UNIVERSITY OF KASHMIR

DEPARTMENT OF BIOTECHNOLOGY

http://biotechnology.uok.edu.in/

(NAAC Accredited Grade "A")

SYLLABI AND COURSE OF STUDY FOR

M.Sc PROGRAM IN BIOTECHNOLOGY

BASED ON CHOICE BASED CREDIT SYSTEM

A candidate has to obtain a minimum of twenty four (24) credits per semester, and a total of ninety six (96) credits in all the four semesters. All the core courses are compulsory for the students pursuing M Sc program in Biotechnology. The remaining credits can be made up from the Elective (Allied) courses offered by the department or other allied departments of the faculty, and from General Open electives offered by departments other than the department of Biotechnology. However, while making up for the remaining credits, following points should be considered.

1. A minimum of eight credits per semester have to be obtained from the pool of Electives (Allied) courses, offered by the department or other allied departments of the faculty
2. A minimum of four (4) credits from Electives (Open) are to be obtained by a candidate from outside the Department during the whole Course.
3. The fourth semester consists of a research based project and all the credits are covered by the core project components

Note: The students are advised to contact the Course Advisor in the department before filling up their choices for allied and general electives

EFFECTIVE FROM MARCH, 2014

LIST OF COURSES

Sr. No.	Course Code	Course Title	Credit distribution			Total Credits	SEE	IA	Total Marks	Semester
			L	T	P					
CORE COURSES (COMPULSORY 12 CREDITS EACH SEMESTER)										
1	BT-101-CR-14	Cell Biology	2	1	1	4	80	20	100	First
2	BT-102-CR-14	Molecular Biology-I	2	1	1	4	80	20	100	
3	BT-103-CR-14	Immune Biology	2	1	1	4	80	20	100	
4	BT-201-CR-14	Plant Biotechnology	2	1	1	4	80	20	100	Second
5	BT-202-CR-14	Molecular Biology-II	3	1	0	4	80	20	100	
6	BT-203-CR-14	Advanced Enzymology	2	1	1	4	80	20	100	
7	BT-301-CR-14	Genetic Engineering	2	1	1	4	80	20	100	Third
8	BT-302-CR-14	Animal cell Science and Technology	2	1	1	4	80	20	100	
9	BT-303-CR-14	Bioprocess Engineering and Fermentation technology	3	1	0	4	80	20	100	
10	BT-401-CR-14	Proposal writing	1	1	0	2	0	50	50	Fourth
11	BT-402-CR-14	Research based Project	0	0	16	16	320	80	400	
12	BT-403-CR-14	Seminar and Journal Club	0	2	0	2	25	25	50	
13	BT-404-CR-14	Project presentation	0	2	0	2	40	10	50	
14	BT-405-CR-14	Project viva	0	2	0	2	50	0	50	
ELECTIVE S (ALLIED) - EA: These courses are open to students of Biotechnology and other allied Departments										
1	BT-104-EA-14	Protein Structure and Function	1	1	1	3	60	15	75	First
2	BT-105-EA-14	Microbiology	2	1	0	3	60	15	75	
3	BT-106-EA-14	Biostatistics	1	1	1	3	60	15	75	
4	BT-107-EA-14	Electrophoresis and chromatography	1	1	1	3	60	15	75	
5	BT-204-EA-14	Radioactivity and Centrifugation	1	1	0	2	40	10	50	Second
6	BT-205-EA-14	Oxidant signaling	1	1	0	2	40	10	50	
7	BT-206-EA-14	Chromatin Biology and Epigenetics	1	2	0	3	60	15	75	
8	BT-207-EA-14	Non-Coding RNA and Neurological Diseases	1	1	0	2	40	10	50	
9	BT-208-EA-14	Protein Folding Dynamics	1	1	1	3	60	15	75	
10	BT-304-EA-14	Intermediary Metabolism	1	1	0	2	40	10	50	Third
11	BT-305-EA-14	Stem Cell Biology	1	1	0	2	40	10	50	
12	BT-306-EA-14	Bioinformatics	1	1		2	40	10	50	
13	BT-307-EA-14	Human and Medical Genetics	2	1	0	3	60	15	75	
14	BT-308-EA-14	Cancer Immunology	1	1		2	40	10	50	
15	BT-309-EA-14	Transcriptional Biology	1	1	1	3	60	15	75	Open
ELECTIVE OPEN (EO): These courses are open to students from all Departments except Biotechnology										
1	BT-001-EO-14	Basics in Biotechnology	1	1	0	2	40	10	50	First/ Third
2	BT-002-EO-14	Basics in Metabolism	1	1	0	2	40	10	50	
3	BT-003-EO-14	Basics in Immunology	1	1	0	2	40	10	50	Second/ Fourth
4	BT-004-EO-14	Concepts in Molecular Biology	1	1	0	2	40	10	50	

Grading Scheme

It is compulsory to fulfill 75% or above of attendance (both regular and interdisciplinary courses) for appearing in the semester end examinations. **NOTE:** Pending required attendance candidates shall not be allowed to appear neither in internal assessment test nor in semester – end examination, unless he/she completes the deficiency in attendance and shall appear in the successive examination for that paper. However, the other provision like medical leave, representation of student in NCC, NSS, sports, cultural activities etc recommended by Head of the Department shall be taken into consideration.

Actual Marks Transformation into Grade Letters (Performance) and Grade Points (Weightage)

Range of Percentage Marks obtained in a particular course / paper	Grade Letters	Grade Points (GP)
90 to 100	A+	10
80 to <90	A	9
70 to <80	B	8
60 to <70	C	7
50 to <60	D	6
40 to <50	E	5
Less than 40	F	0

Grading Scheme at the end of Semester examination: Grades at the end of semester will be based on **Semester Grade Points Average (SGPA).** ***Note:*** SGPA is calculated only when the candidate passes in all the papers and gets a minimum of "E" grade. An Example of Candidate who secures 100% Marks in cumulative credit of 24/Semester.

	Category	Credits	T. Marks		% Marks Obtained	Grade letter	Grade points (GP)	Credit Points (CP) (CP is calculated by multiplying GP earned for a particular paper with the credit allotted for the same paper).	SGPA (SGPA is calculated by dividing total Credit Points earned in a given semester divided by total Credits taken in a given semesters)
			SEE	IAA					
Semester I	CR	4	80	20	100	A+	10	40	
	CR	4	80	20	100	A+	10	40	
	CR	4	80	20	100	A+	10	40	
	EO	2	40	10	50	D	6	12	
	EA	3	60	15	75	A	9	27	210/24 = **8.75**
	EA	3	60	15	75	A	9	27	
	EA	2	40	10	50	D	6	12	
	EA	2	40	10	50	D	6	12	

Grading Scheme at the end of two year program: Grades at the end of two years will be based on **Cumulative Grade Point Average (CGPA**). ***Note:*** CGPA is calculated only when the candidate passes in all papers of all the semesters.
An Example of Candidate who secures different Credit Points in each semester.

Period	Total Credits taken/Semester	Total Credit Points earned	CGPA (Total Credit Points in all Semesters divided by Total Credits taken in all semesters).
Semester 1	24	210	. 210+200+190+210/24+25+24+26 = **8.18**
Semester 2	25	200	
Semester 3	24	190	
Semester 4	26	210	

FINAL RESULT

Result	CGPA
1st Division with Distinction	9-10
1st Division	8-8.99
2nd Division with 55 % Marks	7-7.99
2nd Division	6-6.99
Pass	5-5.99

1st Semester Core papers		
1	BT-101-CR-14	Cell Biology
2	BT-102-CR-14	Molecular Biology-I
3	BT-103-CR-14	Immune Biology

Course No:	BT-101-CR-14	Maximum marks		100	
Course title:	Cell biology	Theory		Practical	
		IA	SEE	IA	SEE
Credits:	Four	15	60	10	15

UNIT-I: Cellular diversity: An Overview. Structural features of Prokaryotic and Eukaryotic cells. Cyanobacteria. Mycoplasmas. Viruses. Structure of Viruses. Microscopy: Fundamentals of Light and electron microscopy. Phase contrast Microscopy. Fluorescence Microscopy. Confocal Microscopy. Cellular organelles—Plasma membrane, Lysosomes, Cell wall, Mitochondria, Chloroplast, Vacuoles, Nucleus and other organelles. Structural organization of cellular organelles. Structure and function of endoplasmic reticulum, ribosomes and Golgi complex.

UNIT-II: Membranes. Various membrane models. Membrane lipids. Asymmetry of membranes. Membrane Proteins. Glycosylation of membrane Proteins. Transport of nutrients, ions and macromolecules across membranes. Transmitter-gated ion channels. Facilitated diffusion through cell membrane. Active transport. Endocytosis. Exocytosis. Phagocytosis and pinocytosis. Vesicular transport and secretory pathways. Protein trafficking across organelles. TIM-TOM complexes. Role of mitochondria and chloroplast in energy harvest. Electron transport chain and proton pumps. Cyclic and non-cyclic photophosphorylation. Proton-motive force in mitochondrion and chloroplasts.

