AC/24.9.22/RS 2

(*Affiliated to University of Mumbai*)

Faculty: Science

Program: M.Sc.-I

Subject: ZOOLOGY

Academic Year: 2022 – 2023

Revised Syllabus in Zoology
under Choice Based Credit System (CBCS)
Approved by the Board of Studies in Zoology
Effective from academic year 2022 – 2023

M.Sc. Part I - Zoology Syllabus (Autonomous)
Semester I and Semester II
(Choice Based Credit System, with effect from academic year 2022-23)

Preamble

"Essential to a great discoverer, in any field of Nature, would seem an intuitive flair for raising the right question. To ask something which the time is not ripe to answer is of small avail. There must be the means for reply and enough collateral knowledge to make the answer worthwhile."
— Sir Charles Scott Sherrington (Nobel Laureate in Physiology or Medicine in 1932)

Academic autonomy signifies a paradigm shift to Academic freedom, which is instrumental in promoting Academic excellence. This paradigm shift served as an impetus for restructuring and refining the curriculum for the postgraduate program in the subject of Zoology.

Clarity of the basic concepts of science is a requisite to build a strong foundation in scientific knowledge. Thus, in addition to enable students to acquire an in depth knowledge of the core subject, the current syllabus also attempts to integrate the applications of Biotechnology with classical zoology, which will help students to be equipped with the necessary skills to enhance their core competencies in understanding synergism of pure and applied sciences.

Some new topics included in this syllabus are Medical Biotechnology, Applications of Industrial and Agricultural Biotechnology, Bioinformatics which will keep the students abreast with cutting edge technological applications in medicine, healthcare, agriculture, industry etc. The essence of classical zoology is retained with topics like Phylogeny and Systematics, Genetics and Evolution which will help students recognize that there are common threads that connect all living organisms. The topics on Tools and Techniques in Biology have been restructured with inclusion of concepts of Globally Harmonized System, Standard Operating Procedure and Calibration so as give the students exposure to Good Laboratory Practices and Hazard Communication, which will inculcate a professional and analytical approach towards Lab safety, Instrumentation and Techniques. Moreover, the topics on Research Methodology have been redesigned with the purpose and rationale to not only inculcate amongst students a research aptitude, but also develop and enhance their research skills in order to make them adapt to the research culture. It also aims to nurture critical thinking and develop analytical reasoning amongst students. The topics on Biochemistry and Metabolism, the intricate chemical reactions which sustain life, will help students appreciate the fact that the same principles/ laws govern the physical and the living worlds.

This syllabus is a collective and constructive effort of the faculty, experts from research institutions, alumni and the board members whose valuable suggestions and expertise were instrumental in materializing this syllabus. The comments and recommendations of the contributors and reviewers have been carefully considered and implemented wherever feasible. The syllabus was approved by the Board of Studies in the meeting held on 23rd July 2022 at SIES College of Arts, Science and Commerce (Autonomous), Sion, Mumbai.

In conclusion, we hope this syllabus will inculcate an interdisciplinary approach in students and develop a mind for scientific inquiry aspiring to explore new dimensions of the subject. Moreover, this syllabus will also encourage and maximize learning among students to develop open, inquiring minds.

Dr. Satish Sarfare
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Members of the Board of Studies in the subject of Zoology

- ✓ *Professor (Dr.) Manisha Kulkarni – Professor, Department of Zoology, Institute of Science, Mumbai (Vice Chancellor's Nominee)*
- ✓ *Professor (Dr.) Manoj Mahimkar – Principal Investigator, Cancer Research Institute, ACTREC, Kharghar, Navi Mumbai; (Subject expert from outside the Parent University to be nominated by the Academic Council)*
- ✓ *Dr. Sasikumar Menon – Director, Institute for Advanced Training & Research in Interdisciplinary Sciences (IATRIS), (Therapeutic Drug Monitoring Lab), Sion, Mumbai; Faculty, Pharma Analytical Sciences, Ruia College, Mumbai (Subject Expert from outside college/Industry expert)*
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M.Sc. Part I - Zoology Syllabus (Autonomous) – Semester I
Choice Based Credit System (With effect from academic year 2022-23)

THEORY				
Course name and code	**Unit**	**Topic Headings**	**Credits**	**Lectures/ week**
SEMESTER I				
Paper I: Non chordates and their Phylogeny, Genetics and developmental biology - I				
SIPSZO11	1	Phylogeny, Systematics of Nonchordates - I	**4**	**1**
	2	Phylogeny, Systematics of Nonchordates – II, Hemichordata		**1**
	3	Developmental biology - I		**1**
	4	Genetics: Chromosome theory, Mendelian and Non Mendelian inheritance		**1**
Paper II: Biochemistry and Metabolism – I				
SIPSZO12	1	Biomolecules- A structural and functional approach-I	**4**	**1**
	2	Biochemical Thermodynamics		**1**
	3	Metabolic Pathways and Integration of Metabolism - I		**1**
	4	Regulation of Metabolism		**1**
Paper III: Biotechnology and Gene manipulation - I				
SIPSZO13	1	Large scale culture and production from recombinant microorganisms	**4**	**1**
	2	Medical Biotechnology		**1**
	3	Genome management and analysis		**1**
	4	Agriculture Biotechnology		**1**
Paper IV: Tools and Techniques in Biology - I				
SIPSZO14	1	Principles and applications of Microscopy and Centrifugation	**4**	**1**
	2	Principles and applications of Radioisotopes and Microtomy		**1**
	3	Principles and applications of Spectroscopy		**1**
	4	Good laboratory practices and Research Methodology - I		**1**
PRACTICAL				
SIPSZOP11	1	Based on SIPSZO11	**2**	**4**
SIPSZOP12	2	Based on SIPSZO12	**2**	**4**
SIPSZOP13	3	Based on SIPSZO13	**2**	**4**
SIPSZOP14	4	Based on SIPSZO14	**2**	**4**
		Total	**24**	**32**

M.Sc. Part I - Zoology Syllabus (Autonomous) – Semester II
Choice Based Credit System (With effect from academic year 2022-23)

THEORY				
Course name and code	**Unit**	**Topic Headings**	**Credits**	**Lectures/ week**
SEMESTER I				
Paper I: Non chordates and their Phylogeny, Genetics and developmental biology - I				
SIPSZO21	1	Phylogeny of Protochordates, Agnatha	**4**	**1**
	2	Phylogeny, Systematics of Chordates - I		**1**
	3	Developmental biology - II		**1**
	4	Evolution - I		**1**
Paper II: Biochemistry and Metabolism – I				
SIPSZO22	1	Biomolecules- A structural and functional approach-II	**4**	**1**
	2	Enzymes and Enzyme kinetics		**1**
	3	Metabolic Pathways and Integration of Metabolism - II		**1**
	4	Inborn Errors of Metabolism		**1**
Paper III: Biotechnology and Gene manipulation - I				
SIPSZO23	1	Microbial synthesis of commercial products	**4**	**1**
	2	Enzyme technology in large scale production		**1**
	3	Bioinformatics		**1**
	4	Environmental Biotechnology		**1**
Paper IV: Tools and Techniques in Biology - I				
SIPSZO24	1	Principles and applications of Chromatography - I	**4**	**1**
	2	Principles and applications of 1 Chromatography - II (Gel Chromatography and Affinity Chromatography)		**1**
	3	Principles and applications of Chromatography (GC, HPTLC) and Electrophoresis		**1**
	4	Good laboratory practices and Research Methodology - II		**1**
PRACTICAL				
SIPSZOP21	1	Based on SIPSZO21	**2**	**4**
SIPSZOP22	2	Based on SIPSZO22	**2**	**4**
SIPSZOP23	3	Based on SIPSZO23	**2**	**4**
SIPSZOP24	4	Based on SIPSZO24	**2**	**4**
		Total	**24**	**32**

Programme: Master of Science, M.Sc. Part 1 – Zoology

"The world can only be grasped by action, not by contemplation."- Jacob Bronowski

The characteristic graduate attributes comprising of Programme Outcomes, Programme Specific Outcomes and Course Outcomes for a science Post graduate in the subject of Zoology are as follows:

Note the list of abbreviations:

PO: Programme Outcome, PSO: Programme Specific Outcome, CO: Course Outcome
Cognitive Levels:- R: Remember, U: Understand, Ap: Apply, An: Analyze, E: Evaluate, C: Create

Serial Number	Details of Programme Outcomes (POs)
PO1 *(Skill Level)*	Problem Solving Ability *(U, Ap)* • Apply the knowledge of various courses learned under a program to break down complex problems into simple components. • Adopt and assimilate problem-based learning models and apply one's learning to solve real life problem situations.
PO2 *(Skill Level)*	Critical Thinking *(U, An, E)* • Develop critical thinking based on a rationale to identify assumptions, verifying the accuracy and validity of assumptions, and making informed decisions. • Inculcate the ability of logical reasoning to question the rationale behind concepts, ideas, and perspectives.
PO3 *(Skill Level)*	Effective Communication Skills *(Ap, C)* • Improve written and oral communication skills so as to express thoughts and ideas effectively. • Demonstrate the ability to listen carefully and imbibe soft skills to convey and receive instructions clearly. • Develop presentation skills to present complex information in a clear, lucid and concise manner.
PO4 *(Skill Level)*	Proficiency with Information and Communication Technology *(U, An, E)* • Demonstrate ability to access, evaluate and use a variety of relevant information resources inclusive of internet and electronic media for the purpose of collating and analyzing data. • Understand the scope and limitations of tools or software used in Information and Communication Technology.
PO5 *(Skill Level)*	Leadership Skills and Team Work *(U, Ap, An, C)* • Demonstrate leadership skills formulating an inspiring vision, thereby building a team, motivating and inspiring team members to engage and achieve that vision. • Develop management skills to guide people in takings tasks to their logical conclusion. • Inculcate the ability to facilitate coordinated effort as a group or team in the interests of common cause and recognize the contribution of team members.
PO6 *(AttitudeLevel)*	Self-directed and Lifelong Learning *(U, Ap, An)* • Demonstrate the ability to work independently and take responsibility for ones actions. • Acquire the ability to explore and evolve by becoming self-sufficient and self-reliant. • Adapt lifelong learning approaches to broaden one's horizons for personal growth and development.
PO7	Ethical Values and Environmental Concerns *(U, Ap, E)*

(AttitudeLevel)	• Embrace moral or ethical values in conducting one's life and implement ethical practices in all aspects of life. • Create awareness and concern for environmental and sustainability issues. • Understand and realize the significance and relevance of co-habitation and co-evolution in attaining the needs of sustainable development.
PO8 *(AttitudeLevel)*	Gender Sensitization and Community Service *(U, Ap, An)* • Respect gender sensitivity, gender equity and gender justice. • Encourage mutual understanding and express empathetic social concern towards different value systems and different strata of society. • Engage in community service through Institutional Social Responsibility.

Serial Number	**Details of Programme Specific Outcomes (PSOs)**
PSO1	Conceptual Understanding and Emerging Applications *(R, U, Ap, An)* • Inculcate conceptual and coherent understanding of zoology, and demonstrate a broad understanding of animal diversity, including fundamental and systematic knowledge of the scientific classification, taxonomy and evolutionary relationships of major groups of animals. • Understand the nature and basic concepts of cell biology, biochemistry, animal physiology, molecular biology, ecology among other topics, so as to recognize the relationships between structure and functions at different levels of biological organization for the major groups of animals. • Demonstrate interest in different areas of zoology so as to analyze the scope of emerging applications of biological sciences in medicine, genetics, wild life, etc. and apply appropriate methodologies with cutting edge tools/techniques in biological sciences to seek solutions to emerging problems faced by mankind. • Demonstrate the relevance of the procedural subject knowledge that creates different types of professionals related to the disciplinary/subject area of zoology, including professionals engaged in research and development, teaching and government/public service.
PSO2	Analytical reasoning and Scientific Inquiry *(U, An, E)* • Inculcate a sense of inquiry and capability for asking relevant or appropriate questions, articulating problems or concepts or questions. • Encourage the ability to analyze, interpret and draw conclusions from qualitative/quantitative data and critically evaluate ideas, experiences, theories and concepts by following scientific approach to knowledge development from an open minded and reasoned perspective. • Develop analytical skills involving paying attention to detail and imbibe the ability to construct logical arguments using correct technical language related to the relevant subject. • Analyze and interpret data/information collected or related to experiments or investigations, using appropriate methods involving Biostatistics, Bioinformatics among others and report accurately the findings of the experiment/investigations while relating the conclusions/ findings to relevant theories of zoology.
PSO3	Laboratory Skills and Fieldwork *(R, U, E, C)* • Understand and apply standard operating procedures as per Good Laboratory Practices so as to develop laboratory skills and qualities required for successful career in teaching, research, industry, etc. • Demonstrate awareness regarding animal ethics, human ethics, conservation of flora and fauna, so as to promote safe environment and ecosystem, in the pursuit of disciplinary knowledge. • Develop instrumentation handling skills and laboratory techniques relevant to academia and industry; integrate knowledge, skills with technical competency, so as to create solutions for issues and problems related to biological sciences.

