Scheme of Semester Examination & Syllabus, 2016-2018

M. Sc. Bioscience (Semester I to IV)

Pt. Ravishankar Shukla University, Raipur

First Semester [July 2016 – December 2016]

Paper	Title of Paper	Marks		
		(External)	(Internal*)	Credit
I	Cell Biology	80	20	4
II	Biomolecules	80	20	4
III	Microbiology	80	20	4
IV	Biology of Immune System	80	20	4
LC-I	Lab Course I (Based on Theory papers I & II)	80	20	2
LC-II	Lab Course II (Based on Theory papers III & IV)	80	20	2
	Total		600	20

Second Semester [January 2017 – June 2017]

Paper	Title of Paper	(External)	(Internal)	Credit
I	Genetics and Molecular Biology	80	20	4
II	Bioenergetics & Metabolism	80	20	4
III	Instrumentation and Molecular Techniques	80	20	4
IV	Biometry, Computer and Scientometry	80	20	4
LC-I	Lab Course I (Based on Theory papers I & II)	80	20	2
LC-II	Lab Course II (Based on Theory papers III & IV)	80	20	2
	Total		600	20

Third Semester [July 2017 – December 2017]

Paper	Title of Paper	(External)	(Internal)	Credit
I	Molecular Plant Physiology	80	20	4
II	Ecology and Environmental Biology	80	20	4
III	Animal Physiology	80	20	4
IV	Developmental Biology and Evolution	80	20	4
LC-I	Lab Course I (Based on Theory papers I & II)	80	20	2
LC-II	Lab Course I (Based on Theory papers III & IV)	80	20	2
			600	20

Fourth Semester [January 2018 – June 2018]

Paper	Title of Paper	(External)	(Internal)	Credit
I	Seed Science	80	20	4
II	Plant Biotechnology	80	20	4
III	Special Paper A: Parasitology/ Special Paper B: Basic Chronobiology	80	20	4
IV	Special Paper A: Immunology/ Special Paper B: Applied Chronobiology	80	20	4
LC-I	Lab Course I (Based on Theory papers I & II)	80	20	2
LC-II	Lab Course II (Based on Theory papers III & IV)	80	20	2

	Total			**600**	**20**
	OR				
	Project Work**			**600**	
	Distribution of Marks	Dissertation	**240**	**60**	**11**
		Seminar based on project	**160**	**40**	**6**
		Viva-voce	**80**	**20**	**3**
				600	**20**
Grand total [Semester I + II + III + IV]				**2400**	**80**

Important Note:

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Continuous evaluation of Performance*

Each student will be evaluated continuously throughout the semester.

There will be a class test based on each theory paper. The full marks will be 10 for each paper.

There will be a poster/oral presentation based on each theory paper. The full marks will be 10 for each presentation.

Each student will be required to submit a brief write-up (not more than 15-20 pages) on his/her poster/oral presentation.

Project Work**

A student of IV semester will have the choice to opt for project work in lieu of four theory papers and two lab courses provided he/she secures at least **75%** or more marks in aggregate in semester I and II.

The project has to be carried out in recognized national Institutes/Laboratories or UGC-recognized universities. No student will be allowed to carry out project work in private laboratories/ college/ institutions, excluding the colleges recognized as research centers by the RDC of Pt. Ravishankar Shukla University, Raipur.

The valuation of all the projects will be carried out by an external examiner and HoD of UTD or its nominee at the UTD Centre.

Scheme for Lab Course (LC) Examination (Applicable for each LC in each Semester)

1.	Major exercise based on paper I	**20**
2.	Minor exercise based on paper I	**10**
3.	Major exercise based on paper II	**20**
4.	Minor exercise based on paper II	**10**
5.	Spotting/ Interpretation***	**10**
6.	Viva-voce	**10**
7.	Sessional [Internal]	**20**
	Total	**100**

***A student will be required to interpret on the displayed item/ material

July 2016 – December 2016

M.Sc. Bioscience

First Semester	
Paper I: Cell Biology	
Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.	
Unit-I	Molecular organization of membranes- asymmetrical organization of lipids, proteins and carbohydrates. Osmosis, ion channels, membrane pumps and electrical properties of membranes. Active transport by ATP-powered pumps: types, properties and mechanisms.
Unit-II	Transport of proteins into mitochondria, chloroplast and endoplasmic reticulum. Transport of proteins into and out of nucleus. Transport by vesicle formation: exocytosis, endocytosis and its molecular mechanism.
Unit-III	Cell signaling: Signaling via G-protein linked and enzyme linked cell surface receptors, MAP kinase pathways. Eukaryotic cell division cycle: different phases and molecular events, regulation and control of cell cycle. Apoptosis. Oncogenes and tumor suppressor genes: viral and cellular Oncogenes, retinoblastoma, E2F and p53 proteins.
Unit-IV	Organization of chromosomes: Structure of chromosomes, centromere and telomere. States of chromosomes during cell cycle. Mitotic chromosome. Organization of genes in chromosomes Banding pattern of chromosomes. Lampbrush and Polytene chromosomes. Chromatin, nucleosomes, DNA packaging, heterochromatin and euchromatin.
Lab Course:	
	1. Study of chromosome behaviour during Mitosis and meiosis (Onion / Garlic root tips, Onion buds, human lymphocytes, rat or bird testis /grass hopper testis or any other materials). 2. Calculation of mitotic index in growing Onion / Garlic root tips 3. Squash preparation: Polytene chromosome (in chironomus / Drosophila or other insect salivary gland) and Barr body (in buccal epithelial cells). 4. Demonstration of secretory granules in the salivary gland cells of insect. 5. Demonstration of mitochondria by vital staining. 6. Study of permanent slides. 7. Estimation of DNA 8. Estimation of RNA 9. Sub-cellular fractionation and marker enzymes 10. Identification of biomolecules in different tissues by histochemical techniques 11. Preparation of mitotic plate by carmine squashing method and phase identification. 12. Demonstration of the nuclear matrix networks in onion cells. 13. Study of the effect of chemical agents on chromosomes plant cells. 14. Isolation of protoplast, measurement of cell density plating efficiency. 15. Preparation of Karyotype of metaphase plate. 16. Preparation of Meiotic plate and determination of phases. 17. Computation of Chaisma frequency and Terminalization of phases. 18. Micrometry and Camera Lucida drawings.
Recommended Books	
H Lodish *et al.*	Molecular Cell Biology

B Alberts *et al*.	Essential Cell Biology
H Lodish *et al.*	Molecular Cell Biology (Lodish, Molecular Cell Biology)
B Alberts *et al*.	Molecular Biology of the Cell
G Karp	Cell and Molecular Biology: Concepts and experiments