UNIT-III: Molecular signaling: Introduction. Scaffolding proteins. Modular proteins. Classes of receptors. G-proteins. Structure. Signaling through G-protein linked cell surface receptors. Role of cAMP, Diacylglycerol and Inositol. Ca^{2+} in signaling. CaM Kinases. Signaling through Enzyme linked cell surface receptors. PI3K and Shc operated pathways. JAK-STAT pathway. Notch signaling pathway. MAP Kinases in signaling. Signaling through ion-channel linked receptors. Ubiquitination. Signaling through regulated proteolysis. Cell cycle—Molecular events and regulatory controls, with emphasis on animal cells and yeast cell divisions. Role of different Cyclin-dependent Kinases. Regulation by cdc25 phosphatase. Cell cycle checkpoints. G1 and G2 checkpoints. Role of Rb and p53 proteins. Extracellular control of Cell division.

UNIT-IV: Control of cell numbers in multi-cellular organisms. Programmed cell death. Caspases. Intrinsic and extrinsic pathways of apoptosis. Role of Bcl2 family of proteins. Cancer: Introduction. Types. Cancer Grades/Stages. Molecular basis of cell proliferation. Viruses and chemicals as a cause of cancers. Oncogenes. Loss of Tumor suppressors. Cancer therapeutics and treatment. Cytoskeletal structures: Structure and function of Microtubules, Microfilaments and Intermediary filaments. Dynamic instability and Treadmilling. Regulation of cytoskeletal filaments. Higher order structures of Cytoskeletal filaments. Microtubule motor protein and their significance, microtubules and actin filaments, actin-myosin complex, Mechanism of muscle contraction and motor proteins. Cytoskeletal structures and Cell behavior. Brief introduction to cellular basis and differentiation and development with special reference to Drosophila and Arabidopsis.

Practical(s):

1. Demonstration of safety rules in laboratory.
2. Autoclaving.
3. Culturing of bacteria (*E. coli*).
4. Serial dilution technique.
5. Growing yeast *Saccharomyces cerevisiae* in liquid and solid media.
6. Plating techniques; spread plating, streak plating and replica plating.
7. Extraction of proteins from E. Coli and mammalian tissues.
8. Western blotting of extracted proteins.
9. Immunoprecipitations and co-immunoprecipitation experiments.

Books Recommended:

1. Molecular Biology of the Cell by Alberts et al: Garland Science, Taylor and Francis, New York. USA.
2. Molecular Cell Biology by Lodish et al: W.W Freeman and Company, New York, USA.

Course No:	BT-102-CR-14	Maximum marks		100	
Course title:	Molecular biology-I	Theory		Practical	
		IA	SEE	IA	SEE
Credits:	Four	15	60	10	15

UNIT-I: DNA Replication: DNA as a genetic material. Building blocks of DNA. Structure of B-DNA, A-DNA and Z- DNA. General biophysical properties of DNA. Forces that stabilizes DNA structure. General features of DNA replication: Semi-conservative versus conservative and dispersive mode of replication. Semi-discontinuous replication. Directionality of DNA replication with examples from prokaryotic and eukaryotic systems. Priming of DNA replication. General features of sigma mode of replication. Rolling circle mode of replication with examples from M13 and lambda phage genome replication. Enzymology of DNA replication (prokaryotic and eukaryotic): Structure and function of various enzymes/proteins involved in DNA replication. DNA helicases: Structure/function and the experimental method to elucidate the DNA helicase activity. Primases: Structure/function. Single stranded binding proteins, Topoisomerases: structure/function and the mechanism/model involved in relieving DNA super- coils during replication. DNA polymerases: Structure and function of various prokaryotic (DNA Pol I, DNA Pol III holoenzyme) and eukaryotic DNA polymerases. Molecular mechanism of DNA polymerization. Role of magnesium during the polymerization of nucleotides. Proofreading activity of DNA polymerases and its molecular mechanism.

UNIT-II: Replication initiation (prokaryotes and eukaryotes): Origin of replication. Molecular components involved. Formation of Primosome and origin recognition complex. Various mechanisms involved in the regulation of replication in prokaryotes and eukaryotes. Replication elongation: Processivity of DNA polymerases. Structure and function of beta-clamp and PCNA (proliferating cell nuclear antigen). Structure and function of DNA pol III gamma-complex as clamp loader and unloader. Model for leading and lagging strand synthesis. Replication Termination: Termination in prokaryotes and the molecular components involved. Decatenation of newly replicated circular genomes. End replication of linear genomes. Telomers: Function and structure. Telomerase: role in the formation of telomers and the molecular mechanism involved. Telomer binding proteins. t-loop formation and the proteins involved. Telomerase in ageing and cancer.

UNIT-III: DNA Repair and Recombination: DNA damage and Mutation: Physical and chemical DNA damaging agents. Spontaneous hydrolysis and deamination of DNA bases. Alkylating agents and radiations. Base analogues and intercalating agents. DNA repair systems: Direct reversal repair system (examples from prokaryotes and eukaryotes). Excision Repair system: Base excision and nucleotide excision repair mechanisms (examples from prokaryotes and eukaryotes). Mismatch repair system. Double-strand DNA break repair system: Homologous recombination repair and non-homologous end-joining (NHEJ) repair systems. DNA damage by- pass systems: Error-prone bypass in prokaryotes. Molecular Recombination. Homologous recombination: General features: Alignment of homologous DNAs. Generation of double-stranded breaks. Strand invasion and hetro-duplex formation.Holliday junctions and Branch migration. Homologous recombination in Eukaryotes. Molecular mechanism of meiotic recombination and its significance.

UNIT-IV: Prokaryotic Transcription: Promoters: structure and function. RNA polymerases: Molecular composition, structure and function of each subunit. Role of sigma factor in promoter recognition and open promoter formation. Alternative sigma factors and their biological role. Single subunit RNA Polymerases (T3, T7 RNA Polymerases). Molecular events of transcription initiation. Transcription elongation. Elongation core complex: Structure and function. Proofreading during elongation. Transcription termination: Molecular mechanism of Rho dependent and independent termination. Regulation of bacterial transcription: Operons: Lac operon: Basic features. Mechanism of negative control. Lac repressor (structure and function). Role of CAP in lac operon. Trp operon: Structure and regulation. Negative regulation. Regulation by attenuation.

Practical(s):

1. Isolation of Genomic DNA, and RNA.
2. Agarose electrophoresis and Quantification of DNA and RNA.

Books Recommended:

Transcriptional Regulation in Eukaryotes: Concepts, Strategies, and Techniques by Michael F Carey, Stephen T Smale and Craig L Peterson.

Gene Regulation by David S. Latchman fifth edition.

Molecular Biology by Robert F Weaver: McGraw-Hill Higher Education.

Molecular Biology of the Gene by James D. Watson, et al: Pearson.

Lewins gene XI by Jocelyn E Krebs, et al: Jones and Bartlett Learning

Course No:	**BT-103-CR-14**	**Maximum marks**		**100**	
Course title:	**Immune biology**	**Theory**		**Practical**	
		IA	**SEE**	**IA**	**SEE**
Credits:	**Four**	**15**	**60**	**10**	**15**

UNIT-I: Non-Specific Innate Immunity: External resistance factors: Physical: connective tissue, blood brain barrier. Chemical barriers: lysozymes and other enzymes in blood and tissue system. Cytokine and their receptors. Cellular Defenses: Receptors Involved in the Innate Immune System. Phagocytosis and Extracellular Killing. Inflammation. Complement fixation and activation. Humoral mechanisms. Natural Killer cell receptors and its effector function.

UNIT-II: Specific Acquired Immunity: B cell activation and differentiation. Immunoglobulins structure and function. T cell activation and differentiation. TCR structure and function. B cell effector functions, and Humoral Immune response. T cell effector functions, and cell mediated immune response. Major histocompatibility genes and proteins. Antigen processing and presentation. The generation of diversity for antigen recognition. Adaptive Immunity to Infection. The mucosal immune system. Immunological memory.

UNIT-III: The Immune System in Health and Disease: Immunological tolerance and its loss. Resistance and Immunization to Infectious diseases. Mechanisms by which Pathogens evade Immune response. Types of Hypersensitivity. Transplantation. Tumor Immunology. Inherited and acquired immune diseases.

UNIT-IV: Immunological methods and application: Antigen and Antibody interaction. Immunoassays, Immunofloresence. Fluorescence Activated Cell sorting system (FACS). Immunoabsorption and Immunoadsorption. Cellular assays: B, and T cell proliferation and function assays. Cell culture: Primary cell culture and cloned lymphoid cell lines. B cell hybridomas and Monoclonal Antibodies. T cell Hybridoma.

Practical(s):

1. Immunoprecipitation (IP)
2. Western Blotting

Books recommended:

1. Immunology by Janis Kuby, W.H.Freeman & Co Ltd.
2. Basic Immunology: Abul K. Abbas, Andrew H. Lichtman.
3. Janeway's Immunobiology, Garland Sciernce.

2nd Semester Core papers		
1	BT-201-CR-14	Plant Biotechnology
2	BT-202-CR-14	Molecular Biology-II
3	BT-203-CR-14	Advanced Enzymology

Course No:	BT-201-CR-14	Maximum marks		100	
Course title:	Plant biotechnology	Theory		Practical	
		IA	SEE	IA	SEE
Credits:	Four	15	60	10	15

UNIT-I: General structure, organization & Molecular basis of Shoot Apical Meristem(SAM) & Root Apical meristem (RAM). Totipotency of Plant cell, Plant cell cycle, Role of various hormones in regulating plant cell cycle, Micropropagation (Seed V/S Soma), Stages & methods of micropropagation. Production of virus free plants. Tissue culture media (Composition & preparation),Role of micro, macro nutrients & other components present in tissue culture media, Commonly used media (Murashige and Skoog etc) Initiation and Maintenance of callus and suspension culture, Single cell clones Organogenesis: Basis, applications & control of Somaclonal variation. Somatic embryogenesis- acquisition of embryogenic competency, factors & genes influencing the embryogenic competency of cell during somatic embryogenesis, Synthetic seeds. Embryo rescue.

