



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
<b>Total</b>			<b>600</b>	<b>20</b>

**Important Note:**

Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words.

**Continuous evaluation of Performance\***

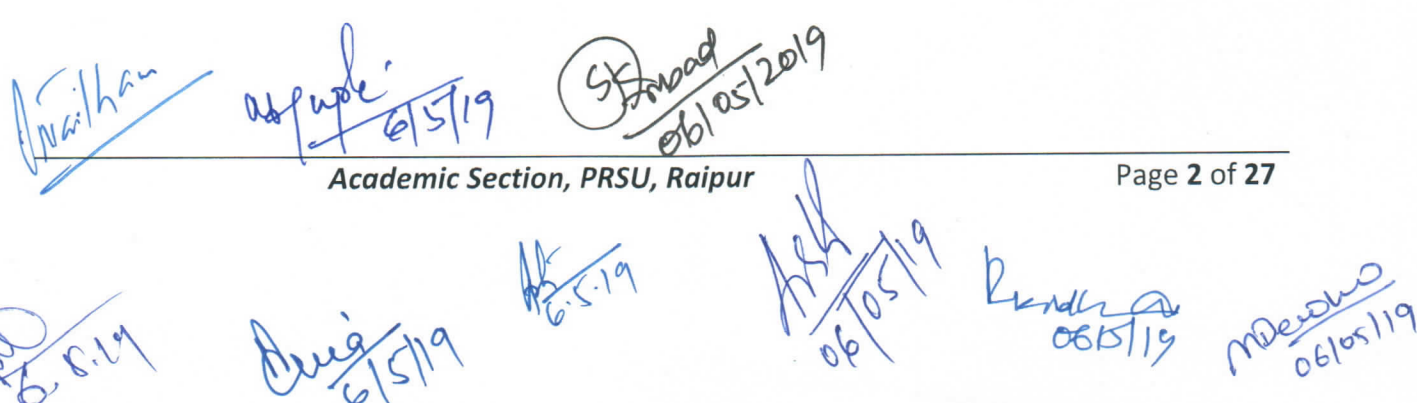
Each student will be evaluated continuously throughout the semester. There will be a class test based on each theory paper. The full marks will be 10 for each paper. There will be a poster/oral presentation based on each theory paper. The full marks will be 10 for each presentation. Each student will 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 secure at least 75% or more marks in aggregate in semester I and II. The project has to be carried out in recognized national 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 (for each Semester)	Maximum Marks	100
<b>External/Internal</b>		
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
<b>Internal</b>		
1- Sessional		20
<b>Total</b>		<b>100</b>

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


  
 A collection of handwritten signatures and dates in blue ink, including names like 'Anilhan', 'Aspude', 'SK', 'Ash', 'Rendra', and 'MDeo', with dates such as '6/5/19' and '06/05/2019'.

**M. Sc. Bioscience**  
**FIRST SEMESTER (July 2019 – December 2019)**  
**PAPER - I: CELL BIOLOGY**  
**[Credit: 4 and Maximum Marks: 80]**

(Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words).

- UNIT-I** Molecular organization of membranes - Asymmetrical organization of lipids, proteins and carbohydrates. Membrane transport: Passive transport, Osmosis, ion channels, membrane pumps and, Active transport: ATP-powered pumps-types, properties and mechanisms, electrical properties of membranes.
- UNIT-II** Protein trafficking: Transport of proteins into mitochondria, chloroplast, endoplasmic reticulum and nucleus [in and out]. 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. Oncogenes: retinoblastoma, E2F and p53 proteins.  
Apoptosis: regulation by CASPases and formation of apoptosome. Pro- and anti-apoptotic factors.
- UNIT-IV** States of chromosomes during cell cycle. Mitotic chromosome. Organization of genes in chromosomes. Banding pattern of chromosomes. Lampbrush and Polytene chromosomes. DNA packaging: Chromatin, nucleosomes, 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 Chiasma frequency and Terminalization of phases.
18. Micrometry and Camera Lucida drawings.

