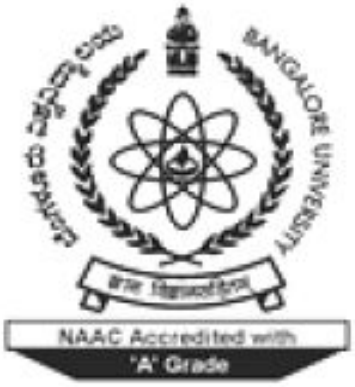

Bangalore University
Department of Molecular Biology

M.Sc., MOLECULAR BIOLOGY
SYLLABUS (CBCS Pattern)

FIRST TO FOURTH SEMESTER

FROM THE

ACADEMIC YEAR 2014-2015 ONWARDS

2014

PROCEEDINGS OF THE MEETING OF THE BOARD OF STUDIES (PG) IN MOLECULAR BIOLOGY BANGALORE UNIVERSITY HELD ON 18th JULY 2014 IN THE DEPARTMENT OF MOLECULAR BIOLOGY, BANGALORE UNIVERSITY, BANGALORE-560 056

Venue: Department of Molecular Biology, J.B.Campus,
Bangalore University, Bangalore -560 056

Date : 18-07-2014 Time : 10.00 am

Agenda:

1. To finalize the draft syllabus for Choice Based Credit System for M.Sc., Molecular Biology, for approval.
2. To approve the question paper format (for HC and SC)
3. Any other academic matter with the permission of the Chair.

Sl.No	Name		**Signature**
1.	**Dr. V.R.K.Reddy,** Professor, Department of Botany, Bharathiar University Coimbatore-641 046	Member-External	Sd/-
2.	**Dr K. Kemparaju,,** Professor, Department of Biochemistry University of Mysore , Mysore -570 006	Member-External	Sd/-
3.	**Dr. S.K.Sarangi ,** Professor, Department of Microbiology Bangalore University, Bangalore –560 056.	Member-Internal	Ab
4.	**Dr. M.V.V.Subramanya** Professor, Department of Life Science Bangalore University, Bangalore – 560 056	Member-Internal	Sd/-
5.	**Prof. Janhnavl**, Department of Statistics, Bangalore University, Bangalore – 560 056	Member-Internal	Ab
6.	**Dr. L. Rajanna Co-ordinator** Department of Molecular Biology Bangalore University, Bangalore – 560 056	Chairman	Sd/-

MINUTES OF THE BOS (PG) MEETING:

Chairman of the BOS welcomed the members to the meeting and thereafter the agenda was taken up for discussion

a. The draft Scheme of Study, Examination and Syllabus for Choice Based Credit System for I, II, III and IV M.Sc., Molecular Biology, were scrutinized, discussed and approved after making necessary corrections.

b. The Chairman BOS was authorized to make minor necessary modifications wherever required.

c. The Chairman finally thanked the members for their kind cooperation.

Dr.L.RAJANNA
Chairman BOS
MOLECULAR BIOLOGY

BANGALORE UNIVERSITY

NAAC Accredited with 'A' Grade

ADMISSION ELIGIBILITY AND SCHEME OF EXAMINATION FOR M.Sc., MOLECULAR BIOLOGY COURSE

(SEMESTER SCHEME)

Eligibility for Admission: The candidates must have studied Chemistry/Biochemistry as one of the Optional / Electives along with any two subjects like Botany / Zoology / Biochemistry / Biotechnology / Microbiology / Applied Genetics/Genetics / Applied Botany / Applied Zoology / Sericulture and other Bioscience subjects studied in all the three years of graduation.

The candidates must have scored a minimum of **50% marks in aggregate of all optional subjects**. In case of SC/ST and Category I students relaxation is as per Bangalore University rules.

Admission rules: Admission to the course will be done as per the statutory provisions of the University.

Intake: Twenty two only (22)

Fee structure: Rs. 34,130/- per candidate per year. However, the fee structure for SC/ST students will be as per the provisions of the University.

Scheme of examination: – Semester scheme:

i) **Theory:** There shall be a written examination at the end of each semester. There shall be five theory papers each in I, II and III semester and four theory papers in IV Semester for a maximum of 70 marks each except paper SCT: MLB- 304 (for 35 marks).

ii) **Practical:** There shall be four practicals each in I & II semester, three practicals in III Semester and two practicals in IV semester for a maximum of 35 marks per practical.

iii) **Continuous Evaluation:** Maximum marks of 30 for each theory paper (15 marks each, for test, 5 marks for assignment, 5 marks for seminar and 5 marks for attendance) and 15 for each practical (5 marks for record submission ,5 marks for test and 5 marks for attendance

iv) **Project work :** In IV semester for 70 marks

PROFORMA FOR THE SCHEME OF STUDY AND EXAMINATION OF CHOISE BASED CREDIT SYSTEM, MASTER OF SCIENCE IN MOLECULAR BIOLOGY

Paper	Title of the Paper	Instruction hrs/week		Total No.Hrs.		Duration of Exam (hrs)		Max. Marks for Examination							Credits		
								IA		Exam		Total		Grand Total			
		Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical		Theory	Practical	Total
Semester I																	
HCT: MLB -101	Biochemistry-I	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB -102	Molecular Cell Physiology	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB -103	Molecular Cell Biology	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB -104	Microbiology	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
SCT: MLB -105	Tools and Techniques of Molecular Biology	3	-	**39**	**-**	**3**	**-**	**30**	**-**	**70**	**-**	**100**	**-**	**100**	**2**	**-**	**2**
Semester II																	
HCT: MLB-201	Molecular Biology-I	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB-202	Genetic Engineering	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB-203	Principles of Genetics	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB-204	Plant Tissue Culture	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
SCT: MLB-205	Microbial Biotechnology	3	-	**39**	**-**	**3**	**-**	**30**	**-**	**70**	**-**	**100**	**-**	**100**	**2**	**-**	**2**
Semester III																	
HCT: MLB- 301	Biochemistry –II	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT: MLB -302	Molecular Biology-II	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
HCT :MLB- 303	Molecular Biology of Development	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**150**	**4**	**2**	**6**
SCT :MLB- 304	Bioethics and Biosafety	2	-	**26**	**-**	**2**	**-**	**15**	**-**	**35**	**-**	**50**	**-**	**50**	**2**	**-**	**2**
OET:MLB- 305	Applied Molecular Biology	3	-	**39**	**39**	**3**	**-**	**30**	**-**	**70**	**-**	**100**	**-**	**100**	**4**	**-**	**4**
Semester IV																	
HCT:MLB- 401	Immunology	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**100**	**4**	**2**	**4**
HCT: MLB-402	Molecular Biology-III	4		**52**		**3**		**30**		**70**		**100**		**150**	**4**		**6**
HCT: MLB-403	Genomics and Proteomics	4	4	**52**	**52**	**3**	**4**	**30**	**15**	**70**	**35**	**100**	**50**	**100**	**4**	**2**	**4**
HCT: MLB-404	Plant Biotechnology & Animal Biotechnology	4		**52**		**3**		**30**		**70**		**100**		**150**	**4**		**6**
PRJ : MLB- 405	Project work	8	-	**-**	**-**	**Report Evaluation**		**30**	**-**	**70**	**-**	**100**	**-**	**100**	**-**	**-**	**4**

MOLECULAR BIOLOGY- M.Sc., COURSE

Duration – Two Years	**:**	Four semesters, consisting of five theory and four practical papers in each I and II semester, five theory and three practical in III semester and four theory and two practical and project work in IV semester. Continuous evaluation by Assignments, Seminars, Tests and Attendance.

SEMESTER – I

Theory:

Paper - I	**:**	**HCT: MLB -101**	**:**	**Biochemistry-I**
Paper - II	**:**	**HCT: MLB -102**	**:**	**Molecular Cell Physiology**
Paper - III	**:**	**HCT: MLB -103**	**:**	**Molecular Cell Biology**
Paper - IV	**:**	**HCT: MLB -104**	**:**	**Microbiology**
Paper - V	**:**	**SCT: MLB -105**	**:**	**Tools and Techniques of Molecular Biology**

Practical:

Practical - I	**:**	**HCP: MLB-106**	**:**	**Of paper –HCT: MLB-101**
Practical - II	**:**	**HCP: MLB-107**	**:**	**Of paper – HCT: MLB -102**
Practical - III	**:**	**HCP: MLB-108**	**:**	**Of paper – HCT:MLB -103**
Practical - IV	**:**	**HCP: MLB-109**	**:**	**Of paper – HCT:MLB -104**

SEMESTER – II

Theory:

Paper - I	**:**	**HCT: MLB-201**	**:**	**Molecular Biology-I**
Paper - II	**:**	**HCT: MLB-202**	**:**	**Genetic Engineering**
Paper - III	**:**	**HCT: MLB-203**	**:**	**Principles of Genetics**
Paper - IV	**:**	**HCT: MLB-204**	**:**	**Plant Tissue Culture**
Paper - V	**:**	**SCT: MLB-205**	**:**	**Microbial Biotechnology**

Practical:

Practical - I	**:**	**HCP: MLB- 206**	**:**	**Of paper– HCT: MLB- 201**
Practical - II	**:**	**HCP: MLB -207**	**:**	**Of paper – HCT: MLB-202**
Practical - III	**:**	**HCP: MLB- 208**	**:**	**Of paper – HCT: MLB-203**
Practical - IV	**:**	**HCP :MLB- 209**	**:**	**Of paper – HCT: MLB-204**

SEMESTER – III

Theory:

Paper - I	**:**	**HCT: MLB- 301**	**:**	**Biochemistry –II**
Paper - II	**:**	**HCT: MLB -302**	**:**	**Molecular Biology-II**
Paper - III	**:**	**HCT :MLB- 303**	**:**	**Molecular Biology of Development**
Paper - IV	**:**	**SCT :MLB- 304**	**:**	**Bioethics and Biosafety**
Paper - V	**:**	**OET:MLB- 305**	**:**	**Applied Molecular Biology**

Practical:

Practical - I	**:**	**HCP: MLB -306**	**:**	**Of paper – HCT: MLB- 301**
Practical - II	**:**	**HCP: MLB -307**	**:**	**Of paper – HCT :MLB- 302**
Practical - III	**:**	**HCP: MLB-308**	**:**	**Of paper – HCT: MLB- 303**

SEMESTER – IV

Theory:

Paper - I	**:**	**HCT:MLB- 401**	**:**	**Immunology**
Paper - II	**:**	**HCT: MLB-402**	**:**	**Molecular Biology-III**
Paper - III	**:**	**HCT: MLB-403**	**:**	**Genomics and Proteomics**
Paper - IV	**:**	**HCT: MLB-404**	**:**	**Plant Biotechnology & Animal Biotechnology**
Project work	**:**	**PRJ : MLB- 405**	**:**	**Project work**

Practical:

Practical – I	**:**	**HCP:MLB-406**	**:**	**Of paper –HCT: MLB-401 & 402**
Paper – II	**:**	**HCP:MLB-407**	**:**	**Of paper – HCT: MLB- 403 & 404**

PROFORMA FOR THE SCHEME OF STUDY AND EXAMINATION OF THE COURSE

1. Name of the course : **Master's Degree in MOLECULAR BIOLOGY**
2. Duration of the course : **TWO years with FOUR semesters**
3. Eligibility : Graduates who have secured 50% marks in aggregate of all optional subjects **with compulsory, Chemistry/Biochemistry** along with Botany / Zoology / Biotechnology / Microbiology / Applied Genetics/ Genetics / Applied Botany / Applied Zoology / Sericulture and other Bioscience subjects as one of the optional subjects in the qualifying University Examination are eligible. In the case of SC/ST and Category-I students relaxation is as per Bangalore University rules.
4. Intake : Twenty two **students only. (22)**
5. Admission : Based on the marks secured at B.Sc. Examination.

