Bio-3012	Animal Biotechnology	Core	36	2	20	30	50
2	Bio-3022	Genetics	Core	36	2	20	30	50
2	Bio-3032	Industrial Biotechnology	Core	36	2	20	30	50
3	Bio-3042	Bioinformatics and Bio entrepreneurship	Core	36	2	20	30	50
4	Bio-3054	Immunology	Core	72	4	40	60	100
5	Bio-3062	Analytical Techniques	Core	36	2	20	30	50
6		**Discipline Centric Elective (DCE)[#]**	**Elective**	**36**	**2**	**20**	**30**	**50**
	Bio-3512	Crop Biotechnology[#]	DCE	36	2	20	30	50
	Bio-3522	Human Genetic Disorders[#]	DCE	36	2	20	30	50
	Bio-3532	Signal Transduction and Cancer Biology#	DCE	36	2	20	30	50
	Bio-3542	Protein Engineering#	DCE	36	2	20	30	50

8	Bio-3712	**Laboratory VII:** Bioinformatics and Industrial Biotechnology	Core	72	2	25	25	50
9	Bio-3722	**Laboratory VIII:** Immunology and Animal Biotechnology	Core	72	2	25	25	50
10	Bio-3732	**Laboratory IX:** Analytical Techniques and Genetics	Core	72	2	25	25	50
	Bio-3742	**Laboratory X:** Discipline Centric Elective Lab	DCE	72	2	25	25	50
Sub-total			**Core**	Theory	**14**	**140**	**210**	**350**
				Practical	**6**	**75**	**75**	**150**
			Elective (DCE) Theory		**2**	**20**	**30**	**50**
			Elective (DCE) Practical		**2**	**25**	**25**	**50**
TOTAL					**24**	**285**	**315**	**600**

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

SEMESTERIV

PAPER					**CREDITS**	**MARKS**		
S. No.	**Code**	**Title**	**Category**	**Duration [Hours]**		**Internal Assessment**	**University Examination**	**Total Marks**
1	Bio-4824	Dissertation	Core	864	24		600	600
TOTAL					**24**		**600**	**600**

LIST OF OPEN ELECTIVES

SECOND SEMESTER			
S.	**Paper**	**Paper Title**	**Course**

No.	Code		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-205	Mysteries of Green Plants	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
THIRD SEMESTER			
S. No.	**Paper Code**	**Paper Title**	**Course Type**
1	Bio-3512	Protein Engineering	DCE
2	Bio-3522	Human Genetic Disorders	DCE
3	Bio-3532	Crop Biotechnology	DCE
4	Bio-3542	Signal Transduction and Cancer Biology	DCE

LIST OF DISCIPLINE CENTRIC ELECTIVES

Paper Code Nomenclature:

Bio-ABCD

Bio: Biotechnology

A: Semester (1=Ist; 2=2nd; 3=3rd; 4=4th)

B: 0 = Theory; 5 = Elective Course;
6 = JC; 7 = Practical; 8=Dissertation;

C: Paper No.

D: 2 = 2 Credit; 4 = 4 Credit

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 bioharzrdous 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.

Bio-1014 **FOUNDATION COURSE** Total Marks: **100**

Compulsory Foundation Internal Assessment: **40**

Credits: **4** University Examination: **60**

Duration: **72**Hours Duration of Exam: **3 Hours**

Unit – 1 Cellular Foundations

1.1 The Origin of Life: Chemical evolution of biomolecules; RNA world: First gene and Catalyst; Biological evolution; Evolution of initial eukaryotic cells.

1.2 Cells as structural and functional units of life. The three domains of life: Bacteria, Archaea and Eukarya. Typical and distinguishing features of Bacteria and Archaea.

1.3 Eukaryotic Cells: Membrane, Cytoplasm and Organelles; Photosynthetic Plant Cells and Animal Cells: Common and distinguishing features. Unicellular and Multicellular organisms.

1.4 Genetic Information and its storage: Concept of gene and genome; Flow of genetic information.

Unit – 2 Chemical and Physical Foundations

2.1 Chemical Elements, Atoms and Molecules; Molecular interactions: Strong Interactions (Covalent, Coordinate covalent, Ionic and Metallic bonds), Weak interactions (Hydrogen bonding, Salt bridge, Vander Waal Interaction and Hydrophobic Interactions).

2.2 Stereochemistry: Definition, Classification of Isomerism in Organic compounds: structural isomerism, stereoisomerism – geometrical and optical isomerism.

2.3 Laws of thermodynamics; Free energy change (□G); Relationship between free energy change and equilibrium constant; Exergonic and Endergonic reactions; Coupled reactions and addition of ΔG.

2.4 Enthalpy and Entropy and its relation with free energy change. Redox reactions: redox potential and its relation to free energy change.

Unit – 3. Introduction to computer and its applications

3.1 Computer Fundamentals and Organization: Central Processing Unit-Control Unit, Arithmetic Unit, Instruction Set, Register, Processor Speed, Memory Units, Storage Evolution Criteria, Memory Organization, Capacity, RAM, ROM, Secondary Storage.
3.2 Operating systems and data base management system: Introduction to MS-Office, MS-Word, and MS-Excel, Statistical Data analysis through MS-Excel, Storage of data, filing, retrieving, and reproduction.
3.3 Application of computers in current biological research: Internet: definition and practical utility; Introduction of digital computers.

3.4 Computer programming: Data types: Constants, variables, expressions, operations, functions, flow charts, commands, simple programs and their execution- scope and limitations.

Unit – 4. Introduction to Biostatistics

4.1 Concepts of statistical population and sample from a population; qualitative and quantitative data; discrete and continuous data; Primary data; designing a questionnaire and a schedule; secondary data and sources of secondary data.

4.2 Presentation of data: Diagrammatic and graphical representation of data; frequency distributions and cumulative frequency distributions; histogram and frequency polygon. Descriptive statistics: concepts of central tendency.

4.3 Brief description and tabulation of data and its graphical representation: Measures of central tendency and dispersion - mean, median, mode, range, standard deviation, variance.

4.4 Introduction to probability and laws of probability: Random Events, Events-exhaustive, mutually exclusive and equally likely (with simple exercises)

Unit – 5 . Application of Biostatistics

5.1 Tests of significance: T-test, F-test and χ^2test.

5.2 Binomial, Poisson and Normal distribution; Deviation, properties and applications of normal distribution.

5.3 Correlation: types, methods; Karl Pearson's coefficient and regression (linear) analysis and their uses.

5.4 Principles of experimental designs: Completely Randomised Designs (CRD) and Randomised Block Designs (RBD)

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 provide the very basic knowledge of Physical Chemistry and Biology, which acts as foundation to imbibe the details of the specialized course as outlined in rest of the curriculum.
- The course is interdisciplinary and describes interaction between various domains of natural sciences.
- Furthermore, it will also provide basic knowledge of computer organization and functioning
- It will introduce students to statistical methods in order to understand the underlying principles, as well as practical guidelines of "how to do it" and "how to interpret it" statistical data particularly for bio systems.
- Students will be acquainted with the concept of biostatistics.

Recommended Textbooks and References:

1. E. H. Segel. *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd Edition, John Wiley Publications.
2. Nelson, D. D. L., Lehninger, A. L. and Cox, M. M. (2013). *Lehninger: Principles of Biochemistry*. W.H. Freeman Publishers.
3. Tanford, C. (1961). *Physical Chemistry of Macromalocules*. John Wiley and Sons.
4. Voet, D., &Voet, J. G. (2016). *Biochemistry* (5thed.). Hoboken, NJ: J. Wiley & Sons.
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.
7. Jaype Brothers, (2011), Methods in Biostatistics for Medical Students and Research Workers (English), 7th Edition.
8. Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge University Press.
9. P. N. Arora and P. K. Malhan, (2006), Biostatistics, 2nd Edition, Himalaya Publishing House.
10. Jerold Zar, Biostatistical Analysis, 4th Edition. Pearson Education.
11. Biostatistics: A Foundation for Analysis in the Health Sciences, 7th Edition, Wiley and Sons.

Bio-1024

MOLECULAR BIOLOGY

Total Marks: **100**

Core Course

Internal Assessment: **40**

Credits: **4**

University Examination: **60**

Duration: **72**Hours

Duration of Exam: **3 Hours**

Unit - 1 Nucleic acid structure and functions

1.1 Nucleic acid as genetic information carriers: experimental evidence; Concept of gene and genome

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, repair and recombination

2.1 Need for replication of DNA, semi-conservative, bidirectional and semi- discontinuous DNA replication; Mechanism of DNA replication, Enzymes and accessory proteins required in DNA replication of *E. coli* chromosome.

2.2 Replication of extrachromosomal DNA and phage DNA. Replication of DNA in eukaryotes; enzymes and accessory proteins involved, control of replication.

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

2.4 Recombination: homologous recombination; Holiday junction; Proteins involved in recombination; Site-specific recombination; *Cre-lox* recombination.

Unit - 3 Transcription

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

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

3.3 Transcription in eukaryotes; general and specific transcription factors, mechanism,

enhancers and silencers and DNA binding motifs, antibiotic inhibitors of transcription in eukaryotes.

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

Unit – 4 Translation

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

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

4.3 Translation in eukaryotes; mechanism of initiation, elongation and termination, inhibitors of translation.

4.4 Post-translational modification of proteins and transport of proteins; mitochondrial genetic code.

Unit-5 Genome instability and cell transformation

5.1 Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens.

5.2 Types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome.

5.3 Viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action.

5.4 Activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

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 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.

Recommended Textbooks and References:

1. Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., &Losick, R. (2014) *Molecular Biology of the Gene.* (7^{th}ed.). Pearson Publications USA.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Molecular Biology of the Cell.* New York: Garland Science.
3. Lodish, H. F. (2000). *Molecular Cell Biology*. New York: W.H. Freeman.
4. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). *Lewin's Genes XI*. Burlington, MA: Jones & Bartlett Learning.
5. Cooper, G. M., &Hausman, R. E. (2009). *The Cell: a Molecular Approach*. Washington: ASM; Sunderland.
6. David P. Clark & Nanette J. Pazdernik (2013). *Molecular Biology*. Elsevier Academic Press, UK. 2^{nd} Ed.
7. Lehninger, A. L. (2012). *Principles of Biochemistry*(6^{th}ed.). New York, NY: Worth.

Bio-1032

MICROBIAL BIORESOURCES

Total Marks: **50**

Core Course

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

Unit-1 Microbial Characteristics and Their Control

1.1 Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods.

1.2 Bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

1.3 Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms.

1.4 Antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit-2 Microbial Diversity

2.1 Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification.

2.2 Classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma.

2.3 Archaea: Halophiles, Methanogens, Hyperthermophilicarchae, Thermoplasm.

2.4 Eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit-3 Virology and Host-Microbe Interaction

3.1 Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses.

3.2 Sub-viral particles – viroids and prions.

3.3 Host-pathogen interaction, ecological impacts of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis).

3.4 Microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

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 is to introduce students to field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and host-microbe interactions.
- Explain the principles of the energy-yielding and consuming reactions and mechanism of energy conservation in microbial metabolism.
- Identify the various physiological groups of bacteria/archaea with their special features.
- Execute various experiments commonly involved in microbial physiology research.

Recommended Textbooks and References:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (1977). Microbiology (5th ed.). New York: McGraw-Hill.
2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). *Prescott's Microbiology.* New York: McGraw-Hill.
3. Matthai, W., Berg, C. Y., & Black, J. G. (1999). *Microbiology, Principles and Explorations.* Boston, MA: John Wiley & Sons.
4. Alcamo, I.E. 2001. *Fundamentals of Microbiology*. VIth Edition, Jones and Bartlett Publishers, Sudbury, Massachusett.