UNIT-II: Protoplast isolation (mechanical & enzymatic methods), maintenance, purification, viability, Culture and fusion (Spontaneous & induced fusion, sodium nitrate, calcium ion, PEG, electrofusion). Identification & Selection of hybrid cells and regeneration of hybrid plants; Symmetric & Asymmetric hybrids, Cybrids-formation and applications. Anther, pollen and ovary culture for the production of haploid homozygous lines, Molecular mapping, Introduction to genetic and physical maps, physical mapping

UNIT-III: Plant Transformation Technology; Morphology of Agrobacterium tumefaciens, Features of Ti Plasmids, Opines and its Types, Basis of tumor formation, Factors influencing binding of Agrobacterium to plant, Mechanism of T-DNA transfer & Role of virulent proteins in (Formation of T-DNA strand, movement of T-Complex & Integration of T-DNA into Plant genome), Features of Binary vectors & its Types (pBIN19, pGreen, pCAMBIA, etc), Promoters used in Ti vectors (CaMV 35S and other promoters), Use of reporter genes(Opine synthase, CAT, GUS, LUX, GFP) and selectable markers (antibiotic & herbicide resistant genes, Metabolic intermediates etc) Generation of marker free plants (using Cre-Lox & other Excision techniques), Vector less or direct DNA transfer (Particle bombardment, Electroporation, WHISKERS, Pollen tube entry, Floral dip, Liposome mediated,etc). Plant transformation for productivity and performance with special example of

Herbicide resistance (Glyphosate & Phosphinothricin resistance), Insect resistance (Bt based plants), Disease resistance (Role of R-proteins & other molecules), long shelf fruit and flowers, Stress tolerance (water deficit stress, Role of osmoprotectants and other molecules).

UNIT-IV: Molecular farming: Methodology involved in the production of Golden rice, Metabolic engineering of carbohydrates (Starch and fructan production), lipids (production of shorter & longer chain fatty acids, Modification of the degree of saturation). Production of Biodegradable plastic, Production Therapeutic protein in plants (Hirudin, Glucocerebrosidase, etc), Purification strategies for proteins-Oleosin partitioning Technology, Plantibodies (full length, scFv, Minibody, Diabody, Bispecific) Edible Vaccines, Manipulation of Shikimate pathway for the production of Vitamin E, Chloroplast Transformation (Mechanism & Advantages), Principle & applications of Gene termination technology, Concerns about Genetically modified plants

Practical(s):

1. Preparation of plant tissue culture media.
2. Tissue culture of some plants.

Books Recommended:

1. Plant Biotechnology: The Genetic Manipulation of Plants Adrian Slater Nigel W. Scott Fowler: Oxford University Press.
2. Introduction to Plant Biotechnology: H S Chawla: Science Publishers, Inc.
3. Plant propagation by Tissue Culture : Edwin F. George,Michael A Hall: Springer-verlag.
4. Agrobacterium: From Biology to Biotechnology: Tzfira,Tzvi,Citovsky,Vitaly: Springer verlag

Course No:	**BT-202-CR-14**	**Maximum marks:**	**100**
Course title:	**Molecular biology-II**	**Continuous assessment:**	**20**
Credits:	**Four**	**Semester end examination:**	**80**

UNIT-I: Eukaryotic transcription: Eukaryotic RNA polymerases: RNA Pol I, RNA Pol II and RNA pol III (structure and the genes they regulate). Promoters: Class II promoters: Structure and function (core promoter elements, upstream elements, downstream elements, initiator elements). Class II general transcription factors: structure and function. Mechanism of transcription initiation at class II promoters. Pre-initiation complex. Recruitment and holoenzyme model of pre-initiation complex formation. Promoter clearence and RNA Pol II CTD phosphorylation. Class I promoters: Structure and function (core elements, upstream elements). Class I transcription factors. Class III promoters: Structure and function. Class III transcription factors. Transcription elogation: Molecular mechanism. Proofreading and RNA pol II pausing. Transcription termination. Termination signals and the molecular events.

UNIT-II: Eukaryotic Gene Regulation: Mechanism of Regulation. Regulatory Elements, Enhancers, Silencer Elements. Transcription Factors, Methods of Studying Transcription Factors. Domain Structure of Transcription factors, –DNA binding domains (Zinc Finger Domains, Leucine Zipper Domains, Homeodomains, Basic Domains). Transcription activation domains. Mechanism of Activator function. Transcriptional coactivators, Mediator Complex. Repressors and their role in Transcription. Chromatin Structure and Transcriptional Gene Regulation. Histones, Nucleosome, Nucleosomes as Transcription Barriers. Regulation of Nucleosome Dynamics. Histone Modifications and Transcription. Chromatin Remodeling and Histone Eviction in transcription. Transcription Memory and Maintenance of Genome Integrity. Structure & Epigenetics of Euchromatin versus Heterochromatin. Heterochromatin Gene Silencing. Regulation of Eukaryotic Gene Expression by Small RNAs. Gene Regulation During Development Transcription factor and developmentally regulated gene expression. Gene Regulation during Drosophila Development. Homeobox containing genes of Drosophila. Homeobox like genes in other organism

UNIT-III: Post-transcriptional RNA processing Heteronuclear RNA (hnRNA): Exons, introns, exon-intron junctions and splicing signals. RNA splicing: Molecular mechansim. Splicesome (structure, assembly and function). Alternative splicing. Regulation of splicing.

Self-splicing RNAs with refrence to group-I introns and group-II introns. Ribosomal rRNA processing: Eukaryotic and prokaryotic rRNA processing. t-RNA processing and modifications. Trans-splicing. RNA editing and molecular mechanism. Post-transcriptional modifications of mRNA: Capping at 5`end. Structure and types of caps. Function of 5` end capping. Polyadenylation: Polyadenylation signals and mechansim of polyadenylation. Poly(A) polymerase. Functions of poly "A" tail.

UNIT-IV: Protein Translation. Translational machinery apparatus mRNA: Structural features of prokaryotic and eukaryotic mRNA Ribosomes: General structural features. Molecular components (prokaryotic and eukaryotic) t- RNA: Secondary and tertiary structure. Amino-acyl tRNA synthetases. Chemistry of tRNA charging with specific aminoacids Translational Initiation in prokaryotes: Molecular details. Formation of 30S and 70S initiation complex. Shine-Dalgarno sequence and its role in initiation complex formation. Translation initiation in eukaryotes: Initiation factors and their function. Role of eIF4E, eIF4G, eIF4A, eIF3, eIF2, eIF1, eIF5, eIF6. Scanning model of initiation. Formation of 48S and 80S initiation complex. Kozak sequence and its significance. Cap-dependent and Cap-independent translation. Role of Internal Ribosome Entry Sites (IRES). Cap-independent translation under stress conditions. Translational regulation: Prokaryotic regulation: Role of secondary structures, small RNAs and riboswithches. Eukaryotic regulation: Role of phosphorylations (stimulatory and inhibitory), Role of 4E-binding proteins in translation regulation. Secondary structures and translation regulation. microRNAs and their role in translation regulation Genetic code: General characteristic features. Breaking of genetic code. Whobble hypothesis and degeneracy. Translation elongation: Three-site ribosome model of tRNA binding. Role of EF-T. Proofreading during translation elongation. Peptidyl transferase reaction (chemistry and molecular components). Translocation and role of EF-G. Translation termination: termination codons. Release factors. Ribosome dissociation and the factors involved.

Books Recommended:

1. Transcriptional Regulation in Eukaryotes: Concepts, Strategies, and Techniques by Michael F Carey, Stephen T Smale and Craig L Peterson.
2. Gene Regulation by David S. Latchman fifth edition.
3. Molecular Biology by Robert F Weaver: McGraw-Hill Higher Education.
4. Molecular Biology of the Gene by James D. Watson, et al: Pearson.
5. Lewins gene XI by Jocelyn E Krebs, et al: Jones and Bartlett Learning.