SEMESTER I

SCHEME OF INSTRUCTION AND EXAMINATION

Paper Code	Title of the Papers	(Hrs / week)		Total No. of Hrs/ Semester	Examination				Credits
		Theory	Practical		Duration (Hrs)	Max. Marks	Internal Assessment	Total Marks	
HCT: MLB-101	Biochemistry – I	4	--	52	3	70	30*	100	4
HCT: MLB-102	Molecular cell physiology	4	--	52	3	70	30*	100	4
HCT:MLB- 103	Molecular Cell Biology	4	--	52	3	70	30*	100	4
HCT: MLB-104	Microbiology	4	--	52	3	70	30*	100	4
SCT: MLB-105	Tools and Techniques of Molecular Biology	3		39	3	70	30*	100	2
HCP: MLB-106	Of paper – HCT: MLB- 101	--	4	52	4	35	15**	50	2
HCP: MLB-107	Of paper – HCT : MLB- 102	--	4	52	4	35	15**	50	2
HCP: MLB-108	Of paper – HCT : MLB- 103	--	4	52	4	35	15**	50	2
HCP: MLB-109	Of paper – HCT: MLB- 104	--	4	52	4	35	15**	50	2

Total marks =700, Total Credits= 26

***** 15 marks for Test + 5 marks for Assignment + 5 marks for Seminar +5 marks for Attendance.

** 5 marks for Practical Record submission + 5 marks for test + 5 marks for Attendance

SEMESTER II
SCHEME OF INSTRUCTION AND EXAMINATION

Paper Code	Title of the Papers	(Hrs / week)		Total No. of Hrs/ Semester	Examination				Credits
		Theory	Practical		Duration (Hrs)	Max. Marks	Internal Assessment	Total Marks	
HCT: MLB-201	Molecular Biology-I	4	--	52	3	70	30*	100	4
HCT: MLB-202	Genetic Engineering	4	--	52	3	70	30*	100	4
HCT: MLB-203	Principles of Genetics	4	--	52	3	70	30*	100	4
HCT: MLB-204	Plant Tissue Culture	4	--	52	3	70	30*	100	4
SCT: MLB-205	Microbial Biotechnology	3		39	3	70	30*	100	2
HCP:MLB-206	Of paper – HCT: MLB-201	--	4	52	4	35	15**	50	2
HCP:MLB-207	Of paper – HCT: MLB-202	--	4	52	4	35	15**	50	2
HCP:MLB-208	Of paper – HCT: MLB -203	--	4	52	4	35	15**	50	2
HCP:MLB-209	Of paper – HCT: MLB -204	--	4	52	4	35	15**	50	2

Total marks=700, Total Credits= 26

***** 15 marks for Test + 5 marks for Assignment + 5 marks for Seminar +5 marks for Attendance.

** 5 marks for Practical Record submission + 5 marks for test + 5 marks for Attendance

SEMESTER III
SCHEME OF INSTRUCTION AND EXAMINATION

Paper Code	Title of the Papers	(Hrs / week)		Total No. of Hrs/ Semester	Examination				Credits
		Theory	Practical		Duration (Hrs)	Max. Marks	Internal Assessment	Total Marks	
HCT: MLB- 301	Biochemistry –II	4	--	52	3	70	30*	100	4
HCT :MLB- 302	Molecular Biology-II	4	--	52	3	70	30*	100	4
HCT: MLB- 303	Molecular Biology of Development	4	--	52	3	70	30*	100	4
SCT: MLB- 304	Bioethics and Biosafety	2	--	26	2	35	15***	50	2
OET: MLB- 305	Applied Molecular Biology	4		52	3	70	30*	100	4
HCP: MLB- 306	Of paper – HCT: MLB-301	--	4	52	4	35	15**	50	2
HCP: MLB- 307	Of paper – HCT: MLB-302	--	4	52	4	35	15**	50	2
HCP: MLB-308	Of paper – HCT: MLB-303	--	4	52	4	35	15**	50	2

Total marks= 600, Total Credits= 24

***** 15 marks for Test + 5 marks for Assignment + 5 marks for Seminar +5 marks for Attendance

** 5 marks for Practical Record submission + 5 marks for test + 5 marks for Attendance

*** 5 marks for test + 5 marks for Seminar + 5 marks for Attendance

SEMESTER IV
SCHEME OF INSTRUCTION AND EXAMINATION

Paper Code	Title of the Papers	(Hrs / week)		Total No. of Hrs/ Semester	Examination				Credits
		Theory	Practical		Duration (Hrs)	Max Marks.	Internal Assessment	Total Marks	
HCT: MLB-401	Immunology	4	--	52	3	70	30*	100	4
HCT:MLB-402	Molecular Biology-III	4	--	52	3	70	30*	100	4
HCT: MLB-403	Genomics and Proteomics	4	--	52	3	70	30*	100	4
HCT: MLB-404	Plant Biotechnology & Animal Biotechnology	4	--	52	3	70	30*	100	4
PRJ: MLB-405	Project work	8	--			70	30***	100	4
HCP: MLB-406	Of paper – HCT:MLB- 401 & 402	--	4	52	4	35	15**	50	2
HCP: MLB-407	Of paper – HCT:MLB- 403 & 404	--	4	52	4	35	15**	50	2

Total marks=600, Total Credits= 24

* 15 marks for Test + 5 marks for Assignment + 5 marks for Seminar +5 marks for Attendance.

** 5 marks for Practical Record submission + 5 marks for test + 5 marks for Attendance

*** 30 marks for presentation.

I Semester
HCT: MLB-101: BIOCHEMISTRY - I

52 hrs

UNIT-I : Introduction to basic concepts: Chemical bonds - covalent bonds, involvement of molecular orbitals in chemical bond formation; non-covalent bonds - types of non-covalent interactions;hydrogen bonds, ionic bonds, van der Waaals forces, hydrophobic bonds; bond strength, bond energy and bond radius; Geometry of carbon compounds: asymmetric centres, optical activity, stereoisomers, cis-trans configuration charge-charge interactions.

Ionic Equilibria : acids and bases- proton donors and acceptors; strong/weak acids/bases; ionization of water and the ion product; the pH scale and the physiological pH range; weak acid and base equilibria; dissociation constant - Ka and pKa; factors affecting acid dissociation; titration of weak acids: the Henderson-Hasselbalch equation; buffer solutions; molecules with multiple ionizing groups - ampholytes, polyampholytes, and polyelectrolytes; pI; isoelectric focusing. Interactions between Macroions in Solution -Influence of small ions: ionic strength; Debye-Huckel theory – salting-in and salting-out. **13 hrs**

UNIT-II: Chemistry of biomolecules: Carbohydrates-Classification; monosaccharide nomenclature; sugar ring structures, derivatives of monosaccharides – phosphate esters, acids and lactones; amino sugars; glycosides and glycosidic bonds; oligosaccharides; polysaccharides – storage and structural polysaccharides;

Lipids - Definition, classification, structure of fatty acids, triacylglycerols, phospholipids and sphingolipids, Fluid Mosaic Model. Steroid hormones – androgens and estrogens, prostaglandins, thromboxanes and leukotrienes; lipids as constituents of biological membranes Amino acids - structure, properties (acid-base properties), classification; non-protein amino acids, essential and non-essential amino acids; modified amino acids and function.

Nucleic acids: Structures of bases, nucleosides and nucleotides; phosphate diester bond formation, general structure of nucleic acids in brief. Hypochromicity, hyperchromicity, Tm, Chargaf's rule, importance of nucleotides. **13 hrs**

UNIT- III Protein structure: Primary, secondary, tertiary and quaternary structures

Peptide bond – structure, stability and formation; steric interference ; Ramachandran plots and their importance; regular ways to fold the polypeptide chain; alpha helices and beta sheets; helix turn helix, helix loop helix and combination of them, fibrous proteins and globular proteins-varieties of globular protein structure; Factors determining secondary and tertiary structure: information for protein folding, thermodynamics, disulfide bonds; prediction of secondary and tertiary protein structure; roles of chaperones and isomerases in protein folding; structures of collagen and DNA binding proteins (leucine zipper and zinc finger proteins); Quaternary structure of proteins - multisubunit proteins: homotropic and heterotropic protein-protein interactions. **13 hrs**

UNIT-IV: Enzymes: Classification and nomenclature; enzyme structure, monomeric, and multi enzyme complex systems with examples; structural features such as substrate binding site, catalytic site, allosteric site; mechanism of enzyme activation, induced conformational changes.

Cofactors and activators – characteristics, role of nicotinamide and flavin co-enzymes in redox reactions; concept of apozymes, prosthetic groups and holoenzyme.

Enyme kinetics :Rate of reaction, kinetic orders- first, second, third and zero and pseudo-order reactions; turn over, k_{cat}; Derivation of Michaelis-Menton equation, Km value, Vmax, Lineweaver-Burk plot; effects of pH and temperature on reaction rates.
Mechanism of enzyme catalysis- Activation energy, binding energy, transition states, acid-base catalysis, covalent catalysis, metal catalysis; single substrate and multisubstrate reactions;

Enzyme inhibition - reversible, competitive, noncompetitive, irreversible inhibition;
Regulation of enzyme activity - substrate-level control; feedback control; allosteric regulation – homoallostery; heteroallostery – examples; covalent modifications to regulate enzyme activity – role of proteases. **13 hrs**

References:

1. Buchanan, B.B., Wilhelm Gurssem & Jones R.L. (2000), Biochemistry & Molecular Biology of plants. American Society of Plant Physiologists, Rock Ville, USA, Maryland.
2. Colowick, S.P. *et al*., [Eds.] (1987) Methods in Enzymology; Vol. 152, Academic press.
3. Conn, E.E and Stumpf, P.K, G.Bruencing and R.G. Dol (1995). Outlines of Biochemistry. John Wiley, Singapore.
4. Conn, E.E and Stumpf, P.K. (1976), Outlines of Biochemistry, John Wiley and sons Inc, New York
5. Cox, M., Michael., Nelson,L.D. (2008). Principles of Biochemistry. 5th edition.W.H. Freeman and company, Newyork.
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8. Marks,B.D., Marks,D.A. and Smith, M.C. (1996). Basic Medical Biochemistry. Lippincoll Williams and Wilkins, USA.
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10. Stryer, L.(1995), Biochemistry (4th Edition) W.H.Freeman and company, New York
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12. Voet , D and Voet, J.G. (2004), Biochemistry, 2nd edition J.Wiley and sons
13. Wilson, K and J. Walker (1995), Practical Biochemistry; Principles and Techniques; Cambridge University Press.
14. Zubey G.L. (1998). Biochemistry, Wn. C. Brown publisher, Sydney
15. Zubey, G.L. Parson, W.W. and Vance, D.E. (1994), Principles of Biochemistry Wn. C. Brown publishers. Oxford.

HCT: MLB-102: MOLECULAR CELL PHYSIOLOGY

52 hrs

Unit-I Water and Osmoregulation: Chemical and physical properties of water, its colligative properties; hydrodynamic and thermodynamic properties of water, diffusion, fluidity; surface tension, cohesive property, tensile strength and tensile properties. Osmosis, concepts like osmotic pressure, osmotic potential and pressure potential. Chemical free energy of water, Kinetics of movement, Water Potential, Ficks law of diffusion, turgour pressure, hydraulic conductivity, Regulation of cellular pH. **Cytoplasmic fluidity:**Cytoskeletal elements- their chemistry and structural organization and their dynamics, fluidity, cytoplasmic streaming, cell movement, and the mechanism. Energy based cellular dynamics; role of molecular motors-kinesins, dyneins; structure and role of myosin, microfilaments, microtubules-actins and their role in cytoplasmic flux. **13 hrs**

Unit II: Membrane Structure and Function: Membrane composition, structure models and turnover; Membrane associated transport systems: transport of water –Structure and mechanism of transport by Aquaporins. Structure and function of different types of transporters, ion gates, passive and active transport, Bulk Transport. Facilitated –Passive and Active-uniport, ATP powered pumps-P-class, V-class, F-class pumps, and ABC family transporters, Muscle Ca-ATPase pumps, Calmodulin mediated Ca ATPase pumps, Na/K ATPase pumps, H+ATPase pumps, Ion coupled transport, voltage gated, ligand gated channels, antiport and symport mechanisms.