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Anshuman  
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Adarsh  
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S. Jaiswal  
06/05/2019  
H.S.H.  
6/5/19  
M. Deo  
06/05/19

**Books Recommended:**

H. Lodish, A. Berk, S L Zipursky, P. Matsudaira D. Baltimore, and James Darnell.	Molecular Cell Biology
B. Alberts, D. Bray, K. Hopkin, A. Johnson	Essential of Cell Biology
H. Lodish, A. Berk, C. A. Kaiser & M. Krieger B. Alberts, A. Johnson, J. Lewis and M. Raff Gerald Karp	Molecular cell Biology Molecular Biology of the Cell Cell and Molecular Biology Concepts and experiments

**M. Sc. Bioscience**  
**FIRST SEMESTER (July 2019 – December 2019)**  
**PAPER – II: Biomolecules**  
**[Credit: 4 and Maximum Marks: 80]**

(Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words).

- UNIT-I** Classification, structure and function of Carbohydrates, Lipid:  
Carbohydrate: Monosaccharides, homo and hetero-polysaccharides, Peptidoglycan glycoproteins and liposaccharide.  
Lipids: Simple; cholestrol and complex; phospholipids and TAG
- UNIT-II** Classification, structure and functions of amino acids, Synthesis of peptides, Proteins- properties, secondary, tertiary and quaternary structure of proteins, Ramchandran plot.  
Nucleic Acid: Structure and functions of Purine and pyrimidine, DNA-types, linking number, RNA-types.
- UNIT-III** Enzyme: apoenzymes, cofactors, coenzymes, active site, factors contributing to the catalytic efficiency of enzyme; enzyme kinetics- Michaelis-Menten equation, determination of Km, enzyme inhibition, allosteric enzymes, isoenzymes, multienzyme complexes
- UNIT-IV** Structure and biological role of:  
Porphyrins in biology, structure of hemoglobin and chlorophyll  
Animal hormones: protein, peptide and steroid hormones.  
Vitamins: fat and water soluble.

**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)

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*Ugupte*  
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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

**Books Recommended:**

Kuby's Immunology	R.A. Goldsby, T. J Kindt and B. A. Osborne
Immunology- A short Course	E. Benjamini, R. Coico and G. Sunshine
Immunology	Roitt, Brostoff and Male
Fundamentals of Immunology	William Paul
Immunology	Tizard
Immunology	Abbas et al

**M. Sc. Bioscience**

**SECOND SEMESTER** (January 2020 – June 2020)

**PAPER – I: Genetics and Molecular Biology**

[Credit: 4 and Maximum Marks: 80]

(Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words).

- UNIT- I** Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants, complementation analysis. Mutation: Types, mutagens and detection. Mutant types – lethal, conditional, biochemical, loss of function, gain-of-function, germinal verses somatic mutants, insertional mutagenesis.
- UNIT-II** DNA replication in eukaryotes and prokaryotes : 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.  $p_{53}$  and  $p_{21}$ .
- UNIT-III** RNA synthesis and processing: enzymes involved, formation of initiation complex, transcription activator and repressor, elongation, and termination, RNA processing, capping, RNA editing, splicing, and polyadenylation, RNA transport.
- UNIT-IV** Protein synthesis and processing: Ribosome, formation of initiation complex, initiation factors, elongation and elongation factors and their regulation, termination. Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors. Post Translational modification of proteins.

**Lab Course:**

1. Isolation, purification and estimation of RNA

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Anupam 6/5/19  
Anita 6/5/19  
S.H. Sharma 06/05/2019  
ASH 06/5/19  
Renuka 06/5/19  
Ash 6.5.19  
MDevi 06/05/19

2. Isolation, purification and estimation of DNA
3. Determination of  $T_m$  of nucleic acid
4. Fraction of poly (A) RNA
5. Restriction Mapping
6. Restriction Digestion
7. Ligation
8. DNA molecular size determination

**Books Recommended:**

Molecular Cell Biology	H. Lodish, A. Berk, SL Zipursky, P. Matsudaira, D. Baltimore, and James Darnell.
Essential Cell Biology	B. Alberts, D. Bray, K. Hopkin and A. Johnson
Molecular Biology of the Cell	B. Alberts, A. Johnson, J. Lewis and M. Raff
Cell and Molecular Biology : Concepts and experiments	Gerald Karp
Molecular Biology of the Gene	JD Watson et al.
Molecular Biology of the Cell The Problems	John Wilson, Tim Hunt
Molecular Biology of the Cell	Bruce Albert's, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter
Genes VIII	Benjamin Lewin

**M. Sc. Bioscience**  
**SECOND SEMESTER (January 2020 – June 2020)**  
**PAPER – II: Bioenergetics & Metabolism**  
**[Credit: 4 and Maximum Marks: 80]**

(Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words).