	• Demonstrate leadership qualities, command trust and respect, thereby, motivating and inspiring team members to work effectively in diverse teams during excursions or study tours. Realize the relevance of participation in field studies in the context of teamwork as well as life on the outdoors.
PSO4	Research Aptitude and Interdisciplinary Approach *(Ap, An, E, C)* • Inculcate and adapt to research aptitude and culture, integrate research-based knowledge in an interdisciplinary framework, and realize the relevance of choosing research as an alternative career option. • Demonstrate the awareness regarding compliance with research ethics, awareness about conflicts of interests and Intellectual Property Rights, and avoiding unethical behavior such as fabricating, falsifying or misrepresenting data or to committing plagiarism. • Inculcate the ability to recognize cause and effect relationships, formulate hypothesis, reporting the results of an experiment or investigation, andapplication of research tools for analysis and interpretation of data. • Inculcate an interdisciplinary approach, to understand and consolidate fundamental concepts through inquiry based curriculum, develop critical thinking and problem solving ability required to solve different types of biology related problems with well-defined solutions, and tackle open-ended problems that may cross disciplinary-area boundaries.

Course Outcomes for M.Sc. Part 1

At the root of all (science) education (Core Learning Outcome):

"The imaginative and original mind need not be overawed by the imposing body of present knowledge or by the complex and costly paraphernalia which today surround much of scientific activity. The great shortage in science now is not opportunity, manpower, money, or laboratory space.What is really needed is more of that healthy scepticism which generates the key idea – the liberating concept." *– P.H. Abelson*

Purity of mind leads to clarity in thought and action for creation of an original archaic work.As well, to consciously attempt the basic pursuit of understanding human existence.

Semester I – Theory

Course Code: SIPSZO11
Course Name: Non chordates and their Phylogeny, Genetics and developmental biology - I
The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit 1: Phylogeny, Systematics of Nonchordates - I	**CO1:** • Appreciate the diversity of non-chordates living in varied habitats and having varied habits. • Learn about the importance of systematics, taxonomy, and structural organization of animals. • Attempt to gain an insight of the hierarchy of life forms from the simplest to the most complex ones by a study of the levels of organization in animal kingdom. Also, to know the different modifications the animal life has made for its survival, through phylogenetic and taxonomic studies. • Understand evolutionary history and relationships of different non-chordates through functional and structural affinities. • Critically analyze the organization, complexity and characteristic features of non-chordates and familiarize with the morphology and anatomy of representatives of various animal phyla.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 2: Phylogeny, Systematics of Nonchordates, Hemichordata	**CO2:** • Appreciate the diversity of non-chordates and Hemichordates living in varied habit and habitats. • Understand evolutionary history and relationships of different non-chordates and Hemichordates through functional and structural affinities. • Critically analyze the organization, complexity and characteristic features of Non-chordates, Hemichordates and familiarize with the morphology and anatomy of representatives of various animal	*R, U, An*	*PO1, PO2* *PSO1,PSO2*

	phyla.		
Unit 3: Developmental Biology - I	**CO3:** • To appreciate how a single cell becomes an organized group, which is then programmed at specific times to become specialized for certain tasks, ultimately to form an entire organism. • Understand the basic concepts in developmental biology. • Learn the detailed account on cell differentiation and totipotency. • Get acquainted to the concept of stem cells, their types, function, role in cancer biology and ethical issues related to stem cells.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 4: Genetics - Chromosome theory, Mendelian and Non-Mendelian Inheritance - I	**CO4:** • To uncover the rules governing the transmission of genetic traits and the relation between genes and chromosomes, through the study of classical genetics and its extension. • To inculcate the understanding of organization of genetic material, structure of chromosomes, chromosome number, shape, and types. • Acknowledge the lasting contribution of Gregor Mendel and his methodology demonstrating his scientific and perseverant traits. • Build a conceptual framework of the science of inheritance – genetics, through discussion on Mendelian inheritance, cytoplasmic inheritance and touching on human genetics.	*R, U, An, Ap*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO12
Course Name: Biochemistry and Metabolism – I
The study of this course will accomplish the following outcomes:

Unit	**Course Outcome (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
Unit 1: Biomolecules - A structural and functional approach-I	**CO1:** • Understand the basic concepts of Biochemistry for advancing in varied fields of biological sciences having social relevance. • Understand the Biochemistry by a discussion about Biomolecules (here, focusing on Carbohydrates, Proteins, Lipids, Nucleic acids, and some complex biomolecules), their structure, function, classification, reactions and uses.	*R, U*	*PO1, PO2* *PSO1, PSO2*
Unit 2: Biochemical Thermodynamics	**CO2:** • To know about the energy transductions that occurs in or between organisms through thermodynamic study. • To get acquainted to the laws of	*R, U, An*	*PO1, PO2* *PSO1, PSO2*

	thermodynamics. • To understand the role of high energy compounds in living organisms. • Understand the roles of ATP and reduced co-factors in shuttling energy and electrons within the cells. • Comprehend the mechanism of biological oxidation and its significance.		
Unit 3: Metabolic Pathways and Integration of metabolism - I	**CO3:** • Thoroughly learn about the regulation of carbohydrates and lipid metabolism. • Understand the properties of enzymes and importance of catalysis with respect to energy production. • Understand the concepts of bioenergetics including determining and evaluating the free energy and redox potential in relation to metabolism. • Understand the functioning of enzymes and cofactors in bioenergetics reactions. • Describe the central role of ATP. Understand the switches in metabolic pathways during fasting and fed state.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 4: Regulation of Metabolism	**CO4:** • Understand the roles of hormones in regulating metabolism. • Get acquainted to various enzymes incorporated in regulation of metabolic pathways. • Comprehend the regulation of metabolism by extracellular signals such as nutrient supply, nutrient transport, endocrine control and neural control.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO13
Course Name: Biotechnology and Gene manipulation - I
The study of this course will accomplish the following outcomes:

Unit	**Course Outcome (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
Unit 1: Large scale culture and production from recombinant microorganisms and genetically engineered animal cells	**CO1:** • Keep abreast with the current trends in this fast-moving field of Biotechnology, which is an intersection of technology and Biology. • Gain an in-depth knowledge of the application of recombinant DNA technology in food, microbial technology and for the production of genetically engineered animal cells to obtain commercial products for human use. • Learn about different types of fermenters employed to obtain different commercial products and to understand basics of recombinant cell physiology, for process development and industrial production of recombinant proteins	*R, U, Ap, An*	*PO1, PO2, PO7* *PSO1, PSO2*

	• Comprehend the knowledge of animal cell cultures and their role as adequate test systems for studying biochemical pathways, virus production, pathological mechanisms, and intra/intercellular responses.		
Unit 2: Medical Biotechnology	**CO2:** • To emphasize the significance of Biotechnology in the field of medicine for production of therapeutic agents viz., vaccines and monoclonal antibodies that have revolutionized medical science. • Get acquainted to the modern tools practiced in medical biotechnology. • Learn about the biological reagents such as engineered monoclonal antibodies and their role in improved laboratory diagnostics. • Gain knowledge about improvements in vaccine technology and improved therapeutics such as humanized monoclonal antibodies, genetically engineered cytokines like interferons, hormones, and growth factors.	*R, U, Ap, An,*	*PO1, PO2* *PSO1, PSO2*
Unit 3: Genome Management and Analysis-I	**CO3:** • Explore the basic tools of genetic engineering practiced in genome management and analysis. • To get acquainted to various gene transfer techniques employed in genome management- a skill-based approach in biotechnology. • Understand various methods used in genome analysis. Also, elucidate the mechanism, instrumentation, and commercial applications of the same.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2*
Unit 4: Agricultural Biotechnology	**CO4:** • To emphasize the significance of Biotechnology in the field of Agriculture. • Understand the mechanism of nitrogen fixation and the application of biotechnology to enhance nitrogen fixation for the betterment of humans. • Comprehend the use of Agriculture biotechnology in developing virus resistant and herbicide resistant plants and other genetically modified crops.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO14
Course Name: Tools and Techniques in Biology - I
The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO

Unit 1: Microscopy and Centrifugation	**CO1:** • Get acquainted to the principle, working and applications of centrifugation techniques. • Learn about the standard operating procedure and calibration, use, care/maintenance of centrifuge- a skill-based approach. • Get acquainted to the principle, working and applications of various microscopy techniques so as to develop a focused approach and get a magnified view of diverse prospects in biology. • Learn about the standard operating procedure and calibration, use, care/maintenance of microscopes- a skill-based approach.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2, PSO3*
Unit 2: Principles and applications of Radioisotopes, Microtomy techniques	**CO2:** • Get acquainted to the principle and applications of radioisotopes. • To learn about the principles of microtomy which bridge the process between specimen collection and microscopic analysis. • To get habituated to the standard operating procedure and calibration, use, care/maintenance of microtome- one of the most essential skills in histological studies.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2, PSO3*
Unit 3: Principles and applications of Spectroscopy	**CO3:** • Get acquainted to the principle, working and applications of various spectroscopy techniques which represent a scientific measurement of matter through its interaction with different components of the electromagnetic spectrum. • Learn about the standard operating procedure and calibration, use, care/maintenance of spectrophotometer- a skill-based approach.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2, PSO3*
Unit 4: Good Laboratory Practices and Research Methodology-I	**CO4:** • Analyze the importance of laboratory safety practices and safety symbols, for awareness regarding conduct as a science student. • Inculcate in students research aptitude and to develop an open, inquiring mind that is willing to explore new territories and learn new things. • Encourage the spirit of curiosity of students, in order to develop the potential to be problem solvers and scientific investigators in their own way. • Develop and enhance the research skills in order to make students adapt to the research culture. • Develop an ability to distinguish between a purpose statement, a research question or hypothesis, and a research objective. • Identify and discuss the complex issues inherent in selecting a research problem,	*R, U, Ap, An*	*PO1, PO2, PO3, PO4, PO5, PO7* *PSO1, PSO2, PSO3, PSO4*

	selecting an appropriate research design, and implementing a research project. • Develop a skill of reviewing the literature which facilitates the deeper understanding of chosen topic, identifying experts and current research within that area, and answering key questions about current trends.		

PRACTICAL

"*Study nature not books.*" – An old dictum.

The practical course in Zoology is designed for first hand study of animal life through observation of preserved specimens, *in situ* organ systems, microscopic examination of permanent slides, etc. as wellas to perform experiments to strengthen the concept base.

It is an effort to invigorate a thought process that can analyze and reason for the sake of awareness, hence to reach a valid answer.