July 2016 – December 2016	
M.Sc. Bioscience	
First Semester	
Paper II: Biomolecules	
Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.	
Unit-I	Carbohydrates: Structure, classification, properties and function; derivatives of monosaccharides, homo and hetero-polysaccharides, Peptidoglycan glycoproteins and liposaccharide Lipids: Classification, structure and function Nucleic Acid: Structure of purine and pyrimidine bases, nucleoside and nucleotide; DNA- structure and conformation; RNA - Structure, types and functions
Unit-II	Amino acids: Structure, classification and functions; Synthesis of peptides and protein sequencing; Proteins- properties, covalent structure; secondary, tertiary and quaternary structure of proteins, Ramchandran plot
Unit-III	Enzyme classification, coenzymes, active site of enzyme, factors contributing to the catalytic efficiency of enzyme; enzyme kinetics- Michaelis-Menten equation, determination of Km, enzyme inhibition, allosteric enzymes, isoenzymes, ribozyme, multienzyme complexes
Unit-IV	Chemistry of porphyrins: Importance of porphyrins in biology; structure of hemoglobin and chlorophyll porphyrins, structure and biological role of animal hormones, structure and biological role of water soluble and fat soluble vitamins.
Lab Course:	
1.	Specific tests for sugars, amino acids and lipids
2.	Formal titration of amino acids
3.	Estimation of proteins using ninhydrin and biuret method
4.	Estimation of sugar by Anthrone and Folin-Wu method
5.	Saponification value and iodine number of fat.
6.	Estimation of ascorbic acid
7.	Achromic point determination using salivary amylase
8.	Effect of ions on salivary amylase activity
9.	Enzyme assay and kinetics (ex. Amylase, Protease)

Recommended Books:	
Nelson, Cox and Lehninger	Principles of Biochemistry
G Zubay	Biochemistry
Stryer	Biochemistry
Garrett and Grosham	Biochemistry
West, Tood, Mason and Bbruglen	Text book of biochemistry
White, Handler and Smith	Biochemistry
D Voet and JC Voet	Biochemistry

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M.Sc. Bioscience	
First Semester	
Paper III: Microbiology	
Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.	
Unit-I	General characteristics of fungi, classification of fungi, life cycle of selected fungal genus (Aspergillus, Pencillium, Fusarium and Mucor). Economic importance of fungi. Fungi and bioremediation, parasitism, mutualism and symbiosis with plants and animals. Heterothallism, sex hormone in fungi, Mycorrhiza, VAM. Algae: Distribution, classification, reproduction, ecology and importance.
Unit-II	Morphology and ultra structure of bacteria, morphological types, cell wall of archaebacteria, gram negative, gram positive eubacteria, eukaryotes. Cell membranes – structure, composition and properties. Structure and function of flagella, cilia, pili, gas vesicles. Cyanobacteria, protozoa, mycoplasma and Rickettsia Gene transfer mechanisms, transformation, transduction, conjugation and transfection. Plasmids F: factors colicins and col factors, plasmids as a vector for gene cloning.
Unit-III	Nutritional types (autotrophs, heterotrophs, phototrophs, chemotrophs), growth curves, measurement of growth, factors affecting growth, generation time, growth kinetics. Batch and continuous culture, asynchronous, synchronous culture. Basis of microbial classification, classification and salient feature of bacteria according to Bergey's manual of determinative bacteriology, cyanobacteria, prochlorons and cyanelles.
Unit-IV	Viruses: Structure and classification of viruses; morphology and ultra structure; capsids and their arrangements, types of envelopes, viral genome, their types and structure, virus related agents (viroids, prions). General feature of virus reproductions, early events in virus multiplication, virus restriction and modification of host, virus mRNA. General overview of bacterial viruses, RNA and DNA bacteriophages (MS2, ϕX174, M13, T3, T4). Lysogeny and Lytic phase.

	General account of plant and animal viruses (TMV, HIV and other oncogenic virus, Hepatitis virus).
Lab Course:	
1.	Glassware preparation and sterilization techniques- wet heat- dry heat- filter types- laminar flow chamber types- CDC- safety levels
2.	Preparation of liquid & solid media, plating, pouring, inoculation and incubation for growth of microorganism
3.	Methods of obtaining pure culture of microorganisms (a) streak plate (b) Pour plate, and (c) spread plate methods
4.	Microscopic examination of the microorganisms, identification and staining methods
5.	Micrometery and camera lucida drawings
6.	Study of bacterial growth by turbiditimetry/ spectrophotometry
7.	Biomass measurement for fungi
8.	Isolation and enumeration of microorganisms from soil by serial dilution agar plating method
9.	Enumeration of viruses by plaque assay technique
10.	Motility of bacteria by hanging drop technique

Recommended Books:

LM Prescott, JP Harley and DA Klein	Microbiology, McGraw Hill Publication
RY Stanier et al.	General Microbiology, Mac Millian Press
RM Atlas	Principles of Microbiology
Peleczar, Chan and Krieg	Microbiology
Luria, Darnell, Baltimore and Campbell	General Virology
CJ Alexopoulos and CW Mims	Introduction to Mycology, Wiley Eastern Ltd, New Delhi

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M.Sc. Bioscience

First Semester

Paper IV: Biology of Immune System

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Innate immune mechanism and characteristics of adaptive immune response; Cells of immune system: Hematopoiesis and differentiation, mononuclear cells and granulocytes; Antigen presenting cells; Primary and Secondary lymphoid organs and tissues; Ontogeny and phylogeny of lymphocytes; Lymphocyte traffic
Unit-II	Antigen receptor molecules: B-cell receptor complex, Immunoglobulin - structure, types and function; T-cell receptor complex; Major Histocompatibility Complex- types, structural organization, function and distribution; Transplantation and Rejection; Complements in immune function
Unit-III	Antigens: nature of antigens, factor affecting immunogenicity, Haptens and super antigens; Antigenic determinants; Recognition of antigens by T and B cell; Antigen processing; Role of MHC molecules in antigen presentation and co-stimulatory signals; Antigen and antibody interaction.

