

Deccan Education Society's

**Kirti M. Doongursee College of
Arts, Science and Commerce
(AUTONOMOUS)**



Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for
Program: Masters of Science
Course: MSc Part 1
Subject: Zoology

Choice Based Credit System (CBCS)
with effect from
Academic Year 2023-2024

PROGRAM OUTCOMES

PO	Description
A student completing Master's Degree in Science Program will be able to	
PO1	<p>Disciplinary Knowledge:</p> <p>Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate Programme. Execute strong theoretical and practical understanding generated from the specific graduate Programme in the area of work.</p>
PO2	<p>Critical Thinking and Problem solving:</p> <p>Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.</p>
PO3	<p>Social competence:</p> <p>Display the understanding, behavioral skills needed for successful social adaptation, work in groups, exhibits thoughts and ideas effectively in writing and orally.</p>
PO4	<p>Research-related skills and Scientific temper:</p> <p>Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.</p>
PO5	<p>Trans-disciplinary knowledge:</p> <p>Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem.</p>
PO6	<p>Personal and professional competence:</p> <p>Performing dependently and collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.</p>
PO7	<p>Effective Citizenship and Ethics:</p> <p>Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.</p>
PO8	<p>Environment and Sustainability:</p> <p>Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.</p>

Semester	Course Code	Course Title	Vertical	Credits
I	K23PSZOOMJ11 1	Non-chordates, chordates and their phylogeny –I	Major	4
	K23PSZOOMJ11 2	Biochemistry and Metabolism – I	Major	4
	K23PSZOOMJP 11	Non-chordates, chordates and their phylogeny I AND Biochemistry and Metabolism – I	Practical	4
	K23PSZOOOE13 1	Tools and Techniques in Biology - I	Elective	4
	K23PSZOORM14 1	Research Methodology	RM	4
II	K23PSZOOMJ21 1	Non-chordates, chordates and their phylogeny - II	Major	4
	K23PSZOOMJ21 2	Biochemistry and Metabolism- II	Major	4
	K23PSZOOMJP 21	Non-chordates, chordates and their phylogeny and Biochemistry and Metabolism- II	Practical	4
	K23PSZOOOE23 1	Tools and Techniques in Biology-II	Elective	4
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Course Code	Major SEM – I	Credits	Lectures/Week
K23PSZOOMJ111	Paper I Non-chordates, chordates and their phylogeny –I	4	4
Course Outcomes:			
After successful completion of this course, students would be able to			
<ul style="list-style-type: none"> ● Knowledge of characteristics of organisms mentioned ● Segregate the role of characteristics in placing the organisms in specific taxonomic classification ● The learner will be well versed with the knowledge of application of characteristics for taxonomic hierarchy ● Analysis of given animal to place them in appropriate taxonomic hierarchy and their roles in evolution ● Critically assess the effectiveness of conservation strategies or management practices for animal populations. ● Develop conservation plans or strategies to protect endangered animal species or habitats. 			
Unit			
Unit	Topics	No of Lectures	
I	Phylogeny, Systematics of non-chordates and assorted topics-I 1.1. Principles of systematic, importance of taxonomic studies in Biology, use of morphometric studies, Osteological studies, use of homologous organs. 1.1. Taxonomic keys: Different kinds of taxonomic keys, their merits and demerits. 1.2. Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla-	15	

	<p>1.3.1 Protista (Protozoa)</p> <p>1.3.2 Porifera</p> <p>1.3.3 Coelenterata</p> <p>1.3.4 Ctenophora</p>	
<p style="text-align: center;">II</p>	<p>Phylogeny, Systematics of non-chordates, Hemichordata & assorted topics</p> <p>2.1. Phylogeny, salient features, classification (wherever applicable) up to classes</p> <p>of the following phyla-</p> <p>2.1.1 Mollusca</p> <p>2.1.2 Bryozoa</p> <p>2.1.3 Brachiopoda</p> <p>2.1.4 Echinodermata</p> <p>2.1.5 Chaetognatha</p> <p>2.2 Systematic position and affinities of Hemichordata.</p> <p>2.3 Assorted Topics:</p> <p>2.3.1 Economic importance of Protozoa.</p> <p>2.3.2. Mesenteries in Coelenterata.</p> <p>2.3.3 Economic importance of Arthropoda.</p> <p>2.3.4 Sense organs in Arthropoda.</p> <p>2.3.5 Spines and Pedicellariae in Echinodermata.</p> <p>2.3.6 Invertebrate larvae- larval forms of free living invertebrates, larval forms of parasites,</p> <p>Strategies and evolutionary significance of larval forms.</p>	<p style="text-align: center;">15</p>