Semester I – Practical

Course Code: SIPSZOP11
Course Name: Practical I based on SIPSZO11

Course	Course Outcomes (CO)	Cognitive Level	Affinity with PO/PSO
SIPSZOP11	• Identify and describe various specimens, permanent microscope slides with respect to specific characteristic features in invertebrate animal kingdom. • Understand chromosomes by performing and observing (under light microscope) squash preparation of onion root tip. • Understand the different mouthparts of insects and its mode of feeding in several ways using various sources of food. • Temporary preparation of polytene chromosomes from *Drosophila* or Chironomus larva, to provide an important model system for studying the architectural changes in chromatin morphology associated with the process of transcription initiation and elongation. • Detect the presence of Barr body in the buccal smear and understand its genetic and clinical significance. • Learn in detail about the common fruit fly, *Drosophila melanogaster*, as a versatile model organism in diverse range of biological studies. Also, to learn about the contrasting traits between the female and male *Drosophila melanogaster* and its use in genetic studies.	*R, U, An, C*	*PO1, PO2, PO8* *PSO1,PSO2, PSO3*

Course Code: SIPSZOP12
Course Name: Practical II based on SIPSZO1

Course	Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
SIPSZOP12	• Detection and identification of carbohydrates in the given test sample based on changes in color due to chemical reactions, which further have many commercial applications in the fields of food science, biochemistry, medicine etc. • Understand the glycogen metabolism, its clinical significance by estimating it in a given tissue sample. • Learn about the breakdown of glycogen which is an energy yielding process by subjecting it to the hydrolysis using acids and enzymes. • Understand the process of isolation of starch from potato in a laboratory. • Determine the acid value, saponification value and RM number of fat/oil sample which have their commercial applications in evaluating the quality of raw materials and their degradation during storage of fats/oils, checking for the adulteration, determining the purity of fat/oil sample respectively.	*R, U, An, E*	*PO1, PO2, PO6* *PSO2, PSO3*

Course Code: SIPSZOP13
Course Name: Practical III based on SIPSZO13

Course	Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
SIPSZOP13	• Comprehend the significance of aseptic techniques in biotechnological experiments and demonstrating those techniques-an important step to skill development in biotechnology. • Understand the significance of culture media in microbiology, develop necessary skills for preparing culture media, demonstrate the techniques to culture bacteria using some commonly practiced techniques in laboratory. • Isolation of genomic DNA from the given strain of bacteria/ tissue and show the purity of the isolate by performing agarose gel electrophoresis, thereby developing skills in electrophoretic techniques. • Estimate the number of bacteria in the given culture by the technique of Nephelometry.	*R, U, An, Ap, E*	*PO2, PO5, PO6* *PSO1, PSO2, PSO3*

Course Code: SIPSZOP14
Course Name: Practical IV based on SIPSZO14

Course	Course Outcomes (CO)	Cognitive Level	Affinity with PO/ PSO
SIPSZOP14	• Analyze the importance of laboratory safety practices and safety symbols, for awareness regarding conduct as a science student. • Explain the principle and working of pH meter, an instrument to measure pH – a parameter with implications on functioning of biological system. Use pH meter for plotting titration curve and determining pKa. • Explain the principle and working of colorimeter – a light sensitive instrument used for measuring concentration of coloured solutions, in biochemical assays, etc.; perform selection of best filter for a coloured solution in question. • Explain the principle and working of a microtome- an instrument used in various histo-pathological studies. Learn and demonstrate the techniques of tissue preservation and fixation, dehydration, infiltration, paraffin embedding and block preparation, sectioning using a microtome, staining and analyzing the sections.	*R, U, An, Ap, E*	*PO2, PO5, PO6* *PSO1, PSO2, PSO3*

Semester II – Theory

Course Code: SIPSZO21

Course Name: Chordates and their Phylogeny, evolution and developmental biology - II

The study of this course will accomplish the following outcomes:

Unit	Course Outcome (CO)	Cognitive Level	Affinity with PO/ PSO
Unit 1: Phylogeny of Protochordates and Chordates - II	**CO1:** • Expand the knowledge of diversity of life forms by an account of more complex life forms. • Connecting the dots of extinct life with the extant one by understanding the evolutionary history and relationships of different Chordates through functional and structural affinities. • Critically analyze the organization, complexity and characteristic features of chordates and familiarize with the morphology and anatomy of representatives of various animal phyla.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 2: Phylogeny, Systematics of Chordates II	**CO2:** • Expand the knowledge of diversity of life forms by an account of more complex life forms. • Connecting the dots of extinct life with the extant one by understanding the evolutionary history and relationships of different Chordates through functional and structural	*R, U, An*	*PO1, PO2* *PSO1, PSO2*

	affinities. • Critically analyze the organization, complexity and characteristic features of chordates and familiarize with the morphology and anatomy of representatives of various animal phyla.		
Unit 3: Developmental Biology- II	**CO3:** • Introduction to the morphogenetic, molecular, and cellular, and genetic aspects of the developmental biology of animals**.** • Become familiar with the major animal model systems used in developmental biology, such as Sea urchin, Tunicates, *C. elegans*, *Drosophila*, Amphibians, Fish, Chick, and Mouse. • Students will understand the general developmental mechanisms, including terms and concepts of developmental biology, such as induction, autonomous specification, morphogens, differential adhesion etc. • The biological information that underlies ethical issues such as stem cells and human cloning.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 4: Evolution - I	**CO4:** • To demonstrate understanding of ecological and evolutionary processes including the role of genetic variation, heredity. • Students will be able to understand natural selection as well as the implications these processes have for the origins and evolution of modern humans and their biology.	*R, U, An, Ap*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO22
Course Name: Biochemistry and Metabolism - II
The study of this course will accomplish the following outcomes:

Unit	**Course Outcome (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
Unit 1: Biomolecules - A structural and functional approach - II	**CO1:** • Understand the basic concepts of Biochemistry for advancing in varied fields of biological sciences having social relevance. • Understand the Biochemistry by a discussion about Biomolecules (here, focusing on Proteins), their structure, function, classification, reactions.	*R, U*	*PO1, PO2* *PSO1, PSO2*
Unit 2: Enzymes and Enzyme kinetics	**CO2:** • Understand the dynamics of enzyme functioning and their kinetics, their classification, and types. They will also be introduced to the concept of enzyme inhibition and how enzymes can be halted for therapeutic purposes**.** • Understand the quantitative terms, chemical changes catalyzed by the component enzymes	*R, U, An*	*PO1, PO2,* *PSO1, PSO2*

	of the route.		
Unit 3: Metabolic Pathways and Integration of metabolism- II	**CO3:** • Thoroughly learn about the metabolism of Proteins including the metabolism of amino acids and ammonia. • Thoroughly learn about the mechanism of Nucleic acids. • Understand the integration of major metabolic pathways of energy metabolism.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*
Unit 4: Regulation of Metabolism and Inborn Errors of Metabolism	**CO4:** • Comprehend the knowledge of metabolism in health and disease. • Familiarize with various inborn errors in the metabolism of carbohydrates, proteins, lipids and minerals.	*R, U, An*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO23
Course Name: Biotechnology and Gene manipulation - II
The study of this course will accomplish the following outcomes:

Unit	**Course Outcome (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
Unit 1: Microbial synthesis of commercial products	**CO1:** • Students will gain in-depth understanding of basic aspects of microbiological science pertaining to industrial applications. The student will be able to assess treatment strategies.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2*
Unit 2: Enzyme technology in large scale production	**CO2:** • Students will learn about the process of fermentation which is frequently used for the cultivation of biomass and in the production of enzymes, pharmaceuticals, energy, food and feedstock, bioactive compounds, biopolymers, etc., in which different microorganisms are involved.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2*
Unit 3: Bioinformatics	**CO3:** • Use and understand bioinformatics tools to analyses proteomics data, involving identification and quantification approaches. • Discuss standards in proteomics bioinformatics and recognize its importance. • Evaluate the strengths and weaknesses of several experimental and bioinformatics analysis approaches. • Use tools to perform functional annotation of lists of protein. • Students will understand how to utilize bioinformatics tools and databases for retrieving, analyzing, understanding, and managing biological data. • The program aims to understand how genes and proteins determine their functions and establish evolutionary relationships.	*R, U, Ap, An*	*PO1, PO2, PO4* *PSO1, PSO2, PSO4*

Unit 4: Environmental Biotechnology	**CO4:** • The aim of environmental biotechnology is to prevent, arrest and reverse. environmental degradation through the appropriate use of biotechnology in combination with other technologies. • The course is an introduction to environmental biotechnology and focuses on the utilization of microbial processes in bioremediation. And elementary relevant microbiological processes, microbial ecology and basic principles in bioremediation and biological waste water treatment. • Evaluate the potential for biodegradation of organic pollutants, taking microbial and physical/chemical environments, as well as the chemical structure of the compound itself, with respect to bioleaching.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2*

Course Code: SIPSZO24
Course Name: Tools and Techniques in Biology - II
The study of this course will accomplish the following outcomes:

Unit	**Course Outcome (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
Unit 1: Principles and applications of Chromatography - I	**CO1:** • Understand the analytical techniques for separating chemical components in biological samples. • Gain knowledge about the principles and applications of chromatography. • Get familiar to the principle, working and applications of Planar Chromatography. • Understand the principle, working and applications of Column Chromatography. • Understand the principle, working and applications of Ion Exchange Chromatography.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2, PSO3*
Unit 2: Principles and applications of Chromatography - II	**CO2:** • Understand the analytical techniques for separating chemical components in biological samples. • Gain knowledge about the principles and applications of chromatography • Get familiar to the principle, working and applications of Gel Chromatography. • Comprehend the different types of Chromatography media, immobilized ligands, attachment of ligands to the matrix, experimental procedure of affinity chromatography.	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2, PSO3*
Unit 3: Principles and applications of Chromatography	**CO3:** • Get acquainted to the instrumentation, selection of operating conditions, analysis of data and applications of advanced	*R, U, Ap, An*	*PO1, PO2* *PSO1, PSO2,*

and Electrophoresis	techniques of chromatography like Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC). • Understand the electrophoretic techniques used for separating macromolecules in biological samples and their applications. • Since all solutes are not colored knowledge of visualizing agent will help the students locate the isolated solutes in electrophorogram.		*PSO3*
Unit 4: Good Laboratory Practices and Research Methodology - II	**CO4:** • Get an insight into overview of Globally Harmonized System (GHS) Physical Hazards and GHS Health and Environmental Hazards. • Preparation of standard operating procedure and calibration, use, care/maintenance of advanced laboratory instruments such as HPTLC, HPLC, GC. • Acquire an overview of Good Manufacturing Practices (GMP) / Good Clinical Practices (GCP) guidelines. • Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project. • Develop a skill of reviewing the literature which facilitates the deeper understanding of chosen topic, identifying experts and current research within that area, and answering key questions about current trends. • Get acquainted to ethics in research, ethical standards, policies, issues, improve ethical judgment and decision making. • Gain knowledge about different funding agencies and how to apply for grants and securing research funding of conducting research.	*R, U, Ap, An*	*PO1, PO2, PO3, PO4, PO5, PO7* *PSO1, PSO2, PSO3, PSO4*

Semester II – Practical

Course Code: SIPSZOP21
Course Name: Practical I based on SIPSZO21

Course	Course Outcomes (CO)	Cognitive Level	Affinity with PO/PSO
SIPSZOP21	• Appreciate the complexity of organisms in a hands-on learning environment. • Expand the understanding of diversity of animal life by an account of animals with more complex levels of organization (Protochordates and Vertebrates); an understanding that may aid a healthy man-animal coexistence.	*R, U, An*	*PSO2, PSO3*

	• Examine a beating heart under light microscope and determine its rate by using crustacean arthropod Daphnia. Also effect of stressors on its heart rate. Also, elucidate the effect of stressors on its heart rate. • Demonstration of isolation of limb bud and its chorio-allantoic grafting to explores the ability of the chick *chorio-allantoic membrane to support an excised limb bud from a donor embryo.*		

Course Code: SIPSZOP22
Course Name: Practical II based on SIPSZO2

Course	**Course Outcomes (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
SIPSZOP22	• Determination of total cholesterol and HDL cholesterol from serum in order to understand the clinical significance. • Detection and identification of amino acids and proteins in the given test sample based on changes in color due to chemical reactions, which further have many commercial applications in the fields of food science, biochemistry, medicine etc. • Determine the creatinine in serum and urea in order to deduce the functioning of kidneys. • Get acquainted to the significance of SDH in respiration by determining its specific activity based on changes in colour due to chemical reactions. • Comprehend the role of casein in milk and demonstrate its isolation from the given milk sample.	*R, U, An, E*	*PO1, PO2, PO6* *PSO2, PSO3*