Unit-IV	Cell mediated immune response; Cytokines and interleukins- structure and function; Immunity to infections; Hypersensitive reactions and their types; Immunodeficiency disorders; Autoimmunity
Lab Course:	
1.	Identification of cells of immune system
2.	Separation of mononuclear cells by Ficoll-Hypaque
3.	Identification of Lymphocytes and their subsets
4.	Lymphoid organs and their microscopic organization
5.	Isolation and purification of Antigens
6.	Purification of IgG from serum
7.	Estimation of Levels of gamma globulins and A/G ratio in blood
8.	Antigen antibody interaction

Recommended Books:

RA Goldsby *et al.*	Kuby's Immunology
E Benjamini, R Coico and G Sunshine	Immunology- A short Course
Roitt, Brostoff and Male	Immunology
William Paul	Fundamentals of Immunology
Tizard	Immunology
Abbas *et al.*	Immunology

January 2017 – June 2017

M.Sc. Bioscience

Second Semester

Paper I: Genetics and Molecular Biology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Mendelian principles: Dominance, segregation, independent assortment. Concept of gene : Allele, multiple alleles, pseudoallele, complementation tests Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions. Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis
Unit-II	DNA replication, repair and recombination: Mechanism of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms; Repair of Base-excision, Nucleotide excisions, Mismatch and Double Strand. Guardian of DNA; p_{53} and p_{21}. Homologous and site-specific recombination.
Unit-III	RNA synthesis and processing: transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA

	polymerases, elongation, and termination, RNA processing, capping, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport.
Unit-IV	Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post Translational modification of proteins. Protein targeting.
Lab Course:	
	1. Isolation, purification and estimation of RNA 2. Isolation, purification and estimation of DNA 3. Determination of Tm of nucleic acid 4. Fraction of poly (A) RNA 5. Restriction Mapping 6. Restriction Digestion 7. Ligation 8. DNA molecular size determination

Recommended Books

H Lodish *et al.*	Molecular Cell Biology
B Alberts *et al.*	Essential Cell Biology
B Alberts *et al.*	Molecular Biology of the Cell
G Karp	Cell and Molecular Biology: Concepts and experiments
JD Watson *et al.*	Molecular Biology of the Gene
J Wilson and T Hunt	Molecular Biology of the Cell: The Problems
B Lewin	Genes VIII
JE Krebs *et al.* (Ed.)	Genes X (Lewin's), Jones and Bartlett Publishers, Sudbury, Massachusetts, (2011)

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Second Semester

Paper II: Bioenergetics and Metabolism

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Energy transformation and laws of thermodynamics; Concept of free energy, Determination of free energy change by different methods; Structural basis of free energy change during hydrolysis of ATP; High energy compounds, Other high energy biological compounds; ATP cycle
Unit-II	Basic concepts of intermediary metabolism: Carbohydrate metabolism - Glycolysis, Kreb's cycle, glycogenolysis, glycogenesis, pentose phosphate pathway, gluconeogenesis, and glyoxylate pathway, inborn errors of carbohydrate metabolism; Regulation of carbohydrate metabolism
Unit-III	Electron transport and oxidative phosphorylation: electron carriers, Complexes I to

	IV, Shuttle system for entry of electron substrate level phosphorylation, mechanism of oxidative phosphorylation; Biosynthesis and degradation of Lipids; Regulation of lipid metabolism, inborn errors of lipid metabolism
Unit-IV	Nitrogen Assimilation; Biosynthesis and degradation of amino acids; Regulation of amino acid metabolism; Biosynthesis and degradation of purine and pyrimidine nucleotides

Lab Course:	
1.	Protein estimation by Lowry, Bradford and Spectrophotometric method
2.	Estimation blood cholesterol
3.	Estimation of sugar by Nelson-Sompgy and Benedict's reagent
4.	Isolation and estimation of lipid from seeds and egg
5.	Estimation of inorganic and total phosphorus by Fiske-Subba Rao method
6.	Assay of phosphatases in blood and seeds
7.	Urease estimation in plant tissues

Recommended Books:	
Nelson, Cox and Lehninger	Principles of Biochemistry
G Zubay	Biochemistry
Stryer	Biochemistry
Garrett and Grosham	Biochemistry
West, Tood, Mason and Bbruglen	Text book of biochemistry
White, Handler and Smith	Biochemistry
D.Voet and J C Voet	Biochemistry
Dixon and Webb	Enzymes
Price and Steven	Fundamentals of Enzymology
Plummer	Practical biochemistry
G Tripathi	Enzyme biotechnology
Walsh	Enzyme Reaction Mechanism
Hammes	Enzyme catalysis and regulation

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Second Semester

Paper III: Instrumentation and Molecular Techniques

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Centrifugation: Principle, techniques. Preparative, analytical and ultracentrifuges, sedimentation coefficient and factors affecting sedimentation coefficient. Application of centrifugation. Photometry: Basic principles of colorimetry, UV- visible spectrophotometry & IR- spectrophotometry. Spectroflurometry Atomic absorption spectroscopy: Principle, Instrumentation and applications Electrophoresis: Paper electrophoresis, Starch gel, agarose, PAGE-type, 2D-E.
Unit-II	Microscopic techniques: light microscopy, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM,

	freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy Microtomy: types, principle and applications *Lyophilization*: Principle, instrumentation and applications
Unit-III	Chromatography: Paper and Thin Layer Chromatography. Gel filtration, Ion exchange chromatography and Affinity chromatography. Gas-liquid chromatography and HPLC. Histochemical and immunotechniques: Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, *In situ* localization; FISH and GISH. Radioactivity: GM counter, liquid Scintillation counter, solid Scintillation counter, gamma counters
Unit-IV	Molecular techniques: Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, separation methods; RNA, DNA and proteins; 1-D and 2-D, isoelectric focusing gels; Molecular cloning of DNA and RNA fragments in bacterial systems; Expression of recombinant DNA; DNA sequencing. Gene expression; mRNA, cDNA using PCR and qRT-PCR. Micro array based techniques. Molecular Markers for diversity analysis: RFLP, RAPD, AFLP, VNTR, SSR, ISSR, SNP, DArT.
Lab Course:	
	• Verification of Beers Law • Determination of absorption maxima • Quantitative determination, Enzyme kinetics • Amino acid and carbohydrate separation by paper and TLC • Ion exchange and gel filtration chromatography • SDS Polyacralamide Gel Electrophoresis • DNA electrophoresis • Isoenzymes • Separation of sub-cellular organelles by differential centrifugation. • Isolation of DNA and Agarose gel Electrophoresis • Amplification of RAPD and AFLP markers. • Isolation of RNA and Electrophoresis of RNA on denaturing gels. • cDNA synthesis and cloning • Isolation of Protein and SDS-PAGE • In vitro DNA ligation, transformation of E. coli • Characterization of transformants: DNA gel electrophoresis, Restriction map analysis

Recommended Books:

- K Wilson and John Walker — Practical Biochemistry: Principles & Techniques
- RF Boyer — Biochemistry Laboratory: Modern Theory & Techniques
- S Carson, H Miller and D Scott — Molecular Biology Techniques: A Classroom Laboratory Manual
- TC Ford and J. M. Graham — An Introduction to Centrifugation
- R Baserga and D Malamud — Autoradiography: techniques and application
- T Chard — An Introduction to Radioimmunoassay and Related Techniques , Volume 6
- MD Bruch — NMR Spectroscopy Techniques
- BA Wallace and R William — Modern Techniques for Circular Dichroism and Synchrotron Radiation, Volume 1
- J Sambrook, EF Rritsch and I Maniatis — Molecular cloning: A Laboratory Manual
- PD Dabre — Introduction to Practical Molecular Biology
- JD Watson, NH Hopkins, JW Roberts, JA Steitz and AM Weiner — Molecular Biology of Gene (4th Edition)
- J Darnell, H Lodish and D Baltimore — Molecular Cell Biology (2nd Edition)
- B Alberts, D Bray, J Lewis, M Raff, K Roberts and JD Watson — Molecular Biology of the Cell (2nd Edition)
- Benjamin Lewin — Gene VII
- JM Walker and R Rapley — Molecular Biology and Biotechnology
- SB Primrose — Molecular Biotechnology

January 2017 – June 2017

M.Sc. Bioscience

Second Semester

PAPER IV: BIOMETRY, COMPUTER AND SCIENTOMETRY

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Introduction to biostatistics. Types of biological data: data on different scales. Frequency distributions. Cumulative frequency distributions. Random sampling. Parameters and statistics. Measures of central tendency and dispersion: Mean, Median, Mode, Range, Variance and Standard deviation. Coefficient of variation. The effects of coding data. Data transformations: Log-transformation, Square-root transformation and Arcsine transformation. Distribution: normal and binomial. Probability: Basic laws of probability, addition law, multiplication law. Probability and frequency.
Unit-II	Statistical errors in hypothesis testing. Testing goodness of fit: Chi-square goodness of fit. Heterogeneity Chi-square. The 2 x 2 contingency table. One sample hypothesis. Two-sample hypothesis. Testing for difference between two means (*t*-test). Testing for difference between two variances (*F*-test). The paired sample *t*-test. Multiple-sample hypothesis (ANOVA): Single factor and two factors ANOVA. Multiple comparisons: Duncan's multiple-range tests. Simple linear regression. Regression *vs.* Correlation. Regression equation. Interpretations of regression functions. Simple linear correlation. The correlation coefficient.

Unit-III	Introduction to MS-Office software: Word processing; Creating new document, Editing documents, Adding graphics to documents, Word tables. Management of Workbook & Worksheets; Applications, Features, Using formulas and functions, Features for Statistical data analysis, Generating charts/ graph. Presentation software; Working in PowerPoint, Creating new presentation, Working with slides.
Unit-IV	Introduction to Internet and Applications. Basics of internet, e-mailing, Search engine – Google and Yahoo; Pubmed, Scopus, Web of Science, Google Scholar, Indian Citation Index, Science Citation Index (SCI), h-index, i-10-index. Journal Impact Factor (JIF). Introduction to Plagiarism and Cyber laws.

Lab Course

1.	Exercises for data distribution
2.	Exercises for computation of measures of central tendency
3.	Exercises for computation of measures of variability
4.	Computation of correlation coefficient, r, and regression constants
5.	Data analysis by ANOVA and multiple-range tests
6.	Hypothesis testing by *t*-test, F-test, and Chi-square test
7.	Graphical presentation of data using a suitable package
8.	Statistical analysis of a data using a suitable package
9.	Preparation of document using a suitable package
10.	Preparation of slides using a suitable package

Books Recommended

Campbell RC	Statistics for biologists
Zar JH	Biostatistical Analysis
Wardlaw AC	Practical Statistics for Experimental Biologists
Snedecor GW & Cochran WG	Statistical Methods
Sokal RR & Rohlf FJ	Introduction to Biostatistics
Sumner M	Computers: Concepts & Uses
White R	How Computers Work
Cassel P *et al.*	Inside Microsoft Office Professional
Coleman P and Dyson P	Mastering Internets
Gralla P	How the Internet Works
Shelly GB, Vermaat ME, Cashman TJ	Microsoft® 2007: Introductory Concepts and Techniques
Habraken J	Microsoft® Office 2003 All in One
	Microsoft® Office 2010 In Depth
Gilmore B	Plagiarism: Why it happens, How to prevent it?
Buranen L and Roy AM	Perspectives on Plagiarism and Intellectual Property in a Post-Modern World
Kumar Anupa P	Cyber Law
Sood V	Cyber Law Simplified

July 2017 – December 2017

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Third Semester

Paper I: Molecular Plant Physiology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be

unit wise having internal choice within each unit.	
Unit-I	Membrane transport : Pumps; F-type H^+ -ATPase mitochondria, P-type PM H^+ -ATPase, V Type H^+ -ATPase, and ABC type. Ion Channels; Voltage gated channels of K and Ca. Water transport through Aquaporins. Physiology of Mineral Nutrition: Molecular mechanism and regulation of K, Fe and Zn transport. Phosphorous nutrition and transport. Phytoremediation. Mineral toxicity
Unit-II	Photosynthesis: Light absorption and energy conversion, photosystems I and II, ATP synthesis, Assimilation of carbon in C_3, C_4 and CAM pathways, Photorespiration
Unit-III	Phytohormones: Structure, biosynthesis, molecular mechanisms of Auxin, Gibberellins, Cytokinin, Abscisic acid and Ethylene, Brassinosteroids
Unit-IV	Senescence and Programmed cell death: Senescence; Metabolism and regulation of pigment and nucleic acid, PGR regulation, SAG. PCD; Formation of TE and mobilization of cereal endosperm, Formation of aerenchyma. Signal transduction and PCD

Lab Course:	
1.	Spectrophotometric determination of chlorophyll-a, chlorophyll-b and total chlorophyll in young, mature and senescent leaves
2.	Kinetin estimation by cucumber cotyledons expansion bioassay
3.	Auxin bioassay using wheat coleoptiles
4.	GA bioassay by inducing *de-novo* synthesis of Amylase in de-embryonated seeds of wheat
5.	Estimation of mono, di and total phenols in the young and aged leaves
6.	Estimation of Guaiacol peroxidase activity in fresh and aged seeds
7.	Determination of Superoxide dismutase levels in the healthy and deteriorated seeds
8.	Estimation of metal toxicity induced changes in the AOS levels in leaf tissues
9.	Determination of Nitrate reductase activity in leaf tissues
10.	Separation of isozymes of SOD and GPX