Concept of membrane electrical potential: Resting potential, and action potential and propagation of the same in neuronal cells; neurotransmitters and receptor and transport; mechanism of signal transmission at synapses. Synaptosomes. **13 hrs**

Unit III: Cell Receptors: Structure and function of cell surface receptor; Intracellular receptors and nuclear receptors; signal mediated signal transduction for different types of signaling molecules G-protein and PI3 mediated signal transduction. INF and cytokine. Insulin dependent pathway, TGFB induced Receptor serine/Threonine receptor kinase, NFkB pathway and Wnt-b Catenin pathways and down stream cascade of signal transductions. LDL receptor and Chloesterol metabolism. Protease activated receptors.

Signal Transduction: Cell to cell communication- autocrine, paracrine, endocrine systems; Synaptic; role of Gap junction in signal sharing, cell potential to receive signals and competence, kinds of signals, external and internal; Effect of concentration of signals; short-term and long-term signal induction and sustenance; chemistry of signaling molecules. **13 hrs**

Unit IV: Intracellular Membrane and Protein flow

Intracellular compartments and their characteristic features; membranes and proteins involved in transport-structures involved in trafficking of proteins. Protein sorting- secretory pathway; receptor mediated endocytosis and sorting of internalized proteins; structure and role of variety proteins involved in vesiculation, transport and targeting; clathrin and its associated proteins, adaptor proteins, CopI and Cop II and its associated proteins, receptor proteins,

docking proteins, proteins involved in fusion of membrane to membranes, endocytosis, exocytosis and transcytosis

Fluid flow circulation in Plants and Humans: Include fluid flow and circulation in plants and animals-human; plants-Transpiration and Guttation, Absorption of water and mineral salts and flow, Ascent of sap, structures involved and mechanism. Fluid flow in human body structures involved and mechanism-heart, Veins and arteries, Blood Circulation and Excretion-structure and function involved. **13 hrs**

References:

1. Buchanan, B.B, Gruissem, W. and Jones, R.L. (2004). Biochemistry and Molecular Biology of plants. I.K. International Pvt., New Delhi.
2. Conn, E.E., Stumpf., Bruenning, G and Doi, R.H. (1987). Outlines of Biochemistry. John Wiley and Sons, New York.
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10. Thomas Zeuthen and Wilfred D,Stein (2002). Molecular mechanisim of water transport across Biological membranes Vol.215 (International Review of Cytology) Academic Press 442 pages ISBN-0123646197 (Flipkart.com).

HCT: MLB-103: MOLECULAR CELL BIOLOGY

52 hrs

Unit-I Extracellular matrix and cell-cell interaction: Animal systems: Extracellular components – cell matrix adhesion, collagens – types of collagens, elastins, basal lamina and its components, connective tissues, proteoglycans and laminin. Cell - cell adhesion, cadherins, CAMS (NCAMS), selectins, integrins, desmosomes, hemidesmosomes, tight junction, gap junction, Catenins, actins, Tubulins, intermediate filaments, glycosaminoglycans.

Plant systems: Extracellular matrix components of plants-cell wall, cellulose and hemicelluloses, extensins, WAKs, secondary wall structure, pits-primary and secondary pits and their development, plasmodesmota-structure and functions, pectins, cutins, lignins, turnover of cell wall components during cell elongation and cell division, function of specific planthormones involved in cell elongation and transformation**.** Structural organization, biogenesis and functions of: Endoplasmic reticulum, Golgibodies, Lysosomes, plant cell vacuoles, peroxisomes-glyoxysomes **13 hrs**

Unit-II Nucleus: Structure, nuclear membrane, nuclear lamins, pore complexes, nuclear matrix composition and its role, cajal bodies, SFCs, nuclear speckles, PML bodies, nucleolus- its structure and function**.**

Chromosomes: Types of chromosomes, basic structural features, chromosomal numbers, chromosomal banding, molecular organization of eukaryotic chromosome, MARS/SARS.

Heterochromatin, euchromatin structures; structural organization of Centromeric region, components and structure of Kinetochore, difference between mitotic kinetochores and meiotic kinetochores; structural organization of telomeres, proteins involved in heterochromatization of telomeric regions. Structural organization and molecular biology of salivary gland and Lampbrush chromosomes, importance of their study at specific stages of development. **13 hrs**

Unit-III Cell cycle: Comparative account of cell cycle events in yeasts and animal cells; check points during cell cycle-G1 to S, progression of S phase, G2 to M phase, Anaphase check points and components involved as regulators of check points, role of cyclins and CDKs, synthesis and degradation of cyclins, structural features of CDKs and cyclins, activation and inactivation of cyclin dependent kinases; role of RBs, E2Fs, and DP proteins, P53, different types of Cyclin dependent CDKs, CDC25, CAKs, Wee1 proteins, nim-proteins, SCFs, APC complexes (cyclosomes), licensing factors, replication origin and replication initiation complexes.

Centrosome activation- structure, duplication of centrosomes, Role of nucleophosmins, organization of mitotic apparatus, binding of tractile fibers to kinetochore complexes, molecular motors involved in movement of chromosomes to equatorial plate and in anaphase movement; cytokinesis by cleavage and phragmoplast formation- different gene products and structures involved and the mechanisms of cytokinesis. **13 hrs**

Unit-IV Apoptosis;Characteristic features of cells undergoing apoptosis and necrosis, par apoptosis and cell death forms. Apoptosis during developmental process and irregular apoptosis and disease.

Death signals-Withdrawal of growth factors and nutrients, peroxides, ceramides; receptors for death signals, TNF alpha, Fas ligands, their receptors, activation and transduction effects. Death causing genes – Ceds, proteins – Caspases, mechanism of programmed cell death (PCD), direct activation by death signals. Pathways of Apoptosis.

Cancer: Types of cancer, development of cancer, cancer stem cells, causes of cancer, properties of cancer cells. Metastasis, description of some common cancers – breast cancer, colon cancer, leukemia. Retroviral oncogenes, protooncogenes, tumor suppressor genes (P53) and their functions. Early detection of cancer, molecular diagnosis, treatment (radio therapy, chemotherapy, immunotherapy and use of RNAi techniques and stem cells) **13 hrs**

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1. Alberts. B., Bray, D., Lewis, J., Raff, M., Roberts, K and Watson, J.D. (1994). Molecular Biology of the cell. Garland Publisher Inc., New York
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HCT: MLB-104: MICROBIOLOGY

52 hrs

Unit-I

Viruses: Classification of viruses and the basis; Occurrence, structural organization of capsids (including geometrical pattern), DNA or RNA viruses, infection method, replication of the genomes, regulation of replication, assembly of the viral particles, M13 virus, T4 phages, Lambda phage (Lytic and lysogenic pathways), Orthomixovirus and Adenovirus, CaMV.

Bacteria: Occurrence, structure of bacteria in general, classification- Ultra structure of E.coli, fagella, cilia, fimbriae, sex pili, , Genome organization, cell division and its regulation.
Recombination in Bacteria- E.coli as an example; sex determination, F+, HfR strains, conjugation mechanism, mapping and genetic recombination, transductions, sexduction. **13 hrs**

Unit-II

Bacterial plasmids: Features, plasmid with Sex factors, R-plasmids, pathogenic plasmids, ColE1 plasmids; transformation mechanism of bacteria; transposable elements IS type, Tn type, retrotranspons, structural features and their occurrence, mode of transposition, transposons mediated drug resistance, to locate genes using transposons and disrupt normal genes.
Cyanobacteria: Occurrence, structural features; structural organization; mechanism of photosynthesis. Importance of Cyanobacteria. ***Agrobacterium***: Occurrence, structural features, Genome and its plasmid T-DNA and Ti and Ri plasmids, mechanism of infection and causing crown galls. **13 hrs**

Unit-III

Fungi: General features, classification of fungi, detailed account of Yeast types, structure and reproduction, genetics of mating, cytoplasm inheritance, cell division mode, and the regulationof yeast cell cycle in brief.
Microbial metabolism: Mechanism of bacterial photosynthesis, chemosynthesis, Light and dark reactions, - oxidative process. Bacterial carbohydrate metabolism, EMP pathway, Entner-Doudoroff pathway, Warburg Dickens pathway, pentose and hexose-ketolase pathways, electron transport chain, anaerobic pathways. Mechanism of Nitrogen fixation, regulation of Nod, Nif genes, hup genes. **13 hrs**

Unit-IV

Microbial pathogenesis: Viral-pathogenesis (Influenza), Protozoan parasites (Plasmodium), mechanism of infection, effects on host cells, host response to infection; resistance to pathogenesis in plants, role of pathogen resistant genes R genes and the mechanism of resistance.
Medically important bacteria: Mode of infection and pathogenesis of Staphylococcus, Clostridium, Streptococcus, Enteropathogenic bacteria, Salmonella and Mycobacterium. **13 hrs**

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SCT: MLB-105: TOOLS AND TECHNIQUES OF MOLECULARBIOLOGY

39 hrs

Unit I:Microscopy and Microscopic techniques: Mechanism, application of light, inverted phase contrast, electron microscope (SEM & TEM), confocal microscope, scanning tunneling microscope, fluorescence microscope, Micrometry and flow cytometry, Rotary and ultra microtomes.

pH measuring divices, biochemical buffers, principles of electrochemical techniques, potentiometry and voltametry, conductivity bridge, oxygen electrode and biosensors. Cell disruption techniques sonication, freeze-thaw techniques, enzymatic methods. Centrifugation – basic principles of sedimentation, types of centrifuges and rotors, ultracentrifugation, differential centrifugation, density gradient and analytical ultracentrifugation and its application,Turbidometry. **13 hrs**

Unit II: Cell culture and Molecular biology tools: laboratory organization, media, sterilization techniques, cell suspension culture, micro propagation, protoplasts isolation and fusion and cryopreservation. Explant cultures, isolation of animal cell primary cultures and cell lines. PCR, RT-PCR, nano-drop, DNA analyzer. Definition of eletrophoresis, PAGE, SDS-PAGE, isolectrofocussing, 2D electrophoresis, agarose gel electrophoresis, recovery of DNA from agarose gels, Pulse-field gel electrophoresis**.** **13 hrs**

Unit III: Separation methods -general principles and definition, Partition, absorption, gas-liquid chromatography, paper chromatography and TLC. Gel filtration and principles of affinity chromatography, HPLC and ion-Exchange chromatography.

Spectroscopy-instrumentation and application of UV- visible spectrophotometer, fluorescence spectroscopy, NMR, Mass spectroscopy, IR, Raman, X-ray diffraction in determining molecular structure of proteins. **13hrs**

References:

1. The Principles and practice of electron microscopy. Watt IM, Cambridge Unive, press, London, 1989.
2. Gordon.M.H. and Macrae.M. instrumental analysis in biological sciences., Blackie and sons Ltd. London 1998
3. Principles of physical biochemistry. Vanholdem.W.C and Johnson, P.S. Printice Hall, 1998.
4. Principles and techniques in practical biochemistry.Wilson.K and Walker.J.M. Foundation books, New Delhi, 1994.

Practicals:

HCP: MLB-106: Biochemistry-I

1. Estimation of carbohydrates – Hagedorn & Jensen method
2. Estimation of amino acids – Ninhydrin method
3. Estimation of proteins – biuret method, Lowry method, Bradford method
4. Estimation of total sugars (anthrone method), reducing sugars (Nelson-Somogyi method)
5. Estimation of cholesterol (Zach's method)
6. Isolation and partial purification of urease and determination of specific activity
7. Effect of substrate concentration on urease activity and determination of Km
8. Effect of temperature and pH on urease activity

HCP: MLB-107: Molecular Cell Physiology

1. Extraction of lipids-Plant and animal sources.
2. Qualitative estimation of lipids-using standard curve, emulsion test, solubility and saponification test, acid value test.
3. Determination of Iodine Number of different lipids.
4. Salicylic acid chromatography of Lipids
5. TLC of lipids and identification of different lipids.
6. Separation of Sugars by TLC.
7. Separation of amino acids by TLC.
8. Preparation of proteins by acetone extraction method and also ammonium sulfate fractionation method and running the gel.

HCP: MLB-108: Molecular Cell Biology

1. Preparation of Meiotic chromosomes using Haemotoxylin/Feulgen stain-*Poecilocera picta*
   X- linked chromosomes-Bar Bodies
2. Isolation of Nuclei and determination of its purity
3. Isolation of mitochondria and plastids and Examination under microscope
4. Isolation of mitochondria and chloroplast DNA – run a gel to check the quality of DNA
5. Preparation of salivary gland chromosome-*Drosophila melanogaster*
6. Vital Staining-Animal and plant, Dye exclusion technique to determine cell viability.