Bio-1042

Core Course

Credits: **2**

Duration: **36** Hours

PLANT BIORESOURCES

Total Marks: **50**

Internal Assessment: **20**

University Examination: **30**

Duration of Exam: **2 Hours**

Unit-1 Plant Bioresources:Origin, Domesticationand Improvement

1.1 Prehistoric plant human interactions; discovery of plant use to humans, hunter-gathering to practice of agricultural plant exploitation, resurgence of interest in plant bioresources due to plant explorations and ethnobotanical studies during 19^{th} and 20^{th} centuries.

1.2 Importance of classification and taxonomy of plants; Classification systems of plants with emphasis on Angiosperm Phylogeny Group IV (APG IV) classification.

1.3 Origin of cultivated plants: Vavilovian concept of Centres of origin of crop plants; Centres of origin of maize, rice and wheat; concept of primary and secondary Centres of origin of crop plants; Domestication of crop plants; beginning of agriculture; dissemination and spread of agriculture; domestication and evolution of crop plants.

1.4 Plant improvement: development of improved agricultural crops through plant breeding; evolution of high yielding crop varieties through genetic engineering; uses and production of improved varieties in wheat, rice and maize.

Unit-2 Plant Bioresources: Traditional Uses

2.1 Food supplements: *Solanumtuberosum, Ipomoea batatas, Agaricusbisporus*and*Hippophaerhamnoides*(distribution, classification, parts used and method of use, nutritive value); spices and condiments: *Crocus sativus, Piper nigrum, Zingiberofficinale*and*Apiumgraveolens*(distribution, classification, parts used and method of use).

2.2 Sources of beverages: non-alcoholic: *Camellia sinensis*(tea) and *Coffeaarabica*(coffee); alcoholic: *Vitisvinifera*(grapes) (distribution, classification, parts used and method of use).

2.3 Fodders, fibres, timbers: Fodders: *Avenabyzantina, Grewiaoptiva*and*Morusalba*(distribution, classification and method of use); Fibers: *Gossypium*spp., *Chorchoruscapsularis, Cocosnucifera,* (distribution, classification, part used and durability); Timbers: *Pinusroxburghii, Tectonagrandis*and*Dalbergiasissoo*(distribution, classification, wood structure and properties), non-timber forest products (bamboos and canes).

2.4 Dye-yielding plants: Definition; history and sources of natural dyes, commonly used dye plants: *Bixaorellana, Buteamonosperma, Lawsoniainermis*and*Indigoferatinctoria;* less used colouring matter: balsam, marigold, and pomegranate (distribution, part used and commercial importance); Biofuels: Waste to wealth.

Unit-3 Medicinal And Other Useful Plants And Value Addition Of Plant Resources

3.1 Medicines: antioxidants *(Ginkgo biloba, Camellia sinensis, Hippophaerhamnoides);* adaptogens*(Eleutherococcussenticosus, Cordycepssinensis);* anodynes *(Atropabelladona, Zingiberofficinale);* laxatives *(Aloe vera*and*Plantagoovata);* nervines*(Melissa officinalis, Avena sativa);* aromatic oils *(Thymus serpyllum*and*Lavandulaangustifolia);* immunostimulants*(Eupatorium perfoliatum, Acanthopanaxcenticosus);* anti-cancerous *(Taxuswallichiana, Podophyllumhexandrum)*; anti- malarial *(Artemisia annua)* (distribution, classification, part used and method of use, and medicinal value).

3.2 Bio-sweeteners *(Stevia rebaudiana*and*Glycyrrhizaglabra);* bio-flavors *(Vanilla planifolida*and*Fragariavirginiana);* bio-alginates *(Laminariahyperboria, Ascophyllumnodusum);* bio-gums *(Caesalpinaspinosa, Trigonellafoenum-graecum)* (distribution, classification, part used and method of use, and efficacy).

3.3 Bio-cosmetics *(Aloe vera, Crocus sativus*and*Santalum album);* bio-preservatives (vinegar, sugar) (distribution, classification, part used and method of use; efficacy); Current scenario and recent advancements in pharmaceutical and cosmoceutical industries.

3.4 Principle and applications of steam distillation for medicinal and aromatic plants; Solvent extraction principle and methods; Super critical CO_2 extraction principle and applications.

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:

- This course has been designed to acquaint students with plant bioresources, their traditional and non-traditional uses, current status and recent developments in value addition and future prospects.
- To know about origin and domestication of important food and medicinal plants.
- To acquaint students with traditional uses of plant Bioresources.
- To know about value addition of medicinal plants.

Recommended Textbooks and References:

1. Anonymous (1970-1988). *The Wealth of India: Raw Materials,* Vol. I- XI. CSIR, New Delhi.
2. *Biodiversity International (2013). Bioversity collecting mission database.*
3. Guarino L, Ramanatha Rao V, Reid R, edss. (1995). *Collecting Plant Genetic Diversity: Technical Guidelines.* International Plant Genetic Resources Institute (IPGRI), Rome, Italy.
4. Judd, W. S., Campbell, C. S., Kollogg, E. A., Stevens, P. F. and Donoghue, M. J.

(2008). *Plant Systematic: Phylogenetic Approach.* Sircuier Associates, Inc.

5. Sharma, O.P. (2001). *Hill's Economic Botany,* Tata McGraw-Hill Pub. Ltd.
6. Sharma, Ramniwas. (2006). *Growth and Development of Agriculture.* Biotech Book.
7. Singh, R.V. (1982). *Fodder Trees of India,* Oxford & IBH Publishing Co.
8. Thormann I, Gaisberger H, Mattei F, Snook L, Arnaud E. (2012). *Digitization and Online Availability of Original Collecting Mission Data to Improve Data Quality and Enhance the Conservation and Use of Plant Genetic Resources.* Genetic Resources and Crop Evolution. 59:5 635-644.
9. Vankar, S. P. (2006). *Handbook on Natural Dyes for Industrial Applications.* National Institute of Industrial Research, Delhi.
10. Varnam, H. Alan and Suther Land, P. Jane (1994). *Beverages (Technology, Chemistry and Microbiology),* Chapman and Hall.
11. Bennett, B.C. *Plant Domestication and the Origins of Agriculture*. Encyclopedia of Life Support System (EOLSS) Online.
12. AmeenahGurib-Fakim. (2014). *Novel Plant Bioresources: Applications in Food, Medicine and Cosmetics.* Wiley-Blackwell.
13. Timothy R. Tomlinson, OlayiwolaAkerele (1998). *Medicinal Plants: Their Role in Health and Biodiversity.* University of Pennsylvania Press.
14. Khare, C. P. (2008). *Indian Medicinal Plants: an Illustrated Dictionary.* Springer Science & Business Media.
15. Trivedi, P.C.(2006). Medicinal Plants: Traditional Knowledge. IK International Pvt Ltd.
16. Das, S. K. (1959). *Medicinal, Economic and Useful Plants of India-* (Alphabeticallyarranged).

Bio-1052 **ANIMAL BIORESOURCES** Total Marks: **50**

Core Course Internal Assessment: **20**

Credits: **2** University Examination: **30**

Duration: **36** Hours Duration of Exam: **2 Hours**

Unit-1 Animal Diversity And Taxonomy

1.1 Diversity and classification of animals; need of classification, hierarchy of groups; five kingdom system of classification.

1.2 Taxonomy: definition, history and importance, kinds of taxonomy (morphotaxonomy, karyotaxonomy, cytotaxonomy and molecular taxonomy); phases of taxonomy.

1.3 Identification; identification by keys, types of keys, construction and use of keys; curating (collection, killing, preservation and storage); concept of species and sub-species.

1.4 Zoological nomenclature (ICZN), principles of nomenclature, publication of scientific names, typification and kinds of types, principle of priority.

Unit-2 Aquatic Animals, Insects and Earthworms

2.1 Edible species of fishes; fish culture: sources of fish seed, types of culture practices, selection of species; Indian and exotic cultivable fish species.

2.2 Layout of a typical fish pond, types of fish ponds, management techniques, control of aquatic weeds and predators; maturing, supplementary and artificial feeding.

2.3 Edible species of aquatic invertebrates, prawn, lobster, mollusks and crabs; shell fish prawn and pearl oyster farming.

2.4 Sericulture, apiculture, lac culture, vermiculture; diseases associated with various cultures, advances in insect-based industries in India; Insects as food and nutrition.

Unit-3 Animal Products and Management

3.1 Pharmaceuticals from animals; (seafood): value addition and export, role of Marine Product Export Development Authority (MPEDA) in promoting production and export of marine products.

3.2 Meat, leather and wool industries and their production with special emphasis on their export potential; Poultry farming (chicken, duck and quail); commercial poultry breeds in India, poultry diseases; egg industry - present status in India.

3.3 Dairy farming in India: breeds of cattle and buffalo, milk production and pasteurization techniques.

3.4 Animal waste recycling: biogas and its production, types of biogas plants; slaughter house wastes and their utilization; fish byproducts; fish meal- methods of processing and uses.

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 is designed to acquaint students with biology of animals, their management and judicious utilization based on scientific principles.
- To know the diversity of animal resources.
- Provides students with a broad background in domestic animal biology.
- The course focuses on animal products and their management.

Recommended Textbooks and References:

1. Blackwelder. E. Richard. (1996). *Taxonomy: a Text and Reference Book,* 3rd Edition, John Wiley and Sons INC.
2. Jabde V. Pradip. (2005). *Text Book of Applied Zoology,* 1st Edition, Discovery Publishing House, New Delhi.
3. Malhotra P. (2008). *Economic Zoology,* 5th Edition, Adhyayan Publishers, New Delhi.
4. Shukla G.S. and Upadhay (2001). *Economic Zoology,* 4th Edition, Rastogi Publications, Meerut.
5. Hickman, C. P., & Roberts, L. S. (2011). Animal *Diversity,* 6th ed., McGraw-Hill Education.
6. Helfman, G., Collett, U. B., &Facey, U. E. (2011). *The Diversity of Fishes: Biology, Evolution and Ecology,* 2nd ed., Wiley-Blackwell.
7. Venkataraman, K., &Sivaperuman, C. (2014). *Marine Faunal Diversity in India: Taxonomy, Ecology and Conservation.* Academic Press.

Bio-1062

CELL BIOLOGY

Total Marks: **50**

Core Course

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

Unit – 1 Structure of Cells and Its Organelle

1.1 Structure and diversity of prokaryotic and eukaryotic cells; characteristics that distinguish

prokaryotic and eukaryotic cells. An outline of their ultra-structure.

1.2 Subcellular fractionation: concept, principle and isolation of plasma membrane, nuclei, mitochondria, microsomes and cytosol, applicability of the technique in contemporary researches in cell biology. Chemical organization of the cell- a general account.

1.3 Structure and functions of mitochondria, Golgi complex, vacuoles, lysosomes, microbodies, nuclear envelope and nucleolus.

1.4 Cytoskeleton: structure, composition and functions of microtubules, microfilaments, cilia and flagella.

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; membrane turnover.

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 Cell Cycle and Signaling

3.1 Signal transduction: General features, role of effector proteins and secondary messengers in signaling, structure of G-protein coupled receptors (GPCR), trimeric G-protein; classes and functions.

3.2 Signaling pathway that regulate ion channels: Rhodopsin signaling pathway in Rod cells of the eye. Gene controlling signaling pathways: tyrosine kinase pathway and Ras/MAP kinase pathway.