Recommended Books:

Fosket DF	Plant Growth & Development
Foyer CH	Photosynthesis
Bacon Ke	Photosynthesis: Photobiochemistry & Photobiophysics
Leopold AC & Kriedemann PE	Plant Growth & Development
Moore TC	Biochemistry & Physiology of Hormones
L Taiz & E Zeiger	Plant Physiology
BB Buchanan, W Gruissem & RL Jones	Biochemistry & Molecular Biology of Plants
MB Wilkins	Advanced Plant Physiology
JA Hopkins	Introduction to Plant Physiology
FB Salisburry & CW Ross	Plant Physiology
Hans-Walter Heldt	Plant biochemistry & Molecular Biology

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Third Semester

Paper II: Ecology and Environmental Biology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Ecosystem: Concept, Components and types. Productivity, Ecological energetics, Energy flow in ecosystem, Energy flow models, Ecological pyramids, Food chain, Food web. Ecological succession, Ecological niche.
Unit-II	Aquatic ecosystem: Biotic and abiotic components, lentic and lotic ecosystems, wetlands. Terrestrial ecosystems: Forest types of India with special reference to Chhattisgarh. Natural and plantation (artificial) forests, Agroforestry, Social forestry, National parks and Sanctuaries in Chhattisgarh.
Unit-III	Environmental pollution: Definition, types (air, water, soil, noise, thermal & radioactive), causes, effects and control. Solid waste management: Causes, effects and control measures of urban and industrial wastes. Disaster management: Floods, earthquake, cyclone and landslides.
Unit-IV	Biodiversity, ex-situ and in- situ conservation. Intellectual property right (IPR) with special reference to India. Natural resources: Water, Forest and Medicinal plants.

Lab Course:	
1.	To determine the minimum size of the quadrate by 'Specis –Area-Curve' method
2.	To study the community by quadrate method by determining frequency, density and abundance of different species present in the community
3.	Chromatographic separation of chlorophyll pigments in leaf
4.	Measurement of pH and Total alkalinity in water
5.	Measurement of Free carbon dioxide and dissolved oxygen in given water
6.	Identification and drawing of at least 15 medicinal plants

Recommended Books:	
A Beattie and PR Ehrlich	Biodiversity, 2001
EP Odum	Fundamentals of Ecology, 2nd ed., 494-496
EP Odum	Basic Ecology (Philadelphia: Saunders, 1983), 518.
PD Sharma	Ecology and Environment, 2009, Rastogi Publications
M Calver	Environmental Biology, Murdoch University, Western Australia
Aggarwal	Concept of Ecology
NS Subrahmanyam	Ecology, Narosa Publications

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Third Semester
Paper III: Animal Physiology
Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	**Circulation**: Composition of blood, Cell types, Hemopoiesis, Structure and function of hemoglobin - Oxygen and carbon dioxide transport, Cardiac cycle and its regulation. Blood pressure, Blood Coagulation, **Respiration**: Mechanism and regulation of breathing, Factors influencing oxygen uptake, Diving and high altitude adaptations. Measurement of metabolic rate and Q_{10}
Unit-II	**Nervous system**: Mechanisms of conduction along axon and across synapses, Nernst equation and measurement of action potential, Neurotransmitters, Types and physiology of reflexes. **Myology**: Types of muscles, Ultrastructure, mechanism and regulation of contraction of skeletal muscle.
Unit-III	**Endocrinology**: Communication (autocrine, paracrine, neuroendocrine and endocrine) between cells and within the cells, Classification of hormones, General principles of nature of hormone action, Hormone receptors, Structure and physiology of following endocrine glands: hypothalamus, pituitary, thyroid and parathyroid, pancreas, adrenal, and pineal.
Unit-IV	**Hormones, Reproduction and Pheromones**: Hormones in reproduction, Structure and function of testis and ovary, sexual cycles, Mechanism of action of gonadotropins; Types of pheromones, primer pheromone, releaser pheromone, imprinting pheromone, Lee-Boot effect, Bruce effect, Whitten effect, Human pheromones, Sex pheromones in insect control.

Lab Course (8-10 out of the following):

1.	Examination of RBC in Piscine/Avian/Human blood.
2.	Examination of WBC in Piscine/Avian/Human blood.
3.	Differential leukocyte counts in Human blood.
4.	Determination of Hb/Hct/ Absolute values in Piscine/Avian/Human blood.
5.	To determine prevalence of different types of polymorphs in human blood (Based on Arneth's classification).
6.	Demonstration of hemin crystal.
7.	Determination of osmotic resistance in Piscine/Avian/Human blood.
8.	Determination of specific gravity of Piscine/Avian/Human blood
9.	Study of histological preparation of endocrine glands & Microtomy
10.	ELISA/ RIA for T4, T3 & TSH
11.	ELISA/ RIA for Cortisol and Melatonin
12.	Androgen bioassay (chick comb method).
13.	Study of vaginal smears in rat/mouse.
14.	Effects of surfacing prevention on opercular activity in *C. batrachus*/ *H. fossilis*
15.	Determination of rate of oxygen consumption (Whole body and tissue)

Books Recommended:

PJ Bentley	Comparative vertebrate endocrinology
WF Ganong	Review of medical physiology
A Gorbman & HA Bern	A textbook of endocrinology
AC Guyton	Textbook of medical physiology
WS Hoar & DJ Randall	Fish physiology [Series]
CR Martin	Endocrine physiology
D McFarland	Animal behaviour, psychobiology, ethology & evolution

CL Prosser	Adaptational biology: molecules to organisms
CL Prosser & FA Brown	Comparative animal physiology
K Schmidt-Nielsen	Animal physiology: Adaptation & environment
CD Turner & JT Bagnara	General endocrinology
JD Wilson & DW Foster	Textbook of endocrinology
D Randall, W Burggren & K French	Animal Physiology: Mechanisms and adaptations
TD Wyatt	Pheromones and animal behavior: Communication by smell and taste
G Litwack	Pheromones

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Third Semester

Paper IV: Developmental Biology and Evolution

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Gametogenesis in animals. Molecular events during fertilization. Activation of egg metabolism. Cleavage patterns and fat maps. Regulation of Cleavage cycle. Cleavage and nuclear activity.
Unit-II	Concepts of determination, competence, induction and differentiation. Determination in *Caenorhabditis elegans*. Germ cell determination, migration and differentiation. Totipotency and nuclear transfer experiments. Embryonic induction. Formation of vulva in *C. elegans*. Mechanism of differentiation in *Dictyostelium*.
Unit-III	Morphogenetic determinants in egg cytoplasm. Role of maternal contributions in early embryonic development. Genetic regulation of early embryonic development in Drosophila. Homeotic genes. Genetic interaction during differentiation. Hox genes and limb patterning.
Unit-IV	Concepts and theories of organic evolution. The processes of Evolutionary change-Genetic drift, Natural selection and the Hardy-Weinberg equilibrium. Speciation. Molecular evolution and origin of life. Evolution of Prokaryotes and Eukaryotes. A brief outline of the evolutionary history of Metazoans including-Evolution of tissue grade, coelomic body plans and Chordates. Evolution of Mankind.