Course No:	BT-203-CR-14	Maximum marks		100	
Course title:	Advanced Enzymology	Theory		Practical	
		IA	SEE	IA	SEE
Credits:	Four	15	60	10	15

UNIT-I: Properties of enzymes as catalytic power, specificity cofactors, brief nomenclature & classification of enzymes, isoenzymes, Monomeric and oligomeric enzymes, Enzyme localization, Enzyme assay, Direct and coupled assays. Review of uni-substrate enzyme kinetics and factors affecting the rate of enzymes catalyzed reactions. Derivation of Michaelis Menten equation using steady state and equilibrium assumptions. Enzyme constants. Transformation of Michaelis – Menten plot to linear forms. Lineweaver-Burk plot, Eadie-Hofstee plots, Hanes plots, Eisenthal and Cornish-Bowden plot. Merits and demerits of linear plots. Haldane relationship for reversible reactions. King and Altman procedure for derivation of rate equation. Michaelis pH functions and their significance

UNIT-II: Classification of multi substrate reactions with examples of each class. Ping-pong bi-bi mechanism, Random order mechanism, compulsory order mechanism, Kinetics of multi substrate reactions. General rate equation of Alberty. Derivation of rate expression for ping-pong & ordered Bi -Bi reaction mechanism. Primary and secondary plots for determination of kinetic constants for Multisubstrate reactions. Investigation of reaction mechanism using steady state methods. Use of initial velocity, inhibition and exchange studies to differentiate between multi substrate reaction mechanism. Methods of examining enzymes-complex's, trapping E-S Complex, Use of substrate analogs, chemical modifications and protease treatment, Site directed mutagenesis & effect of changing pH. Flexibility & conformational mobility of enzymes

UNIT-III: Determination of rate constant for enzymes catalyzed reactions, Protein –Ligand binding including measurement, analysis of binding isotherm. Cooperatively phenomenon . Hill and Scatchard plots Allosteric enzymes, sigmodial kinetics and their physiological significance. Symmetric and sequential modes for action of allosteric enzymes and their significance

UNIT-IV: Multi enzyme system: Occurrence, isolation and properties. Polygenic nature of multi enzyme system. Mechanism of catalysis of serine proteases, Ribonucleases and Triose

phosphate isomerase. Enzyme regulation: general mechanism of catalysis viz Acid-base, electrostatic, Covalent and enzymes Immobilized enzymes and their industrial application. Effects of partition on kinetics and performance with special emphasis on changes in pH and hydrophobicity.

Practicals:

1. Assay of Enzyme activity
2. Effect of temperature and pH on enzyme activity
3. Determination of Kinetic constants Km and V max

Books Recommended:

1. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Trevor Palmer,
2. Horwood Publishing
3. Fundamentals of Enzyme kinetics by Athel Cornish-Bowden, Portland press
4. Fundamentals of Enzymology by Nicholas Price and Lewis Stevens,
5. Oxford University Press
6. Enzyme Structure and Mechanism by Alan Fersht, W. H. Freeman
7. Enzymology by T. Devasena , Oxford University Press

3rd Semester Core papers		
1	BT-301-CR-14	Genetic Engineering
2	BT-302-CR-14	Animal cell Science and Technology
3	BT-303-CR-14	Bioprocess Engineering and Fermentation technology

Course No:	**BT-301-CR-14**	**Maximum marks**		**100**	
Course title:	**Genetic engineering**	**Theory**		**Practical**	
		IA	**SEE**	**IA**	**SEE**
Credits:	**Four**	**15**	**60**	**10**	**15**

UNIT-I: Recombinant DNA Technology Tools: Restriction endonucleases: Historical perspective. Nomenclature. Different types of restriction-modification systems and their characteristic features. Blunt end and cohesive end cutters with examples. Four, six and eight cutter restriction enzymes. Restriction enzymes that create 5` and 3` overhangs. Isochizomers and isocaudemers. Restriction modification enzymes and their importance in DNA recombinant technology (Dam, DCM methylases). DNA ligases: E.coli and T4 DNA ligases. Chemistry of T4 DNA ligase reaction. DNA Phosphatases and their role in recombinant DNA technology. DNA Pol I and Klenow fragment and their role in recombinant DNA technology. Vectors: Plasmids: General features of plasmid vectors. Molecular regulation of high and low copy number plasmids. Characteristics features of pBR322, pUC series of plasmid vectors. General scheme of cloning in plasmid vectors. Selectable marker genes used in plasmid vectors and their mechanism of action. Molecular details of blue-white selection. Expression plasmid vectors: transcriptional and translation regulatory elements in expression plasmids. Characteristics feature of inducible plasmid expression vectors. yeast plasmid vectors: General features and mode of selection. Transformation of plasmid DNA in bacterial cells (Physical and chemical methods). Bacteriophages as cloning vectors: lambda- phage vectors: General characteristics features. Insertional lambda phage vectors (λ-gt10, λ-gt11). Replacement lambda phage vectors (λEMBL series). General scheme of cloning in lambda phage vectors and the criteria for recombinant vector selection. In-vitro packaging and its importance. M13 vectors: General features and scheme of cloning in M13 phage. Phagemid vectors: General features and their importance. Cosmid vectors: General characteristics and scheme of cloning in cosmid vectors. YACs: General characteristic features and scheme of cloning in YACs. BACs: General characteristic features and their importance.

UNIT-II: Genetic engineering techniques. Polymerase chain reaction: Principle and methodology. Setting of PCR reaction. source of template DNA (genomic DNA, RNA, etc). Features of an ideal primer. Primer design with restriction sites at the ends. Primer design for fusion protein constructs. Degenerate primers and their importance. DNA polymerase for PCR: characteristic features of error prone (Taq) and high fidelity DNA polymerases.

different types of PCR (nested, asymmetric, multiplex). Applications of PCR. Reverse Transcription PCR (RT- PCR): Principle and methodology. Different methods of first strand and second strand cDNA synthesis. Characteristic features of different reverse transcriptases (RT) used in RT-PCR. Real-Time PCR: Principle and methodology. Ct value and its importance. Different methods of fluorescent detection and probes (SYBER green, Taqman probe, Molecular beacon probes). Melting curves and their importance. Quantification and normalization of raw data. Applications of Real-Time PCR. DNA microarray: Principle and methodology. Different types of DNA arrays (Spotted microarrays and oligonucleotide arrays) and their characteristic features. Differential gene expression using fluorescent dyes. Application of microarrays. Proteomics: Protein separation by 2D Gel electrophoresis. Protein separation by multi-dimensional chromatography. Mass spectrometry: Electrospray Ionization (ESI), Matrix assisted Laser Desprption Ionization (MALDI), Mass analyzers, MS/MS. Different methods of protein identification. Protein arrays and their applications.

UNIT-III: Genomic and cDNA library construction. Different methods of screening. Site-Directed mutageneis: M13 vector based methods, plasmid vector based methods (single primer and double primer methods), PCR based methods. Protein engineering: Different methods and application of protein engineering. Hetrologous expression systems Expression in bacterial systems: Promoters and translation elements used in expression vectors. Inducible promoter systems. Expression and purification of GST fusion proteins. Expression in yeast: Various promoters elements used in expression vectors. Inducible expression systems in yeast (Gal and CUP1 system). Pichia pastroris as yeast expression systems. Expression in Insect cell line (Sf9/21): Baculovirus expression vectors. structure and construction of Basmid vectors. Expression of protein in baculoviral vectors. Expression in mammalian cells. Mammalian expression vectors. Viral and cellular promoter used in expression vectors. Importnace of kozak in expression vectors. Selectable marker genes. Tet-Off/On Inducible systems . Expression of proteins with fusion tags (HA, His, Myc, Flag, GFP) and their significance. In-vitro Transcription and translation and its application

UNIT-IV: Studying protein-protein interaction. Yeast Hybrid systems: Two hybrids based on split transcriptional activation, Split ubiquitin system, SOS recruitment system. Reverse two hybrid. Yeast three hybrid systems for protein-protein, protein-RNA interactions. Transfections: Transient and stable transfection in animal cell. Physical, chemical and biological transfection agents. Repoter assays: Repoter genes and applications

(Chlorophenicol acety transferase (CAT), Luciferase (Firefly and Renilla), living colours (Green fluorescent, yellow fluorescent and their application in co-localization studies). Dual luciferase assay and its application. Gene knock-downs: Antisence RNA technology with examples from animal and plant systems. RNA interference: Methodology and applications. Transgenics: Gene knock-in: Various methods of making transgenics (animals). Applications of transgenics with reference to animals. Gene knock outs: Methodology based on Cre-LoXp system. Conditional and specific knock-outs. Gene targetting. Insertional mutagenesis: Transposon tagging: Different methods . Use of Plasmid rescue vectors, gene-trap vector, enhance trap vectors. Activation tagging. Different type of transposons used in gene tagging. Tagging with T-DNA (Brief account). Gene Therapy: Different types of gene therapies. Viral vectors and their role in gene therapy. Gene therapy and clinical trials. Success and failure stories.

Practical(s):

1. Competent cell preparation.
2. Bacterial Transformation.
3. Plasmid preparation, PCR gene amplification, and gene cloning.

Books Recommended:

1. Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman: Blackwell Publishing Professional.
2. Analysis of Genes and Genomes by Richard J. Reece: Wiley.
3. Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick, Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press.
4. DNA recombinant Technology and molecular techniques by M U Hussain: Black Prints India INC

Course No:	**BT-302-CR-14**	**Maximum marks:**	**100**
Course title:	**Animal cell science and technology**	**Continuous assessment:**	**20**
Credits:	**Four**	**Semester end examination:**	**80**

UNIT-I: Structure and organization of Animal Cell, Primary and established Cell lines, Setting up of Tissue culture facility. Equipments and facilities needed, Introduction to balanced salt solutions and simple/complete growth medium, Role of CO2, serum and supplements. Serum components necessary for growth of cells in culture. Serum and serum free defined media. Limitations and applications of serum and serum free media.