Course Code: SIPSZOP23
Course Name: Practical III based on SIPSZO23

Course	**Course Outcomes (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
SIPSZOP23	• Immobilize yeast cells in calcium alginate and prepare a bioreactor column to demonstrate invertase activity in the bioreactor column in order to understand the catalytic role of invertase and its commercial significance. • Plot a growth curve for the microorganisms provided to determine patterns of growth over time and to understand differential effects of media, genetics, and stress on microbial population growth. • Quantitative estimation of DNA and RNA from a suitable tissue by Diphenylamine and Orcinol method respectively which provide an	*R, U, An, E*	*PO1, PO2, PO6* *PSO2, PSO3*

	estimate of purity of nucleic acids with respect to contaminants. • Construction of phylogenetic tree- used as a tool to *represent hypotheses about the evolutionary relationships among a group of organisms.*		

Course Code: SIPSZOP24
Course Name: Practical IV based on SIPSZO24

Course	**Course Outcomes (CO)**	**Cognitive Level**	**Affinity with PO/ PSO**
SIPSOP24	• Separation of pigments from leaves or flowers by adsorption column chromatography. • Separation of amino acids by ion exchange chromatography using cation exchanger. • Separation and identification of amino acids by two-dimensional paper chromatography. • Demonstrate the SDS-polyacrylamide gel electrophoresis in order to obtain high resolution separation of complex mixtures of proteins.	*R, U, An, E*	*PO1, PO2, PO6* *PSO2, PSO3*

M.Sc. Part I - Zoology Syllabus (Autonomous)
Choice Based Credit System (With effect from academic year 2022-23)

Semester I – Theory

Paper Code: SIPSZO11
Non chordates and their Phylogeny, Genetics, and developmental biology – I

Learning Objectives:

- *To attempt to gain an insight of the hierarchy of life forms from the simplest to the most complex ones by a study of the levels of organization in animal kingdom. Also, to know the different modifications the animal life has made for its survival, through phylogenic and taxonomic studies.*
- *To uncover the rules governing the transmission of genetic traits and the relation between genes and chromosomes, through the study of classical genetics and its extension.*
- *To study Developmental Biology to appreciate how embryonic cells interact ultimately to form the entire organism.*

Unit 1: Phylogeny, Systematics of Nonchordates - I **15 Lectures**

1.1: Principles of Systematics, importance of taxonomic studies in Biology, use of morphometric studies, osteological studies, use of homologous organs

1.2: Phylogeny, salient features, classification up to classes (wherever applicable) of the following Phyla:

1.2.1: Protista (Protozoa)
1.2.2: Porifera
1.2.3: Coelenterata
1.2.4: Ctenophora
1.2.5: Platyhelminthes and Nemathelminthes
1.2.6: Acanthocephala
1.2.7: Annelida
1.2.8: Sipunculoidea

Unit 2: Phylogeny, Systematics of Nonchordates, Hemichordata **15 Lectures**

2.1.: Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla:

2.1.1: Arthropoda
2.1.2: Onychophora: Peripatus, a connecting link between Annelida and Arthropoda
2.1.3: Mollusca
2.1.4: Bryozoa
2.1.5: Brachiopoda
2.1.6: Echinodermata
2.1.7: Chaetognatha

2.2.: Systematic position and affinities of Hemichordata

Students' activity:

Field visits/Field trips/Excursions/Study tours/field projects to the relevant locations such as Zoological/National parks, Sanctuaries, museums, shores in order to observe organisms in their natural habitat as well as to combine theoretical/experiential learnings with actual observations in the field.

Unit 3: Developmental Biology - I **15 Lectures**

3.1: Basic concepts in Developmental Biology

3.1.1: Cell fate and commitment

3.1.2 : Mechanism of developmental commitment

3.1.3 : Mosaic and regulative development

3.1.4 : Pattern formation and compartments

3.1.5 : Morphogenesis and cell adhesion:

a) Differential cell affinity
b) Cadherins and catenins
c) Sorting out of embryonic tissues and cell recognition

3.2: Cell differentiation and Totipotency

3.2.1 : Nucleocytoplasmic interaction

3.2.2 : Mechanism of gene action during cell differentiation

3.2.3 : Factors affecting cellular differentiation

3.2.4 : Maintenance of differentiation

3.3: Stem cells.

3.3.1: Types of stem cells and their function in development

3.3.2: Stem cells and their role in cancer biology.

3.3.3: Ethical issues related to stem cells.

Unit 4: Genetics - Chromosome theory, Mendelian and Non-Mendelian Inheritance - I **15 Lectures**

4.1: Organization of Genetic material:

4.1.1: Structure of chromosomes

4.1.2: Chromosome number, shape and types

4.1.3: Variations in chromosome structure and chromosome number

4.2 : Principles of Mendelian Genetics

4.2.1: Mendel's laws

4.2.2: Incomplete or partial dominance and co-dominance

4.2.3: Epistasis

4.2.4: Multiple alleles

4.2.5: Lethal alleles (recessive and dominant)

4.2.6: Polygenic inheritance

4.3 : Linkage & crossing over

4.3.1: Chromosomal theory of linkage

4.3.2: Mechanism and types of crossing over

4.4 : Non-Mendelian Inheritance

4.4.1: Maternal effects; Shell coiling in snails, pigmentation in moths

4.4.2: Cytoplasmic inheritance: Mitochondria, chloroplasts, plasmids, infective particles

Paper Code: SIPSZO12
Biochemistry and Metabolism – I

Learning Objectives:

- *To go into the details of biomolecules which form the chemical basis of life*
- *To know about the energy transductions that occurs in or between organisms through thermodynamic study*
- *To study in detail the chemical processes that occur in living organisms that maintain life and the modes to regulate them.*

Unit 1: Biomolecules - A structural and functional approach - I **15 Lectures**

1.1: Concepts
- 1.1.1: Biological macromolecules
- 1.1.2: Polymerization and macromolecules
- 1.1.3: Central role of Carbon
- 1.1.4: Common functional groups
- 1.1.5: Common ring structure and isomerization in biological molecules

1.2: Carbohydrates
- 1.2.1: Classification: Monosaccharides, oligosaccharides and polysaccharides
- 1.2.2: Monosaccharides: Structure, classification, D- and L-isomers, anomers and mutarotation, open chain and ring forms, pyranose and furanose forms, reactions of monosaccharides, glycosidic bond and nomenclature.
- 1.2.3: Oligosaccharides
- 1.2.4: Polysaccharides: Homopolysaccharides and heteropolysaccharides
- 1.2.5: Biological functions of carbohydrates

1.3: Lipids
- 1.3.1: Classification: Simple and complex lipids
- 1.3.2: Fatty acids: Even and odd carbon fatty acids, numbering the carbon atoms, saturated and unsaturated fatty acids, cis- and trans-configuration, nomenclature and short hand representation of fatty acids
- 1.3.3: Acylglycerols: Monoglycerides, diglycerides and triglycerides; stereospecific numbering of glycerols in glycerides; properties of triacylglycerols
- 1.3.4: Complex lipids: Phospholipids, sphingolipids, sterols and waxes, amphipathic lipids – Membrane lipid bilayers
- 1.3.5: Biological functions of lipids

1.4 : Nucleic acids (RNA and DNA)
- 1.4.1: Components: Pentose, nitrogenous bases, nucleosides, tautomeric forms of purines and pyrimidines
- 1.4.2: Structure of DNA: Watson and Crick model; different forms of DNA double helix
- 1.4.3: Structure, types and functions of RNA

1.5 : Complex biomolecules
- 1.5.1: Glycoproteins: Blood group substances
- 1.5.2 Glycolipids: Gangliosides
- 1.5.3 Lipoproteins: Classification and functions – Chylomicrons, VLDL, LDL, HDL and free fatty acid-albumin complex

Unit 2: Biochemical Thermodynamics **15 Lectures**

2.1: Laws of thermodynamics, free energy, entropy, enthalpy, exergonic and endergonic reactions

2.2: High energy compounds: ATP, ADP, ATP-ADP cycle, ATP-AMP ratio

2.3: Biological oxidation: Electron transport chain and mitochondria; Oxidative phosphorylation

– mechanism, uncoupling of oxidative phosphorylation and its significance

2.4: Free radicals, antioxidants and antioxidant system

Unit 3: Metabolic Pathways and Integration of metabolism - I **15 Lectures**

3.1: Metabolism: Concept, definitions, catabolism, anabolism

3.2: Carbohydrate metabolism

3.2.1: Glycolysis: Reaction sequence, flow of carbon, conversion of pyruvate to lactate and Acetyl coenzyme-A; significance of pyruvate-lactate interconversion; aerobic and anaerobic glycolysis; energetics of glycolysis; regulation of glycolysis

3.2.2: Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate, lactate; regulation of gluconeogenesis

3.2.3: Glycogen metabolism: Glycogenesis, Glycogenolysis; regulation of the two pathways

3.2.4: Significance of the following pathways: Hexose monophosphate shunt as a multifunctional pathway; Uronic Acid Pathway; Glyoxalate cycle

3.3: Lipid Metabolism

3.3.1: Dynamics of body lipids, mobilization of fats, regulation of hormone sensitive TG-lipase, fate of glycerol and free fatty acids

3.3.2: Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acids, oxidation of

3.3.3: unsaturated fatty acids, biosynthesis of fatty acids including desaturation; metabolism of phospholipids, cholesterol and *alcohol

Unit 4: Regulation of Metabolism **15 Lectures**

4.1: Concept of homeostasis

4.2: Regulation of metabolic flux by genetic mechanisms: Control of enzyme synthesis, constitutive and inducible enzymes; *induction and repression of enzymes (lac operon and trp operon); regulatory proteins – Helix turn Helix, Zinc Fingers, Leucine Zippers

4.3: Regulation of metabolism by extracellular signals: nutrient supply, nutrient transport, endocrine control and neural control

Paper Code: SIPSZO13
Biotechnology and Gene manipulation - I

Learning Objectives

- *To keep abreast with the current trends in this fast-moving field of Biotechnology, that is an intersection of technology and Biology.*
- *To gain an in-depth knowledge of the application of recombinant DNA technology in food, microbial technology and for the production of genetically engineered animal cells to obtain commercial products for human use.*
- *To emphasize the significance of Biotechnology in the field of medicine for production of therapeutic agents viz., vaccines and monoclonal antibodies that have revolutionized medical science*.

Unit 1: Large scale culture and production from recombinant microorganisms and genetically engineered animal cells **15 Lectures**

1.1 : Large scale culture and production from recombinant microorganisms:

1.1.1 : Batch fermentation

1.1.2 : Fed batch fermentation

1.1.3 : Continuous fermentation

1.1.4 : Maximizing the efficiency of fermentation process

1.1.5 : Harvesting, disrupting and downstream processing

1.1.6 : Basic Design of bioreactors and its types.
1.1.7 : Mammalian cell lines and their characteristics
1.1.8 : Media for the cultivation of mammalian cells
1.1.9 : Commercial products produced with mammalian cell culture

Unit 2: Medical Biotechnology **15 Lectures**

2.1: Subunit vaccines:
2.1.1: Subunit vaccine production against viruses: Herpes simplex, Bovine foot and mouth disease virus
2.1.2: Peptide vaccines: Synthetic drugs (engineered proteins)
2.1.3: Genetic immunization: DNA vaccines, Antisense DNA, Therapeutic ribozymes
2.1.4: Live recombinant vaccines
2.1.5: Attenuated vaccines against Cholera, Salmonella sp.
2.1.6: Vector vaccines: Vaccine directed against viruses – Rabies virus G-protein, Hepatitis B surface antigen.
2.1.7: Anti-idiotypic vaccine for cancer treatment.
2.1.8: Recent development in vaccine development w.r.t. Covid19
2.2 : Monoclonal antibodies (mAbs) and therapeutic applications:
2.2.1: mAbs for prevention of rejection of transplanted organs
2.2.2: Treatment of bacterial blood infection
2.2.3: Human monoclonal antibodies
2.2.4: Hybrid human-mouse monoclonal antibodies
2.2.5: HIV therapeutic agents
2.2.6: Anti-tumour antibodies

Unit 3: Genome Management and Analysis I **15 Lectures**

3.1: The basic tools of genetic engineering:
3.1.1: Cloning vectors: General purpose plasmid vectors: pUC19, pBR322 (Bacterial vectors) Bacteriophage and cosmid vectors.
3.1.2: Yeast artificial chromosomes (YACs) as vectors
3.2: Gene transfer techniques:
3.2.1: Calcium phosphate co-precipitation, electroporation.
3.2.2: Liposome mediated, crispr- cas9,
3.2.3: Gene gun or Biolistic approach, Protoplast fusion, viral mediated gene transfer techniques.
3.3: Analysis of Genome:
3.3.1: DNA fingerprinting
3.3.2: Immunological assays: Western blot, ELISA
3.3.3: Polymerase chain reaction and its Variants (RT-PCR, qPCR)
3.3.4: Chemical synthesis of DNA: Oligonucleotide synthesis by Phosphoramidite method.
3.3.5: DNA Sequencing: Sanger's dideoxy nucleotide method.