III	<p>Phylogeny, Systematics of Chordates and Assorted topics- I</p> <p>3.1. Discovery of Coelacanth.</p> <p>3.2. Overview of fish phylogeny.</p> <p>3.3. Primitive tetrapods- Labrynthodonts.</p> <p>3.4. Crossopterigians- A blue print.</p> <p>3.5. Dipnoi- a group that has failed to evolve as Amphibia.</p> <p>3.6. Lissamphibia.</p> <p>3.7. Sphenodon- a living fossil.</p> <p>3.8. Extinct reptiles.</p> <p>3.9. Adaptive radiation in Reptilia.</p>	15
IV	<p>Comparative Vertebrate Osteology- I</p> <p>4.1. Embryonic development of- a) neurocranium, b) splanchnocranium and c) dermatocranium.</p> <p>4.2. Comparative account of jaw suspension.</p> <p>4.3. Embryonic development of Vertebra.</p> <p>4.4. Vertebral column of tetrapods- Atlas, Axis, Typical Vertebra, Thoracic vertebra, Trunk vertebra,</p> <p>Caudal vertebra of Dog fish and Bony fish, Frog, Varanus, Pigeon, and Rabbit.</p>	15
<p>Textbooks:</p> <ul style="list-style-type: none"> ● 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 Publication.
- Analysis of Vertebrate Structure: Milton Hildebrand, Wiley International

Additional References:

- Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company
- Life of Invertebrates; Russell, W.D. Hunter, McMillan
- Invertebrate Zoology: Bares, R.D., Saunders Publication

Course Code	Major SEM – I	Credits	Lectures/Week
K23PS ZOOMJ112	Paper II- Biochemistry and Metabolism – I	4	4
Course Outcomes:			
After successful completion of this course, students would be able to			
<ul style="list-style-type: none"> ● Knowledge of structures and functions of various biomolecules ● Understanding energy consumptions of various biomolecules in pathways ● To estimate the use of energy in different forms and interaction of biomolecules ● To analyze new molecules and pathways and their energy consumptions ● Evaluate the impact of biochemical processes on human health, disease development, and therapeutic interventions. ● Design experiments or investigations to study specific biochemical processes or metabolic pathways. 			
Unit			
Topics			
No of Lectures			
I	Biomolecules- a structural and functional approach-I 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: mono-, oligo- and poly-saccharides.	15	

	<p>1. Monosaccharides- structure, classification, D- and L- isomers, Anomers and mutarotation, open chain and ring forms, pyranose and furanose forms, reactions of monosaccharides, glycosidic bonds and nomenclature.</p> <p>2. Oligosaccharides.</p> <p>3. Polysaccharides- homo- and heteropolysaccharides.</p> <p>1.2.2. Biological functions of carbohydrates.</p> <p>1.3. Lipids:</p> <p>1.3.1 Classification: simple and complex lipids.</p> <p>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.</p> <p>1.3.3. Acylglycerols- Mono-, di- and triglycerides, stereospecific numbering of glycerols in glycerides, properties of triacylglycerol.</p> <p>1.3.4. Complex lipids- Phospholipids, Sphingolipids, Sterols and waxes, Amphipathic lipids: Membrane lipid bilayers.</p> <p>1.3.5. Biological functions of lipids.</p> <p>1.4. Nucleic acids: Types- RNA and DNA.</p> <p>1.4.1. Components: Pentose, Nitrogenous bases, Nucleosides, tautomeric forms of purines</p>	
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	<p>and pyrimidines.</p> <p>1.4.2. Structure of DNA: Watson and Crick model; different forms of DNA double helix.</p> <p>1.4.3. Structure, types and functions of RNA.</p> <p>1.5. Complex biomolecules</p> <p>1.5.1 Glycoproteins: Blood group substances</p> <p>1.5.2. Glycolipids: Gangliosides.</p> <p>1.5.3 Lipoproteins: Classification and functions- chylomicrons, VLDL, LDL, HDL, and free fatty acid-albumin complex.</p>	
II	<p>Biochemical Thermodynamics</p> <p>2.1. Biochemical Thermodynamics:</p> <p>2.1.1 Laws of thermodynamics, free energy, entropy, enthalpy, exergonic and endergonic reactions.</p> <p>2.1.2 High energy compounds: ATP, ADP, ATP-ADP cycle, ATP-AMP ratio.</p> <p>2.1.3 Biological oxidation: Electron transport chain and mitochondria; Oxidative phosphorylation- mechanism, uncoupling of oxidative phosphorylation and its significance.</p> <p>2.1.4 Free radicals, antioxidants and antioxidant system.</p>	15
III	<p>Metabolic pathways and Integration of metabolism-I</p> <p>3.1. Metabolism: Concept; Definitions; Catabolism; Anabolism.</p> <p>3.2. Carbohydrate Metabolism:</p>	15