UNIT-II: Cell Lines: Introduction, types and precautions in handling of cell lines. Contaminations in cell culture. Types and their eradication/contamination control. Biology and characterizations of the cultured cells. Cryopreservation. Basic techniques of mammalian cell culture in vitro: Disaggregating of tissue and primary culture. Transfection of cell lines. Types and Methods of Transfection. Transfection applications. Scaling-up of animal cell culture. Equipments and reagents. Advantages and Disadvantages of Scale-up techniques. Cell synchronization, cell cloning and micromanipulation. Application of Animal cell culture.

UNIT-III: Cell transformation: Properties of transformed cells. Methods of cell Transformation. Immortalization: Introduction. Methods used to immortalize cells. Mechanisms involved in cell immortalization. Measurements of viability and cytotoxicity assay: Cell viability assays using dye exclusion or dye uptake, MTT, TUNNEL and ELISA based assays. Fluorescence based cell viability assays. Cell culture based vaccines: Introduction to Subunit vaccines, peptide vaccines, recombinant vaccines, genetic vaccines and attenuated vaccines. Advantages and disadvantages of all the types of vaccines.

UNIT-IV: Three dimensional culture: Introduction. Multicellular tumour spheroids (MCTS). Spheroid culturing techniques. Tissue engineering: Introduction. Tissue Engineering of Skin, Nerve implants. Tissue engineered Urothelium implants. Design criterion for tissue engineering. Cell substrates and support material. Organ and Histotypic cultures:

Introduction. Advantages and limitations. Differences between Organotypic and Histotypic cultures. Factors affecting the growth of Organotypic and Histotypic cultures.

Practical(s):

1. Animal Cell Culture.

Books Recommended:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, by, R. Ian Freshney, published by Wiley-Blackwell, UK.
2. Animal Cell Culture: A Practical Approach by JRW Masters, published by Oxford University Press, UK.
3. Basic Cell Culture: A Practical Approach by John M. Davis, published by Oxford University Press, UK.

Course No:	**BT-303-CR-14**	**Maximum marks:**	**100**
Course title:	**Bioprocess engineering and Fermentation technology**	**Continuous assessment:**	**20**
Credits:	**Four**	**Semester end examination:**	**80**

UNIT-I: Basic concepts, Kinetics of Cell Growth: Kinetics of batch culture, Growth kinetics for continuous culture, Material balance for CSTR. Fundamentals of material and energy balance for processes with/without chemical reaction: Biomass Balances (Cells) in a Bioreactor, Material Balance in Terms of Substrate in a Chemostat, Modified Chemostat. Problems & Examples. Metabolic stoichiometry: Biomass and Product Yields, $Y_{X/S}$ and $Y_{P/S}$. Overview of biosynthetic mechanisms.

UNIT-II: Sterilization: Types of sterilization. Thermal death kinetics of microorganism. Heat sterilization of liquid medium, Batch mode, Continuous mode, Problems & Examples. Air sterilization. Fermentation overview: Inoculum development. Various types of Fermentation: submerged fermentation, aerobic and anaerobic fermentation. Bioreactor operations: Different types of bioreactors, Configuration of Bioreactors and their main components. Modes of bioreactor operation. Important bioreactor accessories.

UNIT-III: Whole cell immobilization and their applications. Single cell protein. Cell disruption: mechanical, enzymatic, and chemical methods. Pre-treatment strategies. Solid-liquid separation: filtration, centrifugation, Adsorption, Problems/Examples. Liquid-liquid extraction, Solvent selection, Operating Conditions, Mode of Operation, Extractor Type Design Criteria. Membrane separation: ultrafiltration (Theory, Experimental set-up) reverse osmosis dialysis.

UNIT-IV: Precipitation of proteins by different methods: Salting out, Isoionic precipitation, Two-carbon (C_2) organic cosolvent precipitation of proteins, C_4 and C_5 organic cosolvent precipitation, phase partitioning, and extraction of proteins, Protein exclusion and crowding agents (neutral polymers) and osmolytes, Synthetic and semisynthetic polyelectrolyte precipitation, Metallic and polyphenolic heteropolyanion precipitation, Hydrophobic ion pairing (HIP) entanglement ligands, Matrix-stacking-ligand coprecipitation, Di- and trivalent metal cation precipitation. Native Page and SDS Page. Crystallization. Distillation (Principle,

types of columns, boiling point diagram, factors affecting the process). Drying. Lyophilization. Stabilization of biproducts.

Books Recommended:

1. M.L.Shuler and F.Kargi, "Bioprocess Engineering--basic Concepts", 2nd Edn. Prentice-hall of India Pvt Ltd
2. P.M.Doran, "Bioprocess Engineering Calculations", Elsevier India Pvt Ltd (2008).
3. C. Ratledge & B. Kristiansen, "Basic Biotechnology" 3rd Edn. Cambridge University Press
4. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Elsevier India Pvt Ltd.(2007).

4th Semester Core papers		
1	BT-401-CR-14	Proposal writing
2	BT-402-CR-14	Research based Project
3	BT-403-CR-14	Seminar and Journal Club
4	BT-404-CR-14	Project presentation
5	BT-405-CR-14	Project viva

The objective of this semester is to expose students with broader needs of Research. Students will choose their project advisor upfront based on interest and their merit in the first two semesters.

Course No:	**BT-401-CR-14**	**Maximum marks:**	**50**
Course title:	**Proposal writing**	**Credits:**	**Two**

The students in consultation with their faculty advisor will prepare a synopsis of the project to be pursued. In the following months, the synopsis should include the rationale, objectives, proposed methodology and significance of the study. The students shall make an open presentation of the synopsis during the fourth week of the semester. The proposal will be evaluated internally by the project supervisor.

Course No:	**BT-402-CR-14**	**Maximum marks:**	**400**
Course title:	**Research based Project**	**Internal assessment:**	**160**
Credits:	**Sixteen**	**Semester end examination:**	**240**

The project will be based upon research and actual bench work, carried under the guidance of faculty supervisor and in close collaboration with the research group. The students are expected to put in at least six working hours daily for a maximum of six months. The students will participate in Journal club and Lab meetings of the research group. Project report will be submitted and will be evaluated at the end of 4th semester.

Project will be continuously monitored by the project supervisor. The internal assessment component will be assessed by the Project supervisor and will carry 160 marks. The semester end component will carry 240 marks, and the evaluation will be carried as follows.

Part 1 of the project will be based upon introduction to the subject and a general review of the literature pertaining to the project. The students should be encouraged to write a review of the problem or on a related topic.

Part 2 of the project will be based on the actual experimental work, presentation and analysis of the data generated. The project report should consist of Abstract, Rationale, Review of literature, Methodology, Results and discussion, and bibliography. Two examiners will evaluate the project reports of the students. The examiners will be nominated by the Head of the department from the panel of examiners proposed by the Project advisor, one of them will be the advisor. The examiners should be either from the department or from allied departments.

Course No:	**BT-403-CR-14**	**Maximum marks:**	**50**
Course title:	**Seminar and journal club**	**Credits:**	**Two**

Each student under the supervision of a faculty advisor will deliver a seminar on a topic related to his/her Project work. The seminars will be conducted in 10th week of the semester, and will form one credit equal to 25 marks. Two faculty members nominated by the Head of the department will evaluate the seminar. The journal club will form one credit and will carry 25 marks. It will consist of a research paper presentation to be assigned and evaluated by the Project supervisor.

Course No:	**BT-404-CR-14**	**Maximum marks:**	**50**
Course title:	**Project presentation**	**Credits:**	**Two**

The students should make an open presentation defending their project work. One external expert and two faculty members nominated by the Head of the department will evaluate the presentation. The presentation will be open to all the students, scholars and teachers of the department and other allied departments.

Course No:	**BT-405-CR-14**	**Maximum marks:**	**50**
Course title:	**Project viva**	**Credits:**	**Two**

Project viva will be conducted by a committee comprised of at least one external expert and two faculty members of the department. However all the faculty members including the Head of the department will be associated with the viva voce. The viva will be based upon the project and related contents.

Elective Allied (EA) Courses

1	BT-104-EA-14	Protein Structure and Function
2	BT-105-EA-14	Microbiology
3	BT-106-EA-14	Biostatistics
4	BT-107-EA-14	Electrophoresis and chromatography
5	BT-204-EA-14	Radioactivity and Immunological techniques
6	BT-205-EA-14	Oxidant signaling
7	BT-206-EA-14	Chromatin Biology and Epigenetics
8	BT-207-EA-14	Non-coding RNA and Neurological Diseases
9	BT-208-EA-14	Protein Folding Dynamics
10	BT-304-EA-14	Intermediary Metabolism
11	BT-305-EA-14	Stem Cell Biology
12	BT-306-EA-14	Bioinformatics
13	BT-307-EA-14	Human and Medical Genetics
14	BT-308-EA-14	Cancer Immunology
15	BT-309-EA-14	Transcriptional Biology

THESE COURSES ARE OPEN TO THE STUDENTS OF BIOTECHNOLOGY AND ALLIED DISCIPLINES

Course No:	**BT-104 -EA-14**	**Maximum marks**		**75**
Course title:	**Protein structure and function**	**Theory**		**Practical**
		IA	**SEE**	**IA**	**SEE**
Credits:	**Three**	**10**	**40**	**10**	**15**
Course Instructor:	**Khalid Majid Fazili**				