Lab Course:

1.	Study of developmental stages in Snail/Amphibian/Chick
2.	Study on Drosophila development
3.	Role of hormones in metamorphosis and development
4.	Effect of Vitamin A on tail regeneration in frog
5.	Biochemical estimations in developing embryos
6.	Structure of hen's egg and its vital staining
7.	Demonstration of cell death by vital staining
8.	Study of permanent slides of chick embryos
9.	Histological studies of Gametogenesis
10.	Induced breeding in fishes

Recommended Books	
Alberts *et al*.	Molecular Biology of the Cell
SF Gilbert	Developmental Biology
Lewin Benjamin	Gene VIII
	Developmental Genetics
PO Moody	Introduction to Evolution, 1970, Harper and Row
Dobzhansky et al.	Evolution, W. H. Freeman. New York
SW Fox and K Dose	Molecular Evolution and the Origin of Life, 1972, W.H. Freeman & Co Ltd.
FJ Ayala and JW Valentine	Evolving: The theory and processes of Organic evolution, 1979, Benjamin/Cummings Pub. Co.
EO Dodson	Evolution: Process and Product
MW Strickberger	Evolution, 1979, James and Barlett International

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Fourth Semester

Paper I: Seed Science

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Seed development: Phases of development, Maturation; accumulation of desiccation related compounds, ABA regulation. Seed Dormancy: Physiological and molecular basis, Testa, Endosperm, Aleurone layers & Hormonal cross talk in dormancy. Alleviation of dormancy; Protein oxidation. Dormancy breaking chemicals and mechanism.
Unit-II	Seed Germination: Pre-germination, Germination and post germination Metabolism. Reactivation of the metabolic pathway. Cellular repair. Hormonal regulation and metabolism; GA & ABA, ROS metabolism.
Unit-III	Seed Ageing: Seed storage physiology: Orthodox & Recalcitrant; ROS metabolism, Mechanism of desiccation tolerance, dehydrins/LEA/peroxiredoxin, HSPs, Sugars. Longevity markers; β- mercaptopyruvate sulfurtransferase (MST), L –isoaspartyl O-methyltransferase (PIMT).
Unit-IV	Seed Technology: Priming technology; biochemical and molecular aspects. Cryobanks, Cryopreservation of seed and embryo; Cryoprotective molecules, Vitrification, Encapsulation and Drying. Synthetic seeds.
Lab Course:	
1.	Hydro and chemical priming effect on seed germination.
2.	To perform accelerated ageing in seeds and its comparison with the control.
3.	Testing seed viability and vigour by :
	(a) germination
	(b) triphenyl tetrazolium test
	(c) Specific conductance of leachates and

	(d) Germination Index
4.	Lipid peroxidation in ageing seeds.
5.	Extraction and estimation of seed proteins, carbohydrates and lipids.
6.	Quantitative and qualitative estimation of antioxidant enzymes in seeds:
	(a) SOD
	(b) Peroxidase and
	(c) catalase
7.	Peroxidase assay by tissue printing method.
8.	Seed cryopreservation technique and post-cryopreservation recovery.
9.	Separation and determination of Molecular weight of seed proteins by SDS-PAGE.

Recommended Books

JD Bewley & M Black	Physiology & Biochemistry of Seeds, Vol. I & II
JD Bewley & M Black	Seeds : Physiology of Development & Germination
Black *et al*.	Desiccation and Survival of Plants : Dying without Drying
PK Agrawal & M Dadlani	Techniques in Seed Science & Technology
FAO Report 113	Ex-situ storage of seeds, pollen & *in vitro* cultures
Copeland & McDonald	Seed Science & Technology
RL Agrawal	Seed Technology
J Kigel & G Galili	Seed Development & Germination
W Ayad *et al*.	Molecular Genetic Techniques for Plant Genetic resources
EE Benson	Plant Conservation Biotechnology
DE Fosket	Plant Growth & Development
RB Taylorson	Recent Advances in the Development & Germination of Seeds
McDonald & Copeland	Seed Technology Laboratory Manual
Khullar & RC Thapliyal	Forest Seed
L Schmidt	Guide to Handling of Tropical & Sub-tropical Forest Seed

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Fourth Semester

Paper II: Plant Biotechnology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Introduction to cell and tissue culture, tissue culture as a technique to produce novel plants and hybrids Tissue culture media (composition and preparation) Initiation and maintenance of callus and suspension culture; single cell clones Organogenesis; somatic embryogenesis; transfer and establishment of whole plants in soil Shoot tip culture: Rapid clonal propagation and production of virus free plant
Unit-II	Embryo culture and embryo rescue Anther, pollen and ovary culture for production of haploid plants and homozygous lines Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids Germplasm conservation: Cryopreservation and slow growth cultures

	Chloroplast Transformation: Advantages, vectors, success with tobacco and potato
Unit-III	Plant transformation technology: Basis of tumor formation, Mechanism of DNA transfer, Features of Ti and Ri plasmids, role of virulence genes, use of Ti and Ri as vectors, binary vectors, markers, use of reporter genes, 35S and other promoters, use of scaffold attachment regions, multiple gene transfers, particle bombardment, electroporation, microinjection Applications of plant transformation for productivity and performance: herbicide resistance, insect resistance, Bt genes, Non–Bt like protease inhibitors & amylase inhibitors, virus resistance, nucleocapsid gene, disease resistance, PR (Pathogenesis Related) proteins, nematode resistance, abiotic stress, male sterile lines
Unit-IV	Metabolic Engineering and Industrial Products: plant secondary metabolites, control mechanisms and manipulation of phenylpropanoid pathway, shikimate pathway, biodegradable plastics, therapeutic proteins, antibodies, edible vaccines Molecular Markers– RFLP maps, linkage analysis, RAPD markers, STS (Sequence Tagged Strands), microsatellites, SCAR (Sequence characterized amplified regions), SSCP (Single strand conformational polymorphism), AFLP, map based cloning, molecular marker assisted selection