HCP: MLB-109: Microbiology

1. Laboratory Safety including Chemical, Biological and Radiations. Principles and Practices of Sterilization.
2. Preparation and Sterilization of Media, Buffers, Solutions and Reagents.
3. Enumeration of microbes (bacteria and fungi) from water and soil.
4. Growth curve of *E. coli*
5. Isolation and culture of *Rhizobium* from soil and root nodules of leguminous plant.
6. Isolation and growth of cyanobacteria (Study of preserved specimens)
7. Preparation of competent cells by calcium chloride genetic transformation using PUC 18
8. Isolation of bacterial plasmid by Alkali lysis method.
9. Restriction of plasmid DNA and agarose gel electrophoresis.

II Semester

HCT: MLB-201: MOLECULAR BIOLOGY –I

52 hrs

Unit I: DNA: Chemical composition of DNA

DNA structure-single stranded DNA, detailed account of double stranded DNA-BDNA, Z.DNA, and other structural forms, triple stranded DNA and quadruplex DNAs, curved DNA, rod shaped DNA, and their importance. Super coiled DNA:

Changes from one form to the other, and the enzymes involved, concept of Linking numbers. Importance of super helical DNA and their structural forms. Types of Topoisomerases and their function in adding or removing superhelical structures. Characteristic features of highly repetitive DNA; Tandemly repetitive DNA and Mini and microsatellite DNA and Insertional elements and their role and importance **13 hrs**

Unit II: Cvalue paradox- Genome size and content over members of different orders and of the same family; cDNA value paradox. Resolving the paradox by DNA-DNA and DNA-RNA hybridization kinetics.

Kinetics of DNA-DNA hybridization, DNA-RNA hybridization, Cot curves, Rot curves, kinetic complexity, chemical complexity, Results of kinetics – determining the portion of genomic DNA which has highly repetitive DNA, moderately repetitive DNA and Non repetitive DNA.

Rot curve analysis to find the number and the kind of gene expressed in general and tissue specific manner, the copy numbers of each species of mRNAs, by subtractive method, additive method and micro array method. **13 hrs**

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Unit III: DNA replication:

Prokaryotic DNA replication; replication origin and site and structure and DNA Ter regions and structure. DNA polymerases, composition and features, replication factors and the mechanism of replication, leading strand and lagging strand synthesis, procesessivity and fidelity and regulation of replication. Replication of single stranded DNA, M13 viral DNA-use of them as cloning vectors.

Eukaryotic-replication origins, replication initiation complexes and their assembly, licensing factors, DNA polymerases and their composition, telomerase and mode of action, replication factors, disassembly of chromatin components and reassembly during replication. Organelle genome and composition, replication origins, Enzymes and factors involved in the Replication of mitochondrial DNA and Chloroplast DNA and the mechanism involved. **13 hrs**

Unit IV:

DNA damage: types and there repair – Factors involved DNA damage: types and their repair mechanisms-mechanism of DNA repair and the regulation of it; direct repair-excision-repair transcriptional excision repair, glycosylase pathway, miss-match repair, UVr A,B & C mechanism, broken end repair, recombination repair and SOS repair system.

RNAs: types

rRNAs; Structural features of rRNAs- prokaryotic and eukaryotic. tRNAs: structural features, their anticodon feature.

mRNAs- prokaryotic and eukaryotic mRNAs, structural features,

Genomics RNAs, Replication of Picorna and Rabies Viral RNA and mechanism; Structure of retroviruses, classification, Replication of HIV viral RNA; Sn-RNAs, Sno RNAs, RNAi **13 hrs**

References:

1. Alberts, B., Bray, D. and Hopkin, K. (2004). Essential Cell Biology. 3rd edition. Garland Science, U.S.A
2. Cox, M., Michael., Nelson,L.D. (2008). Principles of Biochemistry. 5th edition.W.H. Freeman and company, Newyork.
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13. Watson, Baker, Bell, Gann, Levine and Losick. (2006). Molecular Biology of the Gene, 5th edition, Pearson Education.
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15. Watson, J.D., Baker,A.T. and Bell, P.S. (2008). Molecular Biology of Gene. 5th edition. Pearson Education Inc.

HCT: MLB-202: GENETIC ENGINEERING

52 hrs

Unit I: Restriction enzymes:
Restriction and modifying enzymes, Type I , Type II and Type III enzymes and their characteristic features; Use of Type II restriction enzymes for recombinant DNA technology (restriction sequences, sticky tail with 5' and 3' and blunt ends, isoschizomers, rare cutting enzymes, enzyme cutting similar sequence in different manner). RFLP and restriction site mapping

DNA Modifying enzymes:
Characteristics and applications of Nucleases – DNase and RNase, DNA-Pol I, Klenow fragment, T4DNA polymerase, T7 DNA polymerase, Sequenase, T4 Polynucleotide kinase, Phosphatase, Reverse transcriptase, TAQ polymerase and Ligase. Terminal deoxy ribonucleotidyl transferase. **13 hrs**

Unit II: Cloning vectors:
Description of different vectors- pBR 322, pUC plasmids, Lambda,and M13 Phage, SV40, ADV, HPV-EPV viruses, Retroviral vector, cosmid, YAC, BAC and PAC vectors and their characteristic features, for general cloning, sub cloning, Design of prokaryotic and eukaryotic expression vectors.

Cloning hosts:
Bacteria, Yeast, Plant cells and Animal cells, preparation of competent cells for genetic transformation.

Protocols:
(a) Agarose gel electrophoresis, (b) Methods of Cloning, sub cloning and characterization of cloned material, (c) DNA transfer techniques:- Transformation, Transfection, Electroporation and Gene gun methods. **13 hrs**

Unit III: Gene Isolation methods:
(a)DNA libraries – Genomic and cDNA libraries, (b) Molecular probes and their labeling (radioactive and non radioactive labeling), (c) Hybridization and gene screening (d) Blotting of macromolecules – Southern, Northern and Western blotting, (e) Positional cloning- RFLP, chromosome jumping and chromosome walking.

PCR Techniques:
Different PCR techniques; RACE, Stand alone, Long term PCR, PCR cloning, PCR based DNA Profiling, application of PCR techniques (AFLP, RAPD, ISSR).

13 hrs

Unit IV:
(a) DNA sequencing: Synthesis of Oligonucleotides, Maxam-Gilbert and Sanger methods. Preparation of dsDNA or ssDNA, manual, automated and capillary sequencing systems and their advantages and drawbacks. High throughput sequencing systems. Prosequencing, polony sequencing and nanopore/solex sequencing.

(b) In Vitro Translation : By cell free extracts from bacteria, wheat germ and Rabbit Reticulocytes and their applications. **13 hrs**

References:

1. Brown,T.A. (1995). Gene Cloning: An introduction. Chapman and Hall, London
2. Glick,B.R. and Pastenak, J.J. (1994). Molecular Biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington D.C.
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HCT: MLB-203: PRINCIPLES OF GENETICS

52 hrs

Unit-I

Mendelism: Mendelian laws of inheritance**:** Law of dominance, Law of segregation and Law of independent assortment, Chi-square test.

Extensions of Mendelian principles: Incomplete dominance, co-dominance, multiple alleles, lethal alleles, interaction of genes (13:3, 15:1, 9:7), penetrance and expressivity.

Evolution of genes concept: Factor, allele. pseudoallele, (cistron, recon, muton) fine structure of gene: rII locus of gene, split genes, over lapping genes, jumping genes. **13 hrs**

Unit-II

Linkage and chromosomal mapping: crossing over frequency, chiasma frequency, multiple crossovers, limits of recombination; genetic mapping- mapping distance, two point test cross, three point test cross, gene order, recombination percentage and map distance, interference and coincidence; linkage maps, mapping function and cross over suppression, Balanced lethal system.

Linkage and crossing over: Meiosis and mitosis as the basis of Law if segregation, and law of independent assortment Regulation of Meiosis, synaptosomal complexes, biochemistry of meiosis apparatus and chromosomal movements, and regulation of the same; molecular basis of crossing over and recombination, detailed account of synapsis, synaptosomes and separation.

Inbreeding depression and Heterosis: Inbreeding depression, heterosis- manifestation of heterosis; Genetic basis of inbreeding depression and heterosis, Interallelic dominance hypothesis and over dominance, super dominance; application of heterosis. **13 hrs**

Unit-III

Sex linkage and sex determination: Sex linked inheritance in *Drosophila* and Man. Sex linked traits, Sex influenced traits and sex limited traits and sex reversal.

Chromosomal and Molecular basis of sex determination: *Drosophila*, C. *elegans*, Man and *Melandrium.*

Extrachromosomal Inheritance in *Chlamydomonas*, Yeast, Paramecium,male sterility in maize, Leaf variegation in *Mirabilis jalapa*. Maternal effect (*Limnaea peregra*)

Mutation: Types of mutations: Spontaneous, induced, somatic, germline, Physical and chemical mutagens.

Chromosomal Mutations: Deletion, Duplications, Inversions and Translocations and their cytogenetic implications.

Molecular mechanisms of gene Mutations: Transitions, transversion, insertions, deletions, missense mutation, nonsense mutation, silent mutation, neutral mutation, suppressor mutation.

Detection of mutations: Dominant lethal, II-III translocations, tetrad analysis and Ames test. **13 hrs**

Unit-IV

Population genetics: Statistical approach-concept of gene pool, gene frequency, genotype frequency. Hardy Weinberg law of equilibrium; calculation of gene frequencies.

Quantitative genetics: Distribution, samples, populations, correlations, and regression; Heritability- phenotypic variability, types, calculations of heritability and limitations.

Evolutionary genetics: Biological species concept, Mechanisms of reproductive isolation, modes of speciation, Molecular evolution – nucleotide and amino acids variation, molecular clock, neutral theory of evolution, genome evolution (Primate evolution). **13 hrs**

References:

1. Alberts, B, Johnson, J Lewis, M.Raff, K Roberts and P.Watter. (2002). Molecular Biology of the cell IV eds Garland Science, New York
2. Beatty,, B.S. Mai and J. Squire (2002). FISH. Oxford Univ. Press, Oxford
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4. Dobzhansky Th., F.J. Ayala,, G.L. Stebbins and J.M. Balentine, (1976). Evolution. Surjeet Publication, Delhi
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6. Hollander A (Editor) (1971-76) Chemical mutagens: Principles and methods of their detection. Vols.1-3, Plenum press New York
7. Lodish, Berk, Matsudaira, Kaiser, Krieger, Scott, Zipursky and Darnell (2005) Molecular Cell Biology, 5th Editon, W.H. Freeman and Company, NY
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13. Verma R.S. (Editor) (1988) Heterochromatin: Molecular and Structural aspects. Cambridge University Press, Cambridge.

HCT: MLB-204: PLANT TISSUE CULTURE

52 hrs

Unit I: History and applications of Plant Tissue Culture: Concept and development of tissue culture, role of auxins and cyctokinins, improvement of media and recent advances in plant tissue culture. **Requirments**: Media preparation, Basic laboratory organization, instruments and equipments, culture media composition of media, selection of media, sterilization.
Totipotency: Vascular and organogenic differentiation, dedifferentiation, redifferentitation, totipotency of epidermal and crown gall cell. **13 hrs**

Unit II: Clonal Propagation:Techniques: multiplication by axillary bud, apical bud and adventitious shoots, factors influencing shoot multiplication and rooting Hardening and acclimatization of plants to the soil.

Organ, tissue and cell culture: Meristem, Leaf, Root, Flower, Anther, Pollen, Ovary, Ovule and Embryo, Nucellus and Endosperm. A General account of single cell culture. **13 hrs**

Unit III: Somatic Embryogenesis: Types, embryo maturation and plantlet development, factors affecting somatic embryogenesis and practical application of somatic embryogenesis.
In vitro Pollination and Fertilization: Methodology, factors affecting seed setting after in vitro pollination and applications.

Protoplast Culture: Isolation of protoplast, methods source of materials, culture, media, regeneration and protoplast fusion, somatic hybrids, cybrid production and their practical application.