UNIT-I: Amino acids: Structure and classifications. Standard and non standard amino-acids, Essential amino-acids, Derived amino acids, Non protein amino acids, Optical activity of amino acids, Stereo-chemical representations, D and L system, RS system, Chemical and physical properties, Acid base characteristics, Titration of acidic, basic and neutral amino acids, Analysis of titration graphs. Proteins: Peptide bond formation and characteristics, oligo and poly peptides, Biological roles of small peptides. Hierarchy of protein structures: Primary structure of Proteins, Determination of Primary structure. Secondary structures, Characteristics of a peptide bond, φ and ψ bonds in peptides, α-helix, 3_{10} helix, π-helix, β-sheets, β-turns, Reverse turns, Ramachandran plots. Prediction of secondary structure of proteins. Super secondary structures, Protein domains and motifs

UNIT-II: Tertiary structure of proteins: Core versus surface, Stabilizing interactions, Physical methods of determining three dimensional structures of proteins, X-ray crystallography and NMR spectroscopy. Quaternary structure: Characteristics, dimensions and complexity, Subunit interactions Advantages: Active site diversity, coupling of metabolic related proteins in time and space, regulation of enzyme activity, stability, enhancing the translational efficiency of proteins. Structure and function of fibrous proteins: Amino acid composition and organization of fibrous proteins, Keratin, Fibroin, Collagen

Practicals:

1. Preparation of buffers (Acetate, Tris and Phosphate).
2. Acid base titration of amino acids.
3. UV and visible absorption spectra of Proteins.
4. Difference absorption spectrum of proteins

Books Recommended:

1. Biochemistry by Donald Voet and Judith G Voet, John Wiley & Sons
2. Protein Structure and Function by David Whitford, John Wiley & Sons, UK
3. Introduction to Proteins: structure and function and motion by Amit Kessel and Nir-Ben Tal , CRC Press.

Course No:	**BT-105 -EA-14**	**Maximum marks:**	**75**
Course title:	**Microbiology**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor: Bilal Ahmad Reshi			

UNIT-I: Bacteria: Morphology of Bacterial cell, Classification of bacteria on various criteria's, Structure & function Cell wall (Peptidoglycan), Outer membrane of Gram Negative bacteria; cell wall and cell membrane synthesis, Flagella and motility, cell inclusions like endospore (mechanism of endospore formation), Gas vesicles.etc Bacterial growth phase, Generation time, Kinetics of growth, Physical features influencing growth (temperature, pH).

UNIT-II: Viruses: Discovery classification and structure of viruses, DNA Viruses, Positives strand, negative strand viruses, replication of retroviruses (HIV), structure & function of viroids and prions. Bacteriophage: General structure of phages, Life cycle of lambda phage, Regulation of gene expression in lambda phage (Lysogenic & lytic options).

UNIT-III: Transformation: Plasmid- structure & properties (copy number, Incompatibility, Host range). Molecular mechanism of natural transformation. Transposition: Structure of transposons (Composite & non Composite) Mechanism of transposition. Conjugation: Mechanism of conjugation, Mechanism involved in the formation of F,HFr and F-prime. Transduction: Mechanism of specialized and generalized conjugation. Toxins: Endo & Exotoxins and their mode of action. Antimicrobial agents: Anti-bacterial, Anti-Fungal antibiotics, Mode of action, Mechanism of drug resistance.

Recommended references:

1. Molecular Genetics of Bacteria. Jeremy W. Dale, Simon F. Park: Wiley-Blackwell.
2. Microbiology by Prescott, Joanne M. Willey, Linda M. Sherwood, Christopher J. Woolverton: McGraw-Hill.
3. Fundamental Bacterial Genetics. Nancy Trun, Janine Trempy: Wiley- Blackwell**.**

Course No:	**BT-106-EA-14**	**Maximum marks:**	**75**
Course title:	**Biostatistics**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor: Ehtishamul Haq			

UNIT I: Sampling and data collection: Populations and Samples. Samples Selection. Simple Random Sampling, Convenience Sampling, Systematic Sampling, Stratified Random Sampling, Cluster Sampling. **Medical/Biological Uncertainties:** Surveys and Cross-Sectional Studies. Retrospective Studies, Prospective Studies, Experimental Studies and Quality Control Clinical Trials, Epidemiological Studies**. Measurement of central tendencies (mean, mode, median, SD):** The Arithmetic Mean, The Median, The Mode, The Geometric Mean, The Harmonic Mean, Which Measure Should You Use? Measures of Dispersion: Range, Mean Absolute Deviation, Population Variance and Standard Deviation, Sample Variance and Standard Deviation, Calculating the Variance and Standard Deviation from Grouped Data, Coefficient of Variation (CV).

UNIT-II: Presentation of variation by figures; data representation: Histogram, Stem-&-Leaf Plot,Line Diagram, Frequency Polygon, Frequency Curve, Pie Diagram, Bar Diagrams, Scatter Diagram, Box-&-Whisker Plot, Bubble Plot, Growth chart, Dendrogram, Nomogram, Partogram, Pedigree Chart, Cartogram**. Confidence Intervals:** Confidence Intervals, Confidence Intervals for a Single Population Mean, Z and t Statistics for Two Independent Samples. Paired t Test. **Principles of test of significance:** One-Tailed Versus Two-Tailed Tests, p-Values, Type I and Type II Errors, The Power Function, Two-Sample t Test (Independent Samples with a Common Variance). **Students t-test, ANOVA:** Comparison of means in one or two groups (student's t-test) Comparison of means in three or more groups (ANOVA F-test

Books Recommended:

1. Introduction to Biostatistics and Research Methods by Sunder Rao and J Richards
2. Medical Statistics by David Machin, Michael J Campbell and Stephen J Walters, John Wiley and Sons

Course No:	**BT-107-EA-14**	**Maximum marks:**	**75**
Course title:	**Electrophoresis and Chromatography**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor:	**Firdous Ahmad Khanday**		

UNIT-I: Electrophoresis and Immunological techniques: Basic principles & types of electrophoresis, Agarose gel electrophoresis, PAGE , SDS-PAGE and isoelectric focusing. Blotting techniques: Southern, Northern, Western , Far-western , South-western and their applications. Determination of antigen antibody concentration by immunodiffusion, immunoelectrophoresis, ELISA.

UNIT-II: Chromatography: Theory of Chromatography; Migration. Dispersion. Chromatographic Resolution. Detectors: General Criteria Of Performance (Sensitivity, Linearity, Noise, Instrumental limit of detection, Specifity, Time response). Types: Paper, thin-layer, partition, Ion Exchange Affinity Chromatography: Purification steps, Media selection, Preparation of media and buffers, Sample preparation and application, Elution. Purification of specific groups of molecules (Immunoglobulins, GST fusion proteins, Poly (His) fusion proteins, Protein A fusion proteins). Components of an affinity medium, Selection and combination of purification techniques. Gas Chromatography.

Books Recommended:

1. Chromatography: Basic Principles, Sample Preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk . WILEY.
2. Basics of Centrifugation. ThermoFisher

Course No:	**BT-204-EA-14**	**Maximum marks:**	**50**
Course title:	**Radioactivity and Centrifugation**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor: Ehtishamul Haq			

UNIT-I: Radioactive Techniques: Basics: atomic structure, isotopes, modes of radioactive disintegration, Radioactive decay Radioimmunoassay. Interaction of ionising radiation with matter. Radiation quantities and units. Radiation detectors & monitors (gas filled detectors, scintillation detectors, thermo-luminescent dosimeters), Radiation monitoring instruments . Biological effects of ionizing radiation. Principles of radiological protection. Radiation hazards, evaluation and control. The Principles of Radioactive Waste Management (Objective & Principle). The Classification of Radioactive Waste. How Do We Assess Risk. Who Is Responsible for Regulating Radioactivity in India (A). Regulatory aspects of radiological safety.

UNIT-II: Centrifugation: Basic principles of centrifugation, types of centrifugation differential centrifugation density gradient centrifugation and material used for making density gradient . Determination of Sedimentation Coefficient. Types of centrifugal separations, Rate zonal centrifugation, Buoyant density centrifugation. Swinging-bucket rotors, Fixed-angle rotors, Vertical rotors, Self-generating gradients. Materials used for making rotors of centrifuges . Choosing the Right Centrifuge for Your Application. Safe Procedures for Centrifugation. Ultra centrifugation: Design and principles of an analytical ultracentrifugation. Applications for characterization of biomolecules (sedimentation equilibrium and sedimentation velocity method).

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Books Recommended:

1. Principles & Techniques Biochemistry & Molecular Biology. Wilson & Walker.
2. Principles of Radioactive Techniques, Use & Handling. BARC
3. Biological Centrifugation (The Basics) by Dr John Graham

Course No:	**BT-205-EA-14**	**Maximum marks:**	**50**
Course title:	**Oxidant signaling**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor: Firdous Ahmad Khanday			

UNIT-I: Reactive Oxygen Species. Origin, Production, Enzymatic and Non-enzymatic sources of reactive oxygen Species (ROS) production. Mitochondria as a source of ROS. Involvement of cytochrome complexes, Xanthine oxidase and NADPH oxidase. Effects on cell and biomolecules. Lipid peroxidation. Protein oxidation. Inactivation of different proteins. ROS as a secondary messenger. Regulation of signal transduction. Role in cancers. ROS detection in the cells.