- UNIT-I** First and second laws of thermodynamics. Gibbs free energy  $G$ , free energy change  $\Delta G$ , endergonic & exergonic reactions. Standard state free energy changes- $\Delta G$ ,  $\Delta G^0$  and  $\Delta G'^0$ , Relationship between equilibrium constant and  $\Delta G^0$ , Feasibility of reactions. ATP-Structure, properties and energy currency of the cell, Importance of Coupled reactions, other high energy compounds.
- UNIT-II** Carbohydrate metabolism: Glycolysis, Kreb's cycle, glycogenolysis, glycogenesis, pentose phosphate pathway, gluconeogenesis, and glyoxylate pathway. Regulation of carbohydrate metabolism.
- UNIT-III** Electron transport and oxidation phosphorylation: electron carriers, complexes I to IV, substrate level phosphorylation, mechanism of oxidative phosphorylation. Shuttle system for entry of electron. Biosynthesis and degradation of Lipids. Regulation of lipid metabolism
- UNIT-IV** Nitrogen Assimilation: Overview of Nitrogen in biosphere and uptake by organism. Biosynthesis and degradation of amino acids. Regulation of amino acid metabolism. Biosynthesis and degradation of purine and pyrimidine nucleotides.

**Lab Course:**

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D. N. Mishra 6.8.19  
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SK Bhowmik 06/05/2019  
ASL 06/5/19  
R. N. Mishra 06/5/19  
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1. Protein estimation by Lowry, Bradford and Spectrophotometric method
2. Estimation blood cholesterol
3. Estimation of sugar by Nelson- Somagy 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

**Books Recommended:**

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

**M. Sc. Bioscience**

**SECOND SEMESTER** (January 2020 – June 2020)

**PAPER- III: Instrumentation and Techniques**

[Credit: 4 and Maximum Marks: 80]

(Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words).

- 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.  
Spectrofluometry  
Atomic absorption spectroscopy: Principle, Instrumentation and applications
- UNIT-II** Microscopic techniques: light microscopy, phase-contrast microscopy, scanning and transmission electron microscopy, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy.
- UNIT-III** Chromatography: Paper and Thin Layer Chromatography. Gel filtration, Ion exchange and Affinity chromatography. GLC and HPLC.  
Histochemical and immunohistotechniques: Detection of molecules using immunoprecipitation, EIA, RIA and FIA.

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S. K. Singh 06/05/2019  
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Rendu 06/5/19  
Al 6.5.19  
M. S. W. 06/05/19

**UNIT-IV** Electrophoresis: Agarose, PAGE, 2D-E.

Radioactivity: GM counter, liquid Scintillation counter, solid Scintillation counter, gamma counters.

*Lyophilization*: Principle, instrumentation and applications.

Microtomy: types, principle and applications

**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
- Isoenzymes
- Separation of sub-cellular organelles by differential centrifugation.
- Isolation of DNA and Agarose gel Electrophoresis

**Books Recommended:**

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
TA Jennings	Lyophilization: Introduction and Basic Principles
James M. Miller	Chromatography: Concepts and Contrasts
LR Synder, JJ Kirkland and JL Glajch	Practical HPLC Method Development, 2nd Edition
Anna Pratima Nikalje & D. Bhosale	A Handbook of Chromatography
Mark F. Vitha	Chromatography: Principles and Instrumentation
AGE Pearse	Histology and Histochemical methods
PA Midgley	The principles of microscopy
DB Murphy & MW Davidson	Fundamentals of Light Microscopy and Electronic Imaging, Second Edition
IW Watt	The Principles and Practice of Electron Microscopy
RF Egerton	Physical Principles of Electron Microscopy
	An Introduction to TEM, SEM, and AEM
P Haselet, G-W Oetjen	Freeze-Drying, 3rd Edition
EC Clayden	Practical Section Cutting and Staining
T Chandak, M Chaudhary & V Chandak	Microtomy: Microtome and its applications
Simon Renshaw	Immunohistochemistry and Immunocytochemistry: Essential Methods, Second Edition
IB Buchwalow & W Bocker	Immunohistochemistry: Basics and Methods
JB Birks	The Theory and Practice of Scintillation Counting

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**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 & 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 & Roy AM	Perspectives on Plagiarism & Intellectual Property in a Post-Modern World
Kumar Anupa P	Cyber Law
Sood V	Cyber Law Simplified