Somaclonal and Gametoclonal Variation: Source of materials, culture, conditions, molecular basis of variation, isolation of variants, disease resistance, herbicide resistant and stress tolerant lines. **13 hrs**

Unit IV: Role of Tissue Culture in Germplasm Conservation: Modes of conservation Need for in vitro conservation, cryopreservation and artificial seeds.
Genetic Transformation: Design of expression vectors with marker or reporter genes for plant systems, gene cloning, methods of transfer of genes into plant tissues and protoplast.
Industrial application with particular reference to Secondary Metabolites: Techniques of selecting cell lines for high yields of compounds of secondary metabolites, mass cultivation of plant cells, Bioreactors, Elicitor-induced accumulation of products, factors limiting large scale production of useful components: application of tissue culture for synthesis of useful compounds. **13 hrs**

References:

1. Bajaj, Y.P.S. (Ed.). **Biotechnology in agriculture and forestry**. Various volumes published time to time. Springer-Verlag, Berlin
2. Bhojwani, S.S. 1990. **Plant tissue culture: Applications and limitations.** Elsevier Publishers, Amsterdam.
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11. Sen, S.K. and Giles, K.L. (Ed.) 1983. **Plant cell culture in crop improvement.** Plenum Press, New York.
12. Street, H.E. 1977. **Plant tissue and cell culture.** Academic Press, Berkeley, University of California. USA.
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15. Yeoman, M.M. 1985. **Practical Cell culture technology.** Blackwell Scientific Pub. London.

SCT: MLB-205: MICROBIAL BIOTECHNOLOGY

39 hrs

Unit I: Use of microbes in industry: Media used, culturing under optimal conditions; Isolation and maintenance of microbial strains, and genetic improvement of strains.
Shake flask method, Bioreactor method, solid-state fermentation method, aerobic and anaerobic fermentation method, immobilized cell bioreactor method, downstream processing and quality control. Production of organic compounds by fermentation-alcoholic beverages (wine and industrial alcohol), Acetone, Butanol, and Gluconic acid.

Biotransformation methods: Biotransformation of D-Sorbitol to L-Sorbose, conversion of biopolymers, conversion of ascorbic acid, Biotransformation of antibiotics (penicillin), steroids and sterols (eg.ergosterol). Expressing heterologous genes - Metabolic engineering (with example) in bacteria, advantages, disadvantages and limitations. **13 hrs**

Unit II:

Production of Restriction enzymes, Production of DNA modifying enzymes, Extreme enzymes (Taq DNA polymerase and keratinase), bifunctional enzymes. Enzyme immobilization and its application: Enzymes used in food (proteases and amylases) and beverage (amylases and invertases) industries, detergent industry, leather industry, wool industry, paper industries.
Production of glucose from Cellulose; application in food, dairy (proteases), beverage and pharma industry. Yeast expression systems for production of therapeutical agents: Hepatitis-B surface antigen, Human platelet derived growth factor B.

Production of single cell proteins: Large scale production and application. *Spirulina maxima* (Cyanobacteria), *Kluyveromyces fragilis* (yeast), *Candida lipolytica* (yeast), *Chaetomium cellulolyticum* (fungus), *Methylophilus methylotrophu*s (bacterium). **13 hrs**

Unit III: Microbes and environment-I: Brief account of pollution control-use of cleaner technology, treatment of industrial effluents, toxic sites, Genetically engineered microbial systems (GEMS) for environmental remediation. Production of biofuels from municipal and agricultural waste. Methanogenic and hydrogen producing bacteria for biofuel production.

Microbes and environment-II: Bioremediation and Bioleaching: Land restoration or reclamation by microbes. Mycorrhizae, biofertilizers, biopesticides. Collection, conservation and cataloguing of microbial biodiversity – their role in environmental conservation and reclamation.
13 hrs

References:

1. Bruce Alberts, Julian Lewis, Alexander Johnson, J. Lewis, M. Raff (1994), Molecular Biology of the Cell, Garland Publisher Inc., New York
2. Buchnan and Grussem et al, (2000) Biochemistry and Molecular biology of Plants by 5th edition, Oxford University Campus
3. Goodwin and Mercer- CBS, Plant Biochemistry
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7. Taiz, L. and Zeiger, E. (2003). Plant Physiology. 3rd edition. Panima Publishing Corporation, New Delhi/Bangalore
8. Taiz, L. and Zeiger, E. (1998). Plant Physiology. 2nd edition. Sinauer Associates, Inc., Publishers, Massachusetts, USA.
9. Wilkins, M.B. (eds.) (1989). Advanced Plant Physiology. Pitman Publishing Ltd., London.
10. Taiz,L. and Zeiger, E.(2006). Plant Physiology. 4th edition.Sinaver Association Inc. Sunderland, USA
11. Pareek,K.L. and Swarnkar,P.L. (2006). Trends in Plant Tissue Culture and Biotechnology. Agro bios, Jodhpur.

PRACTICALS

HCP: MLB- 206: MOLECULAR BIOLOGY –I

1. Spectral analysis of DNA.
2. Spectral analysis of Proteins.
3. Isolation of genomic DNA from plants, animals and microorganisms.
4. Isolation of plasmid and determination of purity.
5. Estimation of DNA.
6. Estimation of RNA.
7. Determination of molecular weight and quantification of DNA using AGE..

HCP: MLB-207: GENETIC ENGINEERING

1. Restriction digestion of genomic DNA from plants.
2.Restriction digestion of genomic DNA from animal tissue.
3.Restriction digestion of genomic DNA from microorganisms. .
4. Agarose gel electrophoresis of restriction fragment.
5. PCR amplification of DNA.
6. Extraction of total RNA from Plant tissue
7.Separation of RNA through AGE.

HCP: MLB–208: PRINCIPLES OF GENETICS

1. Culture of *Drosophila* .
2. Studies of inversion polymorphism in *Drosophila.*
3. Bacterial culture and preparation of competent cells.
4. Identification of mutants in *Drosophila.*
5. Studies of phylogenetic trees.
6. G, C and Q banding techniques.

HCP: MLB-209: Plant tissue culture

1. In vitro morphogenetic studies on any one plant system (Seed culture, multiplication of shoots, rooting and hardening)
2. Isolation of explants, establishment, subculture and maintenance of callus.
3. Morphology of callus cells (callus smear preparation) and histological aspects (microtomy).
4. Embryogenesis in culture cells/tissues
5. Anther culture for haploid production.
6. Embryo culture.
7. Preparation of synthetic seeds.
8. Isolation of Protoplasts
9. Secondary Metabolite production by single cell culture

III Semester

HCT: MLB-301: BIOCHEMISTRY –II

52 hrs

UNIT I: Bioenergetics: Concepts of internal energy , enthalpy, entropy, interplay of enthalpy and entropy, free energy and work, free energy change and the equilibrium constant, chemical potential, coupled reactions, laws of thermodynamics in relation to biological systems, Gibbs free energy.

Biological oxidation and electron transport: Oxidations and energy generation; standard reduction (redox) potential; free energy changes from oxidation/reduction; mitochondrial structure and function

Electron transport system – topology, chemical nature and sequence of electron carriers; inhibitors and artificial electron acceptors; shuttling electron carriers into the mitochondrion; oxidative phosphorylation; P/O ratio; mechanism of oxidative phosphorylation - chemiosmotic coupling; structural insights into oxidative phosphorylation - the F_0F_1 complex; integrity of mitochondrial membranes; uncoupling ETS and oxidative phosphorylation; energy yields from oxidative phosphorylation; respiratory control of oxidative phosphorylation, mechanism and photophosphorylation. Oxygen as substrate for other metabolic reactions - oxidases and oxygenases, cytochrome p450, reactive oxygen. **13 hrs**

UNIT II:Carbohydrate metabolism – I: catabolic processes Glycolysis – pathway and regulation; metabolic fates of pyruvate – anaerobic and aerobic; TCA cycle – pathway and regulation; alternate pathways – glucuronate, glyoxalate and pentose phosphate pathways; Catabolism of other monosaccharides and disaccharides

Catabolism of polysaccharides – glycogen mobilization and regulation of breakdown; starch and glycogen digestion, metabolic disorders.

Carbohydrate metabolism – II: Anabolic processes Gluconeogenesis – pathway and regulation; glycogen biosynthesis – pathway and regulation; biosynthesis of other polysaccharides. **13 hrs**

UNIT III: Photosynthesis:

Basic processes of photosynthesis; structure and organization of photosynthetic apparatus; absorption of light – the light harvesting system - the energy of light; light absorbing pigments; light gathering structures; photochemistry in plants and algae - photosystems II and I; cyclic electron flow; bacterial photosynthesis; Calvin cycle; overall reaction and efficiency of photosynthesis; regulation of photosynthesis; RUBISCo structure and function photorespiration; C_4cycle and CAM pathway.

Lipid metabolism: Mobilization of stored fat - oxidation of saturated, unsaturated and odd-numbered fatty acids, regulation, peroxisomal β-oxidation of fatty acids

Fatty acid biosynthesis - relationship of fatty acid synthesis to carbohydrate metabolism; elongation of fatty acid chains; fatty acid desaturation; control of fatty acid biosynthesis; biosynthesis of triacyl glycerol and phosphatidlyl choline.

Biosynthesis of cholesterol and its regulation metabolism of eicosanoids-prostaglandins, thromboxanes and leukotrienes Metabolic disorders. **13 hrs**

UNIT IV: Nitrogen metabolism: The nitrogen cycle; protein turnover; amino acid degradation; urea cycle; ammonia transport in the body **Amino acid metabolism** : citric acid cycle intermediates in amino acid metabolism - glutamate as a precursor to other amino acids, metabolism of ornithine and arginine; metabolism of sulfur-containing amino acids - metabolism of glutathione, S-adenosylmethionine and biological methylations, polyamines; metabolism of aromatic amino acids in plants and animals and histidine – biosynthesis of aromatic rings, biosynthesis of histidine,; biosynthesis and metabolism of serine, glycine and threonine; metabolism of valine, leucine, isoleucine and lysine, metabolic disorders

Nucleic acid metabolism-I : Nucleotide metabolism - biosynthetic routes: *de novo* and salvage pathways; nucleic acid degradation and the importance of nucleotide salvage; *de novo* biosynthesis of purine nucleotides; Purine degradation and clinical disorders of purine metabolism;

Nucleic Acid Metabolism-II: pyrimidine nucleotide metabolism - de novo biosynthesis of the pyrimidine ring, control of pyrimidine biosynthesis, pyrimidine catabolism; Deoxyribonucleotide biosynthesis and metabolism; thymidylate synthase: a target enzyme for chemotherapy. **13 hrs**

References:

1. Bob B. Buchanan, Biochemistry and Molecular Biology of Plants (2004), Wilhelm Guissem and Russel L. Jones, I.K. International Pvt. Ltd, New Delhi
2. Conn E.E. and stumpf, G. Bruenning, R.H. Boi (1987), Outline of Biochemistry by John Wiley & Sons, New York
3. Cox, M., Michael., Nelson,L.D. (2008). Principles of Biochemistry. 5th edition.W.H. Freeman and company, Newyork.
4. David Rawn, J, (Ed.), (1989), Biochemistry Neil Patterson Publishers
5. Donald and Judith Voet (2005), 2nd edition, J.Niley & Sons, Biochemistry
6. Hall, D.O and K.K.Rao (Eds), (1999), Photosynthesis; 6th Ed., Cambridge University Press.
7. Jocelyn Dow, Lyndsay Gordon, and Jim Morrison, Biochemistry: Molecules, cells and the body
8. Lars Garby and Paul S Larsen (Eds), (1995), Bioenergetics and its foundation; Cambridge University Press.
9. Lehninger et al., (Eds), (1997), Principles of Biochemistry; 2nd ed., Worth Publishers.
10. Marks,B.D., Marks,D.A. and Smith, M.C. (1996). Basic Medical Biochemistry. Lippincoll Williams and Wilkins, USA.
11. Peter R Bergethon (Ed), (1998), The Physical Basis of Biochemistry; Springer Verlag.
12. Thomas Devlin (Ed),(2002),Biochemistry with clinical correlations; Wiley-Liss.
13. Tiaz and Zeiger, (2003). Plant Physiology, 3rd edition, Lincoln Taiz and Eduardo Zugier, Parima Publishing Corporation, New Delhi
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15. Voet, D and Voet, J.G. (Eds.), (1999), Biochemistry; 3rd ed., John Wiley and Sons.