	<p>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 and energetic of glycolysis. Regulation of glycolysis.</p> <p>3.2.2. Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate, lactate. Regulation of gluconeogenesis.</p> <p>3.2.3. Glycogen metabolism: Glycogenesis, Glycogenolysis. Regulation of the two pathways.</p> <p>3.2.4. Significance of following pathways: Hexose monophosphate shunt as a multifunctional pathway; Uronic Acid Pathway; Glyoxalate cycle.</p> <p>3.3. Lipid Metabolism:</p> <p>3.3.1. Dynamics of body lipids, mobilization of fats, regulation of hormone sensitive TGlipase, fate of glycerol and free fatty acids.</p> <p>3.3.2. Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acid, oxidation of unsaturated fatty acids, biosynthesis of fatty acids including desaturation, metabolism of phospholipids, cholesterol and *alcohol.</p>	
IV	<p>Regulation of metabolism</p> <p>4.1. Regulation of metabolism</p>	15

	<p>4.1.1. Concept of homeostasis.</p> <p>4.1.2. 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,</p> <p>4.1.3. Regulation of metabolism by extracellular signals: nutrient supply, nutrient transport, endocrine control, neural control.</p>	
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Textbooks:

- Lehninger Principles of Biochemistry 8th Edition by [David L. Nelson](#)
- 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. Publ.
- Biochemistry- a Functional Approach; MacGuilver
- www.enzymesIndia.com

Additional References:

- Biochemistry – by [Donald Voet](#) (Author) Judith voet and more
- **Cell and molecular biology 8th ed- De Robertis E.D.P**

Course Code	SEM I - Non-chordates, chordates and their phylogeny I AND Biochemistry and Metabolism - I	Credits	Lectures/Week
K23PSZOOMJP11	Practical 1 (Paper 1 + Paper 2)	4	8

Course Outcomes:

After successful completion of this course, students would be able to

- Knowledge of characteristics of organisms mentioned structures and functions on various biomolecules
- Understanding the role of characteristics in placing the organisms in specific taxonomic classification, energy consumptions of various biomolecules in pathways
- The learner will be well versed with the knowledge of application of characteristics for taxonomic hierarchy and will be able to estimate the use of energy in different forms and interaction of biomolecules
- Analysis of given animal to place them in appropriate taxonomic hierarchy and their roles in evolution. To analyze new molecules and pathways and their energy consumptions

Paper 1- Non-chordates, chordates and their phylogeny I

1	Study of animal type*: Sepia: Morphology, digestive system, nervous system, reproductive system, Mounting of: jaws, radula, statocyst and spermatophore
2	Study of systematic and major features of: Protozoa (Amoeba, Volvox, Noctiluca, Paramoecium, Plasmodium); Porifera (Leucosolenia, Grantia, Euplectella, Euspongia); Coelenterata (Obelia colony, Physalia, Porpita, Sea-anemone, Madrepora, Aurelia); Mollusca (Chiton, Dentalium, Patella, Aplysia, Limnea/Achatina, Mytilus, Loligo/Octopus, Nautilus); Echinodermata (Starfish, Brittle star, Sea urchin, Sea cucumber, Feather star); Minor Phyla (Comb jelly, Lingula, Sagitta,); Hemichordata (Balanoglossus).
3	Study of accessory respiratory organs in: Anabas, Clarius, Sacchobranthus and Boleopthalmus,
4	Study of Larval forms: Echinoderm larvae and Tornaria larva
5	Cephalochordata (Amphioxus). Study of systematics and major features of: Agnatha (Petromyzon, Myxine); Pisces (Shark, Sting ray, Electric ray,