<b>M.Sc. Bioscience</b>	
<b>Third Semester (July 2020 – December 2020)</b>	
<b>Paper I: Molecular Plant Physiology</b> [Credit: 4 and Maximum Marks: 80]	
Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words	
<b>Unit-I</b>	Membrane transport : Pumps; F-type H <sup>+</sup> -ATPase mitochondria, P-type PM H <sup>+</sup> -ATPase, V Type H <sup>+</sup> -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
<b>Unit-II</b>	Photosynthesis: Light absorption and energy conversion, photosystems I and II, ATP synthesis, Assimilation of carbon in C <sub>3</sub> , C <sub>4</sub> and CAM pathways, Photorespiration
<b>Unit-III</b>	Phytohormones: Structure, biosynthesis, molecular mechanisms of Auxin, Gibberellins, Cytokinin, Abscisic acid and Ethylene, Brassinosteroids
<b>Unit-IV</b>	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

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**M.Sc. Syllabi of Bioscience: 2019-2021**

	Solid waste management: Causes, effects and control measures of urban and industrial wastes. Disaster management: Floods, earthquake, cyclone and landslides.
<b>Unit-IV</b>	Biodiversity, ex-situ and in- situ conservation. Intellectual property right (IPR) with special reference to India. Natural resources: Water, Forest and Medicinal plants.
<b>Lab Course:</b>	
1.	To determine the minimum size of the quadrat by 'Specis –Area-Curve' method
2.	To study the community by quadrat 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
<b>Recommended Books:</b>	
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

<b>M.Sc. Bioscience</b>	
<b>Third Semester (July 2020 – December 2020)</b>	
<b>Paper III: Animal Physiology</b>	
<b>[Credit: 4 and Maximum Marks: 80]</b>	
Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words	
<b>Unit-I</b>	<b>Blood and Circulation:</b> Composition of blood, Cell types, Hemopoiesis, Structure and function of hemoglobin - Oxygen and carbon dioxide transport, Blood Coagulation. Blood volume and its regulation. Blood group. <b>Respiration:</b> Mechanism and regulation of breathing, Factors influencing oxygen uptake, Diving and high altitude adaptations. Measurement of metabolic rate and $Q_{10}$
<b>Unit-II</b>	<b>Nervous system:</b> Mechanisms of conduction along axon and across synapses, Nernst equation and measurement of action potential, Neurotransmitters, Types and physiology of reflexes. <b>Myology:</b> Types of muscles, Ultrastructure, mechanism and regulation of contraction of skeletal muscle.
<b>Unit-III</b>	<b>Cardiovascular System:</b> Anatomy of heart structure, ECG—its principle and significance,

Academic Section, PRSU, Raipur  
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	cardiac cycle, blood pressure and its neural and chemical regulation. <b>Excretory system</b> - Physiology of excretion, kidney, urine formation, urine concentration, waste elimination, regulation of water balance, electrolyte balance, acid-base balance.
<b>Unit-IV</b>	Digestive system - Digestion, absorption, energy balance, BMR. Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.

**Lab Course:**

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.	To determine absolute Eosinophil count in Human blood
8.	To determine blood pressure in different body position [standing, supine, seating position]
9.	To determine the effect of exercise on blood pressure
10.	Computation of mean arterial pressure
11.	To evaluate peak expiratory flow rate [lung efficiency] as function of age and gender
12.	To study different stages of melanophores in scales of the live fish
13.	To study the effect of temperature on melanophores in scales of live fish
14.	To observe the effect of adrenalin [neurotransmitter] on melanophores in scales of live fish

**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
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

**M.Sc. Bioscience**

**Third Semester (July 2020 – December 2020)**

**Paper IV: Developmental Biology and Evolution**

[Credit: 4 and Maximum Marks: 80]

Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words

<b>Unit-I</b>	Gametogenesis in animals. Molecular events during fertilization. Activation of egg metabolism. Cleavage patterns and fat maps. Regulation of Cleavage cycle. Cleavage and
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	nuclear activity.
<b>Unit-II</b>	Concepts of determination, competence, induction and differentiation. Determination in <i>Caenorhabditis elegans</i> . Germ cell determination, migration and differentiation. Totipotency and nuclear transfer experiments. Embryonic induction. Formation of vulva in <i>C. elegans</i> . Mechanism of differentiation in <i>Dictyostelium</i> .
<b>Unit-III</b>	Morphogenetic determinants in egg cytoplasm. Role of maternal contributions in early embryonic development. Genetic regulation of early embryonic development in <i>Drosophila</i> . Homeotic genes. Genetic interaction during differentiation. Hox genes and limb patterning.
<b>Unit-IV</b>	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 <i>Drosophila</i> 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 <i>et al.</i>	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