HCT: MLB-302: MOLECULAR BIOLOGY-II

52 hrs

Unit I: Concept of Gene:

Genome sizes, kinds of genes, gene numbers, functional genes, cryptic genes, pseudogenes, processed genes, overlapping genes, family of genes.

Gene structure: Structural organization of prokaryotic and eukaryotic genes-regulatory elements of genes (proximal or internal, including promoter, operator, activator and enhancers), coding region and terminal region of the genes.

Prokaryotic Gene Expression: Ribosomal RNA operons and ribosomal protein operons; Transcriptional Apparatus: RNA polymerase structure, subunits and their function; sigma factor, their character and role; mechanism of transcription, initiation, elongation and termination.

13 hrs

Unit II: Regulation of prokaryotic genes expression and operons: Genetic regulation of sporulation in *B. subtilis*, role of sigma factors in sporulation. Regulation of Lac operon, Tryptophan operon, Histidine operon and Arabinose-operon, Concept of regulons, stimulons , operons, global regulators.

Lambda phage: Regulation of lytic and lysogenic pathway in *lambda* phage, cI-repressors, cro-repressors, transcriptional terminators and antiterminator, early and late genes, their expression and regulation.

Eukaryotic gene expression: DNA binding proteins- Concise account of Helix turn Helix proteins, Helix loop helix proteins, Helix turn beta, Zinc finger proteins, leucine zipper proteins, homeodomain proteins, beta barrels, bZIP and bHLH domains and proteins with combination of the above and how they bind and bring about regulation of gene expression.

Transcription factors (TFs): Concept of activators, activator domins, coactivators and mediator complex, enhancer proteins and their binding factors, DNA binding sequence elements, response element binding factors and their role in general. (Enzyme complexes and their assembly on the regulator region; sequential assembly of the TFs on promoter and interaction between RNA-Pols and TFs and other upstream factors). Mechanism of transcriptional initiation, elongation and termination. **13 hrs**

Unit III: Eukaryotic RNA polymerase: RNAP-I: rRNA gene clustering, structural organization of rRNA genes, Regulatory regions (core sequences and upstream control elements), coding and terminal regions; RNAP I enzyme subunits, its associated transcriptional factors and their role, mechanism of transcription-initiation, elongation and termination.

RNAP-II : Structural organization of regulatory, coding and terminal regions of house keeping genes; Genes that are regulated in response to stimuli-light, chemicals and hormones, stage specific and tissue specific gene regulation.

RNAP-III: Regulatory elements, (internal promoters), coding and terminal regions of 7sLRNA gene, tRNA genes, and 5SrRNA genes; RNAP III enzyme and its composition, transcriptional factors, assembly of the same and the mechanism of transcription and termination.

Characterization of TATA box: upstream elements to TATA box, InR elements, Downstream promoter elements (DPE), enhancer elements, activator elements, response elements, silencer elements/repressor elements, insulators; Promoters with TATA, InR and DPE, promoters without TATA, promoters without TATA and InR elements, their structure and function. **13 hrs**

Unit IV: Gene expression and Chromosome remodeling: Structural remodeling during and after transcription; effect of Histone modification on transcription of class II genes, changes in nuclear positioning, DNase1 mapping, Histone acetylation-deacetylation, methylation and demethylation, phosphorylation and dephosphorylation. Role of SW1/SNF, NURFs and others in remodeling of chromosomes. Changes in chromosomal organization in the salivary gland chromosomes of *Drosophila* and Lampbrush chromosomes of *Xenopus laevis***.**

Regulation of gene expression at transcriptional level: Modes of regulation- Negative, positive and repression type of regulation. H2B1Histone gene in sea urchin, Globin genes in mammals, Galactose (GAL) gene regulation in yeast cells, Expression of Interferon genes in response to viral infection (mammalian system), hormone regulated gene expression in animal cells; Repression of EGR gene by Wilms tumor gene product. Gene structure and expression of few selected plant genes- light regulated gene expression, phytohormone induced gene expression**.** **13 hrs**

References:

1. Benjamin Lewin (2004), Gene VIII, Published by Pearson Prints Hall, Pearson Education inc.Upper saddle River, New Jerssey-07458
2. Bruce Alberts, Julian Lewis, Alexander Johnson, J. Lewis, M. Raff (1994), Molecular Biology of the Cell, Garland Publisher Inc., New York
3. Buchnan and Grussem et al, (2000) Biochemistry and Molecular biology of Plants by 5th edition, Oxford University Campus
4. Buchnan B.B., W,Gruissem et al and R.L.Jones (2004) Biochemistry and Molecular biology of Plants by I.K. Internationla Pvt., Ltd., New Delhi
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7. Gerald Karp (2003), Cell and Molecular Biology, 3rd edition, John Wiley & Sons Publishers.(Concepts and Experiments)
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11. John Marsten Walker, Ralph Rapley (2000), Molecular Biology and Biotechnology
12. Waldman, S.A. (2002). Genetic Recombination. Scientific American Books, Newyork.

HCT: MLB-303: MOLECULAR BIOLOGY OF DEVELOPMENT

52 hrs

Unit I: Plant Systems: Biochemical and molecular basis of Growth and differentiation:
Concept of growth and differentiation vs. morphogenesis; Site and cell types involved in growth and differentiation. Kinematics of growth, Spatial and material basis of growth, mechanism of differentiation. Polarity fixation: A brief account of polarity fixation in a fertilized egg cell; calcium channel redistribution and transcellular currents, role of mRNAs, Actin and Microtubule cytoskeletons and Golgi derived vesicles in polarity determination (Use example from red algae). Genetic basis: Identity of a gene that control development in Arabidopsis; three stages of development from embryo, axial pattern, apical basal pattern, radial pattern and requirement of gene expression for the development of the above structure in Arabidopsis. The role of homeobox genes.

Phytohormone: Biosynthesis of auxins, Effects of phytohormones on plant growth and development, site of synthesis and mechanism of action; Interaction of Auxins with cytokinins in inducing shoot formation and root formation; Inhibition of gibberellin inductive expression of genes by abscisic acid, synergistic effects of auxin and ethylene, synergistic effects of auxins and cytokinins, synergistic effects of Ethylene and abscisic acid, Brassinosteroids- their role in plant development. **13 hrs**

Unit II: Flowering: Characters of shoot meristems that change into floral meristems and development of four types of floral organs,. Changes in shoot apex, phase changes, floral evocation (competent and determined). Photoperiodism, vernalization effect on growth and flowering. Phytochrome and gene expression: Phytochrome structure, action of phytochromes, plant response to Phytochrome A and Phytochrome B; Phytochrome mediated gene expression-mechanism of action through multiple signaling pathways; Role of cryptochromes. Photomorphogenesis. Biological clocks and circadian rhythms.

Molecular genetics of flowering: A general account of genes that regulate floral organ development (use- Arabidopsis as model system). Biochemistry of signaling pathway to flowering, identification of hypothetical florigen; Chemical basis of flowering substance, site of synthesis, transport, distribution and site of action and mechanism of action; Floral genes-APETALA (AP1, AP2, APETALA3), leafy (LFY), and AGAMOUS genes. Homeotic mutations and their effect on floral organs; Role of MADS box genes in floral organ identity. ABC model of determining floral identity. **13 hrs**

Unit III: Mammalian systems: Stem cells-Different kinds of stem cells and their characters, transformation into different types cell types-molecular approach; Bone marrow multipotent stem cells; hematopoietic stem cells and their mode of differentiation and development into a variety of circulatory cells-molecular approach. Embryonic cells-pleuripotent cells, induction of differentiation and the factors and the mechanism. Stem cell engineering, applications and prospects.

Renewal of tissues and tissue engineering: Renewal of cells that are lost in adult tissues; such as epidermal cells, mammary gland cells, photoreceptor cells in Retina, Liver cells. Differentiation and development of muscle cells-embryonic somites to myoblasts, myogenic genes and expression, muscle developmental factors-such as MEFs and MRFs, terminal Differentiation of myoblasts, cell to cell signaling pathway in determining muscle cell fate and development. **13 hrs**

Unit IV: Developmental Biology in Drosophila –I: Drosophila- Life cycle, Oogenesis-development of oocyte, role of follicle and nurse cells in the programming of the egg cell. Fertilization and the trigger of a cascade of developmental activation, positioning of specific mRNA within the egg cells, role of maternal genes, Gap genes, pair rule genes and segment polarity genes and homeobox genes in the development of drosophila eggs to segmented embryonic stage.

Developmental Biology in Drosophila-II Structural organization of developmental genes and their regulation, syncytial blastoderm, cellular blastoderm, gastrulation stages, dorso-ventral polarity and anterior and posterior polarity fixation, segmentation, regulation of developmental gene expression , a general account homeobox genes and their role in determining identity of body organs in Drosophila. **13 hrs**

References:

1. Atlas R.M. (1998) Microbiology : Fundamental and application (IIeds) Mac millan Publishing company
2. Bruijin et al., (1998). Bacterial genomes, Chapman and Hill
3. Dale J.W. (1994). Molecular genetics and Bacteria. John Wiley and sons
4. Hayes W. (1970). The genetics of Bacteria and their viruses. The English Book society of Blackwell Scientific Publication, Oxford
5. Glick, Molecular Biotechnology, MSM pub, B.R. Glick & J.J.Pasternak, (1994), ASM Press Washington, D.C.
6. Hunderson et al., (1999). Cellular Microbiology Wiley
7. Lewin B (2002). Genes VIII, Oxford
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9. Roger L.P., John T., Knowler and Daviol P. Leadr. (1992). The Biochemistry of Nucleic acids, 11th edition. Chapmann and Hall
10. Samuel Singer (2001). Experiments in Applied Microbiology, Academic Press New York.
11. Stnely R. Maloy, John E. Cronan, Jr., David Freifelour (1994). Microbial genetics. Jones and Barlett Pub. Bosten.
12. Sullia S.B. and S.Shantharam (1998). General Microbiology, Oxford IBH Publishing Con, New Delhi.
13. Presscott,L.M., Hanley,J.P. and Klein,D.A.(1999). Microbiology, Mc Graw Hill, New York.
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15. Varma, A and Podila, K.G. (2007). Biotechnological Application of Microbes. I.K.International Pvt. Ltd., New Delhi.

SCT: MLB-304: BIOETHICS AND BIOSAFETY

26 hrs

Unit I: Bioethics and Biosafety: Introduction, Definition, need of Bioethids: Bioethics and its relations with other branches; Applications. Ethical, legal and social implications of human genome project, Biosafety guidelines and regulations. Intellectual Property Rights: Introduction, forms of intellectual property, international and Regional Agreement Treaties and related legislations in India. International Organizations. Bioterrorism-a short account **13 hrs**

Unit: II Ethical issues in Genetically Modified Organisms: Introduction, history, techniques, policy around the world, Health implications of genetically modified food, Ethical issues associated with consumption of GM food. Use of GMos and their release in the environment .Stem cells research: Definition, Properties of stem cells, stem cells in gene therapy, stem cell biosafety, Ethical issues of stem cell research and use. **13 hrs**

References:

1. Sivaramiah Shantharam and Jane F.Montgomery. 1999. Biotechnology, Biosafety, and Biodiversity: Scientific and Ethical Isssues for Sustainable Development. Science Publishers Inc. Enfield, New Hampshire (USA).
2. David P.Clark and Nanette J.Pazdernik, 2009. Biotechnology: Applying the genetic revolution. Elsevier Academic Press, London, UK.
3. U.Satyanarayana.2007. Biotechnology. Uppala Author-Publisher Interlinks. Vijayawada.
4. B.D.Singh. 2010. Biotechnology. Kalyani Publishers, New Delhi.
5. S.Ignacimuthu. 2012, Biotechnology, Narosa Publishing House Pvt.Ltd., New Delhi.