	Hippocampus, Eel, and any lung fish); Amphibia(Caecilian, Salamander, Frog, Toad); Reptilia (Turtle/Terrapin, Tortoise, Calotes/ Chameleon, Draco, Phrynosoma, Viper, Rattle snake, Hydrophis, Crocodile/Alligator/Gharial)
6	Mounting of spicules of Holothurian
7	Comparative Osteology: Types of vertebrae (Procoelous, Opisthocoelous, Amphicoelous, Heterocoelous)
Paper 2- Biochemistry and Metabolism – I	
8	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
9	Determination of glucose by Benedict's method (volumetric).
10	Determination of reducing sugars by 3,5-dinitrosalicylic acid (colorimetric) method.
11	Determination of glycogen in the given tissue (liver/ skeletal muscle/ kidney/ brain)
12	Acid and enzyme hydrolysis of glycogen and colorimetric estimation of the products by 3,5-DNSA method
13	Isolation of starch from potato
14	Determination of acid value of fats/ oils
15	Determination of saponification value of fats/ oils.
16	Reichert-Meissl (RM) number of fat.
Textbooks:-	
<ul style="list-style-type: none"> ● Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company. ● An introduction to practical biochemistry -Plummer 	

Course Code	Elective SEM – I	Credits	Lectures /Week
K23PSZ000 E131	Tools and Techniques in Biology - I	4	4
<p>Course Outcomes: After successful completion of this course, students would be able to</p> <ul style="list-style-type: none"> ● Knowledge of principles of various tools and techniques ● Understanding of working of tools and techniques ● Applications of tools and techniques in research ● Analysis of various topics based on the above areas ● Critically assess the strengths and limitations of different experimental designs or methodologies in biological research. ● Create reports, presentations, or visualizations to effectively communicate research findings and experimental procedures. 			
Unit	Topics	No of Lectures	
I	<p>Microtomy, microscopy, centrifugation 1.1. Microtomy: Tissue fixation, dehydration, clearing, infiltration, embedding for paraffin method, sectioning, mounting, staining- differential and specific.</p> <p>1.2. Principles and applications of microscopy: Light microscopy, phase contrast microscopy, fluorescence microscopy, polarization microscopy, confocal scanning microscopy, transmission electron microscopy, specimen preparation for electron microscopy, scanning electron microscopy.</p>	15	

	<p>1.3. Principles and applications of centrifugation: Basic principles of centrifugation, Low speed and high speed centrifuges, ultracentrifuge, application of centrifugation-preparative techniques, analytical measurements; care of centrifuges and rotors.</p>	
II	<p>Radioisotopes and extraction techniques</p> <p>2.1. Principles and applications of radioisotopes: Use of isotopes in biological sciences; units of radioactivity, detection and measurement of radioactivity by scintillation counting, autoradiography, preparation for the experiment, performing the experiment.</p> <p>2.2 Principles and application of filtration, distillation and extraction: Ordinary filtration under suction pressure, fractional distillation, steam distillation, technique of extraction with solvents.</p>	15
III	<p>Principles and application of Spectroscopy</p> <p>3.1. Spectroscopy</p> <p>3.1.1. Ultraviolet and visible absorption spectroscopy</p> <p>3.1. 2. Fluorescence spectroscopy</p> <p>3.1.3. Nuclear magnetic resonance spectroscopy</p> <p>3.1.4. Mass spectroscopy</p> <p>3.1.5. Atomic absorption spectrophotometer</p>	15
IV	<p>Data management and analysis</p> <p>4.1 Methods of data collection</p> <p>4.1.1 Primary sources</p>	15

	<p>4.1.2 Secondary sources</p> <p>4.2.5 Data Classification and Presentation</p> <p>4.2.1 Classification of data (Geographical, Chronological, Qualitative, Quantitative)</p> <p>4.2.2 Tabulation of data (one-way table, two-way table, complex table)</p> <p>4.2.3 Type of charts (Line, Column, Scatter plot, Box plot, Heat Map)</p> <p>designs; basic principles of experimental design; important experimental designs.</p>	
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Textbooks:

- 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

Data Management and Analysis:

- The practice of statistics in life sciences - Brigitte Baldi and David Moore, W. H. Freeman.
- Mahajan's methods in Biostatistics for Medical students and Research Workers - Bratati

- Banerjee, Jaypee Publishers.
- Biostatistics: Basic concepts and methodology - Wayne Daniel and Chad Cross, Wiley.
- Biostatistical analysis - Jerrold H. Zar, Pearson.
- Statistics for people who (think they) hate statistics – Neil J. Salkind, SAGE Publications.
- Discovering Statistics using IBM SPSS Statistics – Andy Field, SAGE Publications.
- IBM SPSS Statistics Step by Step – Darren George and Paul Mallery, Taylor & Francis.
 - Statistics for Ecologists using R and Excel – Mark Gardener, Pelagic Publishing.