**M.Sc. Bioscience**

**Fourth Semester (January 2021 – June 2021)**

**Paper I: Molecular Endocrinology  
[Credit: 4 and Maximum Marks: 80]**

Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words

<b>Unit-I</b>	Definition and scope of molecular endocrinology. Chemical nature and general classes of hormones: Peptide, Amino acid derived, Steroid, Neurotransmitters, Neuropeptides,
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	Chalones, Eicosanoids and Pheromones. Hypothalamic octapeptide hormones: Oxytocin and Vasopressin. Purification and characterization of hormones. Hypothalamo-hypophyseal axis.
<b>Unit-II</b>	Genetic control of hormone synthesis: Structure and expression of protein hormone encoding gene. Molecular aspects of peptide hormone biosynthesis and secretion. Molecular aspects of synthesis and delivery of thyroid hormones, biogenic amines and steroid hormones. Production of protein hormones by recombinant DNA technology
<b>Unit-III</b>	Molecular mechanism of hormone action: Membrane, cytoplasmic and nuclear hormone receptors, Non-genomic mechanism of hormone action, Receptor-ligand interactions. Hormonal signal transduction: G-proteins and second messengers. Genomic mechanism of hormone action: Steroid and thyroid hormones.
<b>Unit-IV</b>	Molecular aspects of Reproductive endocrinology: Genetics of sex. Testicular and ovarian determining genes. Mullerian inhibiting substance genes. Stem cell renewal in testis. Molecular basis of male and female contraception. Endocrine disruptors. Neuroendocrine control of reproduction and feedback mechanism.
<b>Lab Course:</b>	
1.	Purification of any protein hormone.
2.	Assay of steroid dehydrogenase
3.	Isolation and characterization of steroid/prostaglandin.
4.	In vivo bio- assay for estrogen/testosterone/LH
5.	Perfusion technique for the fixation of endocrine tissue
6.	Identification of hypothalamic nuclei following histological / histochemical methods
7.	Histological / Cytological / Histochemical study of endocrine glands.
8.	Study of estrus cycle by vaginal smear technique.
9.	Extraction and estimation of Gondotrophin / Pregnanediolo from urine.
10.	Sperm count and motility.
11.	Study of neurosecretory cells/ materials/granules in the given materials.

**Recommended Books**

Franklyn F. Bolander Freedman and Birkhauser	Molecular Endocrinology: Molecular Biology of Steroid and Nuclear Hormone receptors:
An Introduction to Neuroendocrinology	Brown R.
Endocrinology	Mac E. Hadley
Endocrinology (Vol. I-III)	D Groot. L. J. (ed.), W. B. Saunder
Vertebrate Endocrinology	Norris, D. O.
Essential Endocrinology	Brook, C.G.D. and Marshall, N.J.
Williams Textbook of Endocrinology	Shlomo Melmed et al,
Basic Medical Endocrinology	Goodman. H.M.
Introduction to Endocrinology	Negi.
Reproductive Endocrinology	Yen et al (ed)
Reproductive Endocrinology	Adashi et al,
Experimental Endocrinology	Zarrow et al.
Essential techniques in reproductive physiology and Endocrinology	Chinoy et al.
Cell and Molecular Biology of Testis	Claude D and Larry L. E (ed)
Biochemical actions of hormones	Litwack, G.
Nuclear Receptors: Current Concepts and Future Challenges	CM Bunce, MJ Campbell