OET: MLB-305: APPLIED MOLECULAR BIOLOGY

52 hrs

Unit I: Molecular life: An introduction experimental proof of DNA and RNA as genetic material. Structure and function of DNA and RNA. Watson and Crick Model of DNA and other forms of DNA (A and Z). Function of DNA and RNA including Ribosome's. Genetic engineering-objective, tools of gene cloning. **13 hrs**

Unit II: Genomics-Scope and importance, Genome projects- Rice and Human. Methods and applications of DNA fingerprinting, Gene therapy, Stem cell therapy, Genetic counselling and ethical consideration. **13 hrs**

Unit III: Human genetic disease-Types, pedigree analysis, inheritance patterns, Diagnosis-Noninvasive and invasive methods.
Antigens, Antibodies-structure, function and types, Monoclonoal and polyclonal antibodies.Vaccines, Edible vaccines. **13 hrs**

Unit IV: Transgenic plants and animals-microinjection of DNA into fertilized eggs, Ti plasmid of *Agrobacterium tumefaciens*, and their applications. Transgenic plants: For biochemical production, Agrochemicals, Medicinal, Cosmetics, food additives, Enzymes, Biopolymers and vitamins.

13 hrs

References:

1. Cummings, M.R.1994.Human Heredity; Principles and issues. West Publishing Company
2. Epstein.R.J.2003. Human Molecular Biology. Cambridge Univ. Press, Cambridge.
3. Jobling.M.A.Hurles and Tyler-Smith. 2004 Human Evolutionary Genetics- Origin, people & Disease. Garland & Science
4. Khoury, M.J.J Little and W.Burke. 2004. Human Genome Epidemiology. Oxford Univ. Press, Oxford
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7. Brown.T.A.1995, Gene Cloning: An introduction. Chapman and Hall, London
8. Brown .T.A. 2007, Genomes 3. Garland Science Publishing, New York.
9. Cummings.M.R. 1994. Human Heredity: Principles and issues. West Publishing Company.

PRACTICALS

HCP: MLB-306: Biochemistry –II

1. Determination pI of Anmino acids by Titration methods.
2. Determination of Km and Vmax.
3. Cell disruption techniques.
4. Purification of proteins.
5. Determination of Molecular weight of proteins through SDS-PAGE.
6. Isoelectric focusing.
7. Isozyme analysis
8. Extraction and analysis of lipids

HCP: MLB-307: Molecular Biology-II

1. Subcellular fractionation – isolation of nuclei, mitochondria, chloroplasts and analysis of each fraction – estimation of DNA and RNA, protein, marker enzyme activity (rat liver, spinach).
2. Isolation of Choroplast DNA/Mitochondrial DNA.
3. Isolation of RNA from plant or animal tissues.
4. Analysis protein pattern during seed germination using SDS-PAGE.
5. Electroporation technique.
6. Southern Blotting.
7. The effect of Mutation in *E. coli*.
8. Curing of plasmid from a Bacterial Culture.

HCP:MLB-308:Molecular Biology of Development

1. Preparation and sterilization of media (plant and animal media used for culture).
2. Plant growth (using callus) parameters (fresh and dry weight measurements) using different phytohormones and their effects.
3. Induction of root in stem cuttings using various auxins.
4. Study of totipotency in plant (Growing Carrot plant from adult cells).
5. Establishment of *Drosophila* culture and maintenance.
6. *Drosophila* developmental mutants – eye colour, win shape.
7. Protein profiling of *Drosophila* larva at various stages of development.
8. Study of metamorphos in *Drosophila*.

IV Semester

HCT: MLB-401: IMMUNOLOGY

52 hrs

Unit I: Types of immunity: Innate immunity, anatomic barriers, physiological barriers, native microbial flora. Inflammation, fever, interferon's, complement system; Acquired immunity- Active, passive and adaptive immunity. **Organs of immune system:** Primary lymphoid organs: Bone marrow, thymus; Secondary lymphoid organs: Spleen, lymph node, mucosal associated lymphoid tissues. **Cells of immune system:** Hematopoeisis, surface molecules, structure and function of stem cells, NK cells, dendritic cells, macrophages, T and B lymphocytes. **13 hrs**

Unit II: Antigens and Antibodies: Antigens characteristics epitopes types. Valency, haptens, Activation and maturation of B lymphocytes, lymphocyte cell surface receptors/proteins; Immunoglobulin genes organization and expression, somatic gene recombination Ig diversity, factors affecting Ig diversity, types of Abs, class switching. antibody production and maturation; Structure and function of different Ig's; Activation of T lymphocytes- response, action and maturation of T lymphocytes and their surface protein and genes. Structure and types of T lymphocytes and their function. T-cell and B-cell receptors. T_I and To antigens. **13 hrs**

Unit III: Antigen recognition: MHC molecules (Class I and ClassII), Humoral and cell mediated immune response. Grazyme perforins, clonal selection and immunological memory, recognition of endogenous antigens, recognition of exogenous antigens; T and B cell interaction. **Vaccines-**Principles of vaccination, primary and secondary responses, whole organism vaccines, purify macromolecule as vaccines, multisubunit vaccines, DNA vaccines, edible vaccines, Monoclonal antibodies and its applications. Transplantation and rejection. **13 hrs**

Unit IV: Disorders of immune system: Immunological tolerance, autoimmunity and autoimmune diseases. Deficiency of immune system-(congenital and acquired). Tumour Immunology.

Immunological hypersensitivity: Gell and Coomb's classification, salient features of Type I, II, III and IV hypersensitive reactions. RIA, ELISA, agglutination. Immuno electrophoresis, precipitation test. **13 hrs**

References:

1. Abul Abbas, Andrew Lichtman, and Jordan Pober, (2005), Cellular and molecular immunology, Saunders Publishers, 5th edition, 576 pages plus CD
2. Abul Abbas, Saunders,(2006), Basic Immunology, Updated Edition 2006-2007 (Paperback) by Publishers; 2nd edition 336 pages
3. Ashi K Chakravarty, (2006), Immunology and Immunotechnology, Ist edition, Oxford Press.
4. Charles Janeway, Jr. and Paul Travers, (2004), Immunobiology - the immune system in health and disease, by. Garland Science; 6 edition, 800 pages
5. Gupta P K, (2004) Cell and Molecular Biology, Rastogi Publications, Meerut
6. Ivan Roitt, Jonathan Brostoff, and David Male. Mosby, (2006), Immunology, London. 7th edition, 544 pages
7. Lodish et al., (2001) Molecular Biology, W.H.Freeman G Co. 47
8. Thomas Kindt, Barbara Osborne and Richard Goldsby, (2006), Kuby Immunology. W. H. Freeman & Co., Sixth edition, 2006
9. William E Paul, Lippincott Williams & Wilkins;(2003) Fundamental Immunology (Hardcover) by 5th Bk&Cdr edition ,1502 pages

HCT: MLB-402: MOLECULAR BIOLOGY- III

52 hrs

Unit I: Post transcriptional Processing of RNA: Processing of rRNA: Precursor rRNAs of prokaryotic and eukaryotic types.Structural and functional features of U3 RNA-RNPs, sno-RNAs and sno-RNPs, sca RNAs and their role in modification and splicing of rRNAs and some Sn RNAs. Brief structural and functional features of Cajal bodies.

Processing of pre-tRNAs: size of pre-tRNAs, number, size and position of tRNA introns; types of splicing and the mechanism of splicing.

Enzymes involved in rRNA and tRNA processing-RNase P, RNase E (exosomes), RNase D, RNase III, kinases, diesterases, Polynucleotide phosphorylases.

Pre-mRNA processing: Characteristic features of pre heterogenous nuclear RNAs (hnRNAs), structure and sizes of hn RNAs; hnRNP proteins, mRNP proteins; structural features of introns and exons; Processing of pre mRNAs

Capping and polyadenylation: Time of capping, mechanism of capping. Factors, site, enzymes and the mechanism involved in Poly (A) addition, importance of poly (A) tail; poly (A) binding proteins, polyA-polymerases and their role. Importance of polyA-signals, cytoplasmic poly-A additional signals (CPE), CPEB and Maskins, RNA transport sequences and their importance. Splicing: Concept of splicing, types of splicing, types of proteins involved. **Cis Splicing:** Characteristic features of introns splice junction site and intron's internal sites, splicing signals and signal sites; Types of splicing. snRNAs and sn RNPs involved, their structural and functional features; Mechanism of splicing event, role of specific snRNA and snRNPs; role of SR proteins and Exon enhanceosomes (ESE), spliceosomal assembly and mechanism of splicing. Processing of Histone mRNA and the role of sn-U7 RNA and its RNPs. **13 hrs**

Unit II: Alternative splicing: Concept of alternative splicing and its implications. Alternate splicing examples from Fibronectins, Collagens, Tropomyosins, Example from Dscam from *Drosophila*. Alternative splicing in sex determination of *Drosophila*.

Trans splicing: Trans-splicing in *C.elegans*, Trypanosome, worms; splicing components- SL-RNA and other snRNA-RNPs involved in transplicing.

Pre-mRNA Editing: Editing Apo-lipoprotein mRNA and Glutamine receptor mRNA, features and mechanism. Special features of few mitochondrial faulty pre-mRNAs (called pre-edited mRNAs) in Trypanosomes and Leishmania; editosomes, and characters and their composition, genes for Guide RNA and the mechanism of editing.

Self-splicing introns: Group-I introns, Group-II introns, Group III introns, Twinintrons: their characters and functions, mechanism of self-splicing.

Informosomes: Stored mRNAs in mature egg cells, normal cells and seeds, role of mRNPs, importance of poly (A) size, polyadenylation signal elements CPE), role of CPEB and Maskin proteins, reactivation of mRNAs by Poly (A) addition and its regulation, role of RNA transport signal elements; role and importance of 3' and 5' UTR sequence elements.

mRNA stability and turn over:

Sequence elements found in 5' leader sequences and 3' non-coding regions and their structural features, relationship between such sequences and sequence derived structures and stability; mechanism of protection and the mechanism of degradation and causes; ex. Casein mRNA, Transferrin mRNA, Ferretin mRNA.. **13 hrs**

Unit III: Genetic code: Genetic and biochemical basis of Genetic code, Salient features, Deviation from Universal codon dictionary in mitochondrial genomes, evolution of Genetic code.

Prokaryotic Translation: Translation apparatus; ribosomal subunits, initiator-tRNAs, aminoacyl-tRNAs, initiating factors, elongation factors, termination factors; mechanism of chain initiation, elongation and termination; production of specific proteins on translation of a polycistronic mRNA. Post translational processing of polycistronic polypeptides, and targeting the protein to periplasmic space or to the membrane. Regulation of protein synthesis, autogenous regulation, stringent response type regulation. Polyribosomes: rate of synthesis and regulation of protein synthesis.

Eukaryotic translation Translational apparatus- ribosomes, initiator-tRNAs, aa-tRNAs, initiation factors, elongation factors and termination factors; mechanism of translation; **Regulation of protein synthesis**: Regulation of translation at mRNA level, regulation at chain initiation factor level, ex. Heme regulated translated, regulation of Ferretin synthesis, and Transferrin receptor synthesis and interferon mediated regulation. Site of protein synthesis, membrane free site, localized synthesis- example Actin protein synthesis, mode of transportataion of mRNA to specific position in the cell. **13 hrs**

Unit IV: Post translational processing: Cotranslational processing- transferring the translating system onto ER and transferring protein into the lumen of ER, role of SRP particles, docking proteins, Translocator proteins and signal sequences in targeting the protein (mitochondria, chloroplasts, peroxisome and glyoxysomes) and also in orienting N and C- terminal ends of proteins. Mechanism of transfer of proteins into ER lumen. Folding and modification of proteins while they are transported from SER to cis Golgi and trans-Golgi and protein sorting and vesciculation carrying the cargo.

Processing of Pre-pro-proteins: Regulated cleavage of polyproteins and pre-pro proteins in stage specific and tissue specific manner. Splicing of proteins: Brief account of structural domains of proteins to be processed with Intiens and Exiens, splicing of intiens and joining of exiens.