Additional References:

- The Essential Guide to Doing Your Research Project Paperback – 25 January 2011-O’Leary
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches Paperback – 2 January 2018- by [John W. Creswell](#) (Author), [J. David Creswell](#) (Author)
- Case Study Research and Applications: Design and Methods -**By Robert Yin**

Course Code	RM SEM – I	Credits	Lectures /Week
K23PSZOR M141	Research Methodology	4	4

Course Outcomes:

After successful completion of this course the learner will be able to:-

- Explain the importance of defining a research problem and the role of research design in conducting a study.
- Use techniques to define research problems effectively and develop a research design suitable for a specific research problem.
- Evaluate the appropriateness of different research designs for different research problems and assess the validity of research designs.
- Critique research designs, identify potential limitations, and propose improvements to enhance the quality of research designs
- Develop research proposals, including the formulation of research questions, design considerations, and anticipated outcomes.

Unit	Topics	No of Lectures
I	Meaning of research and types of research 1.1 Motivation in research; 1.2 Types of research; research approaches; significance of research; research methods versus methodology; 1.3 Research and scientific methods; Importance of knowing how research is done; 1.4 Research process; Criteria for good research	15
II	Research problem and research design 2.1 Selecting research problem; necessity of defining a problem; techniques involved in defining the problem; 2.2 Meaning of research design; need	15

	for research design; important concepts related to research design; different research	
III	<p>Interpretation and report writing</p> <p>3.1 Interpretation and report writing: Meaning of interpretation; technique of interpretation; precautions in interpretation;</p> <p>3.2 Significance of report writing; layout of research report; types of reports; *Presentation of research work- oral, poster and writing research paper; Precautions for writing research report</p>	15
IV	<p>Review of related literature and Writing research proposal</p> <p>4.1 Review of related literature: Understanding the role of review; how to begin a search for related literature- Library reference, recording and indexing, classification of references, internet sites for biological references; downloading the information through internet; requests for reprints through e-mail and post; classification and filing of reprints.</p> <p>4.2 Writing research proposal: Characteristics of a proposal; content and organization of a proposal; weakness in proposal seeking funding</p>	15
<p>Textbooks:</p> <ul style="list-style-type: none"> ● Practical Research Planning and Design; 2nd Ed. Paul D. Leedy. Macmillan Publ ● Research Methodology. Methods and Techniques; C.R.Kothari. Wiley Eastern Ltd. Mumbai 		

Course Code	Major SEM – II	Credits	Lectures/Week
K23PSZOOM J211	Paper I- : Non-chordates, chordates and their phylogeny - II	4	4
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to</p> <ul style="list-style-type: none"> • Knowledge of characteristics of organisms mentioned • Understanding the role of characteristics in placing the organisms in specific taxonomic classification • The learner will be well versed with the knowledge of application of characteristics for taxonomic hierarchy • Analysis of given animal to place them in appropriate taxonomic hierarchy and their roles in evolution • Critically assess the scientific literature and research findings related to non-chordate and chordate phylogeny. • Design and conduct experiments or investigations to study specific aspects of non-chordate or chordate evolution, such as evolutionary developmental biology or molecular phylogenetics. 			
Unit	Topics	No of Lectures	
I	<p>Phylogeny, Systematics of non-chordates and assorted topic-II</p> <p>1.1. Platyhelminthes and Nemethelminthes</p> <p>1.2. Acanthocephala</p> <p>1.3. Annelida</p> <p>1.4. Sipunculoidea</p> <p>1.5. Arthropoda</p> <p>1.6 Onychophora – Peripatus, A connecting link between Annelida and Arthropoda.</p>	15	