Unit 4: Agricultural Biotechnology **15 Lectures**

4.1: Nitrogen fixation
4.1.1: Nitrogenase: Components of Nitrogenase; Hydrogenase: Hydrogen metabolism Genetic engineering of Nitrogenase & Hydrogenase cluster
4.1.2: Nodulation: Process of nodulation; genetic engineering of nodulation gene
4.2: Microbial insecticides: Toxins of Bacillus thuringiensis, mode of action and use of thuringiensis toxins, thuringiensis toxin gene isolation, genetic engineering of Bacillus thuringiensis strains

and cloning of Bt-toxin gene.

4.3: Developing virus resistant and herbicide resistant plants and other GM crops.

4.4: Algal products: Fuels from algae, marine natural products and their medical potential (anticancer, antiviral compounds; antibacterial agents)

4.5: Ethical issues in Agriculture Biotechnology.

4.6: Regulatory bodies governing GMOs

Students Activity:

Visit to the industries/institutes involved in Biotechnology research:

To gain knowledge about potential areas in research, research trends, methodology, instrumentation, facilities in order to inculcate a research-based and Entrepreneurial approach.

Paper Code: SIPSZO14

Tools and Techniques in Biology - I

Learning Objectives:

- *To deal with the tools and techniques in Biology that have helped enhance our understanding of the various aspects of Biology.*
- *To develop a research attitude among the students by introducing Research methodology.*

Unit 1: Microscopy and Centrifugation **15 Lectures**

1.1: Principles and applications of Microscopy

1.1.1: Light microscopy, Phase contrast microscopy, Fluorescence microscopy, Polarization microscopy, Confocal scanning microscopy.

1.1.2: Transmission electron microscopy, scanning electron microscopy

1.2: Principles and applications of Centrifugation

1.2.1: Basic principles of centrifugation; Low speed and high-speed centrifuges, ultracentrifuge.

1.2.2: Applications of centrifugation: Preparative techniques, analytical measurements; care of centrifuges and rotors

Unit 2: Principles and applications of Radioisotopes, Microtomy techniques **15 Lectures**

2.1: Microtomy: Tissue fixation, dehydration, clearing, infiltration, embedding for paraffin method, sectioning, mounting, staining: differential and specific

2.2 :Principles and applications of Radioisotopes: Use of isotopes in biological sciences; units of radioactivity; detection and measurement of radioactivity by scintillation counting, autoradiography

Unit 3: Principles and applications of Spectroscopy **15 Lectures**

3.1: Ultraviolet and visible absorption spectroscopy

3.2: Fluorescence spectroscopy

3.3: Nuclear magnetic resonance spectroscopy

3.4: Mass spectroscopy

3.5: Atomic absorption spectrophotometer

Unit 4: Good Laboratory Practices and Research Methodology - I **15 Lectures**

4.1: Good Laboratory Practices:

4.1.1: Background of Globally Harmonized System (GHS), Application and relevance of GHS; GHS for classification and labelling of chemicals, chemical hazards/pictograms, symbols, signal words, hazard statements

4.1.2: Preparation of standard operating procedure and calibration, use, care/maintenance of common laboratory equipments such as microscope, pH meter,

colorimeter/spectrophotometer, analytical balance, centrifuge and Glassware

4.2: Research methodology

4.2.1: Basic concepts in research – scientific research method, types of research, significance/relevance of research, research methods versus research methodology

4.2.2: Research process – Literature review/survey/search, primary stages of research process, steps in research process, developing and testing hypothesis

4.2.3: Research problem – formulating research problem, meaning and statement of research problem, identification and selection of research problem, types of variables (experimental and control groups etc)

4.2.4: Research design – types of research design, nature and importance of research design, qualitative versus quantitative research design, design of research posters/research presentations.

Semester I – Practical I (SIPSZOP11)
Based on SIPSZO11

1. *Study of Animal type:
   Earthworm: Morphology, Digestive system, nervous system; mounting of blood glands, setae, spermtheca & nephridia
2. Study of Systematics and major features of:
   a) Protozoa: *Amoeba, Euglena, Paramoecium, Plasmodium*
   b) Porifera: *Leucosolenia, Euplectella, Euspongia*
   c) Coelenterata/ Cnidaria: Sea anemone, *Madrepora*, *Aurelia*
   d) Helminthes: Planaria, Liverfluke, Tapeworm, *Ascaris.*
   e) Annelida: *Nereis*, Earthworm, Leech
   f) Arthropoda: Crab, Scorpion, *Limulus*, Centipede, Millipede, Beetle
   g) Mollusca: Chiton, *Dentalium*, *Patella*, *Achatina*, *Mytilus*, Octopus,
   h) Echinodermata: Starfish, Brittle star, Sea urchin, Sea cucumber, Feather star
   i) Hemichordata: *Balanoglossus*
   j) Study of larval forms:
   Larvae of Helminthes (Miracidium, Redia, Cercaria, Metacercaria); Trochophore larva; Crustacean larvae; Ascidian tadpole, Echinoderm larvae and Tornaria larva
3. Temporary preparation of onion/ garlic root tip cells to study stages of mitosis and calculate mitotic index
4. Study of mouth parts of cockroach
5. Study of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus larva
6. Temporary preparation of buccal smear to study sex chromatin in human
7. Culture and maintenance of fruitfly
8. Determination of sex in drosophila (morphological examination)

Note: *Demonstration practical/ Dissection/ Virtual dissection/ Model (2D or 3D)/ Chart of the animal system as per UGC guidelines

Semester I – Practical II (SIPSZOP12)
Based on SIPSZO12

1. Qualitative tests for carbohydrates and identification of the nature of carbohydrates in the given sample:
   Molisch's test, Anthrone test, Iodine test, Barfoed's test, Seliwanoff's test, Fehling's test, Benedict's test, Picric acid test, Mucic acid test, and Bial's test

2. Determination of glucose by Benedict's (volumetric) method
3. Determination of reducing sugars by 3,5-dinitrosalicylic acid (colorimetric) method
4. Estimation of glycogen in the given tissue (liver/ skeletal muscle/ kidney/ brain)
5. Acid and enzyme hydrolysis of glycogen and colorimetric estimation of the products by 3,5-DNSA method
6. Isolation of starch from potato
7. Determination of acid value of fats/ oils
8. Determination of saponification value of fats/ oils
9. Reichert-Meissl (RM) number of fat

Semester I –Practical III (SIPSZOP13)
Based on SIPSZO13

1. Demonstration of aseptic technique:
   Work place for aseptic handling; packing glassware (flasks, test tubes, pipettes, petri dishes) for sterilization; aseptic transfer of liquids (Pipetting from flask to test tube).
2. Preparation of LB agar plate, slant, butt and demonstration of streaking technique using bacterial culture to obtain isolated colonies.
3. Determination of viable cell count in the given culture of bacteria by dilution and spreading technique.
4. Isolation of genomic DNA from the given strain of bacteria/ tissue and show the purity of the isolate by performing agarose gel electrophoresis.
5. To estimate the number of bacteria in the given culture by Nephelometry.

Semester I – Practical IV (SIPSZOP14)
Based on SIPSZO14

1. Identification of pictograms, symbols and signs of safety in laboratory
2. Microtomy: Tissue preservation and fixation, dehydration, infiltration, paraffin embedding and block preparation, sectioning, staining
3. Solutions and Buffers: Mode of expressing concentration of solutions: Molarity (M), molality (M), normality (N), Mass concentration, mass fraction, mass percentage or % (w/w), % by volume (v/v), parts per million (ppm) (explain with practical exercises).
4. Types of solutions: Stock solutions (explain with practical exercises)
5. Preparation of buffers of different pH using Henderson-Hasselbalch equation and its verification using pH meter
6. Determination of pKa of a weak acid
7. Colorimeter: Selection of filter and determination of unknown concentration of solute

Semester II – Theory

Paper Code: SIPSZO21
Chordates and their Phylogeny, evolution and developmental biology - II

Learning Objectives:

- *To attempt to gain an insight of the hierarchy of life forms from the simplest to the most complex ones by a study of the levels of organization in animal kingdom. Also, to know the different modifications the animal life has made for its survival, through phylogenic and taxonomic study.*
- *To understand the evolutionary processes that have helped shape life on earth through a study of organic evolution; also, to understand the evolutionary path our ancestors walked to attain to this present-day Homo sapiens species.*

Unit 1: Phylogeny of Protochordates and Chordates - II **15 Lectures**

1.1 **:** Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla

1.1.1: Urochordata and its affinities
1.1.2: Cephalochordata and its affinities
1.1.3: Salient features and phylogeny of Ostracoderms
1.1.4: Affinities of Cyclostomes:
1.1.5: Overview of fish phylogeny
1.1.6: Primitive tetrapods: Labyrinthodonts
1.1.7: Crossopterygians: A blue print
1.1.8: Dipnoan: A group that has failed to evolve as Amphibia
1.1.9: Lissamphibia

Unit 2: Phylogeny, Systematics of Chordates II **15 Lectures**

2.1 **:** Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla

2.1.1: Sphenodon: a living fossil
2.1.2: Extinct reptiles
2.1.3: Adaptive radiation in Reptilia
2.1.4: Warm blooded reptiles; Archaeopteryx: A connecting link between Reptiles and Aves
2.1.5: Affinities of Aves and classification up to subclass
2.1.6: Birds as glorified reptiles
2.1.7: Egg laying mammals: A connecting link between reptiles and mammals
2.1.8: Classification of mammals up to orders
2.1.9: Walking gait: Plantigrade, Digitigrade and Unguligrade

Students' activity:

Field visits/Field trips/Excursions/Study tours/field projects to the relevant locations such as Zoological/National parks, Sanctuaries, museums, shores in order to observe organisms in their natural habitat as well as to combine theoretical/experiential learnings with actual observations in the field.