3.3 Cell cycle: mitosis, meiosis (general account); control of cell cycle, role of kinases and kinase inhibitors, checkpoints: concept and role.

3.4 Programmed cell death (Apoptosis)- pathways involved, role in normal and diseased state, various markers of apoptosis. Role of FAS ligand.

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 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 signaling 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.

Bio-1072 **BIOMOLECULES** Total Marks: **50**

Core Course Internal Assessment: **20**

Credits: **2** University Examination: **30**

Duration: **36**Hours Duration of Exam: **2 Hours**

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

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

2.2 Polysaccharides: structural polysaccharides - cellulose and chitin; storage polysaccharides - starch and glycogen; glycoproteins: N- and O-glycosylation; Glycosaminoglycans; Glycoproteins

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

2.4 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.

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.

Recommended Textbooks and References:

1. Stryer, L. (2015). *Biochemistry* (8^{th}ed.). New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry*(6^{th}ed.). New York, NY: Worth.
3. Voet, D., &Voet, J. G. (2016). *Biochemistry* (5^{th}ed.). Hoboken, NJ: J. Wiley & Sons.
4. *Biochemistry* by Geoffrey L. Zubay. Fourth Edition, Addison-Wesley educational publishers Inc., 2008
5. Horton, H.R., Moran, L. A., Scrimgeour, K.G. Perry, M.D and Rawn, J.D. 2006. *Principles of Biochemistry*, IVth Edition. Pearson Education Internationl. London.
6. Dobson, C. M. (2003). *Protein Folding and Misfolding.* Nature, 426(6968), 884- 890. doi:10.1038/nature02261.
7. Richards, F. M. (1991). *The Protein Folding Problem.* Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Bio-1712

Core Course

Credits: **2**

Duration: **72**Hours

LABORATORY – I

MOLECULAR BIOLOGY AND MICROBIAL BIORESOURCES

Total Marks: **50**

Internal Assessment: **25**

University Examination: **25**

Molecular Biology

1. Isolation of plant, animal and bacterial genomic DNA (*Brassica*sp, humans, *E. coli)*
2. Isolation of RNA from the leaves of *Catharanthusroseus, Vallerianawallichii*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.

Microbial Bioresources

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

Course Outcome:

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

Bio-1722	**LABORATORY – II**	Total Marks: **50**
Core Course	**PLANT AND ANIMAL BIORESOURCES**	Internal Assessment: **25**
Credits: **2**		University Examination: **25**
Duration: **72**Hours		

Plant and Animal Bioresorces

1. Collection and identification of a few economically important plant and animal taxa. Honey bee, Earthworm, *Withaniasomnifera, Abelmoschus*spp.,*Phyllanthusemblica.*
2. Introduction to intraspecific variability against backdrop of concept of invariability of a species: maize, beans, brinjal, dogs, poultry.
3. Variability beyond level of species
    a. Intra-generic variation. *Solanum*spp.,*Capsicum* spp., *Allium* spp., *Apis*spp.
    b. Intra-familial variability. Solanaceae, Poaceae.
4. Collect, describe, identify and classify wild bioresources, including wild relatives of crop plants and look for similarities and differences with the cultivated relatives. Wild relatives of: Pear, Indian gooseberry, Olive, Okra, Fig, Grape and Rice.
5. Variability introduced in cultivated plants and animals to suit human fancy, taste and need through classical methods of plant improvement-selection and hybridization: rose, dog, apple, mango, rice, maize, seedless guava and grapes.
6. Spottings on plant and animal bioresources produced through biotechnological interventions - photograph of GM plants and animals like Bt cotton, Flavrsavr tomato, Golden rice, Noori.
7. Aquatic bioresources: Lotus, Water chestnut, *Euryale ferox, Typha*spp., *Nymphaea*spp., Fish, Prawn, Crab, Turtle, Marine algae, Corals, Pearls, Ducks.
8. Subterranean bioresources: potatoes, sweet potato, *Tapioca* sp., *Zingiber* sp.,*Dioscorea*sp., *Curcuma* sp., Groundnut, *Acorus*sp., Earthworm.
9. Terrestrial Bioresources: Trees, fruits: Rosaceous, Non- rosaceous.

10. Study of characteristics of important bioresources - Timbers: hard and soft woods, fuels, medicine, fodder, foliage: silkworm, food, Rubber; Shrubs: food, fodder, medicinal, fruits, fibres, dyes; Herbs: food, fodder, medicinal, fruits, fibres, dyes.
11. Study of characteristics of bioresources used to produce multiple products through processing: Maize- maize floor, Popcorn, Cakes; Soyabean; Potato; *Camelia*sp.; Wheat; *Linum*sp. and Silk.
12. Assessment of Bioresources: Determination of density, abundance and frequency of species by quadrat method.
13. Determination of species diversity by using Shanon -Wiener's index and Simpson Index.
14. Understanding principle and functioning of Global Positioning System (GPS) and its use.
15. Marking and mapping different sites of University campus with help of Global Positioning System.

Course Outcome:

- The objective of this laboratory course is to teach basics of exploration, identification and conservation of plant and animal bioresources.
- Students will learn different techniques for the collection and identification of Plants and animals.
- Enable students to acquire expertise for domestication and introduction of economically important plants and animals.
- Students will acquaint with different methods for the assessment and characterization of bioresources.

Bio-1732	**LABORATORY – III**	Total Marks: **50**
Core Course	**BIOMOLECULES AND**	Internal Assessment: **25**
Credits: **2**	**CELL BIOLOGY**	University Examination: **25**
Duration: **72**Hours		

Biomolecules

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.
3. Overview of Spectrophotometer and validating the Beer- Lambert's Law.
4. To detect the presence of carbohydrate in the given sample by Molish test.
5. To detect the presence of reducing sugar in the given sample by Fehling's test
6. To detect presence of reducing sugar using Benedict's test.
7. To determine the presence of starch in given sample by using iodine solution (starch-iodine test).
8. Tests for amino acids: Ninhydrin test, Xanthoproteic test, Lead sulphide test, Hopkin'test
9. To determine Saponification value of given fat sample.
10. Separation of amino acids by Paper Chromatography/TLC
11. Separation of plant pigments by Paper Chromatography/TLC

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)/*Aillumtuberosum.*
3. Study the structure of somatic chromosomes of *Allium cepa/ Viceafaba,*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.

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.
- Students will learn different techniques of Cell biology.
- Enable students to acquire expertise in the field of microbiology.
- Demonstrate practical skills in different laboratory equipment’s and their handling.

Bio-2014

Core Course

Credits: **4**

Duration: **72**Hours

GENETIC ENGINEERING

Total Marks: **100**

Internal Assessment: **40**

University Examination: **60**

Duration of Exam: **3 Hours**

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; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes.

1.4 Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit – 2 Different Types of Vectors

2.1 Plasmids; Bacteriophages; M13 mp vectors; pUC19 and Bluescript vectors, phagemids;

Lambda vectors.

2.2 Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression: expression vectors, GST, pET-based vectors.

2.3 Protein purification: His-tagged/GST-tagged/MBP- tagged proteins,Inclusion bodies; methodologies to reduce formation of inclusion bodies.

2.4 Mammalian expression and replicating vectors; Baculovirus and *Pichia*vectors system, plant based vectors, Ti and Ri plasmids as vectors, 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, RACE; Touchdown PCR; RAPD and AFLP.

3.3 Cloning of PCR products; TA cloning vectors; PCR based site-specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection.

3.4 Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; Pyrosequencing; Next generation sequencing technologies; Chemical synthesis of oligonucleotides.

Unit-4 cDNA Analysis

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

4.2 Construction of libraries; isolation of mRNA and total RNA; reverse transcriptase, cDNA synthesis and screning.

4.3 Genomic and cDNA libraries: construction and screening. DNA microarrays: construction and applications.

4.4 Study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system and phage display.

Unit-5 Gene Silencing and Genome Editing Technologies

5.1 Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors.

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

5.3 Introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (Drosophila), worms (C. *elegans)*.

5.4 Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

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.*

Bio-2022

Core Course

Credits: **2**

Duration: **36** Hours

GENOMICS AND PROTEOMICS

Total Marks: **50**

Internal Assessment: **20**

University Examination: **30**

Duration of Exam: **2 Hours**

Unit-1 Basics of Genomics, Proteomics and Genome Mapping

1.1 Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

1.2 Genetic and physical maps; markers for genetic mapping.

1.3 Methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping.

1.4 Somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Unit-2 Genome Analysis and Comparative Genomics

2.1 Sequencing and assembly of genomes: whole genome shotgun sequencing and hierarchical shotgun sequencing, genome sequencing projects for microbes, plants and animals, Human Genome Project.

2.2 Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs., DNA barcoding.

2.3 Locating protein-binding sites in the upstream region: Gel retardation assay, DNA footprinting and Chromatin Immunoprecipitation (ChIP). Use of genomes to understand evolution of eukaryotes, track emerging diseases and design new drugs.

Unit-3 Functional Genomics and Proteomics

3.1 Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, proteome databases.

3.2 Transcriptome analysis for identification and functional annotation of gene; Transcript mapping by primer extension and S1 nuclease mapping, deletion analysis of the upstream regions; Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in genome.

3.3 Protein-protein and protein-DNA interactions: yeast 2-hybrid system, phage display; protein chips and functional proteomics; clinical and biomedical applications of proteomics.

3.4 Introduction to metabolomics, lipidomics, metagenomics and systems biology.

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 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.

Recommended Textbooks and References:

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics.* Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology.* Totowa, NJ: Humana Press.
3. Campbell, A. M., &Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics.* San Francisco: Benjamin Cummings.

Bio-2034 **ENZYMOLOGY AND METABOLISM** Total Marks: **100**

Core Course Internal Assessment: **40**

Credits: **4** University Examination: **60**

Duration: **72**Hours Duration of Exam: **3 Hours**

Unit 1--Enzyme Kinetics

1.1 Nomenclature and classification of enzymes: Enzyme Commission's system of classification, six main 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- Kcat, Km and Kcat/Km.
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 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: beta 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, urea cycle and ammonia excretion.
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, Nitrogen fixation: nitrogenase system and nitrate reductase.

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* (8^{th}ed.). New York: Freeman.
6. Lehninger, A. L. (2012). *Principles of Biochemistry*(6^{th}ed.). New York, NY: Worth.
7. Voet, D., &Voet, J. G. (2016). *Biochemistry* (5^{th}ed.). Hoboken, NJ: J. Wiley & Sons.

Bio-2052

PLANT BIOTECHNOLOGY

Total Marks: **50**

Core Course

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

Unit-1 Plant Tissue Cultureand Plant Transformation Techniques

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 culture and triploid production through endosperm culture in crop improvement.

1.3 *In vitro* pollination; wide hybridization; somatic cell hybridization (hybrids and cybrids); embryo culture; Synthetic seeds and their importance.

1.4 Methods of gene transfer- *Agrobacterium* mediated gene transfer and electroporation.

Unit-2 Plant Biotechnology for Abiotic and BioticStress Resistance

2.1 Plant biotechnology for enhancing cold and heat stress tolerance; secondary effects of abiotic stress – production of ROS; genes involved in scavenging of ROS.

2.2 Plant biotechnology in enhancing drought and salt stress tolerance; Plant biotechnology for enhancing resistance against fungal pathogens; anti-microbial proteins.

2.3 Plant biotechnology to enhance viral resistance- pathogen derived resistance.

2.4 Coat protein, antisense, siRNA and ribozyme approaches to enhance resistance for extending shelf life of fruits and flowers (ACC synthase gene and polygalacturonase).