II	<p>Phylogeny of Protochordates, Agnatha and assorted topics II</p> <p>2.1. Urochordata and its affinities.</p> <p>2.2. Cephalochordata and its affinities</p> <p>2.3. Vertebrate ancestry and origin of Vertebrates.</p> <p>2.4. Changes leading to first vertebrates.</p> <p>2.5. Salient features and phylogeny of Ostracoderms.</p> <p>2.6. Affinities of Cyclostomes- a) resemblance with Cephalochordates. b) differences from fishes. c) vertebrate characters. d) specialized characters</p>	15
III	<p>Phylogeny, Systematics of Chordates and Assorted topics- II</p> <p>3.1. Warm blooded reptiles.</p> <p>Archaeopteryx- a connecting link between Reptiles and Aves.</p> <p>3.2. Affinities of Aves and classification up to subclass.</p> <p>3.3. Origin of flight (theory of cursorial & arboreal origin).</p> <p>3.4. Birds as glorified reptiles.</p> <p>3.5. Egg laying mammals- connecting link between reptiles and mammals.</p> <p>3.6. Classification of mammals up to orders.</p> <p>3.7. Dentition in mammals.</p> <p>3.8. Walking gait (Plantigrade, Digitigrade, and Unguligrade)</p>	15
IV	<p>Comparative Vertebrate Osteology- II</p> <p>4.1. Pectoral & Pelvic girdles of Dog fish, Bony fish, Frog, Varanus, Pigeon and Rabbit</p>	15

	<p>4.2. Comparative anatomy of limbs of tetrapods.</p> <p>4.3. Mechanism of support and movements- Running, Jumping and Digging.</p>	
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Textbooks:

- 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 Publication.
- Analysis of Vertebrate Structure: Milton Hildebrand, Wiley International

Additional References:

- Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company
- Life of Invertebrates; Russell, W.D. Hunter, McMillan
- Invertebrate Zoology: Bares, R.D., Saunders Publication

Course Code	MAJOR SEM – II	Credits	Lectures /Week
K23PSZOOM J212	Paper II- Biochemistry and Metabolism- II	4	4
<p>Course Outcomes:</p> <p>After successful completion of this course, students would be able to</p> <ul style="list-style-type: none"> • Knowledge of structures and functions on various biomolecules • Understanding energy consumptions of various biomolecules in pathways • To estimate the use of energy in different forms and interaction of biomolecules • To analyze new molecules and pathways and their energy consumptions • Evaluate the impact of biochemical processes on human health, disease development, and therapeutic interventions. • Create models or simulations to illustrate complex biochemical processes or metabolic networks. 			
Unit	Topics	No of Lectures	
I	<p>Biomolecules- a structural and functional approach-II</p> <p>1.1. Proteins as polymers of amino acids</p> <p>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.</p> <p>1.1.2. Organization of protein structure: Primary structure and peptide bond, secondary, tertiary</p>	15	

	<p>and quaternary structure; conjugate proteins- haemoglobin, cytochromes, myoglobin;</p> <p>bonds involved in protein organization.</p> <p>1.1.3. Properties of proteins: classification, denaturation and protein folding.</p> <p>1.1.4. Biological functions of proteins. Biologically important peptides: glutathione, octa-, nona-, and deca-peptides.</p>	
II	<p>Enzymes and Enzyme kinetics</p> <p>2.1. Enzymes and Enzyme kinetics.</p> <p>2.1.1. Enzymes: Nomenclature and classification with numerical code; chemical nature of enzymes.</p> <p>2.1.2. Mechanism of enzyme action: Fischer's Lock and Key Theory, Koshland's Induced fit model; Mechanism of enzyme catalysis.</p> <p>2.1.3. Enzyme kinetics: Michaelis Menton equation; Lineweaver-Burk plot; significance of Vmax and Km; factors affecting enzyme activity; enzyme activation and inhibition.</p> <p>2.1.4. Regulatory enzymes: a) covalently modulated, b) allosteric regulation, c) Isoenzymes (LDH, CK, ALP, ADH)</p> <p>2.1.5. Non-protein enzymes- Ribozymes.</p> <p>2.1.6. Advanced enzymes in human healthcare (e.g. fungal lactase, Hemicellulase, Trypsin chymotrypsin mix)</p>	15
III	<p>Metabolic pathways and Integration of metabolism</p> <p>3.1. Protein Metabolism:</p> <p>3.1.1. Metabolism of amino acids: Amino acid pool, transamination; oxidative and nonoxidative</p>	15