Unit 3: Developmental Biology- II **15 Lectures**

3.1: Cell specialization: RBC, secretory cell, retinal rod cell
3.2: Organizer and its role in embryonic development
3.3: Primary embryonic induction
3.4: Metamorphosis, Regeneration and Aging:

3.4.1: Metamorphosis:

a) Progressive metamorphosis: Amphibian metamorphosis
b) Metamorphosis in insects – Types of insect metamorphosis; eversion and differentiation of imaginal discs; hormonal control of insect metamorphosis.
c) Retrogressive metamorphosis: Ascidian.
d) Programmed cell death

3.4.2: Regeneration: Regeneration in Hydra; regeneration of salamander limbs
3.4.3: Aging: Senescence, life span and causes of aging

Unit 4: Evolution- I **15 Lectures**

4.1: Concept of evolution and theories of evolution: Lamarckism, Darwinism, De Vries Mutation theory, Neo-Darwinism and other significant theories.
4.2: Geological time scale

4.3: Human evolution

4.4: Population and Evolutionary genetics:

4.4.1 : Gene pool, speciation

4.4.2 : Calculating allelic frequencies

4.4.3 : The Hardy-Weinberg equilibrium and mating systems (non-random mating, assortative mating, inbreeding, dis-assortative mating)

4.4.4 : Processes that change allelic frequencies: Mutation, migration, natural selection, directional selection, stabilizing and disruptive selection, heterozygote advantage; balance between selection and mutation; genetic drift – random genetic drift

Paper Code: SIPSZO22
Biochemistry and Metabolism - II

Learning Objectives:

- *To go into the details of biomolecules which form the chemical basis of life.*
- *To study enzymes, the catalysts found in living organisms.*
- *To study in detail the chemical processes that occur in living organisms that maintain life and the modes to regulate them.*
- *To learn about the inadequacies of the metabolic machinery due to defects at the genetic level.*

Unit 1: Biomolecules - A structural and functional approach - II **15 Lectures**

1.1: Proteins as polymers of amino acids

1.1.1: Amino acids: Structure, classification based on structure, polarity, nutritional requirement and metabolic fate, properties of amino acids, derivatives of amino acids, non-transcribed amino acids as protein constituents, D-amino acids

1.1.2: Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate proteins: Haemoglobin, cytochromes, myoglobin; bonds involved in protein organization

1.1.3: Properties of proteins: Classification, denaturation and protein folding

1.1.4: Biological functions of proteins: Biologically important peptides: Glutathione, octa-, nona-, and deca-peptides

Unit 2: Enzymes and Enzyme kinetics **15 Lectures**

2.1: Enzymes: Nomenclature and classification with numerical code; chemical nature of enzymes

2.2: Mechanism of enzyme action: Fischer's Lock and Key Theory, Koshland's Induced fit model; Mechanism of enzyme catalysis

2.3: Enzyme kinetics: Michaelis-Menten equation; Lineweaver-Burk plot; significance of Vmax and Km; factors affecting enzyme activity; enzyme activation and inhibition

2.4: Regulatory enzymes: Covalently modulated; allosteric regulation; Isoenzymes (LDH, CK, ALP, ADH)

2.5: Non-protein enzymes: Ribozymes

2.6: Advanced enzymes in human healthcare, e.g., fungal lactase, hemicellulase, trypsin chymotrypsin mix

Unit 3: Metabolic Pathways and Integration of metabolism – II **15 Lectures**

3.1: Protein Metabolism

3.1.1: Metabolism of amino acids: Amino acid pool, transamination, oxidative and non-oxidative deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids

3.1.2: Metabolism of ammonia: Urea cycle

3.2: Metabolism of Nucleic acids:

3.2.1: Synthesis of ribonucleotides: A brief idea of de novo pathway and salvation pathway

3.2.2. Conversion of ribonucleotides to deoxyribonucleotides

3.2.3: Degradation of nucleotides

3.3: Integration of Metabolism

3.3.1: Energy demand and supply; integration of major metabolic pathways of energy metabolism

3.3.2: Intermediary metabolism; organ specialization and metabolic integration

3.3.3: Metabolism in starvation

Unit 4: Regulation of Metabolism and Inborn Errors of Metabolism **15 Lectures**

4.1: Inborn errors of metabolism

4.1.1: Carbohydrate metabolism: Glycogen storage disease, G-6-PD deficiency

4.1.2: Lipid metabolism: Metabolic disorders of cerebrosides

4.1.3: Protein metabolism: PKU, Albinism, Cysteinurea

4.1.4: Purine metabolism: Primary Gout

4.2 : Mineral metabolism and diseases: Hypocalcemia, Hypercalcemia and osteoporosis

Paper Code: SIPSZO23
Biotechnology and Gene manipulation - II

Learning Objectives:

- *To familiarize with the basic tools of genetic engineering involved in tailoring genetic information to delve into the genomes of organisms; designing cloning vectors and using DNA fragments as research tools.*
- *To gain insight of the potential of Bioinformatics – a field applying computer knowledge to study genomes.*
- *To procure knowledge of the biotechnological aspects dealing with degradation of xenobiotics that is foreign to our environment, and the effective utilization of biomass.*

Unit 1: Microbial synthesis of commercial products **15 Lectures**

1.1: Organic acids and their commercial applications: Citric acid, gluconic acid, lactic acid

1.2: Antibiotics: Cloning antibiotic biosynthetic gene by complementation and other methods; synthesis of novel antibiotics and improving antibiotic production; Aminoglycosides and their uses

1.3: Polysaccharides:

1.3.1: Bacterial polysaccharides: General properties and their commercial applications – Dextran, xanthan, alginate; genetic engineering for large scale production of xanthan gum and its modification

1.3.2: Marine polysaccharides: General properties and their commercial application – Agar and agarose, Chitosan

1.4: Polyesters: Polyhydroxyalkanoates (PHA) – Biosynthesis of PHA; Biopol, a commercial biodegradable plastic

Unit 2: Enzyme technology in large scale production **15 Lectures**

2.1 : Biotransformations

2.1.1: Biocatalyst immobilization:

Methods of immobilization – Cross linking, supported immobilization, adsorption and ionic binding, covalent coupling, lattice entrapment

2.1.2: Immobilized enzyme reactors: Batch reactors, Continuous reactors.

2.1.3: Enzymes in diagnostic assays – Test strip systems; Biosensors: Principle, Working and types.

Unit 3: Bioinformatics **15 Lectures**

3.1: Biological databases:
- 3.1.1: Nucleotide and amino acid sequence database
- 3.1.2: Primary and secondary database
- 3.1.3: Literature database
- 3.1.4: Patent database

3.2: DNA profiling: ESTs (Expressed sequence tags)
3.3: Basic research with DNA microarrays and its application in healthcare
3.4**:** X-ray crystallography and Mass spectroscopic analysis of macromolecules.
3.5: Multiple sequence alignment.
3.6: Construction and analysis of phylogenetic trees.

Unit 4: Environmental Biotechnology **15 Lectures**

4.1: Biomass utilization:
- 4.1.1: Production of single cell proteins by using biomass as raw material
- 4.1.2: Commercial production of fructose and alcohol from biomass

4.2: Bioremediation of xenobiotic compounds:
- 4.2.1: Characteristics of xenobiotics in the environment
- 4.2.2: Genetic engineering of bio-degradative pathways: Manipulation by transfer of plasmid.

4.3: Bioleaching of metals
- 4.3.1: Biochemical mechanism of bioleaching.
- 4.3.2: Types of bioleaching
- 4.3.3: Methods for bioleaching: Tank and heap bioleaching
- 4.3.4: Microorganisms used for bioleaching

Students Activity:
Visit to the industries/institutes involved in Biotechnology research:
To gain knowledge about potential areas in research, research trends, methodology, instrumentation, facilities in order to inculcate a research-based attitude.

Paper Code: SIPSZO24
Tools and Techniques in Biology - II

Learning Objectives:
- *To deal with the tools and techniques in Biology that has helped enhance our understanding of the various aspects of Biology.*
- *To develop a research attitude among the students by introducing Research methodology and to learn about how to write and present a research proposal in a scientific way.*

Unit 1: Principles and applications of Chromatography - I **15 Lectures**

1.1: Planar chromatography (Paper and Thin layer):
Preparation of stationary support, solvent, detection and measurement of components, applications

1.2: Column chromatography:
Packing and operation of column, loading the column, eluting the column, collection of eluents, detection of eluent, applications

1.3: Ion exchange chromatography:
Ion exchange resins, selection of ion exchanger, choice of buffers, preparation and use of ion exchangers, storage of resins

Unit 2: Principles and applications of Chromatography - II **15 Lectures**

2.1 : Gel chromatography:

Theory of gel filtration, physical characteristics of gel chromatography, chemical properties of gel, selection of gel, gel preparation and storage, operation of gel column, applications

2.2 : Affinity chromatography:

Chromatography media, immobilized ligands, attachment of ligands to the matrix, experimental procedures and applications

Unit 3: Principles and applications of Chromatography and Electrophoresis **15 Lectures**

3.1: Gas chromatography:

3.1.1: Gas chromatography (GC): Instrumentation, selection of operating conditions, analysis of data and applications

3.1.2: HPLC: Instrumentation, selection of operating conditions, analysis of data and applications

3.2 : Electrophoresis:

3.2.1: Theory of electrophoresis

3.2.2: Horizontal agarose gel electrophoresis

3.2.3: Vertical polyacrylamide gel electrophoresis

3.2.4: Pulse field electrophoresis

3.2.5: Capillary electrophoresis

3.2.6: Isoelectric focusing of proteins

3.2.7: Two-dimensional electrophoresis

Unit 4: Good Laboratory Practices and Research Methodology - II **15 Lectures**

4.1: Good Laboratory Practices:

4.1.1: GHS Safety Data Sheet (SDS)/Material Safety Data Sheet (MSDS); Chemical spillage/disposal, Fire safety and extinguishers, overview of GHS Physical Hazards and GHS Health and Environmental Hazards

4.1.2: Preparation of standard operating procedure and calibration, use, care/maintenance of advanced laboratory instruments: High Performance Thin Layer Chromatography (HPTLC), High Performance Liquid Chromatography (HPLC), Gas Chromatography (GC)

4.1.3: Overview of Good Manufacturing Practices (GMP) / Good Clinical Practices (GCP) guidelines

4.2: Research Methodology:

4.2.1: Scientific research writing – writing a research article/paper/manuscript, types of research articles, writing an abstract, types of abstracts, selection of key words, citing references/bibliography (Harvard style, Numeric style, APA style, end note/foot note),

4.2.2: Research review and journals – critique and review of research paper/manuscript, overview of types of research journals and publications (peer-reviewed, open access etc)

4.2.3: Research grants/funds – Overview of funding agencies (government and private organizations), brief of writing a research proposal/research project to funding agencies

4.2.4: Research ethics – Avoiding plagiarism, Awareness of misconduct or fraud, Acknowledgement/Declaration of conflict of interest, overview of ethics in animal research/preclinical trials and clinical trials

Semester II - Practical I (SIPSZOP21)
Based on SIPSZO21

1. *Study of Animal type:

Fish (*Sciaena sp.*): Morphology, Digestive system, Nervous system, mountings of gills, scales.

2. Study of Systematics and major features of:
    a) Cephalochordata: *Amphioxus*
    b) Urochordata: Ascidian
    c) Agnatha: *Petromyzon*, *Myxine*
    d) Pisces: Shark, Sting ray, Mackerel, Hippocampus, Eel.
    e) Amphibia: Caecilian, Salamander, Frog, Toad, Amphiuma
    f) Reptilia: Turtle, Tortoise, Chameleon, *Phrynosoma*, *Hydrophis*, Crocodile, Gharial.
    g) Aves: Kingfisher, Kite, Vulture, Duck
    h) Mammals: Duck-billed platypus, Kangaroo, Shrew, Bat, Loris, Dolphin, Sea Cow (Dugong).
3. Determination of effect of stressors on heart rate of Daphnia.
4. Demonstration of isolation of limb bud and its Chorio-allantoic grafting.

Note: *Demonstration practical/ Dissection/ Virtual dissection/ Model (2D or 3D)/ Chart of animal system as per UGC guidelines.