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M.Sc. Bioscience	
Fourth Semester (January 2021 – June 2021)	
Paper II: Plant Biotechnology [Credit: 4 and Maximum Marks: 80]	
Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words	
<b>Unit-I</b>	Introduction to cell and tissue culture: Tissue culture media (composition and preparation), explant preparation, Callus and suspension culture, cytodifferentiation and organogenic differentiation, somatic embryogenesis, micropropagation. Shoot tip culture: Rapid clonal propagation and production of virus free plant.
<b>Unit-II</b>	Embryo culture and embryo rescue. Anther, pollen and ovary culture for production of haploid plants & homozygous lines. Protoplast isolation, culture and fusion; selection of hybrid cells and regeneration of hybrid plants; symmetric and asymmetric hybrids, cybrids. Germplasm conservation: Cryopreservation & slow growth cultures. Chloroplast Transformation: Advantages, vectors, success; tobacco & potato
<b>Unit-III</b>	Plant transformation technology: Plant transformation technology: basis of tumor formation, hairy root, features of Ti and Ri plasmids, mechanism of DNA transfer, role of virulence genes, use Ti and Ri as vectors, binary vectors, use of 35S and other promoters, use of reporter genes, particle bombardment, electroporation, microinjection.
<b>Unit-IV</b>	Applications of plant transformation for productivity and performance: herbicide resistance, insect resistance, long shelf-life of fruits. 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.
<b>Lab Course:</b>	
1.	Preparation of culture media
2.	To perform 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
<b>Recommended Books:</b>	

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7.	Macroscopic and microscopic examination of stool samples, concentration methods
<b>Recommended Books:</b>	
KD Chatterjee	Parasitology (Protozoology and Helminthology) in Relation to Clinical Med.. 9 <sup>th</sup> Ed.
TC Cheng	General Parasitology. Second Ed.,
CKJ Panicker	Textbook of Medical Parasitology. Jaypee Brothers,
TV Rajan	Textbook of Medical Parasitology.
D Rollinson, and SI Hay,	Advances in Parasitology; Volumes 1 to 78,
JD Smyth and DW Halton	The Physiology of Trematodes.
DJWyler, Ed.	Modern Parasite Biology: Cellular, Immunological and Molecular Aspects.

<b>M.Sc. Bioscience</b>	
<b>Fourth Semester (January 2021 – June 2021)</b>	
<b>Paper III (Special Paper-B) Basic Chronobiology</b>	
<b>[Credit: 4 and Maximum Marks: 80]</b>	
<p>Each theory paper will have questions divided into four sections, A, B, C &amp; D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words</p>	
<b>Unit-I</b>	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, CHI-SQUARE PERIODOGRAM.
<b>Unit-II</b>	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. Plant Rhythms
<b>Unit-III</b>	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.
<b>Unit-IV</b>	Circadian pacemakers in insects with special reference to <i>Drosophila</i> . Suprachiasmatic 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.
<b>Lab Course:</b>	
1.	Terminology in Chronobiology
2.	Study of locomotor activity rhythm in suitable animal models
3.	Actogram construction of locomotor activity of suitable animal models
4.	Study of phase shift in circadian rhythm in a suitable variable, such as locomotor activity
5.	Construction of Cosinor Curves using Mesor (M), amplitude (A) and acrophase/ peak ( $\phi$ ) of circadian, and other low and high frequency rhythms
6.	Computation of period ( $\tau$ ), phase angle ( $\Psi$ )

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**M.Sc. Syllabi of Bioscience: 2019-2021**

7.	Circadian changes in volume of nuclei in onion peel ( <i>Allium cepa</i> ) cells (microscopic observation)
8.	Observation of leaf movement of a plant on circadian and longitudinal time scales
9.	Periodogram, amount of activity and spectral analysis of rhythm data using TSA-Cosinor software

**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 <i>Drosophila</i> 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 Chandrashekar	Time in the Living World
AT Winfree	The Geometry of Biological Time
MC Moore, FM Sulzman, & CA Fuller	The clocks that time us, Harvard University Press, 1982
DS Saunders	Insect clocks, Pergamon, 2002

**M.Sc. Bioscience**

**Fourth Semester (January 2021 – June 2021)**

**Paper III (Special Paper-C): Ethnobotany**

**[Credit: 4 and Maximum Marks: 80]**

Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words

<b>Unit-I</b>	<b>Ethnobotany</b> Introduction, Concept, Scope and objectives; Ethnobotany as an interdisciplinary science. The relevance of Ethnobotany in the present context; major and minor ethnic groups or tribals of India and their life styles. Plants used by the tribals as: (a) Food plants (b) Intoxicants and Beverages (c) Resins, oils and miscellaneous uses.
<b>Unit-II</b>	<b>Methodology of Ethnobotanical studies</b> Field work: collection and confirmation of tribal information; its documentation; assessment of its valuation Herbarium: its role in confirmation of ethnic data; assessment of similarities of data across different habitats