	<p>deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids.</p> <p>3.1.2. Metabolism of ammonia: Urea cycle.</p> <p>3.2. Metabolism of nucleic acids:</p> <p>3.2.1 Synthesis of ribonucleotides- a brief idea of <i>de novo</i> pathway and salvation pathway.</p> <p>3.2.2. Conversion of ribonucleotides to deoxyribonucleotides.</p> <p>3.2.3. Degradation of nucleotides.</p> <p>3.3. Integration of Metabolism, Energy demand and supply; Integration of major metabolic pathways of energy metabolism; intermediary metabolism; organ specialization and metabolic integration. Metabolism in starvation</p>	
<p>IV</p>	<p>Regulation of metabolism and inborn errors of metabolism</p> <p>4.1. Inborn errors of metabolism</p> <p>4.1.1. Carbohydrate metabolism: Glycogen storage disease, G-6-PD deficiency</p> <p>4.1.2. Lipid metabolism: Metabolic disorders of cerebroside.</p> <p>4.1.3. Protein metabolism: PKU, Albinism, Cystinuria</p> <p>4.1.4. Purine metabolism: Primary Gout</p> <p>4.2. Mineral metabolism and diseases: Hypocalcaemia, Hypercalcaemia and osteoporosis</p>	<p>15</p>
<p>Textbooks:</p> <ul style="list-style-type: none"> ● Lehninger Principles of Biochemistry 8th Edition by <u>David L. Nelson</u> ● 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. Publ.
- Biochemistry- a Functional Approach; MacGuilver
- www.enzymesIndia.com

Additional References:

- Biochemistry – by [Donald Voet](#) (Author) Judith voet and more
- **Cell and molecular biology 8th ed- De Robertis E.D.P**

Course Code	SEM II - Non-chordates, chordates and their phylogeny and Biochemistry and Metabolism- II	Credits	Lectures /Week
K23PSZOO MJP21	Practical 1 (Paper 1 + Paper 2)	4	8
Course Outcomes:			
After successful completion of this course, students would be able to			
<ul style="list-style-type: none"> • Knowledge of characteristics of organisms mentioned structures and functions on various biomolecules • Understanding the role of characteristics in placing the organisms in specific taxonomic classification, energy consumptions of various biomolecules in pathways • The learner will be well versed with the knowledge of application of characteristics for taxonomic hierarchy and will be able to estimate the use of energy in different forms and interaction of biomolecules • Analysis of given animal to place them in appropriate taxonomic hierarchy and their roles in evolution.To analyze new molecules and pathways and their energy consumptions 			
Paper 1 Non-chordates, chordates and their phylogeny - II			
1	Study of animal type*: Periplanata americana: Morphology, digestive system, nervous system, reproductive system and life history. Mountings of- cornea, salivary glands, gonapophyses, spermatheca		
2	Study of systematics and major features of: Helminthes (Planaria, Liverfluke, Tapeworm, Ascaris, Trichinella); Annelida (Nereis, Earthworm, Leech); Sipunculoidea: (Sipunculus), Arthropoda (Lobster, Balanus, Crab, Lepas, Scorpion, Spider, Limulus, Centipede, Millipede, Beetle). Urochordata (Simple Ascidian, Salpa/ Doliolum); Cephalochordata (Amphioxus).		
3	Study of Larval forms: Larvae of Helminthes- Miracidium, Redia, Cercaria, Metacercaria; Trochophore, Crustacean larvae, Ascidian tadpole.		
4	Study of systematics and major features of: Aves (Ostrich, Kiwi, Kite, Owl, and Duck); Mammals (Duck billed platypus, Echidna, Kangaroo, Shrew, Bat, Loris, Seal/ Walrus, Dolphin, Sea Cow, Tiger, Giant panda, Tapir, Camel, Striped squirrel, Guinea pig, Porcupine, Rabbit)		
5	Comparative Osteology: Study of pectoral and pelvic girdles (Shark, Bony fish, Frog, Varanus, Pigeon, Rabbit); Study of comparative anatomy of tetrapod limbs (Frog, Varanus, Pigeon and Rabbit).		
*Demonstration practical/ Dissection/Virtual dissection/Model (2D or 3D)/Chart of animal system as per UGC guidelines.			

Paper 2 Biochemistry and Metabolism- II

6	Determination of total cholesterol and HDL cholesterol from serum
7	Qualitative tests for amino acids and Proteins: Ninhydrin test; Xanthoproteic test; Millon's test; Biuret test.
8	Colorimetric estimation of protein by Peterson-Lowry method.
9	Quantitative estimation of amino acids using ninhydrin reagent.
10	Isolation of casein from milk
11	Detection of conformation of BSA by viscosity measurement and effect of varying concentration of urea on viscosity of BSA.
12	SDH specific activity.
	Textbooks
	<ul style="list-style-type: none">• Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company.• An introduction to practical biochemistry -Plummer

Course Code	Elective II SEM – II	Credits	Lectures/Week
K23PSZ000 E231	Tools and Techniques in Biology-II	4	4

Course Outcomes:

After successful completion of this course, students would be able to

- Knowledge of principles of various tools and techniques
- Understanding of working of tools and techniques
- Applications of tools and techniques in research
- Analysis of various topics based on the above areas
- Critically assess the strengths and limitations of different experimental designs or methodologies in biological research.
- Develop new or modified protocols or techniques to optimize experimental procedures or overcome technical challenges.