UNIT-II: Antioxidants. Enzymatic antioxidants. Glutathione Peroxidase. Superoxide dismutase. Catalase. Non-enzymatic antioxidants. Mechanistic involvement of Vitamin C, Vitamin A. Vitamin E. Protective effects on the cell. Aging. Mechanistic players in aging. ROS in aging. Yeast as a model to study aging. C. elegans as a model to study aging. Pathways involved in aging. Role of ROS regulating protein in aging including p53 and p66shc.

Books Recommended:

1. Review Journals Like Antioxidant Redox Signaling.
2. Internet Resources: Pubmed, Google, Google Scholar.

Course No:	**BT-206 -EA-14**	**Maximum marks:**	**75**
Course title:	**Chromatin Biology and Epigenetics**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor: Mohammad Altaf Bhat			

This course is designed to familiarize the students with basic and more advanced concepts of an emerging and rapidly evolving field of epigenetics.

UNIT-I: Chromatin, Histones, Nucleosome, Nucleosome Structure, Chromatin template and higher order chromatin organization, Histone H1 and the compaction of nucleosomal arrays, Chromosomes and Chromosomal territories. Histone Variants and complexes involved in their exchange, Histone Chaperons, Chromatin assembly, nucleosome positioning.

UNIT-II: Modulation of Chromatin Structure, ATP dependent chromatin remodeling, Histone modifications and the enzymes involved (Acetylation, Methylation, Phosphorylation and Ubiquitination), Genome wide analysis of histone modifications, Cross-talk between histone modifications, Histone Code hypothesis, DNA repair in context of chromatin, Interplay of DNA methylation and histone modifications**.** DNA Methylation, Protein Domains that Bind Chromatin Modifications, Polycomb complexes in gene regulation.

UNIT-III. Epigenetics, Chromatin Boundaries: S. cerevisiae Silencing, S. pombe Centromeric Heterochromatin, RNAi-directed Silencing. Epigenetic reprogramming in mammals, genomic imprinting, Epigenetic mechanisms regulating ES cell differentiation, Bivalent Chromatin Marks in maintaining stem cell pluripotency, Epigenetics and pathologies, Epigenetic therapies. Epigenetic phenomena in lower organisms, Position effect variegation, dosage compensation, X chromosome inactivation.

Recommended References:

1. Chromatin Structure and Function by Alan Wolffe.
2. Epigenetics by David Allis, Thomas Jenuwein, Danny Reinberg and Marie- Laure Caparros

Course No:	**BT-207-EA-14**	**Maximum marks:**	**50**
Course title:	**Non coding RNA and neurological disorders**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor: Abrar Ahmad Qurashi			

UNIT-I: From central dogma to ncRNA and now functional RNA: Overview of ncRNA and their important role in current research. Biogenesis of Small (miRNA, piRNA, esiRNA) and long non-coding RNA (lnRNA) and their importance in gene regulation and disease pathogenesis. MicroRNA (miRNA) and lncRNA pathways in Neurodevelopmental and Neurodegerative disorders will be provided as an example.

UNIT-II: Non-Coding RNA (NcRNA) and neural stem cells (NSCs): miRNAs, and self-renewal and proliferation of NSCs. LncRNAs and proliferation of NSCs. NSC survival controlled by ncRNAs. NSC differentiation and cell fate determination mediated by ncRNA. NcRNA as a tool for stem cell based therapy.

UNIT-III: Principles and novel findings in human genetics: Dynamic mutation, anticipation, allelic heterogeneity, protein, and RNA-mediated pathogenesis. The study of Trinucleotide disorders like Fragile X syndrome (FXS) and Fragile X associated Tremor Ataxia Syndrome (FXTAS) will be provided as an example.

Recommended references:

1. The RNA world, CSHL press.

Course No:	**BT-208-EA-14**	**Maximum marks**		**75**	
Course title:	**Protein Folding and Dynamics**	**Theory**		**Practical**	
		IA	**SEE**	**IA**	**SEE**
Credits:	**Three**	**10**	**40**	**10**	**15**
Course Instructor: Khalid Majid Fazili					

UNIT-I: Overview and Introduction - Review of protein structure (primary, secondary, super-secondary, tertiary, quaternary); Protein domains . Conformational restrictions. Dihedral angles . Ramachandran diagrams. Stabilizing interactions, Symmetry and subunit interactions. Aadvantages of quaternary structures. Pathways to and from the native state: Kinetics of protein folding, (the Levinthal paradox; energy landscapes & folding funnels, the denatured state , kinetic traps; the molten globule , intrinsic structural disorder , aggregation).

UNIT-II: Protein folding (macromolecular crowding; co-translational folding; cellular folding catalysts; the molecular chaperone concept; chemical' chaperones. Detailed study of the Hsp70 and GroEL/ES molecular chaperone 'machines' . chaperone networks & pathways). Protein unfolding (unfolding for degradation; unfolding for transmembrane transport. Intracellular protein degradation. Protein misfolding & conformational diseases. Unfolded protein response: Pathways, splicing mechanism of UPR in disease processes, ER Stress, role of calcium in ER stress. Ire1, UPR and apoptosis.

UNIT-III: Practicals

1. Difference absorption spectra of proteins obtained with urea and guanidine hydrochloride
2. Denaturation transition curve
3. Determination of ΔG_D

Books Recommended:

1. Protein Structure and Function by David Whitford, John Wiley & Sons, UK
2. Introduction to Proteins: structure and function and motion by Amit Kessel and Nir-Ben Tal, CRC Press
3. Protein Folding by Thomas E Creighton
4. Proteins: Structures and Molecular properties by Thomas E Creighton

Course No:	**BT-304-EA-14**	**Maximum marks:**	**50**
Course title:	**Intermediary metabolism**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor: Mahboob ul Hussain			

UNIT-I: Over-view of major energy metabolism pathways. Glycolysis, gluconeogenesis, TCA cycle, PPP pathway, Glycogen synthesis/degredation. Fatty-acid oxidation, protein degradation. Regulation of various pathways. Organ specialization and metabolism: Role of liver and nutrient distribution. Role of adipose tissue. Brown adipose and thermogenesis. Muscle and energy metabolism. Brain functions and energy metabolism. Co- ordination of energy metabolism between various organs.

UNIT-II: Hormones and their role in fuel metabolism: Vitamin D, Insulin, Glucagon, Thyroid hormones, Epinephrine. Energy metabolism and diseases. Obesity and body mass. Diet components and their role in obesity. Role of adipose tissue. Leptin and obesity. Genes that regulate body mass. Type-II diabetes and insulin. Metabolic deregulation and Type-II diabetes. Role of diet, medication and exercise in type-II diabetes.

Books Recommended:

1. Principles of Biochemistry by David David Lee Nelson, Albert L. Lehninger, Michael M. COX
   Publisher: W.H. Freeman
2. Biochemistry By Donald Voet, Judith G. Voet
3. Biochemistry by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer

Course No:	**BT-305-EA-14**	**Maximum marks:**	**50**
Course title:	**Stem cell biology**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor: Mohammad Altaf Bhat			

UNIT-I: General introduction to concepts in stem cell biology, Embronic stem cells, Pluripotency and Reprogramming, Lineage Commitment, Epigenetics and RNAs, Stem cell Niche, Epithelial Stem Cells, Neural Stem Cells, Blood Stem Cells, Cancer Stem Cells, Cardiac stem Cells.

UNIT-II: Human ES cells, Therapeutic Prospects and Tissue Engineering, Animal Models of Regeneration, The Stem cell Debate: Politics and Ethics.

Books Recommended:

1. Essentials of Stem Cell Biology, Third Edition by Robert Lanza and Anthony Atala.
2. Control and Regulation of Stem Cells by Terri Grodzicker, David Stewart and Bruce Stillman

Course No:	**BT-306-EA-14**	**Maximum marks:**	**50**
Course title:	**Bioinformatics**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**
Course Instructor:	**Ehtishamul Haq**		

UNIT-I: Introduction and Biological databases: Introduction: What Is Bioinformatics? Goal. Scope. Applications. Limitations. Introduction to Biological Databases : What Is a Database? Types of Databases. Biological Databases. Pitfalls of Biological Databases.

UNIT-II: Sequence Alignment: Pairwise Sequence Alignment. Sequence Homology versus Sequence Similarity. Sequence Similarity versus Sequence Identity. Methods. Scoring Matrices. Statistical Significance of Sequence Alignment. Database Similarity Searching: Unique Requirements of Database Searching. Heuristic Database Searching. Basic Local Alignment Search Tool (BLAST). FASTA. Database Searching with the Smith–Waterman Method.

Books Recommended:

1. Developing Bioinformatics Computer Skills by Cynthia Gibas, Per Jambeck
2. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Second Edition by Andreas D. Baxevanis, B. F. Francis Ouellette
3. Bioinformatics: Sequence and Genome Analysis by David W. Mount

Course No:	**BT-307-EA-14**	**Maximum marks:**	**75**
Course title:	**Human and Medical Genetics**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor: Abrar Ahmad Qurashi			

This course will provide a basic foundation for human genetics and will extend to current research activity and applications in clinical science

UNIT-I: Organization and distribution of the human genome: Overview. Human multigene families and repetitive coding DNA. Extragenic repeated DNA sequences and transposable elements. Genes in pedigrees: Genes in pedigree. Complications to the basic pedigree patterns. Factors affecting gene frequencies. Nonmendelian characters. Human gene expression and Instability of the human genome: Overview of gene expression in human cells. Overview of mutation, polymorphism, and DNA repair. Pathogenic mutations. Nomenclature of mutations and databases of mutations.