Lab Course:

1.	Preparation of culture media
2.	To performe meristem/ bud culture, shoot multiplication & rooting phenomenon
3.	To study organogenesis
4.	To perform somatic embryogenesis
5.	To study the process of plantlet acclimatization
6.	To perform embryo culture
7.	To study the process of anther culture development
8.	Study of molecular markers
9.	Extraction of DNA from plant cultures
10.	Estimation and separation of DNA using agarose gel electrophoresis and spectrophotometer

Recommended Books:

MK Razdan	Introduction to Plant Tissue Culture, 2nd Edition, Oxford & IBH Publishing Co. Pvt Ltd, 2010
IK Vasil	Plant Cell and Tissue Culture; Springer Publication, 1994
SS Bhojwani and MK Razdan	Plant Tissue Culture; Elsevier
TJ Fu, G Singh and WR Curtis	Plant Cell and Tissue Culture for the production of Food Ingredients. Kluwer Academic/ Plenum Press, 1999
J Hammond, P McGarvey and V Yusibov	Plant Biotechnology, Springer Verlag, 2000
HS Chawla	Biotechnology in Crop Improvement, International Book Distributing Co., 1998
HS Chawla	Introduction to plant biotechnology. Oxford & IBH Publishing Co. Pvt. Ltd., 2000
BD Singh	Biotechnology- Expending Horizons. 1st Edition, Kalyani Publisher, Ludhiana, 2004
Roberta H Smith	Plant Tissue Culture: Techniques and Experiments, 2nd Edition: Academic

	Press, 2000
Kyte L and Kleyn J	Plants from Test Tubes: An Introduction to Micropropagation, 3rd Edition, Timber Press, 1996
M Smith	Plant Propagator's Bible, 1st Edition, Rodale Books, 2007
MR Ahuja	Micropropagation of Woody Plants, Springer, 1993
YPS Bajaj	Trees III, Springer, 1991
YPS Bajaj	Trees IV, Springer, 1996

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Fourth Semester

Paper III (Special Paper-A) Parasitology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Parasites and parasitism. The Infection process: Modes of Parasite transmission, invasion, migration within host, maintaining station, obtaining nutrients and resisting host attack. Concept of Disease: Inflammation and Repair, Degeneration, Necrosis. Mechanism of Disease transmission with particular reference to vectors. Vector control measures.
Unit-II	General organization and life cycle patterns of Protozoa; Epidemiology, pathogenesis, diagnosis and control of major human diseases, such as- Malaria, Leishmaniasis and Trypanosomiasis.
Unit-III	General organization and life cycle patterns of Trematodes and Cestodes; Epidemiology, pathogenesis, diagnosis and control of major human diseases, such as- Schistosomiasis and Hydatidosis. Arthopod- related ectoparasitic diseases: Ticks, mites and flies.
Unit-IV	General Organization and life cycle patterns of Acanthocephala and Nematoda; Epidemiology, pathogenesis, diagnosis and control of major nematode diseases, such as- Ascariasis, Ancylostomiasis and Filariasis. Biology of plant parasitic nematodes.

Lab Course:

1.	Identification and comments on permanent mounts of parasitic organisms
2.	Host examination for parasites; preparation of permanent slides and identification
3.	Histology/Histopathology/Histochemistry by routine and differential staining
4.	Biochemistry of parasites and pathophysiology of the hosts
5.	Root knot nematodes: Extraction and isolation (Cobb's sieving and decantation method and Baerman's Funnel technique), preparation of perennial pattern mounts
6.	Detection of blood parasites: Malarial parasite
7.	Macroscopic and microscopic examination of stool samples, concentration methods

Recommended Books:

KD Chatterjee	Parasitology (Protozoology and Helminthology) in Relation to Clinical Medicine. 9th Ed. KD Chatterjee, 236 pages, 1973

TC Cheng	General Parasitology. Second Ed., Academic Press College Division, University of California, 827 pages, 1986
CKJ Panicker	Textbook of Medical Parasitology. Jaypee Brothers, Medical Publishers, 248 pages, 2007
TV Rajan	Textbook of Medical Parasitology. BI Publications, New Delhi, 2009
D Rollinson, and SI Hay, Ed.	Advances in Parasitology; Volumes 1 to 78, Elsevier, 1963-2012.
JD Smyth and DW Halton	The Physiology of Trematodes. Academic Press, Second Edition, 446 pages, 1983
DJ Wyler, Ed.	Modern Parasite Biology: Cellular, Immunological and Molecular Aspects. WH Freeman and Company, New York, 2003

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Fourth Semester

Paper III (Special Paper-B) Basic Chronobiology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Historical developments in chronobiology. Different types of geophysical and biological cycles with examples of circadian rhythms. Quantification of biological rhythms - Average, amplitude, phase, and period. Brief introduction to time series analysis. Methods of time series analyses: COSINOR, AUTOCORRELATION, FOURIER, MESA, CHI-SQUARE PERIODOGRAM.
Unit-II	Characteristics of circadian rhythm: Free-run, Temperature and nutrition compensation, and Entrainment. Zeitgeber Time (ZT) and Circadian Time (CT). After-effects and Aschoff's rule. Aging and circadian clocks. Photoperiodism.
Unit-III	Synchronization (=Entrainment) and masking. Entrainment by single light pulse, complete and skeleton photoperiods. Zeitgebers for circadian clocks. Key properties of a Zeitgeber. Photic and non-photic zeitgebers. Mechanisms of entrainment. Phase response curves (PRC), phase transition curves, strong and weak PRC.
Unit-IV	Circadian pacemakers in insects with special reference to *Drosophila*. Suprachaismatic nucleus as mammalian circadian clock. Multi-oscillatory organization: master and slave oscillators, morning and evening oscillators, pacemaker and peripheral oscillators. Adaptive significance of circadian rhythms. Social consequence of circadian rhythms.