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	Regulation of immune response by antigen, antibody, immune complex, MHC and cytokines.
<b>Unit-II</b>	Immunoprophylaxis: Principles of Vaccination. Immunization practices. Vaccines against important bacterial and parasitic diseases. DNA vaccines; passive prophylactic measures. Viral vaccines and antiviral agents. Vaccination schedules and safety. Production of vaccines.
<b>Unit-III</b>	Diagnosis of microbial diseases - Collection, transport and preliminary processing of Clinical pathogens. Clinical, microbiological, immunological and molecular diagnosis of diseases. Principles of immunodiagnosics. Antigen-antibody based diagnosis and the techniques involved – Enzyme, Radio and Fluorescence Immuno assays, Immunoblotting, Flow cytometry. Effector cell assays, Cytotoxic assays. Isolation of pure antibody. Monoclonal & Designer antibody and their application in immunodiagnosics.
<b>Unit-IV</b>	Modern methods of microbial diagnosis. Use of nanotechnology in diagnosis. Synthesis of Nanomaterials, Nanoparticle based drug delivery, Toxicity and environmental risks of nanomaterials. Biosensors: Biosensor-development, types and characteristics, DNA biosensors, application of biosensors in clinical diagnostics: detection of infectious diseases, food pathogen and environmental monitoring.

**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
6.	Identifications of nanomaterials using physical and chemical properties.
7.	Green and chemical route for synthesis of nanomaterials.
8.	Nanomaterial characterizations using UV-Vis and FT-IR spectroscopy.
9.	Assessment of antibacterial properties of nanomaterials.
10.	Identification of different analyte/ biomolecules for biosensing system.

**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
M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse	Nanotechnology: Basic science and Emerging technologies
G. Cao	Nanostructures and Nanomaterials: Synthesis, properties and applications
Challa S.S.R. Kumar	Nanomaterials for medical diagnosis and therapy
Charles P. Poole Jr. and Franks. J. Qwens	Introduction to Nanotechnology
C. M. Niemeyer, C. A. Mirkin (Editor)	Nanobiotechnology: Concepts, Applications and Perspectives

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M.Sc. Bioscience	
Fourth Semester (January 2021 – June 2021)	
Paper IV (Special Paper-B): Applied Chronobiology [Credit: 4 and Maximum Marks: 80]	
Each theory paper will have questions divided into four sections, A, B, C & D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words	
<b>Unit-I</b>	Molecular mechanisms underlying clock functions in organisms: Autoregulatory transcriptional feedback loops; Circadian clock mutant types in <i>Drosophila</i> ( <i>per</i> , <i>tim</i> , <i>dbt</i> , <i>dclock</i> , <i>cycle</i> , <i>vriille</i> , <i>pdf</i> , <i>lark</i> , <i>takeout</i> ), <i>Neurospora</i> , 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.
<b>Unit-II</b>	Human circadian organization: Methods to study human circadian rhythm; Free-running rhythms in humans, Constant routine protocol, and Forced desynchronization protocol. Chronotypes and its assessment methods. Marker rhythms in humans: Core body temperature (CBT), melatonin, and cortisol. Sleep-wake alertness and performance rhythms in humans.
<b>Unit-III</b>	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).
<b>Unit-IV</b>	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.
<b>Lab Course:</b>	
1.	Study of circadian rhythms in objective variables in human subjects using autorhythmometry technique.
2.	Study of circadian rhythms in subjective variables in human subjects using autorhythmometry technique.
3.	Chronotyping in human population.
4.	Study of circadian rhythm in the rest-activity of humans by using wrist actigraphy.
5.	Study of circadian rhythm in blood pressure of humans by using Ambulatory Blood Pressure Monitor.
6.	Circadian variations in RBC and WBC in suitable animal models.
7.	Circadian rhythm in cortisol and melatonin by ELISA.
8.	Computation of mid-sleep and social jetlag
9.	Observation of functional status of in-built alarm clock in humans.
<b>Recommended Books:</b>	
JC Dunlap, JJ Loros & PJ	Chronobiology: Biological timekeeping

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**M.Sc. Syllabi of Bioscience: 2019-2021**

DeCoursey	
JC Hall	Genetics and molecular biology of rhythms in <i>Drosophila</i> 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 <i>et al.</i>	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 <i>et al.</i>	Handbook of medical chronobiology