Unit-3 Plant Biotechnology for Improving Crop Yield and Quality

3.1 Plant biotechnology in improving fruit ripening and enhancing photosynthesis.

3.2 Golden rice- nutritionally improved rice through biotechnology; transgenic sweet potato.

3.3 Modification of taste and appearance- sweetness, starch and preventing discoloration.

3.4 Bioplastics- biodegradable plastic from plants through biotechnological intervention.

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:

- 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.

Recommended Textbooks and References:

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.* 4th edition. Narosa Publishing House.
5. Primrose, S. B and Twyman, R. M (2007). *Principles of Gene Manipulation and Genomics.* Blackwell Publishing, Oxford, UK.
6. Singh, B. D. (2007). *Biotechnology: Expanding Horizons.* Kalyani Publishers.
7. Slater, A., Scott, N and Fowler, M (2003). *Plant Biotechnology: the Genetic Manipulation of Plants.* Oxford University Press.
8. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 4th Ed. ASM press.
9. H. S. Chawla. (2013). *Introduction to Plant Biotechnology.* Science Publishers.
10. Ruane J, Sonnino A. (2006). *The Role of Biotechnology in Exploringand*Protecting *Agricultural Genetic Resources. Food and Agriculture Organization of the United Nations,* Rome.
11. Razdan, M.K. (1993). *An Introduction to Plant Tissue Culture,* Oxford and IBH.

12. Singh, J.S., Singh, S.P. and Gupta, S.R. (2006). *Ecology, Environment and Resource Conservation*, Anamaya Publishers, New Delhi.

Paper Code:

Open Elective

Credits: **4**

Duration: **72**Hours

OPEN ELECTIVE

Total Marks: **100**

Internal Assessment: **40**

University Examination: **60**

Duration of Exam: **3 Hours**

LIST OF OPEN ELECTIVES

S. No.	Paper Code	Paper Title	Course Type	Credits
1	Math-201	Mathematical Tools for Real World Problems	OE	4
2	IT-202	Soft Skills in Information Technology	OE	4
3	Comp-203	Computer Applications and Operations	OE	4
4	Bot-205	Mysteries of Green Plants	OE	4
5	Bot-206	Botany in Rural Development	OE	4
6	Zol-207	Nutrition, Health and Hygiene	OE	4
7	Arab-208	Fundamentals of Arabic Language	OE	4
8	Eng-209	Applied English	OE	4
9	Edu-210	Higher Education	OE	4
10	Eco-211	Principles of Banking	OE	4
11	HT-212	Basics of Tourism and Travel Agencies	OE	4
12	HT-213	Tourism Resources of J&K	OE	4
13	Mgt-214	Business Communication and Soft Skills	OE	4
14	Edu-215	Instructional Technology	OE	4

Note: Candidate has to opt only 1 course out of the 14 courses offered.

Bio-2514	**FUNDAMENTALS OF BIOTECHNOLOGY**	Total Marks: **100**
Open Elective	**[O.C.E.FOR NON-BIOTECHNOLOGY STUDENTS]**	Internal Assessment: **40**
Credits: **4**		University Examination: **60**
Duration: **72**Hours		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: Basic cloning; Restriction endonucleases, DNA transfer vehicles.

1.4 Methods of gene transfer.

Unit – 2 Plant and Animal Biotechnology

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

2.2 Crop improvement: Bt cotton, Btbrinjal 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, Regulations of GMO's.

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

5.4 Ethical issues in human cloning, clinical trials, foeticide and sex determination.

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.

Bio-2662 **SEMINAR / JOURNAL CLUB** Total Marks: **50**

Core Course Internal Assessment: **50**

Credits: **2**

- Topics of Seminar/Research Article be allotted to every student along with a supervisor / mentor.
- Students should make a 30 min. PowerPoint presentation of the same, which all the faculty of the department and students should attend.
- The seminar should be followed by a small quiz (5 questions; MCQ based), prepared by the concerned faculty on the topic, which all the students should attempt.
- Assessment of the students should be based on their seminar presentation [25 %], as assessed individually by all faculty members, as well as their accumulated averaged performance in 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.

Bio-2712	**LABORATORY – IV**	Total Marks: **50**
Core Course	**ENZYMOLOGYAND METABOLISM**	Internal Assessment: **25**
Credits: **2**		University Examination: **25**
Duration: **72**Hours		

1. Biochemical calculations and reagent preparation
2. Estimation of proteins by Lowery's method.
3. Estimation of proteins by Biuretic method.
4. Effect of pH and temperature on enzyme activity
5. Assay of acid phosphatase from potato.
6. Assay of beta-amylase from sweat potato.
7. Assay of serum alkaline phosphatase.
8. Assay of serum ALT and AST.
9. Estimation of glucose.
10. Estimation of urea.
11. Nitrogen estimation from animal tissue.
12. Cholesterol estimation.
13. Isolation and estimation of starch from potato using iodine test.
14. Isolation of glycogen from animal tissue.

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.

Bio-2722	**LABORATORY – V**	Total Marks: **50**
Core Course	**PLANT BIOTECHNOLOGY AND GENOMICS**	Internal Assessment: **25**
Credits: **2**		University Examination: **25**
Duration: **72**Hours		

Plant Biotechnology

1. Prepare culture media with various supplements for plant tissue culture.
2. Prepare explants of *Vallerianawallichii*for inoculation under aseptic conditions.
3. Attempt *in vitro* andro and gynogenesis in plants *(Daturastramonium).*
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*Vallerianawallichii.*
7. Prepare karyotypes and study morphology of somatic chromosomes of *Alliumcepa, A. sativum, A. tuberosum*andcompare them on the basis of karyotypes.
8. Pollen mother cell meiosis and recombination index of select species (one achiasmate, and the other chiasmate) 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.

Course Outcome:

- The objective of this laboratory course is to provide practical skills on basic plant biotechnology and Genomics.
- To elucidate students with basic training of plant tissue culture.
- Students will learn different techniques pertaining to plant biotechnology.
- Demonstrate practical skills in different laboratory equipment's and their handling.

Bio-2732 **LABORATORY – VI** Total Marks: **50**

Core Course **GENETIC ENGINEERING** Internal Assessment: **25**

Credits: **2** University Examination: **25**

Duration: **72**Hours

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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.

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.

Bio-3012

ANIMAL BIOTECHNOLOGY

Total Marks: **50**

Core Course

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

Unit-1 Animal Cell Culture and Scaling Up

1.1 Primary and established cell line cultures; equipment and materials for cell culture.

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 and their applications.

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 of cultures and maintenance of stem cell lines; stem cell therapy and its applications.

2.3 Hybridoma technology and somatic cell fusion technology its importance in medicine, cell cloning, manipulation and cell synchronization; Flow cytometry techniques.

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

Unit-3 Animal Assisted Reproductive Techniques

3.1 *In-vitro* fertilization in humans, wild animals and cattle, embryo transfer in wild animals and cattle, applications of embryo transfer technology, story of Noori, Garima, *etc.*

3.2Ovum pick-up and applications of animal cloning; Production of transgenic animals with special reference to transgenic mice, cow and sheep.

3.3 Identification and transfer of genes influencing milk quality and disease resistance; production of pharmaceuticals.

3.4 Transfection methods- Ca phosphate precipitation, DEAE-Dextran mediated transfection, lipofection, fusion with bacterial protoplasts, electroporation; targeted gene transfer- gene disruption and gene replacement.

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:

- 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.

Recommended Textbooks and References:

1. Brown, T. A (2007). *Genomes.* BIOS Scientific Publishers Ltd.
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. Primrose, S. B and Twyman, R. M (2007). *Principles of Gene Manipulation and Genomics.* Blackwell Publishing, Oxford, UK.
5. Singh, B. D. (2007). *Biotechnology: Expanding Horizons.* Kalyani Publishers.
6. Bernard R. Glick, Jack J. Pasternak, Cheryl L. Pattten. (2010). *Molecular Biotechnology: Principles and Applications of Recombinant DNA.* 4th Ed. ASM press.
7. Das, H. K (2010). *Textbook of Biotechnology*. Wiley India Pvt. Ltd.
8. Freshney, R. I (2010). *Culture of Animal Cells.* John Wiley and SonsInc.
9. Kumaresan, V (2008). *Applied Animal Biotechnology.* Saras Publication.
10. Shenoy, M (2015). *Animal Biotechnology.* Laxmi Publications; First edition.

Bio-3022	**GENETICS**	Total Marks: **50**
Core Course		Internal Assessment: **20**
Credits: **2**		University Examination: **30**
Duration: **36** Hours		Duration of Exam: **2 Hours**

Unit-1 Genetics Of Bacteria and Bacteriophages

1.1 Concept of a gene in pre-DNA era; mapping of genes in bacterial and phage chromosomes by classical genetic crosses.

1.2 Fine structure analysis of a gene.

1.3 Genetic complementation and other genetic crosses using phenotypic markers.

1.4 Phenotype to genotype connectivity prior to DNA-based understanding of gene.

Unit-2 Yeast Genetics and *Drosophila* Genetics: **A Model of HigherEukaryotes**

2.1 Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch.

2.2 Dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.

2.3 Drosophila Genetics: Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages.

2.4 Drosophila Genetics: Screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism.

Unit-3 Population Genetics and Genetics of Evolution, Quantitative Genetics of Complex Traits (QTLs) and Plant Genetics

3.1 Introduction to the elements of population genetics: genetic variation, genetic drift, neutral evolution; mutation selection, balancing selection, Fishers theorem, Hardy- Weinberg equilibrium, linkage disequilibrium.

3.2 In-breeding depression & mating systems; population bottlenecks, migrations, Bayesian statistics; adaptive landscape, spatial variation & genetic fitness.

3.3 Complex traits, mapping QTLs, yeast genomics to understand biology of QTLs.

3.4 Laws of segregation in plant crosses, inbreeding, selfing, heterosis, maintenance of genetic purity, gene pyramiding.

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.
- 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* 8th Edn. John Wiley and Sons.

Bio-3032

INDUSTRIAL BIOTECHNOLOGY

Total Marks: **50**

Core Course

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

Unit-1 Basic PrinciplesofBiochemicalEngineering, Bioreactor Design and Analysis

1.1 Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

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

1.3 Conventional fermentation v/s biotransformations; immobilized cell systems; large-scale animal and plant cell cultivation; fermentation economics.

1.4 Upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit-2 DownstreamProcessing, Product Recovery and Fermentation Economics

2.1 Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation.

2.2 Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and packaging.

2.3 Isolation of microorganisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs.

2.4 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 ofEnzymeond Microbial Technologyin Food Process Operations andProduction, BiofuelsandBiorefinery.

3.1 Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing.

3.2 Baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

3.3 Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods;

microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products,

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 and biorefinery.

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.

Bio-3042 **BIOINFORMATICS AND BIOENTREPRENEURSHIP**

Core Course

Credits: **2**

Duration: **36** Hours

Total Marks: **50**

Internal Assessment: **20**

University Examination: **30**

Duration of Exam: **2 Hours**

Unit – 1 Elementary concepts of Bioinformatics

1.1 Introduction to Bioinformatics – Genomics and Proteomics, Bioinformatics – Online tools and offline tools, Biological databases.

1.2 Types of databases – Gen bank, Swiss port, EMBL, NCBI, PIR, DDBJ, Swiss-Prot and PDB.

1.3 Evolutionary basis of sequence alignment, Optimal alignment methods, Statistical significance of alignments, Database similarity searching, FASTA, BLAST; Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, ClustalW.