Lab Course:

1.	Study of locomotor activity rhythm in suitable animal models
2.	Actogram construction of locomotor activity of suitable animal models
3.	Study of phase shift in circadian rhythm
4.	Computation of period (τ), phase angle (Ψ), Mesor (M), amplitude (A) and acrophase/ peak (∅) of circadian, and other low and high frequency rhythms

5.	Circadian changes in volume of nuclei in onion peel (*Allium cepa*) cells (microscopic observation)
6.	Periodogram, amount of activity and spectral analysis of rhythm data

Recommended Books:

MJ Berridge	Biochemical oscillations and cellular rhythms. The molecular bases of periodic and chaotic behaviour
E Bunning	The physiological clock
FH Columbus	Trends in chronobiology
G Cornelissen & F Halberg	Introduction to chronobiology
JC Dunlap, JJ Loros & PJ DeCoursey	Chronobiology: Biological timekeeping
JC Hall	Genetics and molecular biology of rhythms in *Drosophila* and other insects
PJ Lumsden & AJ Millar	Biological rhythms and photoperiodism in plants
JD Palmer	The living clock
AK Pati	Chronobiology: The dimension of time in biology and medicine; PINSA (Biological Sciences), December 2001
AK Pati (Ed.)	Chronobiology
DS Saunders	An introduction to biological rhythms
B Thomas & D Vince-Prue	Photoperiodism in plants
V Kumar (Ed.)	Biological rhythms
MK Chandrashekaran	Time in the Living World
AT Winfree	The Geometry of Biological Time
MC Moore-Ede, FM Sulzman, & CA Fuller	The clocks that time us, Harvard University Press,1982
DS Saunders	Insect clocks, Pergamon, 2002

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Fourth Semester

Paper IV (Special Paper-A) Immunology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Generation of diversity in BCR and TCR. Light and heavy chain gene recombination. Recombination Signal sequences. Heavy chain constant region genes. Class switching. Membrane and secreted immunoglobulins. Organization and arrangement of T-cell receptor genes.
Unit-II	Synthesis and production of immunoglobulins. Monoclonal antibody. Designer antibody. Regulation of immune response by antigen, antibody, immune complex, MHC and cytokines. Immunity to infections. Immunological tolerance. Nutrition and Immune response.
Unit-III	Principles of Immunodiagnosis. Antigen-antibody interactions. Precipitation reactions. Haemagglutination. Complement fixation test. Direct and Indirect immunofluorescence. Radio labeled and Enzyme linked assays. Immunoblotting. Isolation of pure antibodies. Assay for complement. Isolation of lymphocyte population. Effector cell assays. Flow cytometry. Plaque forming cell asassay,

	ELISPOT assay, lymphocyte stimulation test, migration inhibition assays, cytotoxic assay. Immunodiagnosis of parasitic diseases.
Unit-IV	Immunoprophylaxis: Principles of vaccination. Immunization practices. Vaccines against important bacterial, protozoan and parasitic diseases. DNA vaccines; passive prophylactic measures. Viral vaccines and antiviral agents. Parasite vaccines.

Lab Course:	
1.	Preparation of Parasite Antigen and analysis by PAGE
2.	Immunizations and production of antibody
3.	Antigen antibody reaction by Double Diffusion, Counter current and IEP, RID and EIA
4.	Western Blot Analysis
5.	Immunodiagnosis using commercial kits

Recommended Books:	
RA Goldsby, TJ Kindt and BA Osborne	Kuby's Immunology
E Benjamini, R Coico and G Sunshine	Immunology-A short Course
Roitt, Brostoff and Male	Immunology
William Paul	Fundamentals of Immunology
Stewart Snell	Immunology, Immunopathology and Immunity
Elgert	Understanding Immune System

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Fourth Semester

Paper IV (Special Paper-B) Applied Chronobiology

Each theory paper will have **5 questions** of equal marks. First question [Multiple choice type or short answer type] will be based on all units [complete syllabus] with no internal choice, whereas remaining questions will be unit wise having internal choice within each unit.

Unit-I	Molecular mechanisms underlying clock functions in organisms: Autoregulatory transcriptional feedback loops; Circadian clock mutant types in *Drosophila* (*per*, *tim*, *dbt*, *dclock*, *cycle*, *vrille*, *pdf*, *lark*, *takeout*), *Neurospora*, cyanobacteria, mouse, and humans. Temporal expression pattern of clock genes, Regulation of expression of clock genes, Expression patterns under constant light and darkness; Autonomous functions of clock genes in peripheral tissues.
Unit-II	Human circadian organization: Methods to study human circadian rhythm; Free-running rhythms in humans, Constant routine protocol, and Forced desynchronization protocol. Circadian pacemaker in humans. Marker rhythms in humans: Core body temperature (CBT), melatonin, and cortisol. Sleep-wake alertness and performance rhythms in humans.
Unit-III	Circadian rhythms and human health: Chronopharmacology; Basics of chronopharmacology – clinical chronopharmacology – circadian dependence of

	drug pharmacokinetics. Chronotherapy; Application of chronotherapy in treatment of cancer, cardiovascular diseases, allergies, asthma, and circadian rhythm sleep disorders (for example, DSPS and ASPS) & mood disorders (SAD).
Unit-IV	Circadian rhythms in occupational and travel stresses: Shift work; Types of shift system, direction and frequency of shift rotation, Effect on rhythm parameters, Desynchronization of circadian rhythm, Consequences on sleep, Psychosocial problems, Clinical and non-clinical problems. Shift work tolerance/ intolerance. Shift optimization: Nap, Bright light therapy, Melatonin therapy. Jet lag: Consequences of jet lag; direction asymmetry & variable asymmetry; Approaches to jet lag alleviation.
Lab Course:	
1.	Study of circadian rhythms in objective/subjective variables in human subjects.
2.	Chronotyping in human population.
3.	Study of circadian rhythm in the rest-activity of humans by using wrist actigraphy.
4.	Study of circadian rhythm in blood pressure of humans by using Ambulatory Blood Pressure Monitor.
5.	Circadian variations in RBC and WBC in suitable animal models.
6.	Circadian rhythm in cortisol and melatonin by ELISA

Recommended Books:

JC Dunlap, JJ Loros & PJ DeCoursey	Chronobiology: Biological timekeeping
JC Hall	Genetics and molecular biology of rhythms in *Drosophila* and other insects
WJM Hrushesky	Circadian cancer therapy
BG Katzung	Basic and clinical pharmacology
G Klein and P Becker	Farewell to the internal clock: a contribution in the field of Chronobiology
AK Pati	Chronobiology: The dimension of time in biology and medicine; PINSA (Biological Sciences), December 2001
AK Pati, Ed.	Chronobiology
TT Postolache	Sports Chronobiology: An issue of clinics in sports medicine
D Purves *et al.*	Molecular mechanisms of biological clocks
PH Redfern and B Lemmer	Physiology and pharmacology of biological rhythms
R Refinetti	Circadian Physiology
A Reinberg	Clinical chronopharmacology: Concepts, kinetics, applications
A Sehgal	Molecular biology of circadian rhythms
LE Scheving	Chronobiotechnology and chronobiological engineering
Y Touitou *et al.*	Handbook of medical chronobiology