<b>M.Sc. Bioscience</b>	
<b>Fourth Semester (January 2021 – June 2021)</b>	
<b>Paper IV (Special Paper-C): Secondary Metabolites</b>	
<b>[Credit: 4 and Maximum Marks: 80]</b>	
<p>Each theory paper will have questions divided into four sections, A, B, C &amp; D. Section A will have 20 MCQ of 1 mark each covering whole syllabus. Section B will have 8 very short answer questions, two from each unit, of 2 marks each to be answered in two to three lines. Section C will have 8 questions, two from each unit, of 3 marks each. The question has to be answered in about 75 words. Section D will have 4 questions, one from each unit with internal choice, of 5 marks each. The question has to be answered in about 150 words</p>	
<b>Unit-I</b>	<p><b>Introduction to secondary metabolites:</b> Definition and systematic of secondary metabolites. Major classes of secondary metabolites i.e. alkaloids, terpenoids/ or isoprenoids, flavonoids and phenolics. Significance of secondary metabolites in plant's life. Roles in chemical defense system, taxonomical and ecological functions. Pharmacological and biological properties of secondary metabolites. Industrial and commercial significance of secondary metabolites</p>
<b>Unit-II</b>	<p><b>Biosynthesis and regulation of secondary metabolites:</b> Biosynthesis of alkaloids derived from Shikimic acid pathway. Biosynthesis of isoprenoids via 3C-methyl-D-erythritol-4-phosphate (MEP) pathway. Biochemical pathways of flavonoids and polyphenol (lignin) biosynthesis. Integration of secondary metabolism with primary metabolic pathways. Regulation: Genetic, developmental, seasonal and geographical factors, roles of precursor feeding, metabolic channeling and compartmentalization. Cross-talk/exchange of intermediates between biochemical pathways. Use of specific enzyme inhibitors in regulation</p>
<b>Unit-III</b>	<p><b>Production of secondary metabolites:</b> Methods of production of secondary metabolites: Tissue, organ and hairy root cultures. Roles of Endophytes in production of secondary metabolites. Production of secondary metabolites in bioreactors. Effects of precursors, co-factors and elicitors on production. Production of Taxol, Camptothecin, Berberine and rubber.</p>

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<b>Unit-IV</b>	<b>Metabolic Engineering of secondary metabolic pathways:</b> Cloning and characterization of enzymes of the Shikimate and MEP pathways. Functional genomics approaches for improvement of secondary metabolite production. Metabolic engineering of <i>Escherichia coli</i> and yeast for the production of flavonoids, terpenoids and alkaloids.
<b>Lab Course:</b>	
1	Isolation of essential oil and determination of the oil yield.
2	Qualitative test for determination of a- terpenoids b- alkaloids c- flavonoids d- saponins
3	Quantitative test for determination of: a- terpenoids b- alkaloids d- saponins e- phenolics
4	Determination of antimicrobial activity of the plant extracts.
5	Demonstration of hairy root culture for production of secondary metabolites
6	RNA extraction and gene expression of key enzymes of Biosynthesis of alkaloid; <i>Strictosidine Synthase [STR1]</i> , <i>Strictosidine glucosidase (SG)</i> , <i>Acetylajmalan Esterase (AAE)</i> etc.

**Recommended Books:**

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|---|---|
| 1. David S. Seigler                                     | Plant Secondary Metabolism,   |
| 2. Alan Crozier   | Plant Secondary Metabolites: Occurrence, Structure and Role in the Human Diet |
| 3- Y. M. Shukla   | Plant Secondary Metabolites   |
| 4- R. Verpoorte, A. W. Alfermann                        | Metabolic Engineering of Plant Secondary Metabolism.                          |
| 5- Herbert, R.B.  | The Biosynthesis of Secondary Metabolites                                     |
| 6- Fett-Neto, Arthur Germano (Ed.)                      | Biotechnology of Plant Secondary Metabolism<br>Methods and Protocols          |
| 7- Keller, Nancy P., Turner,                            | Fungal Secondary Metabolism   |
| 8- Bell, E.A., Charlwood, B.V. (Eds.)                   | Secondary Plant Products  |
| 9- Petroski, Richard J., McCormick, Susan P. (Eds.)     | Secondary-Metabolite Biosynthesis and Metabolism                              |
| 10- Makkar, Harinder P.S., Sidhuraju, P., Becker, Klaus | Plant Secondary Metabolites   |