1.4 Phylogeny: Introduction, phenotypic and molecular phylogeny; Tree building methods; Types of trees; Softwares for phenotypic analysis.

Unit-2 Genomics, Proteomics and Structural biology

2.1 Data Mining –ORF, PubMed, Phylogenetic Analysis, MSA, Gen BANK, COG Cluster, OMIM, Gene Mapping, Sequence Assembly & Expression, Alignment of MS.

2.2 Visualization & prediction of Protein Structure, Methods used in protein structure prediction, PROSITE, DNA Micro array (DNA chip).

2.3 Secondary structure elucidation using peptide bond phi, psi and chi torsion angles, Ramachandran map.

2.4 Homology/comparative modeling, fold recognition, threading approaches, Computational design of promoters, proteins & enzymes.

Unit-3: Innovation and Entrepreneurship in Bio-Business and Bio-Markets

3.1 Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals *vs.* Industrial biotech).

3.2 Strategy and operations of bio-sector firms, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), Concept of Profit and Loss Account; Understanding Balance Sheet related concepts.

3.3 Marketing and Negotiations Strategies: Assessment of market demand for potential product(s) of interest; Identifying needs of customers including gaps in the market.

3.4 Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

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 introduce to provide students with theory and practical experience of use of common computational tools and databases, which facilitate investigation of molecular biology and evolution-related concepts.
- Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology.
- Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects.
- The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Recommended Textbooks and References:

1. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins,* John Wiley and Sons.
2. D.W. Mount, (2001), *Bioinformatics: Sequence and Genome Analysis,* Cold Spring Harbor Laboratory Press.
3. Jones &Peuzner, (2004); *Introduction to Bioinformatics Algorithms;* Ane Books, India.
4. M. M. Rangs, *Bioinformatics* (2007) (2nd Edn.), Agrobios India,
5. DovStekel, (2003); *Microarray Bioinformatics;* Cambridge University Press.
6. Web-resources and suggested reviews/ research papers on Bioinformatics.
7. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences.* Bloxham: Scion.
8. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies.* Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
9. Onetti, A., &Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge.* Routledge.
10. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Sciences.* London: CRC Press.
11. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management.* New Delhi: Himalaya Pub. House.

Bio-3054 **IMMUNOLOGY** Total Marks: **100**

Core Course Internal Assessment: **40**

Credits: **4** University Examination: **60**

Duration: **72**Hours Duration of Exam: **3 Hours**

Unit 1--Introduction to immunology

1.1 1Types of immunity, innate and adaptive, hematopoiesis.The host-microbe relationship: Normal body flora; Pathogen and their abilities to cause disease.Host defense barriers and its breach for the establishment of infection and disease; Virulence factors and ability of pathogen to escape host to spread disease.

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

1.3 Immunoglobulin: structure, classes and subclasses; Nature and biology of antigens, immunogenicity versus antigenicity, epitopes, antigen- antibody interactions and heptans.

1.4 Generation of antibody diversity; Basis of self and non-self-discrimination.

Unit 2--Humoral and cell mediated immunity

2.1 Major histocompatibility complex and HLA system, recognition of antigens by T-cells and role of MHC; implication of linkage disequilibrium and disease association.

2.2 Antigen processing and presentation: endogenous and exogenous antigens; super antigens.

2.3 Complement fixing antibodies and complement pathways; ADCC.

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

Unit 3--Clinical Immunology

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 Arithritis

3.3 Cancer: oncogenes and proto-oncogenes, tumor antigens, tumor evasion of immune system. Organ transplantation: Role of CD4+ T cells; immunological basis of graft rejection and immunosuppressive therapy.

3.4 AIDS, HIV infection of Target Cells and Activation of Provirus.Infectious disease epidemiology: Reservoirs of infectious diseases; Modes of transmittance of infectious diseases; Mode of occurrence of disease in the population; Nosocomial Infections; Infectious diseases and Public Health Organizations.

Unit 4-- Immunodiagnostic Procedures

4.1 Techniques: flow cytometry, ELISA, RIA (principles, properties and applications).Serological reactions and techniques: Neutralization; Precipitation; Agglutination; Complement fixation test
4.2 Immunofluorescence and Fluorescence microscope; Western Blotting
4.3 Immunodiffusion: Mancini and Ouchterlony methods; immunoelectrophoresis.
4.4 Separation of immunoglobulin from serum.

Unit 5—Immunobiotechnology and Transplantation

5.1 Monoclonal antibodies: production, detection and applications; chimeric and hybrid monoclonal antibodies.
5.2 Active and passive immunization: live, killed, attenuated; conventional vaccines**.** Vaccine technology: recombinant DNA and peptide vaccines.
5.3 Stem cells: overview of stem cells, functions and medical applications.

5.4 Transplantation of tissues and organs; Allograft Rejection and role of Immunosuppressive Agents; HLA-matching; Transplant survival and immunotherapy; Xenotransplantation; Role of transgenic animals as organ donors.

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.

Recommended Textbooks and References:

1. Lansing M Prescott, John P. Harley, Donald A Klein, *Microbiology;* Sixth edition, Mc Graw Hill Higher education.
2. Alcomo, I.E. 2001. *Fundamentals of Microbiology*. VI Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts.
3. Coleman, R.M.,Lombard, M.F. and Sicard, R.E. 1992. *Fundamental Immunology*, 2nd ed, Dubuque, Iowa: Wm. C. Brown.
4. Janeway, C.A., and Travers, P. 1997, *Immunobiology: The immune system in health and disease*, 3rd ed. New York, Garland Publishing.
5. Kuby, J. 1997, *Immunology*, 3rded. New York, W.H. Freeman.
6. Male, D., Champion, B., Cooke, A. and Owen, M. 1991. *Advanced Immunology*. Mosby Publication, Baltimore.

Bio-3062 **ANALYTICAL TECHNIQUES** Total Marks: **100**

Core Course Internal Assessment: **40**

Credits: **4** University Examination: **60**

Duration: **72**Hours Duration of Exam: **3 Hours**

Unit – 1 Chromatography and Spectroscopic Techniques

4.1 Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis, Ultrafiltration and other membrane techniques.

4.2 Protein structure, purification and characterization. Chromatographic techniques: Principle and applications of Adsorption, Partition, Ion-exchange, Size exclusion and Affinity chromatography; HPLC and FPLC.

4.3 ***Overview and Applicationsof Spectroscopic Techniques***: Ultraviolet and visible light spectroscopy; Fluorescence spectroscopy; Light Scattering and Circular dichroism spectroscopy.

4.4 ***Overview and Applicationsof Spectroscopic Techniques***: Infrared and Raman spectroscopy; Surface Plasmon Rasonance; NMR and X-ray diffraction

Unit – 2 Electrophoretic, Centrifugation and Immunotechniques (*Overview and Applications only)*

3.1 Electrophoretic Techniques; Electrophoresis of proteins and nucleic acids; Capillary electrophoresis and Microchip electrophoresis.

3.2 Centrifugation: Basic principle of centrifugation; Preparative and Analytical Centrifugation; Mass spectrometry: MALDI-TOF; ESI-MS; Proteomics.

3.3 Radioisotopes and its usage in biochemical techniques. Immunochemical techniques: Production of Antibodies; Immunoassay and Immunoelectrophoresis formats; Immunomicroscopy; Epitope mapping; Immunoblotting;

3.4 Fluorescence Activated Cell Sorting (FACS); Immunocapture PCR; Immunoaffinity chromatography; Biosensors and Antibody-based biosensors.

Unit – 3 Molecular Biology Techniques (*Principles and Applications only)*

3.1 Nucleic acid hybridization: Blotting techniques; Chemical Synthesis of DNA; DNA amplification by PCR; DNA libraries. DNA transfer into Eukaryotic Cells and Mammalian Embryos; Transgenic Animals; Determination of eukaryotic gene function by Gene Silencing or knockout.

3.2 PCR and its modifications: Nested PCR; Quantitative Real-time PCR; RT-PCR; Inverse PCR; Anchored PCR; RACE; Touchdown PCR; RAPD and AFLP; Labeling of Nucleic Acids: Isotopic and Non-Isotopic labeling; Molecular beacons; FISH; Colony hybridization; Phage display; Yeast-two hybrid assay.

3.3 Transcript Analysis; DNA Microarray; Electrophoretic mobility shift assay; Footprinting assay; Site-directed mutagenesis; Cassette mutagenesis; Primer extension method; Overlap extension method; Megaprimer PCR; Random mutagenesis.

3.4 DNA Sequencing; Chain termination method; Automated sequencing; Chemical degradation method; Pyrosequencing. Next generation sequencing technologies: Illumina (Solex) sequencing; Ion torrent Sequencing. Chromatin Immuno precipitation. (ChIP).

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 and molecular biology techniques.

Recommended Textbooks and References:

12. E. H. Segel. *Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry*, 2nd Edition, John Wiley Publications.
13. Branden, C. and Tooze, J. (1999). *Introduction to Protein Structure*. Garland Publishing New York.

14. Tanford, C. (1961). *Physical Chemistry of Macromalocules*. John Wiley and Sons.
15. Wilson, K and Walker, J. (2011). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University press.
16. Friefilder, D. (1987). *Essentials of Molecular Biology*. Jones and Bartlett Publications.
17. Clark, D. P. (2005). *Molecular Biology: Understanding the Genetic Revolution*. Academic Press.
18. Nelson, D. D. L., Lehninger, A. L. and Cox, M. M. (2013). *Lehninger Principles of Biochemistry*. W.H. Freeman Publishers.

Bio-3512/3522/3532/3542
Discipline Centric Elective
Credits: **3**

Duration: **36**Hours

DISCIPLINE CENTRIC ELECTIVE

Total Marks: **50**

Internal 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-3512	Crop Biotechnology	DCE	2
2	Bio-3522	Human Genetic Disorders	DCE	2
3	Bio-3532	Signal Transduction and Cancer Biology	DCE	2
4	Bio-3542	Protein Engineering	DCE	2

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

Bio-3512

CROP BIOTECHNOLOGY

Total Marks: **50**

Discipline Centric Elective

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

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.

Bio-3522

HUMAN GENETIC DISORDERS

Total Marks: **50**

Discipline Centric Elective

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

Duration of Exam: **2 Hours**

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.

Bio-3532

Discipline Centric Elective

Credits: **2**

Duration: **36** Hours

SIGNAL TRANSDUCTION AND CANCER BIOLOGY

Total Marks: **50**

Internal 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, their structure and function.

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

Unit II Signalling II- Functional Diversity

2.1 Mechanism of action of GPCRs: GPCRs that regulate ion channels- acetylcholine receptors in heart muscles and rhodopsin receptors in rod cells of eyes.

2.2 Mechanism of action of Receptor Tyrosine Kinases (RTKs) and Ras/MAP kinase pathway- role of secondary messengers in the pathway.

2.3 Mechanism of action of signalling 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 III Cancer Biology

3.1 General overview of cancer: benign and malignant cancers, their characteristics, properties of cancer cells, general account on Multi Hit model of cancer induction.

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) and BRCA1 (Breast Cancer Susceptibility gene 1) 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.

Bio-3542

PROTEIN ENGINEERING

Total Marks: **50**

Discipline Centric Elective

Internal Assessment: **20**

Credits: **2**

University Examination: **30**

Duration: **36** Hours

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. Protein folding; protein function and structure-function relationships; Identification of putative enzymes in sequence databases, bioinformatic analysis.