UNIT-II: Genomic revolution and Research in the post-genome (sequencing) era: History, organization, goals and value of the Human Genome Project. Genetic and physical mapping of the human genome. Other genome projects. Available genetic data, and functional genomics in laboratory organisms.

UNIT-III: Medical Genetics and Diagnostic techniques: Overview. Modern molecular and cytogenetic methods (Modern PCR methods, FISH, MLPA, arrayCGH, Parent of Origin Effects, Prenatal Diagnosis, chorionic villus sampling (CVS), Preimplantation Genetic Diagnosis (PGD). Emerging technologies (Personalized Medicine, Gene Therapy, Stem Cells). Clinical case studies illustrating Genetic Principles and diagnostics.

Books Recommended:

1. Thompsan and Thompsan: Genetics in Medicine, Elsevier publications.
2. Emery's Elements of Medical Genetics. Elsevier

Course No:	**BT-308-EA-14**	**Maximum marks:**	**50**
Course title:	**Cancer Immunology**	**Continuous assessment:**	**10**
Credits:	**Three**	**Semester end examination:**	**40**
Course Instructor: Raies Ahmad Qadri			

UNIT-I: Immune System and its medical importance. Overview of the Immune system. Immunologic Factors influencing the incidence of Cancer. Innate immune and adaptive immune response to tumor cells. Adaptive Immune Response to Tumor Cells. Tumor Antigen – Specific Immune Response, Suppression of T cell. Responses by Regulatory T Cells, Apoptosis of CD8+ Effector T Cells, Changes in HLA by Tumor Cells.

UNIT-II: Cancer Immunotherapy - Exploitation of Acquired Immune Response, Detection of Meyloma Proteins produced by Plasma cell Tumors. Monoclonal Antibodies, Exploiting Innate Immunity – Lymphokine Activated Killer Cells, Interferon Therapy and Colony Stimulating Factors; Detection of alpha-fetoprotein. Carcinoembryonic Antigen. Detection of Prostate Specific Antigen. Tumor Immunoprophylaxis. Cancer Vaccines: principles and practice.

Books Recommended:

1. Basic Immunology: Abul K. Abbas, Andrew H. Lichtman.
2. Janeway's Immunobiology, Garland Sciernce
3. Essential Immunology by Delvis, Martin , Burton and Roitt

Course No:	**BT-309-EA-14**	**Maximum marks:**	**75**
Course title:	**Transcription biology**	**Continuous assessment:**	**15**
Credits:	**Three**	**Semester end examination:**	**60**
Course Instructor: Khurshid Iqbal Andrabi			

UNIT-I: Cis-acting elements and trans-acting factors: Eukaryotic RNA polymerases and basal transcription factors, Diversity in core promoter elements, Diversity in general transcription factors, Proximal & Distal Promoter Elements, Enhancers and Silencers, Gene-specific Regulators. Domain structure of eukaryotic transcription factors: Transcription factors - DNA binding domains. Transcription factors - Transcription activation domain. Role of chromatin in eukaryotic gene regulation: Role of chromatin in eukaryotic gene regulation, Role of histones in eukaryotic gene regulation, Role of DNA methylation in eukaryotic gene regulation Chromatin remodelling & gene regulation.

UNIT-II: Synthesis of mRNA, rRNA & tRNA: mRNA processing, Role of RNA Pol II in mRNA capping and mRNA splicing mRNA processing, Role of RNA Pol II in polyadenylation & mRNA editing, Regulation of RNA Pol I transcription, Regulation of RNA Pol III transcription. Regulation of gene expression via cell surface receptors: Signal Transduction Pathways Introduction, Regulation of gene expression by cyclicAMP, Regulation of gene expression by second messengers other than cAMP, Regulation of gene expression by Protein Kinase C, Regulation of gene expression by Growth factors, Regulation of gene expression by cytokines Regulation of gene expression by intracellular receptors: Regulation of gene expression by steroid hormones, Regulation of gene expression by type II nuclear receptors, Mechanism of transcriptional activation by nuclear receptors.

UNIT-III: Regulation of gene expression during development: Gene Regulation during Drosophila Development. Signal transduction pathways involved in embryonic development, Homeotic genes, Epigenetic regulations of gene expression during development, Embryonic stem cells and Transcription factor-mediated epigenetic reprogramming.

Books Recommended:

1. Molecular Cell Biology. 4th edition. Lodish et al. New York: W. H. Freeman; 2000.
2. Molecular Biology of the Cell. 4th ed. Alberts et al. New York: Garland Science; 2002.
3. The Cell: A Molecular Approach. 2nd ed. Cooper & Sunderland: Sinauer Associates; 2000.
4. Transcriptional Control of Neural Crest Development. Nelms BL, Labosky PA. San Rafael (CA): Morgan & Claypool Life Sciences; 2010.

Elective Open (EO) Courses		
16	BT-001-EO-14	Basics in Biotechnology
17	BT-002-EO-14	Basics in Metabolism
18	BT-003-EO-14	Basics in Immunology
19	BT-004-EO-14	Concepts in Molecular Biology

THESE COURSES ARE OPEN TO THE STUDENTS OF ALL DEPARTMENTS EXCEPT BIOTECHNOLOGY

Course No:	**BT-001-EO-14**	**Maximum marks:**	**50**
Course title:	**Basics in Biotechnology**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**

UNIT-I: Molecules of life: Basic idea of life molecules- DNA, RNA, Proteins, Sugars and Lipids, their structure & functions Cell: Cell as a basic unit of life, Structure and function of various cell organelles (Plasma membrane, Nucleus, Mitochondria, Chloroplast, Golgi Bodies, Endoplasmic reticulum.

UNIT-II: Genome organization: Chromosomes, chromatin, Gene, Allele, and DNA. Cell Division: Basic concept of Mitosis & Meiosis. Genetic Information: The flow of genetic information (Central Dogma Concept). Cloning: Basic concept of DNA recombinant technology. Transgenic: Advantages, Issues & concerns. Nobel Prize: Eminent Nobel Laureates & their contribution in Biology. Science Ethics: Is science ethically & morally neutral

Books Recommended:

Principles of Biochemistry by David David Lee Nelson, Albert L. Lehninger, Michael M. COX , Publisher: W.H. Freeman

Course No:	**BT-002-EO-14**	**Maximum marks:**	**50**
Course title:	**Basics in Metabolism**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**

UNIT-I: The Biochemical Basis of Life, Important Biological Molecules. Metabolism: Introduction and basic concepts. Energy Balances, Energy Utilization.

UNIT-II: Metabolism of Various Biomolecules: Glycolysis, The citric acid cycle, Gluconeogenesis, Glycogen Metabolism, Overview of Protein Metabolism. Chemistry and metabolism of lipids; transport of lipids.

UNIT-III: Metabolic Disorders: Glycogen storage diseases, diabetes mellitus: its diagnosis and acute metabolic complication. Protein metabolic disorders. Pathological disturbances in lipid metabolism, metabolism of cholesterol and its clinical association with disease; lipids and linkage of cardiovascular diseases with cancer.

Books Recommended:

1. Principles of Biochemistry by David David Lee Nelson, Albert L. Lehninger, Michael M. COX Publisher: W.H. Freeman

Course No:	**BT-003-EO-14**	**Maximum marks:**	**50**
Course title:	**Basics in Immunology**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**

UNIT-I: Basic Concepts in Immunology-The Innate and adaptive Immune system: Overview of innate and adaptive immunity. Overview of the components of the immune system (Organs, Tissues, Cells (lymphoid and Myeloid lineages), Molecules (MHC, Antibodies, TCR, Toll like receptors involved in immune system). Principles of Innate immunity. Pattern recognition in the innate immune system (PAMP and PRR, Scavenger Receptors). Overview of the complement system and cytokines. Inflammatory Response and Diapedesis. Principles of Adaptive immunity. Cell-mediated immune responses. Humoral immune responses. Antigen capture and presentation to lymphocytes (Ag presentation).

UNIT-II: Immunological Diseases: Overview of Immune responses against infectious diseases, tumors and

transplants (Tumor immunology). Immunological tolerance and Autoimmunity. Hypersensitivity. Vaccines: Principles and Practice.

Books recommended:

1. Basic Immunology: Abul K. Abbas, Andrew H. Lichtman.
2. Janeway's Immunobiology, Garland Sciernce

Course No:	**BT-004-EO-14**	**Maximum marks:**	**50**
Course title:	**Concepts in Molecular Biology**	**Continuous assessment:**	**10**
Credits:	**Two**	**Semester end examination:**	**40**

UNIT -1: DNA as genetic material: Experimental approaches. DNA structure and replication, Enzymes involved in DNA replication, Mechanism of DNA replication. RNA structure and biosynthesis, Genome organization. From genes to proteins: Genetic code and protein synthesis .

UNIT -2: Recombinant DNA technology, molecular cloning and gene expression tools. Genetically modified organisms: Use in basic and applied research. DNA typing, and genomics.

1. Principles of Genetics by Gardner
2. Genetics by Atherley
3. Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman: Blackwell Publishing Professional.