Semester II – Practical II (SIPSZOP22)
Based on SIPSZO22

1. Determination of total cholesterol and HDL cholesterol from serum
2. Qualitative tests for amino acids and proteins: Ninhydrin test, Xanthoproteic test, Millon's test, Biuret test
3. Colorimetric estimation of proteins by Peterson-Lowry method
4. Quantitative estimation of amino acids using Ninhydrin reagent
5. Isolation of casein from milk
6. Detection of conformation of BSA by viscosity measurement and effect of varying concentration of urea on viscosity of BSA
7. Determination of creatinine in serum and urea
8. Determination of SDH specific activity

Semester II –Practical III (SIPSZOP23)
Based on SIPSZO23

1. Immobilize yeast cells in calcium alginate and prepare a bioreactor column to demonstrate invertase activity in the bioreactor column
2. To plot a growth curve for the microorganisms provided
3. Demonstrate the effect of media on growth curves of given microorganism, using two different media (minimal and enriched)
4. Quantitative estimation of DNA from a suitable tissue by Diphenylamine method
5. Quantitative estimation of RNA from a suitable tissue by Orcinol method
6. Molecular phylogeny : Construction of phylogenetic trees (using amino acid and nucleotide sequence)

Semester II – Practical IV (SIPSZOP24)
Based on SIPSZO24

1. Identification of lipids in a given sample by TLC
2. Separation of pigments from leaves or flowers by adsorption column chromatography
3. Separation of amino acids by ion exchange chromatography using cation exchanger
4. Separation and identification of amino acids by two-dimensional paper chromatography
5. SDS-polyacrylamide slab gel electrophoresis of plasma proteins

Semester I and Semester II
REFERENCES

SIPSZO11 and SIPSZO21

- Vertebrate comparative anatomy, Function, Evolution, K.V. Kardong, 3rd Ed. Tata McGraw Hill Publication
- Vertebrate Life: F.H.Pough, C.M.Janis, J.B.Heiser, 6th Ed. Pearson Education
- Functional Anatomy of Vertebrates. An evolutionary perspective. K.F.Liem, W.E.Bemis, W, F.Walker, L.Grande, 3rd Ed. Harcourt College Publishers
- The Life of Vertebrates: J.Z.Young, ELBS-Oxford Univ. Press
- A Text Book of Zoology; T.J.Parkar and W.A.Haswell, McMillan
- Chordate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company
- Biology of Invertebrates; J.A.Pechenik, 4th Ed, Tata McGraw Hill.
- Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company
- Analysis of Vertebrate Structure: Milton Hildebrand, Wiley International
- Life of Invertebrates; Russell, W.D. Hunter, McMillan
- Invertebrate Zoology: Bares, R.D., Saunders Publication

SIPSZO12 and SIPSZO22

- Biochemistry- 2nd Ed. 2002 by U. Satyanarayan, Books and Allied Publ.
- Biochemistry- 2nd Ed. S.C. Rastogi, Tata McGraw Hill
- Fundamentals of Biochemistry- 3rd Ed. 1988; J.I.Jain, S. Chand and Co.
- Biochemistry-Lehninger.
- Biochemistry- a Functional Approach; MacGuilver
- www.enzymesIndia.com

SIPSZO13 and SIPSZO23

- Genetics; Daniel J. Fairbanks and W.R. Anderson. Wadsworth Publ.
- Prin. Of Genetics; Robert H. Tamarin; 7th Ed. Tata McGraw Hill
- Basic Human Genetics; Elaine Johansen Mange and Arthur Mange; Indian Reprint; 1997; Rastogi Publ.
- Genes and Evolution: A.P. Jha; MacMillon India
- Concepts of Genetics; William S. Kluge;, M.R.Cummings, Pearson Edu.
- Developmental Biology; Scott F. Gilbert, Sinauer Associates Inc.
- Developmental Biology; T. Subramanian, Narosa Publ.
- Biology of Developing System; Philip Grant; Holt Saunders International Ed.
- Evolution; M. W. Strikberger, CBS Publ.
- Cytology and Genetics; Sumitra Sen and Dipak Kumar Kar, Narosa Publ.
- Instant Notes- Developmental Biology; R.M. Twyman, Bios. Scientific Pub. Ltd.

SIPSZO14 and SIPSZO24

- Modern Experimental Biochemistry; 3rd Ed. Rodney Boyer, Pearson Education
- Principles and Techniques of Practical Biochemistry. Wilson and Walker, Cambridge Univ. Press
- Biological Science; 3rd Ed. D.J. Taylor, N.P.O. Green, G.W. Stou, Cambridge Univ. Press
- Cell and Molecular Biology- Concepts and Experiments, Gerald Karp. John Wiley & Co.
- Introductory Practical Biochemistry; S.K. Swahney, Randhir Sing. Narosa Publ.
- An Introduction to Practical Biochemistry; 3rd Ed. David Plummer. Tata McGraw Hill
- Practical Research Planning and Design; 2nd Ed. Paul D. Leedy. Macmillan Publ.
- Elementary Practical Organic Chemistry Part I: Small Scale Preparations. 2nd Ed. Arthur I. Vogel. CBS Publ. and Distributors
- Research Methodology: Methods and Techniques; C.R. Kothari; Wiley Eastern Ltd. Mumbai
- Nicholas Walliman, Research Methods – the basics, Routledge, 2011

- George Thomas, Research Methodology and Scientific Writing, Ane Books Pvt. Ltd, 2019
- Kenneth Bordens, Bruce Abbott, Research Design and Methods – a process approach, Tata McGraw- Hill, 2011
- Catherine Dawson, Activities for teaching research methods, SAGE publications, 2016
- Priti Majhi, Prafull Khatua, Research methodology – concepts, methods, techniques and SPSS – texts and cases, Himalaya Publishing House, 2013
- Spikard James, Research Basics
- Mcburney, Donald, Research methods
- Hilary Glasman, Scientific research writing
- https://unece.org/about-ghs (Link for GHS- Globally Harmonized System)
- https://unitar.org/sustainable-development-goals/planet/our-portfolio/globally-harmonized-system-classification-and-labelling-chemicals (Link for GHS)
- https://www.ccohs.ca/oshanswers/chemicals/ghs.html (Link for GHS)

M.Sc. Part I - Zoology Syllabus (Autonomous)
Choice Based Credit System
(With effect from academic year 2022-23)
Practical Examination Question Paper Pattern

Semester I – Practical I (SIPSZOP11)
Based on SIPSZO11

Time: 5 hours **Marks: 50**

Q.1 *Demonstrate digestive system / nervous system of Earthworm. **15**

Q.2 *Make temporary preparation/ mounting (stain if necessary) of earthworm: Setae / Blood glands / Spermatheca / Nephridia. **10**

OR

Q.2 Make a temporary preparation of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus larva. **10**

OR

Q.2 * Make a temporary preparation of onion root tip cells and calculate mitotic index. **10**

OR

Q.2 Make a temporary preparation of buccal smear to study sex chromatin in human. **10**

Q.3 Identify specimen/ slide a, b, c, d, e, f, g as per instructions. **14**

Q.4 Viva voce (Based on theory paper 1/Study tour) **06**

Q.5 Journal **05**
(* Demonstration/ Dissection/ Chart of animal system as per UGC guidelines)

****

Marking scheme
Semester I – Practical I (SIPSZOP11)

Time: 5 hours **Marks: 50**

Q.1 *Demonstrate digestive system/ nervous system of Earthworm. **15**

Category	Marks
Diagram	04
Dissection performance and presentation	07
Explanation and viva	04

Q.2 Make temporary preparation/ mounting (stain if necessary) of earthworm: Setae/ Blood glands/ Spermatheca / Nephridia. **10**

Category	Marks
Diagram	03
Mounting and presentation	05
Explanation and viva	02

OR

Q.2 Make a temporary preparation of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus larva. **10**

Category	Marks
Diagram	03
Mounting and presentation	05
Explanation and viva	02

OR

Q.2 * Make a temporary preparation of onion root tip cells and calculate mitotic index. **10**

Category	Marks
Diagram	03
Mounting and presentation	05
Explanation and viva	02

OR

Q.2 Make a temporary preparation of buccal smear to study sex chromatin in human **10**

Category	Marks
Diagram	03
Mounting and presentation	05
Explanation and viva	02

Q.3 Identify the specimen/slide: a, b, c, d, e, f, g as per the given instructions **14**
For each spot:

Category	Marks
Identification	½
Description (as per instruction)	1 ½

Q.4 Viva voce (Based on theory paper1/Study tour) **06**
Q.5 Journal **05**

(* Demonstration/ Dissection/ Chart of animal system as per UGC guidelines)

****

Semester I – Practical II (SIPSZOP12)
Based on SIPSZO12

Time: 5 hours **Marks: 50**

Q.1 Estimate the yield of glycogen from skeletal muscles/ liver. Submit a report **20**

OR

Q.1 Demonstrate the enzymatic/ acid hydrolysis of glycogen from the given sample. Submit a report of the results obtained. **20**

OR

Q.1 Identify the nature of carbohydrates in the given sample using qualitative tests (6 tests) **20**

Q.2 From the given material isolate starch and estimate the yield. Submit a report of the results obtained. **20**

OR

Q.2 Estimate the amount of glucose by Benedict's volumetric method. Submit a report of the results obtained. **20**

OR

Q.2 Determine the amount of reducing sugars from the given sample by DNSA method. Submit a report of the results obtained. **20**

OR

Q.2 Determine the Saponification Value/ Acid Value/ Reichert-Meissl (RM) number of the given sample of lipid. Submit a report of the results obtained. **20**

Q.4 Viva voce (Based on theory paper2) **05**

Q.5 Journal **05**

****

Marking scheme
Semester I – Practical II (SIPSZOP12)

Time: 5 hours **Marks: 50**

Q.1 Estimate the yield of glycogen from skeletal muscles/ liver. Submit a report **20**

OR

Q.1 Demonstrate the enzymatic/ acid hydrolysis of glycogen from the given sample. Submit a report of the results obtained. **20**

OR

Q.1 Identify the nature of carbohydrates in the given sample using qualitative tests (6 tests) **20**

Category	Marks
Aim and requirement	01
Principle	02
Performance	10
Observation and calculations	04
Results and Interpretation	03

Q.2 From the given material isolate starch and estimate the yield. Submit a report of the results obtained. **20**

OR

Q.2 Estimate the amount of glucose by Benedict's volumetric method. Submit a report of the results obtained. **20**

OR

Q.2 Determine the amount of reducing sugars from the given sample by DNSA method. Submit a report of the results obtained. **20**

OR

Q.2 Determine the Saponification Value/ Acid Value/ Reichert-Meissl (RM) number of the given sample of lipid. Submit a report of the results obtained. **20**

Category	Marks
Aim and requirement	01
Principle	02
Performance	10
Observation and calculations	04
Results and Interpretation	03

Q.3 Viva voce (Based on theory paper2) **05**
Q.4 Journal **05**

****

Semester I – Practical III
(SIPSZOP13) Based on SIPSZO13

Time: 5 hours **Marks: 50**

Q.1 Demonstration of streaking technique using bacterial culture to obtain isolated colonies and spreading technique **20**

OR

Q.1 Isolation of genomic DNA from the given strain of bacteria/ tissue and show the purity of the isolate by performing agarose gel electrophoresis **20**

OR

Q.1 Preparation of LB agar plate, slant, butt **20**

Q.2 To demonstrate aseptic techniques: **20**

a) Work place for aseptic handling

b) Packing glassware (flask, test tube, pipette, petri dish) for sterilization
c) Aseptic transfer of liquids (pipetting from flask to test tube)

OR

Q.2 Estimate number of bacteria in the given culture by Nephelometry **20**

Q.3 Viva voce (Based on theory paper3) **05**

Q.4 Journal **05**

****

Marking scheme
Semester I – Practical III (SIPSZOP13)

Time: 5 hours **Marks: 50**

Q.1 Demonstration of streaking technique using bacterial culture to obtain isolated colonies and spreading technique **20**

Category	Marks
Aim and requirement	01
Principle	03
Performance	06
Diagram	05
Results and Interpretation	05

OR

Q.1 Isolation of genomic DNA from the given strain of bacteria/ tissue and show the purity of the isolate by performing agarose gel electrophoresis **20**

Category	Marks
Aim and requirement	01
Principle	05
Performance	08
Results and Interpretation	06

OR

Q.1 Preparation of LB agar plate, slant, butt **20**

Category	Marks
Aim and requirement	01
Principle	03
Performance	10
Results and Interpretation	06

Q.2 To demonstrate aseptic techniques: **20**

Category	Marks
Aim and requirement	01
Principle	03
Performance	10
Results and Interpretation	06

OR

Q.2 Estimate number of bacteria in the given culture by Nephelometry **20**

Category	Marks
Aim and requirement	01
Principle	03
Performance	05
Observation and Graph	05
Results and Interpretation	06