1.2 Isolation of genes from host organisms, 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, an overview of spectroscopic techniques for the analysis of protein secondary and tertiary structure; an overview of techniques for analysis of protein quaternary structure. Introduction to protein crystallography and overview of structure determination by X-ray crystallography and Cryo-Electron microscopy.

Unit-2 Protein Engineering: Targets and Strategy

2.1 Enzymes, enzyme catalysis, factors influencing the speed of enzymatic reaction.

2.2 Enzyme applications and Industrially important enzymes, Proteases, Amylases, Lipases and Esterase, targets of protein engineering, Biosensors and Biomarkers (GFP and its variants), Engineering Therapeutically important proteins (e.g. Streptokinase), Antibodies and its fragments, Alternative scaffolds and artificial binding proteins.

2.3 Protein engineering approaches: their advantages and limitations. Rational design, prediction of the structure of enzyme variant; Site directed mutagenesis, evaluation of the effect of mutations on enzyme structure and function.

2.4 Directed evolution; Library creation, 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; mRNA display.

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 enzyme enantioselectivity and affinity of binding proteins including antibodies and artificial binding proteins. Techniques to monitor protein affinity, including FRET and SPR.

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.

Bio-3712

Core Course

Credits: **2**

Duration: **72**Hours

LABORATORY – VII BIOINFORNATICS AND INDUSTRIAL BIOTECHNOLOGY

Total Marks: **50**

Internal Assessment: **25**

University Examination: **25**

Bioinformatics

1. Determination of protein parameters from available softwares.
2. Retrieval of nucleotide and protein sequences from suitable databases.
3. Determination of protein sequence from nucleotide sequence using available softwares.
4. Study similarity searches using BLAST.
5. Designing primers using online softwares.
6. Studying the alignment of DNA and protein sequences by using bioinformatics tools.
7. Construction of phylogenetic tree of available data (protein and DNA sequences) by using available softwares.
8. Studying the structure of different proteins to appreciate differences and similarities among them using available software's.

Industrial Biotechnology

1. Preparation of YA agar, starch Agar and skimmed milk media.
2. Screening bacterial and fungal isolates for amylase, cellulase and protease activity by plate array method.
3. Isolation of industrially important microorganisms.
4. Basic Microbiology techniques
    a. Scale up from frozen vial to agar plate to shake flask culture.
    b. Instrumentation: Microplate reader, spectrophotometer, microscopy.
    c. Isolation of microorganisms from soil samples.
5. Monitoring bacterial growth through measurement of turbidity in spectrophotometer and plotting of growth curve.
6. Determination of thermal death point of different bacteria.
7. Immobilization of yeast biomass in sodium alginate gel.
8. Isolation of exopolysaccharides produced by lactic acid bacteria.

Course Outcome:

- The objective of this laboratory course is to provide practical skills on basic Bioinformatics.
- 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.

Bio-3722	**LABORATORY – VIII**	Total Marks: **50**
Core Course	**IMMUNOLOGY AND ANIMAL BIOTECHNOLOGY**	Internal Assessment: **25**
Credits: **2**		University Examination: **25**
Duration: **72**Hours		

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 Widalagglutionation 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.

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.

Course Outcome

- 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.
- Students will also be acquainted with techniques in Animal Biotechnology.

Bio-3732	**LABORATORY – IX**	Total Marks: **50**
Core Course	**ANALYTICAL TECHNIQUES AND**	Internal Assessment: **25**
Credits: **2**	**GENETICS**	University Examination: **25**
Duration: **72**Hours		

Analytical Techniques

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

Genetics

1. Demonstration of conjugation in bacteria
2. Prepare karyotypes and study the morphology of somatic chromosomes of *Allium cepa, A. sativum, A. tuberosum*and compare them on the basis of karyotypes.
3. Pollen mother cell meiosis and recombination index of select species (one achiasmate,

and the other chiasmate) and correlate with generation of variation.

4. Mounting of polytene chromosomes.
5. Demonstration of multiple alleles by blood groups in humans
6. Study of *Drosophila* mutant types.

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.
- To study Protein purification by metal chelate chromatography.
- Demonstration of conjugation in bacteria.

Bio-3742

Core Course

Credits: **2**

Duration: **72**Hours

LABORATORY – X

LAB BASED ON DISCIPLINE CENTRIC ELECTIVE

Total Marks: **50**

Internal Assessment: **25**

University Examination: **25**

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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 Vallerianawallichii for inoculation under aseptic conditions.
10. Attempt in vitro andro- and gynogenesis in plants (Daturastramonium).
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. sativum, A. tuberosum and compare them on the basis of karyotypes.

14. Generate RAPD and ISSR profiles of Vallerianawallichii and Zea mays.

15. Pollen mother cell meiosis and recombination index of select species (one achiasmate, and the other chiasmate) 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. Marking and mapping different sites of the University campus with the help of Global Positioning System.

20. Test seed viability by using tetrazolium salt.

21. Effect of plant invasives on plant bioresources:

22. To study the allelopathic effect of different concentrations of leaf extract of Ageratum conyzoides, Partheniumhysterophorus and Sonchusasper on seed germination.

23. Effect of pollution on plant bioresources and water quality: a. To calculate the Leaf Area Index of leaf samples collected from different sites to study the effect of pollution on leaf morphology.

24. To understand the principle and working of Auto Weather Station: collection, collation and representation of data.

25. Analysis of SNP linked to a disease using PCR-RFLP.

26. To perform Southern Blotting procedure.

27. Analysis of pedigrees and patterns of inheritance.

28. To perform DNA Finger printing using RFLPs and VNTRs.

29. To perform Drumstick and Barr body identification.

30. Lab demonstration of fluorescence microscopic techniques.

31. To study chemotaxis in bacteria and Paramecium.

32. Model demonstration of cell signalling pathways.

33. To study Gramene database.

34. Study genetic diversity of the available plant material by using RAPD and ISSR markers.

35. Induction of polyploidy by using cotton swab method.

36. Study genetic diversity by using CAPS marker.

37. Demonstration of FISH and GISH techniques.

38. SDS PAGE

Course Outcome:

- The objective of this laboratory course is to provide the students practical skills in discipline centric electives.
- To understand the principle and working of Auto Weather Station: collection, collation and representation of data.
- To Study genetic diversity by using CAPS markers.
- To study Protein purification by metal chelate chromatography.

Bio-4824 **DISSERTATION** Total Marks: **600**

Core course University Examination: **600**

Credits: **24**

Duration: **864**Hours

SUMMARY OF TOTAL CREDITS AND MARKS IN THE COURSE

Semester	Paper Category		Credits	Marks
Semester-1	Core Courses		14	350
		Practical	6	150
	Foundation Course		4	100
Sub-total			**24**	**600**
Semester-2	Core Courses	Theory	12	300
		Practical	6	150
		Seminar/Journal Club	2	50

	Open Elective [1/14]	4	100
Sub-total		**24**	**600**

S. No.	Course Code	Course Title	Duration [Hours]	Credits	Total Marks

Semester-3	Core Courses	Theory	14	350
		Practical	6	150
	Discipline Centric Elective (Theory) [1/4]		2	50
	Discipline Centric Elective (Practical) [1/4]		2	50
Sub-total			**24**	**600**
Semester-4	Core	Dissertation	24	600
Sub-total			**24**	**600**
Total			**96**	**2400**

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 carrier.
- Dissertation work is important component for admission in Ph.D course.

M.Phil Course Syllabus

1	Paper I	Research Methodology	72	4	100
2	Paper II	Plant Biotechnology	72	4	100
3	Paper III	Inheritance Biology	72	4	100
4	Paper IV	Molecular Biology	72	4	100

ProgrammeOutcome:

- 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.Phil Biotechnology course, the students will be able to:

- Keep pace with the expanding frontiers of knowledge and provides research training relevant to the present social and economic objectives of the country.
- Use the scientific methods, and critical thinking skills to ask questions and solve problems.
- Write a good research report and acquires the skill of presenting data in graphical form.
- 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 bioharzrdous 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.
- Work in a government-based entity such as Universities, research institutes or at private centers as research scientists/assistant in the native country and outside as well.

Syllabus for M.Phil (Biotechnology) Examination-2016

Credits: 04
Maximum Marks: 100
Duration: 3 hrs

Paper I: Research Methodology

Unit I: Fundamentals of a research programme

1.1 Introduction: meaning and definition, objectives of research, types of research.
1.2 Research problem: definition, necessity and techniques of defining research problems, formulation and objectives of research problem.
1.3 Research design: meaning, need and features of good research design, types of research design, basic principles of experimental design (RBD and CRD).
1.4 Sampling design: census and sample survey, different types of sampling designs, their characteristics and techniques.

Unit II: Scientific writing

2.1 Definition and basic concepts of scientific writing, significance & technique of research, finding & evaluating research material, guidelines of literature survey, record compilation.
2.2 Definition and kinds of scientific documents: research paper, review paper, book review, thesis, project reports.
2.3 Basic elements of research paper: title, authors, addresses, abstract, introduction, methods, results, discussion, acknowledgments, references, tables and figures.
2.4 Proposal preparation: instructions, submission to funding agency, manuscript submission.

Unit III: Microscopy and chromatography

3.1 Principles and application of light, phase contrast and fluorescence microscopy.
3.2 Principles, working and application of scanning and transmission electron microscopy.
3.3Types of chromatography: thin layer, column and high performance liquid chromatography (HPLC).
3.4 Principles and application of gel filtration, ion exchange and affinity chromatography.

Unit IV: Electrophoresis and centrifugation

4.1 Electrophoresis: types & principle, support media (agarose & polyacrylamide gels).

4.2 Electrophoresis of proteins: SDS-PAGE, native PAGE, isoelectric focussing gels, 2-D gel electrophoresis, detection, estimation & recovery of proteins from gels.

4.3 Electrophoresis of nucleic acids: agarose gel electrophoresis of DNA, DNA sequencing gels, pulse field gel electrophoresis (PFGE), electrophoresis of RNA.

4.4 Centrifugation: principle & types: differential, density gradient and ultracentrifugation.

Unit V: Nucleic acid isolation and purification

5.1 Methods for isolation of plant genomic DNA, quantification of DNA.

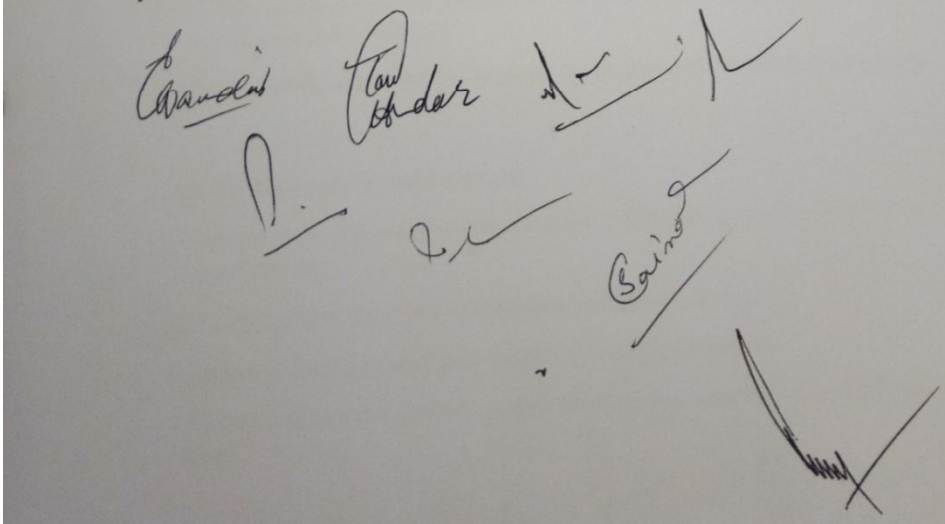
5.2 Recovery and purification of DNA from gels.