Protein stability and turnover: Sequence based structural form, half-life of proteins, unstable proteins, protein degradation, and ubiquitination of condemned proteins and degradation by Proteosome; structure and features of Proteosome and the mechanism of degradation. **13 hrs**

References:

1. Buchnan, B.B. and Wilhelm Grussem et al., (2000) Biochemistry and Molecular biology of Plants , American Society of Plant Physiologists, Rock Ville, USA, Maryland
2. Eduardo Diego Patricio De Robertis, EMF De Robertis (1980) Cell and molecular biology
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5. James Darnell, Harvey Lodish, Paul Matsudaira, Arnold Berk, S. Lawrence Zipursky, (1998) Molecular Biology of the cell
6. John Marsten Walker, Ralph Rapley (2000), Molecular Biology and Biotechnology
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HCT: MLB-403: GENOMICS AND PROTEOMICS

52 hrs

Unit I: Structural Genomics: Concepts of structural genomics, functional genomics, proteomics and metabolomics. **Physical mapping**: top-down and bottom-up approaches; sorting out chromosomes by Fluorescence Activated Chromosome Sorting method (FACS); use of PFGE-Pulse field gel electrophoresis or CHEF-Counter clamped homogeneous electrical field electrophoresis; restriction mapping- preparation of YAC and BAC libraries; use of molecular markers, use of in situ hybridization (ISH) and FISH, use of EST tags (expressed sequence tags) and STS tags (sequence tagged sites) radiation hybrid mapping
Whole genome sequencing: methodology of DNA sequencing; assembly of sequences – shotgun and clone contig approaches – chromosome walking, chromosome jumping, use of positional cloning of cloned sequence of a chromosome and candidate gene approach; developing high resolution mapping, identification genomic sizes by Resolution-Gap mode. Development of integrated genomic map using all the methods mentioned above. **13 hrs**

Unit II: Functional genomics: Locating genes in a genome sequence through sequence inspection - detection of ORFs, homology search Experimental techniques for gene location – northern blotting, cDNA transcript mapping, heteroduplex mapping Transcriptome analysis - use of northern blot, dot blot, use of subtractive library, differential display, additive library, RNase protection, RT-PCR, real-time PCR and SAGE techniques; gene knock out analysis, over-expression studies; construction of two expression plasmid systems in one cell to find out gene interaction, DNA microarray techniques-spotted arrays and printing techniques, oligochips; Transcriptomics and data processing; Proteomics: Characterization of proteins: Concepts , detection and screening techniques. Preparation of proteins from tissues-protocols; Use of 2-D PAGE, sensitivity and resolution and representation of 2-D gels, multiplexed analysis to show expression profiles; use of multidimensional liquid chromatography, Mass spectrometry and high throughput protein annotation, Matrix assisted laser desorption (MALDI), Electrospray ionization (ESI), TIME flight (TOF), collision induced dissociation (CID). Expression analysis at protein level : protein arrays, Weston Blot. **Protein-protein interactions:** Importance of studies on protein-protein interactions; methodologies – purification of protein complexes, yeast two-hybrid system, phage display, RNA-peptide fusions. **13 hrs**

Unit III: Metabolomics and metabolic engineering: Concepts, methods used and applications; engineering metabolic pathways through cloning and expression of heterologous genes for altering feed back inhibition, altering the regulation of desired metabolic pathways, to produce new products for commercial needss, to generate new proteins with altered desirable characteristics. **Comparative Genomics:** Concept of orthologs homologs and paralogs in gene evolution, comparative genomics of bacteria and large microbial genomes, comparative genomics of closely related bacteria in particular and microbes in general, comparative genomics and physiological phenomena; comparative genomics of mitochondria, comparative genomics of eukaryotes to identify genes and regulatory elements, protein evolution through exon shuffling; evolution of key proteins, and evolution of species; comparative genomics and molecular mechanism to generate new gene structures; comparative genomics as an aid to gene mapping.

Unit IV: Bioinformatic tools for genome and proteome analysis: Sequencing genes to sequencing genomes, sequence assembly, accessing genome on the web-NCBI, TIGER EnsEMBL and other resources, annotating and analyzing whole genome sequences; functional genomics- DNA micro array design and analysis; proteomics-experimental approach-informatics from 2D PAGE analysis, tools for proteomic analysis; Biochemical pathway database- WIT and KEGG, pathDB Molecular systematics: Multiple sequence alignment and Phylogenetic analysis. -Familiarize with all DATA banks for DNA sequence, Proteins sequences, metabolic network, RNAs, ORFs etc and how to access to them and retrieve needed information in a specific format. Assembly packages for large scale genome sequencing; PHRED (base calling software with quality identification), PHRAP (Fragment assembly programs or Phil's revised assembly programs, DEMIGLANCE-consed; EST clustering packages, Corpus (contig refinement performance using semantics, Parcl EST clustering package, Biosystems and Computer: Basic concepts of Biosystems, for genome analysis, transcriptome analysis and proteome analysis and Metabolomics, understanding molecular evolution, biological information processing and evolutionary systems.

Applications of genomics and proteomics Human genome project, other whole genome sequencing projects(*Haemophilus influenzae*, Arabidopsis), applications in human health, proteomics and drug discovery, applications in agriculture – development of molecular markers – assessment of genetic diversity, germplasm characterization, marker-assisted selection (molecular breeding); gene discovery for development of transgenics. **13 hrs**

References:

1. Brown, T.A., Genomes (1999). John Wiley &Sons.
2. Caldwell, A.G., Williams, N.S. and Caldwell, A.K.(2006). Integrated Genomics. Jhon Wiley and sons ltd. England.
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4. Daniel, C. Leibler, (2002). Introduction to Proteomics: tools for new biology, Human Press, Totowa, NJ.
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HCT: MLB-404: PLANT BIOTECHNOLOGY AND ANIMAL BIOTECHNOLOGY

52 hrs

Unit I: Plant Biotechnology:

Introduction:History, aim and scope of Plant Biotechnology, Biotechnology Scenario in India. Meristem culture, virus free plants. Large scale micropropogation, hardening and its application. Anther culture for haploid plant production, Doubled haploids, application of haploids in plant breeding and crop improvement. Somaclonal variations and their use in crop improvement.

Liquid culture: Suspension cultures, Batch cultures, continuous cultures. Bioreactors, immobilized bioreactors; Improving and enhancing yield of secondary plant products using bioreactors, Hairy root cultures for production of secondary metabolites. **13 hrs**

Unit II: Transgenic Plants: Vectors for plant transformation - Binary vectors and integration vectors; their characteristic features in detail. Construction of expression vectors, Use of selectable markers. Marker free technology for production of transgenics. Methods for gene transfer: Gene gun and *Agrobacterium* methods. Details of *Agrobacterium*, Ti and T-DNA, mechanism of DNA transfer and integration Transgenic tissue regeneration and screening-of transgenics for gene integration using PCR and western or dot blotting techniques. Organelle Engineering: Targeting of genetically engineered DNA clones into chloroplasts of higher plants.

Disease Resistance: Disease resistance to fungi by engineering chitinase (β-1, 3-glucanase gene) and osmotin. Disease resistance to bacteria by Lysozyme gene. Resistance to pests- Bt-toxin gene, protease inhibitor genes. Generation of herbicide tolerant plants, Development of transgenics to virus resistance, using of antisense and RNA interference technologies. Transgenic plants: Plantibodies, vaccines, Biopolymers and vitamins.

Transgenics for delayed fruit ripening and increased shelf life-Tomato. Increase in the shelf life of cut flowers - (Carnation flowers). **13 hrs**

Unit III: Improvement of food crops: Increase in essential amino acids in cereal seed proteins (phaseolin protein and albumin gene (for increase in methionine content). Increase in lysine by using *E.coli* dihydropicolinate synthase (DHPS gene). Increase and change in the quality oils in Brassica species (increase in medium chain fatty acids and converting unsaturated fatty acid to saturated fatty acids). Increase in sweetness and flavor in fruits and vegetables (tomato). Increase in starch content (potato). **13 hrs**

Unit IV: Animal Biotechnology: Methods and protocols used for tissue and cell cultures. Maintenance of cell cultures. Animal tissue culture: skin cultures, Neuronal cell cultures, muscle cell cultures, cartilage culture, blastocysts cell culture, whole embryo culture and tissue engineering, Large scale production: Large scale animal cell culture for commercial production of the IGs, interferons, vaccines, Mabs, hybridoma cells and other down stream process and problems. Methods to induce stem cells to differentiate into specific tissues.

Animal cell Transformation and immortalization: Methods employed for animal cell transformation, viral and oncogene methods. Characteristic features of transformed cells.
Transgenic animals: Protocols used for developing transgenic animals; use of fertilized egg cells, use of bastocyst cells; success and failures, problems. Transgenic sheep, transgenic goat, transgenic fishes, transgenic cattle, transgenic mice, transgenic pigs for the production of recombinant proteins. Animal cloning: Techniques used in animal cloning- transfer of whole 2n nuclei to enucleated Cells (ex. Xenopus), cultured cell fusion, use of embryonic cells and application and ethics. **13 hrs**

References:

1. Altman, A (1997), Agricultural Biotechnology
2. Bhojwani SS, MK Razdan (1983), Advanced immunology.
3. Blitterswiji, V.C. (2008). Tissue Engineering. Academic press, USA. Plant Tissue Culture: Theory and Practice, - elsevier.com
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PRJ: MLB-405: Project Work.

PRACTICALS

HCP: MLB-406: Immunology and Molecular Biology-III
PART-A
1. Raising antibodies against BSA in rabbit- separation of serum and plasma from blood.
2. Ouchterlony double diffusion
3. Protein electrophoresis by using serum from control and antigen immunized rabbits
4. Identification of pathogens by ELISA. (Kit method), ELISA-Tridot
5. Blood Cell counts and DC counts (Differential cell), Reticulocyte count and estimation of hemoglobin by hemocytometer.
6. Blood Transfusion -Coomb's test (Direct and Indirect)
7. Rheumatoid Arthritis (RA) Test and Anti A_1 lectin test
8. Erythrocyte sedimentation rate
9. Pregnancy test

PART-B
1. Preparation of genomic DNA.
2. PCR amplification of an identified gene.
3. Subcloning of a gene for expression in a prokaryotic expression vector
4. Protein expression analysis

HCP: MLB-407: Genomics and Proteomics and Plant and Animal Biotechnology
PART-A

1. Isolation of RNA and preparation of cDNA
2. Cloning and sequencing of isolated cDNA
3. RAPD analysis for genetic diversity analysis in plants
4. Visit for demo of real-time PCR, DNA micro-arrays, MALDI- TOF and protein arrays

PART-B
1. Study of proteins by native gel electrophoresis- serum proteins (serum albumin)
2. Study of proteins by SDS-PAGE
3. Study of proteins by 2 D gel electrophoresis
4. Western blotting.
5. Computational analysis of the proteome of a given organism
6. Transient expression of a cloned gene in animal cells by electroporation and analysis
7. Tissue culture, micropropagation, anther culture
8. Protoplast isolation and culture
9. Agrobacterium mediated transformation in plants and its molecular analysis by PCR

QUESTION PAPER FORMAT

BANGALORE UNIVERSITY
M.Sc., (I to IV Semesters) Examination
MOLECULAR BIOLOGY
PAPER- MLB:

Time: 03 Hours **Max. Marks: 70**

Instructions:
1. Answer **all** the **parts**
2. **Draw** diagrams **wherever** necessary

PART-A

Define/Explain the following:
1-5 **(5x2=10)**

PART-B

Write critical notes on the following:
6-10 **(5x6=30)**
Examples: 6a or 6b; 7a or 7b ---10a or 10b

PART-C

Answer any **two** of the following
11-14 **(2x15=30)**

QUESTION PAPER FORMAT

BANGALORE UNIVERSITY
M.Sc., (III Semester) Examination
MOLECULAR BIOLOGY
SCT: MLB-304: Bioethics and Biosafety

Time: 02 Hours **Max. Marks: 35**

Instructions:
1. Answer **all** the **parts**
2. **Draw** diagrams **wherever** necessary

PART-A

Define/Explain the following:
1-2 **(2 X 2 $_{1/2}$=5)**

PART-B

Write critical notes on the following:
3-5 **(3 X 5=15)**
Examples: 3a or 3b; 4a or 4b ---5a or 5b

PART-C

Answer any **one** of the following
6-7 **(1 X 15=15)**