Q.3 Viva voce (Based on theory paper3) **05**

Q.4 Journal **05**

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Semester I – Practical IV
(SIPSZOP14) Based on SIPSZO14

Time: 5 hours **Marks: 50**

Q.1 Demonstrate the relationship between absorbance of light and concentration of the dye in the given solution using different wavelengths for five dilutions **15**

OR

Q.1 Determine the pKa of the given weak acid. **15**

Q.2 Using Henderson-Hasselbalch equation, calculate the pH of buffer prepared by mixing known volume of either acid and/ or salt solutions. Check pH using pH meter **15**

OR

Q.2 (A) Identify the pictograms/ signs/ symbols a, b and c and comment on their significance in a laboratory **09**

(B) Problem based on the concept of molarity/ normality/ppm/etc for preparation of solution **06**

Q.3 From the infiltrated tissue prepare a block, trim and mount it on the holder for making or cutting section **10**

OR

Q.3 Trim the given block, mount it on the block holder, cut the sections and from ribbons, prepare slides **10**

OR

Q.3 Dewax the mounted ribbons, rehydration and stain the sections with hematoxylin/eosin **10**

Q.4 Viva voce (Based on theory paper 4) **05**

Q.5 Journal **05**

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Marking scheme
Semester I – Practical IV (SIPSZOP14)

Time: 5 hours **Marks: 50**

Q.1 Demonstrate the relationship between absorbance of light and concentration of the dye in the given solution using different wavelengths for five dilutions **15**

Category	Marks
Aim and requirement	01
Principle	03
Performance	05
Observation and Graph	04
Results and Interpretation	02

Q.1 Determine the pKa of the given weak acid. **15**

Category	Marks
Aim and requirement	01
Principle	03
Performance	05
Observation and Graph	04
Results and Interpretation	02

Q.2 Using Henderson-Hasselbalch equation, calculate the pH of buffer prepared by mixing known volume of either acid and/ or salt solutions. Check pH using pH meter **15**

Category	Marks
Aim and requirement	01
Principle	03
Performance	05
Observation and Graph	04
Results and Interpretation	02

OR

Q.2 (A) Identify the pictograms/ signs/ symbols a, b and c and comment on their significance in a laboratory **09**

Category	Marks
Identification	01
Description (as per instruction)	02

(B) Problem based on the concept of molarity/ normality/ppm/etc for preparation of solution **06**

Category	Marks
Performance	04
Results and Interpretation	02

Q.3 From the infiltrated tissue prepare a block, trim and mount it on the holder for making or cutting section **10**

Category	Marks
Preparation of block	04
Trimming and mounting of block	04
Viva	02

OR

Q.3 Cut the sections and from ribbons, prepare slides **10**

Category	Marks
Cutting sections to prepare ribbons of tissue	04
Preparation of slides	04
Viva	02

OR

Q.3 Dewax the mounted ribbons, rehydration and stain the sections with hematoxylin/eosin **10**

Category	Marks
Dewaxing and rehydration	04
Staining and identification of tissue	04
Viva	02

Q.4 Viva voce (Based on theory paper 4) **05**

Q.5 Journal **05**

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Practical Examination Question Paper Pattern
Semester II – Practical I (SIPSZOP21)
Based on SIPSZO21

Time: 5 hours **Marks: 50**

Q.1 *Demonstrate Digestive system/urinogenital system/of given fish specimen **15**

Q.2 *Demonstrate temporary preparation/ mounting (stain if necessary) of Scale/cartilage/nerve fibre **05**

Q.3 Determination of effect of stressors on heart rate of Daphnia **06**

Q.4 Identify specimen/ slide **a, b, c, d, e, f** and **g** as per instructions **14**

Q.5 Viva voce (Based on theory paper1/Study tour) **05**

Q.6 Journal **05**

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Marking Scheme
Semester II – Practical I (SIPSZOP21)

Q.1 *Demonstrate Digestive system/urinogenital system/of given fish specimen **15**

Category	Marks
Diagram	04
Dissection performance and presentation	07
Explanation and Viva	04

Q.2 *Demonstrate temporary preparation/ mounting (stain if necessary) of Scale/cartilage/nerve fibre **05**

Category	Marks
Diagram	01
Mounting and Presentation	03
Explanation and Viva	01

Q.3 Determination of effect of stressors on heart rate of Daphnia **06**

Category	Marks
Principle/Background theory	02
Performance	03
Explanation and Viva	01

Q.4 Identify specimen/ slide **a, b, c, d, e, f** and **g** as per instructions **14**

Category	Marks
Correct identification	1/2
Mounting and Presentation	1 1/2

Q.5 Viva voce (Based on theory paper1/Study tour) **05**

Q.6 Journal **05**

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Semester II – Practical II (SIPSZOP22)
Based on SIPSZO22

Time: 5 hours **Marks: 50**

Q.1 Estimate the protein content of the given tissue homogenate by Peterson-Lowry method **20**

OR

Q.1 Estimate the amino acid content of the given sample by Ninhydrin reagent, Prepare a standard graph. **20**

OR

Q.1 Demonstrate the effect of inhibitor on Succinic Dehydrogenase activity **20**

OR

Q.1 Demonstrate the effect of variation in Urea concentration on the conformation of Protein by viscosity measurements **20**

OR

Q.1 Estimate the concentration of Creatinine in the given serum/urine sample **20**

Q.2 Isolate Casein from the given sample of milk and determine its yield **20**

OR

Q.2 Determine Total /HDL Cholesterol from the given serum sample **20**

OR

Q.2 Detect proteins /amino acids in the given sample by qualitative tests (4 tests) **20**

Q.3 Viva voce (Based on theory paper2) **05**

Q.4 Journal **05**

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Marking scheme
Semester II – Practical II (SIPSZOP22)

Q.1 Estimate the protein content of the given tissue homogenate by Peterson-Lowry method **20**

OR

Q.1 Estimate the amino acid content of the given sample by Ninhydrin reagent, Prepare a standard graph. **20**

OR

Q.1 Demonstrate the effect of inhibitor on Succinic Dehydrogenase activity **20**

OR

Q.1 Demonstrate the effect of variation in Urea concentration on the conformation of Protein by viscosity measurements **20**

OR

Q.1 Estimate the concentration of Creatinine in the given serum/urine sample **20**

Category	Marks
Aim and requirement	01
Principle	02
Performance	10
Observation and calculations	04
Results and Interpretation	03

Q.2 Isolate Casein from the given sample of milk and determine its yield **20**

OR

Q.2 Determine Total /HDL Cholesterol from the given serum sample **20**

OR

Q.2 Detect proteins /amino acids in the given sample by qualitative tests (4 tests) **20**

Category	Marks
Aim and requirement	01
Principle	02
Performance	10
Observation and calculations	04
Results and Interpretation	03

Q.3 Viva voce (Based on theory paper2) **05**

Q.4 Journal **05**

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Semester II – Practical III (SIPSZOP23)
Based on SIPSZO23

Time: 5 hours **Marks: 50**

Q.1 Extract and quantitatively estimate the amount of DNA/ RNA from the given tissue homogenate **25**

OR

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using enriched media **25**

OR

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using minimal media. **25**

Q.2 Immobilize yeast cells in calcium alginate, prepare beads and keep them overnight in activation medium. **15**

OR

Q.2 Prepare a bioreactor column to demonstrate invertase activity in the bioreactor column. **15**

OR

Q.2 Demonstrate construction of phylogenetic trees (using amino acid and nucleotide sequence) **15**

Q.3 Viva **05**

Q.4 Journal **05**

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Marking scheme
Semester II – Practical III (SIPSZOP23)

Q.1 Extract and quantitatively estimate the amount of DNA/ RNA from the given tissue homogenate **25**

OR

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using enriched media **25**

OR

Q.1 Demonstrate the effect of medium on growth curves of given microorganism using minimal media. **25**

Category	Marks
Aim and requirement	01
Principle	03
Performance	10
Observation, calculations and graph	07
Results and Interpretation	04

Q.2 Immobilize yeast cells in calcium alginate, prepare beads and keep them overnight in activation medium. **15**

Category	Marks
Aim and requirement	01
Principle	03
Performance	07
Results and Interpretation	04

OR

Q.2 Prepare a bioreactor column to demonstrate invertase activity in the bioreactor column. **15**

Category	Marks
Aim and requirement	01
Principle	03
Performance	05
Observation, calculations and graph	04
Results and Interpretation	02

OR

Q.2 Demonstrate construction of phylogenetic trees (using amino acid and nucleotide sequence) **15**

Category	Marks
Performance	08
Interpretation	07

Q.3 Viva **05**
Q.4 Journal **05**

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Semester II – Practical IV (SIPSZOP24)
Based on SIPSZO24

Time: 5 hours **Marks: 50**

Q.1 Demonstrate the technique of two-dimensional paper chromatography to separate the amino acids. Calculate Rf value. **25**

OR

Q.1 Demonstrate the use of adsorption column chromatography to separate the pigments from leaves or flowers. **25**

OR

Q.1 Demonstrate the technique of ion exchange column chromatography in the separation of amino acids using two buffers. **25**

Q.2 Identification of lipids in a given sample by TLC **15**

OR

Q.2 Demonstrate SDS-PAGE under reducing conditions for separation of plasma proteins **15**
Q.3 Viva **05**
Q.4 Journal **05**

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Marking scheme
Semester II – Practical IV (SIPSZOP24)

Q.1 Demonstrate the technique of two-dimensional paper chromatography to separate the amino acids. Calculate Rf value. **25**

OR

Q.1 Demonstrate the use of adsorption column chromatography to separate the pigments from leaves or flowers. **25**

OR

Q.1 Demonstrate the technique of ion exchange column chromatography in the separation of amino acids using two buffers. **25**

Category	Marks
Aim and requirement	01
Principle	02
Performance	10
Observation and calculations	06
Results and Interpretation	06

Q.2 Identification of lipids in a given sample by TLC **15**

OR

Q.2 Demonstrate SDS-PAGE under reducing conditions for separation of plasma proteins **15**

Category	Marks
Aim and requirement	01
Principle	02
Performance	07
Observation and calculations	03
Results and Interpretation	02

Q.3 Viva **05**

Q.4 Journal **05**

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M.Sc Part I – Zoology Syllabus (Autonomous)

Choice Based Credit System (With effect from academic year 2022-23)
Semester I and Semester II

Scheme of Examination

The performance of learners will be evaluated in two parts for the Theory component of the Course:
1. Internal Assessment with 40% marks
2. Semester End Examination (written) with 60% marks

The Practical component of the Course will be evaluated by conducting Semester End Practical Examination of 50 marks.

Internal Assessment Theory (40%)

It is the assessment of learners on the basis of continuous evaluation as envisaged in the Credit Based System by way of participation of learners in various academic and correlated activities in the given semester of the program.

Seminar Marks: 20

Evaluation will be conducted on the basis of Seminar/ Presentation given by the student on a topic chosen from the syllabus for each paper. The marking scheme shall be:

- Content of Presentation: **05 marks**
- Quality of Presentation: **05 marks**
- Presentation skills: **05 marks**
- Question-Answer discussion: **05 marks**

Assignment Marks: 20

Evaluation will be conducted on the basis of Research paper review / Book review / Poster presentation / Abstract writing / Preparation of Standard Operating Procedure or Calibration of Instruments / Role play or Skit on topic relevant to the paper / Report on Industry or Field Visit or Writing an article relevant to the paper etc.

Semester End Assessment Theory (60%)

Marks: 60
Duration: 2.5 hours
Theory question paper pattern:

- There shall be five questions of 12 marks each. On each unit there will be one question and the 5th question will be based on the entire paper.

  OR

  There shall be four questions of 15 marks each, each question based on one unit.
- All questions are compulsory with internal choice within the questions.
- Questions may be subdivided and the allocation of marks depends on the weight age of the topic and by taking into account the Blooms Taxonomy for evaluation.

Semester End Assessment Practical
Marks: 50
Duration: 5 hours

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