5.3 RNA isolation, purification and quantification, plasmid extraction and purification.

5.4 Nucleic acid blotting methods: southern, northern, western and dot blotting.

Note for Paper Setter:

The question paper will have 10 questions, two from each unit. The candidate will be required to attempt five questions in all, selecting one from each unit. All questions carry equal marks.



Course Outcome:

- To develop understanding of the basic framework of research process.
- To develop an understanding of various research designs and techniques.

- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research
- Appreciate the components of scholarly writing and evaluate its quality.

Syllabus for M.Phil (Biotechnology) Examination-2016

Credits: 04
Maximum Marks: 100
Duration: 3 hrs

Paper II: Plant Biotechnology

Unit I: Organisation of plant genome in chromosomes

1.1 Plant nuclear genomes: non-nuclear genomes, and DNA sequences.
1.2 Composition of nuclear DNA, genome size or nuclear DNA content, chromosome number and chromosome size.
1.3 Features of plant chromosome: centromere, euchromatin, heterochromatin, NOR, subtelomers and telomeres, significance of chromosome organisation.
1.4 Sex chromosomes and sex determination in plants.

Unit II: Estimation of plant genome

2.1 Techniques to measure chromosomal change: array comparative genome hybridisation & SNP microarrays.

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

2.3 C- value paradox, range of interspecific and intra specific variation, origin of quantitative DNA variation.

2.4 Determination of genome size in plants: micro densitometry and flow cytometry.

Unit III: Plant gene transfer methods

3.1 Vectors: basic features of vectors for plant transformation, use of reporter genes in plant transformation.

3.2 Co- integrative and binary vectors, family of binary vectors.

3.3 Agrobacterium mediated gene transfer, Ti – plasmid features.

3.4 Direct gene transfer methods: particle bombardment, electroporation, PEG- mediated gene transfer.

Unit IV: Genetically modified crops

4.1 Bt – based genetic modification of plants: insect resistance, herbicide resistance.

4.2 Biotechnological approaches to disease resistance, protection against fungal pathogens, antimicrobial proteins.

4.3 Modification of plant nutritional content (vitamins, amino acids & lipids).

4.4 Modification of food plant taste and appearance (sweetness, starch & preventing discolouration).

Unit V: Molecular markers

5.1 Molecular markers: properties, types and applications; marker assisted selection.

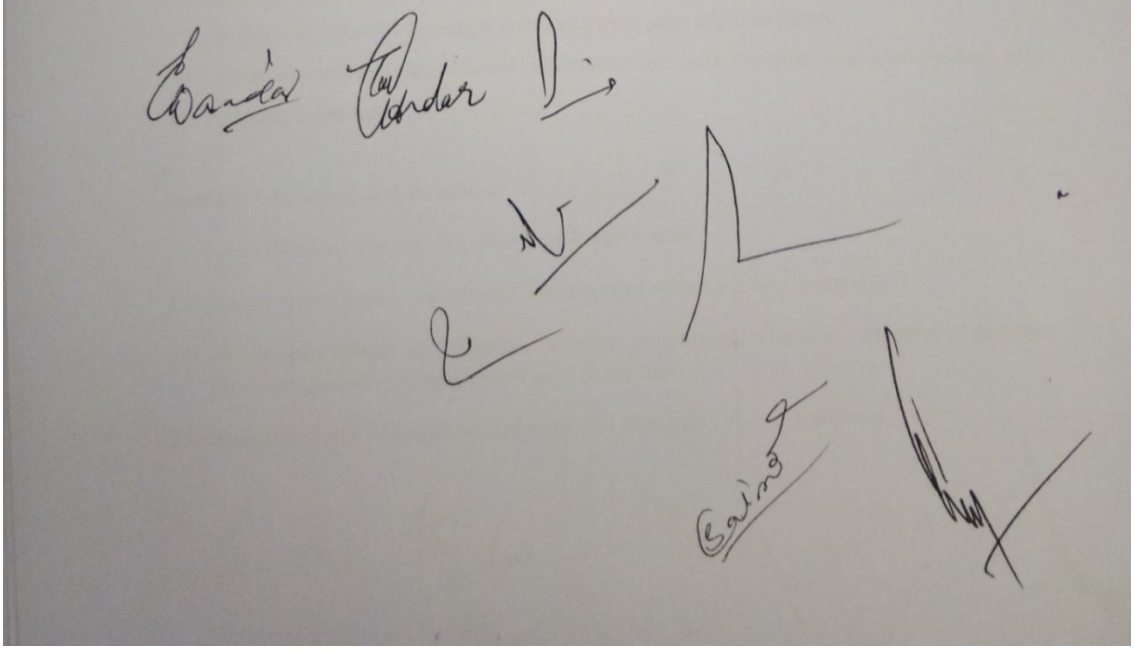
5.2 RAPD, SSR & SNPs: methodology, principle, properties, advantages & limitations.

5.3 AFLP & MSAP: principle, methodology, properties, advantages & limitations.

5.4 Quantitative trait loci (QTL) mapping: introduction & types of mapping populations.

Note for Paper Setter:

The question paper will have 10 questions, two from each unit. The candidate will be required to attempt five questions in all, selecting one from each unit. All questions carry equal 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.

Paper III: Inheritance Biology

Unit I: Mendelian Principles and Extensions

1.1 Mendelian principles: dominance, segregation and independent assortment.

1.2 Entension of Mendelian principles: codominance, incomplete dominance, gene interaction, pleiotropy.

1.3 Genomic imprinting, penetrance and expressivity, phenocopy.

1.4 Mechanism of sex determination in Humans and Drosophila, dosage compensation.

Unit II: Inheritance and Mapping

2.1 Concept of gene, Allele, Multiple alleles, pseudoallele, complementation testes.

2.2 Crossing over: Cytological and molecular mechanism of crossing over.

2.3 Linkage maps, tetrad analysis, mapping with molecular marker, mapping by using somatic cell hybrids, development of mapping population in plants.

2.4 Extrachromosomal inheritance: inheritance of mitochondrial and choloroplast gene, maternal inheritance.

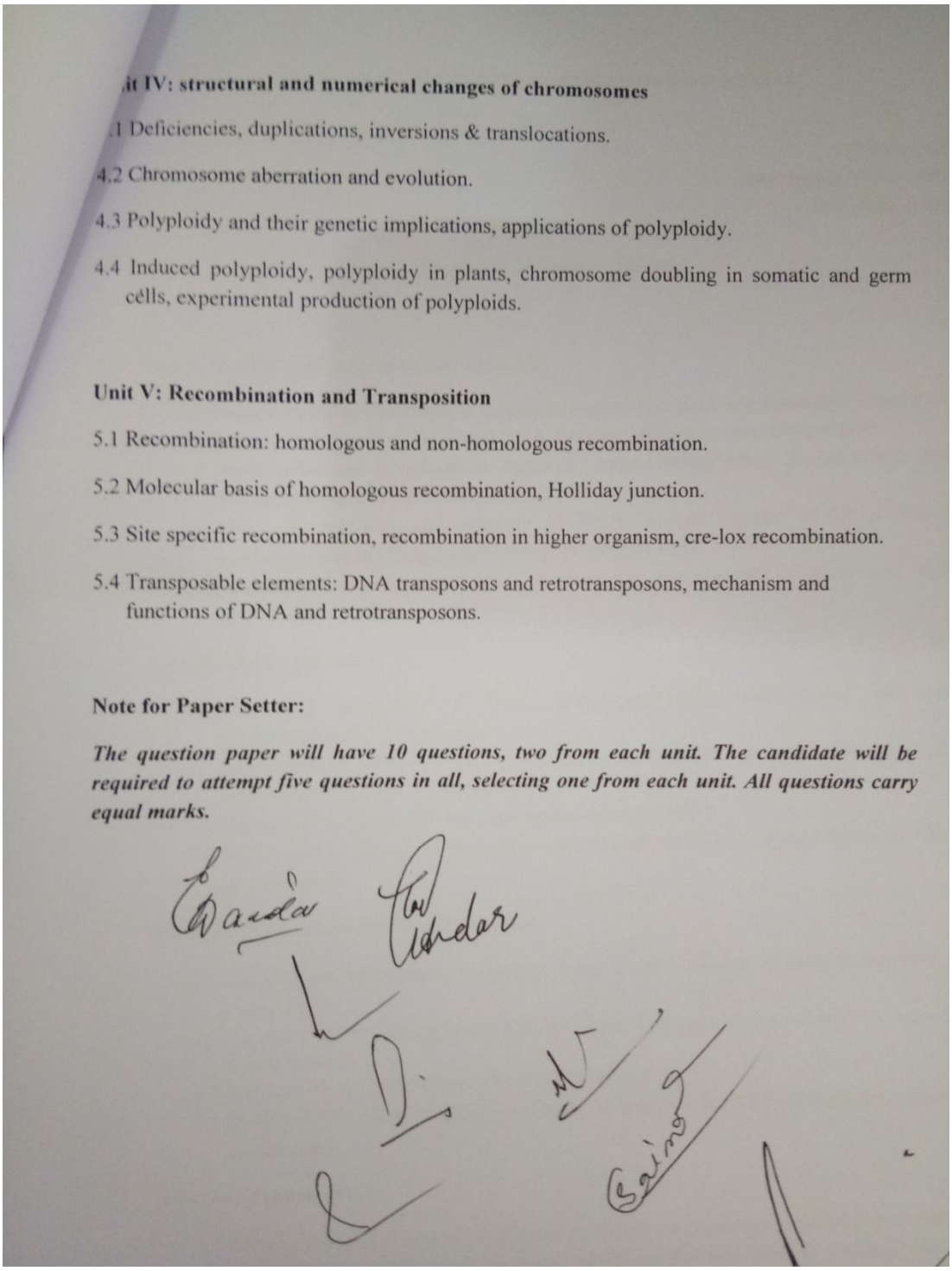
Unit III: Mutation and its effects

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.



it IV: structural and numerical changes of chromosomes

.1 Deficiencies, duplications, inversions & translocations.

4.2 Chromosome aberration and evolution.

4.3 Polyploidy and their genetic implications, applications of polyploidy.

4.4 Induced polyploidy, polyploidy in plants, chromosome doubling in somatic and germ cells, experimental production of polyploids.

Unit V: Recombination and Transposition

5.1 Recombination: homologous and non-homologous recombination.

5.2 Molecular basis of homologous recombination, Holliday junction.

5.3 Site specific recombination, recombination in higher organism, cre-lox recombination.

5.4 Transposable elements: DNA transposons and retrotransposons, mechanism and functions of DNA and retrotransposons.

Note for Paper Setter:

The question paper will have 10 questions, two from each unit. The candidate will be required to attempt five questions in all, selecting one from each unit. All questions carry equal 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.

- 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.

Syllabus for M.Phil (Biotechnology) Examination-2016

Credits: 04
Maximum Marks: 100
Duration: 3 hrs

Paper IV: Molecular Biology

Unit I: Nucleic acid structure and functions

1.1 Nucleic acids as information macromolecules, chemical and molecular structure of nucleic acids, types of DNA and RNA, Satellite, Repetitive and Unique DNA.
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 II: DNA replication

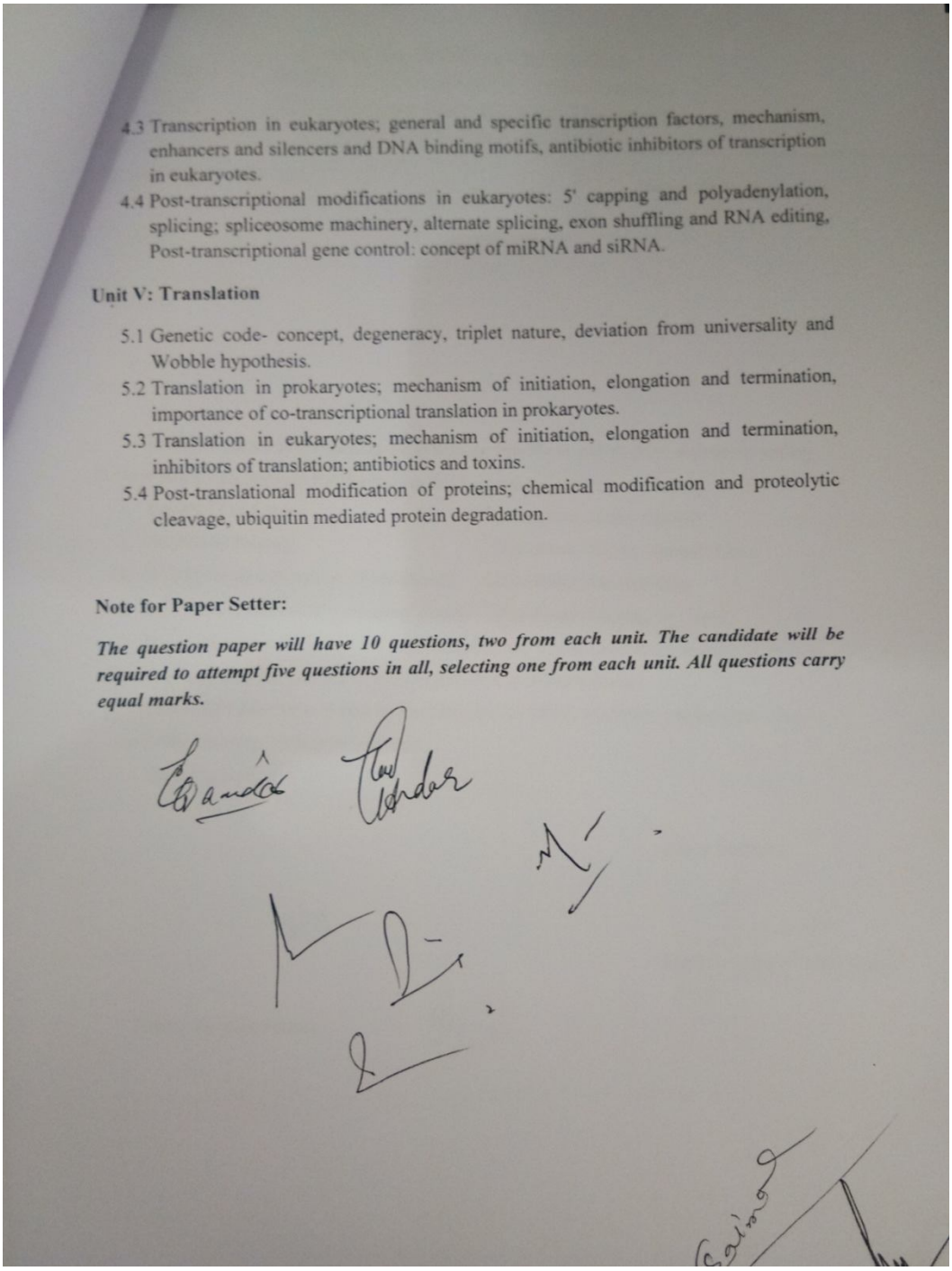
2.1 Need for replication of DNA, semi-conservative, bidirectional and semi-discontinuous DNA replication.
2.2 Mechanism of DNA replication; enzymes and accessory proteins required in DNA replication of *E .coli* chromosome.
2.3 Replication of phage DNA and extrachromosomal DNA.
2.4 Replication of DNA in eukaryotes; enzymes and accessory proteins involved, control of replication.

Unit III: DNA repair and recombination

3.1 DNA repair mechanism; mismatch repair, base excision, nucleotide excision and direct repair.
3.2 Recombination: homologous recombination; Holiday junction; Proteins involved in recombination
3.3 Site specific recombination; *Cre-lox* recombination.
3.4 Mobile DNA; essential parts, insertional sequences, complex transposons, composite transposons.

Unit IV: 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: concept of miRNA and siRNA.

Unit V: 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 10 questions, two from each unit. The candidate will be required to attempt five questions in all, selecting one from each unit. All questions carry equal 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.

Pre-Ph.D Course Syllabus

S.No.	Course Code	Course Title	Duration [Hours]	Credits	Total Marks
1	Paper I	Research Methodology	72	4	100
2	Paper II	Fundamentals of Medical Genetics	72	4	100

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 Ph.D Biotechnology course, the students will be able to:

- Keep pace with the expanding frontiers of knowledge and provides research training relevant to the present social and economic objectives of the country.
- Use the scientific methods, and critical thinking skills to ask questions and solve problems.
- Write a good research report and acquires the skill of presenting data in graphical form.
- 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 bioharzrdous 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.
- Work in a government-based entity such as Universities, research institutes or at private centers as research scientists/assistant in the native country and outside as well.

Syllabus for Pre-Ph.D Examination-2017
Paper I (Zoology & Biotechnology)

Title of the Paper : Research methodology

Credits: 04
Maximum Marks: 100
Duration: 3 hrs

Unit I : Literature survey and scientific writing

1.1 Library and Research Documentation – Methods of literature collection, online Internet and Website.
1.2 Technical papers, Reviews, Monographs and Abstract services, Information storage and retrieval, Plagiarism-concept and its consequences.
1.3 Preparation and presentation of research papers for Journals, Symposia and Conferences-Impact factor-citation index- refereed journals.
1.4 Experimental approach – Designing of Methodology – Planning and Execution of Investigations – Methods of Editing and Abstracting, Preparation of Manuscript and Proof Reading – Thesis Writing.

Unit II : Microscopy

2.1 Microscopy: Light Microscopy, Bright field, Phase contrast, DIC, Fluorescence Microscopy.
2.2 Confocal Microscopy, SEM & TEM, Histology, and Histochemistry.
2.3 Different fixation and staining techniques for EM, freeze-etch and freeze fracture methods for EM.
2.4 Live cell imaging and its applications.

Unit III : Centrifugation and Electrophoresis

3.1 Centrifuges: Types of centrifuge - Differential & density gradient centrifugation.
3.2 Chromatography: TLC and Paper chromatography; Reverse-phase and Affinity chromatography and HPLC.
3.3 Electrophoresis: Agarose gel electrophoresis; isoelectric focusing, Pulsed field gel electrophoresis, SDS PAGE and their Applications.
3.4 ELISA and Radioimmunoassay, FISH and GISH.

Unit IV : Radiation Biology and Spectroscopy

4.1 Isotopes half life, GM counter, autoradiography.
4.2 Principles and Applications of Tracer Techniques in Biology, Brief idea of radiation dosimetry.
4.3 Spectroscopy: Basic principles, instrumentation and use of UV and IR.
4.4 Mass spectroscopy: LC-MS, GC-MS and MALDI-TOF.

Unit V : Nucleic acid isolation and Biostatistics

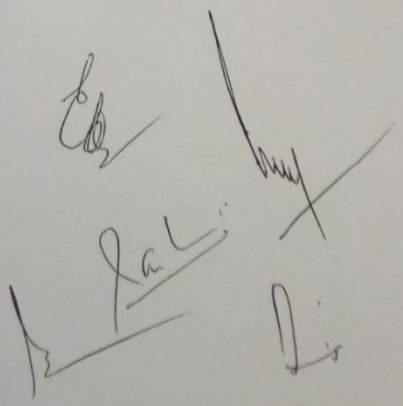
5.1 Genomic and plasmid DNA isolation. PCR: basic principle, types and applications.
5.2 Blotting techniques: Northern blot, Southern blot and Western blot. Flow cytometry, X-ray diffraction by crystals.
5.3 Test of Hypothesis and two types of error's. Tests of means and proportions-students t test, Chi square test and their applications.
5.4 Analysis of Variance (one way and two way). Correlation, simple partial and multiple correlations. Simple and multiple regressions and their use in biology.

Note for Paper Setter:

The question paper will have 10 questions, two from each Unit. The candidate will be required to attempt five questions in all, selecting one from each Unit. All questions carry equal marks.

References

1. Keith Wilson and John Walker (2009). Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University press.
2. William Elliott and Daphne C. Elliott (2009). Biochemistry and Molecular Biology, 4th edition, Oxford University press.
3. Chandler DE, RW. Roberson, (2009). Bioimaging: Current concepts in light and electron microscopy, Jones & Bartlet Publishers, Sndburry, MA, USA.
4. Hoppert M, (2003). Microscopic Techniques in biotechnology, Wile-VCH GmbH & Co., Weinheim, Germany.



Course Outcome:

- To develop understanding of the basic framework of research process.
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research
- Appreciate the components of scholarly writing and evaluate its quality.

BABA GHULAM SHAH BADSHAH UNIVERSITY

School of Biosciences and Biotechnology

Syllabus for Pre-Ph.D Examination-2017

Paper II-Biotechnology

Title:Fundamentals of Medical Genetics **Credits: 04**

Name of Candidate: YaserRafiq Mir **Maximum Marks: 100**

Unit I: 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 & gene interactions: Multiple alleles, pleiotropic effects, partial penetrance &variable expressivity

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 II: Molecular Genetics

2.1 DNA organisation in eukaryotic chromosomes; DNA markers: RFLPs, VNTRs, CNVs, SNPs

2.2 DNA genotyping and sequencing, concept of linkage disequilibrium (LD), haplotypes and tag SNPs

2.3 Molecular basis of mutations: Gene mutations, sources of mutations, types of mutations and effects of mutations

2.4 Genomics: Human genome project; Next generation DNA sequencing; Genome wide association studies;Beyond Genomics: Epigenetics.

Unit III: Genetic Disorders-I

3.1 History of human genetics

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

3.3 Autosomal inheritance: dominant, recessive, consanguinity and its effects

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

Unit: IVGenetic Disorders-II

4.1 Genetic disorders caused by structural and numerical chromosomal abnormalities: DiGeorge Syndrome, Cri-du-chat syndrome, Down's Syndrome, Patau Syndrome, Edward Syndrome

4.2 Genetics of Psychiatric Disorders: Autism Spectrum Disorders (AUT); Bipolar Disorders (BIP); Intellectual Disabilities

4.3 Basic concepts of cancer genetics;Inborn errors of metabolism and their genetic basis- Phenylketonuria, Maple Syrup Urine Syndrome

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

Unit V Bioinformatics

5.1 Introduction and scope of bioinformatics in genetic research

5.2 Nucleic acid sequence databases (GenBank, EMBL), Protein Sequence Databases (SWISS-PROT, TrEMBL, PIR)

5.3 Genome Databases at NCBI, EBI, TIGR, SANGER.

5.4 Database similarity search tools: BLAST (BLASTn, BLASTp, PSI-BLAST); FASTA. Multiple Sequence Alignment by CLUSTALW

Note for the paper setter:

The question paper will have 10 questions, two from each unit. The candidate will be required to attempt five questions in all, selecting one from each unit. All questions carry equal marks.

Books recommended:

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

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