Unit	Topics	No of Lectures
I	<p>Principles and application of chromatography I</p> <p>1.1. Chromatography</p> <p>1.1.1. Planar chromatography (Paper and Thin layer): Preparation of stationary support, solvent, detection and measurement of components, applications.</p> <p>1.1.2. Column chromatography: Packing and operation of column, loading the column, eluting the column, collection of eluent, detection of eluent, application.</p> <p>1.1.3. Ion exchange chromatography: Ion exchange resins, selection of ion-exchanger, choice of</p>	15

	<p>buffers, preparation and use of ion-exchangers, storage of resins.</p>	
II	<p>Principles and application of chromatography II 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, application 2.2 Affinity chromatography: Chromatography media, immobilized ligands, attachment of ligands to the matrix, experimental procedures and application</p>	15
III	<p>Principles and application of chromatography and Electrophoresis 3.1. Gas chromatography 3.1.1. Gas chromatography (GC): Instrumentation, selection of operating conditions, analysis of data and application. 3.1.2. HPLC. 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.</p>	15
IV	<p>Research Methodology and data management -II 4.1 Concepts of Measurements</p>	15

	<p>4.1.1 Univariate (standard deviation, variance, quartiles)</p> <p>4.1.2 Bivariate (correlation and regression)</p> <p>4.1.3 Multivariate (ANOVA: one-way, two-way)</p> <p>4.1.4 Level of significance and p-value</p> <p>4.1.5 Normal distribution, Skewness, Kurtosis, Outliers</p> <p>4.2 Testing of Hypothesis</p> <p>4.2.1 Null hypothesis, Alternative hypothesis</p> <p>4.2.2 Type 1 and Type 2 Errors</p> <p>4.2.3 Testing of Hypothesis (single population mean, two population means)</p> <p>4.2.4 One-tailed and Two-tailed tests</p> <p>4.3 Parametric and Non-parametric tests</p> <p>4.3.1 Parametric tests: t test, z test, F test</p> <p>4.3.2 Non-parametric tests: Chi-square test, Mann-Whitney test, Kruskal-Wallis test, Friedman Test, Wilcoxon signed-rank test</p>	
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Textbooks:

- 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 Data Management and Analysis:
- The practice of statistics in life sciences - Brigitte Baldi and David Moore, W. H. Freeman.
- Mahajan's methods in Biostatistics for Medical students and Research Workers - Bratati
- Banerjee, Jaypee Publishers.
- Biostatistics: Basic concepts and methodology - Wayne Daniel and Chad Cross, Wiley.
- Biostatistical analysis - Jerrold H. Zar, Pearson.
- Statistics for people who (think they) hate statistics – Neil J. Salkind, SAGE Publications.
- Discovering Statistics using IBM SPSS Statistics – Andy Field, SAGE Publications.
- IBM SPSS Statistics Step by Step – Darren George and Paul Mallery, Taylor & Francis.
- Statistics for Ecologists using R and Excel – Mark Gardener, Pelagic Publishing.

Additional References:

- The Essential Guide to Doing Your Research Project Paperback – 25 January 2011-O'Leary
- Research Design: Qualitative, Quantitative, and Mixed Methods Approaches Paperback – 2 January 2018- by [John W. Creswell](#) (Author), [J. David Creswell](#) (Author)
- Case Study Research and Applications: Design and Methods -**By Robert Yin**

Evaluation Scheme for First Year (PG) under NEP (4 credits)

I. Internal Evaluation for Theory Courses – 40 Marks

1) Continuous Internal Assessment(CIA) Assignment –

Project – 40 marks

II. External Examination for Theory Courses – 60 Marks

Duration: 2 Hours

Theory question paper pattern:

Question	Based on	Marks
Q.1	Unit I	15
Q.2	Unit II	15
Q.3	Unit III	15
Q.4	Unit IV	15

- All questions shall be compulsory with internal choice within the questions.
- Each Question may be sub-divided into sub questions as a, b, c, d, etc. & the allocation of Marks depends on the weightage of the topic.

III. Practical Examination

- Each core subject carries 50 Marks
- Duration: 3 Hours for each practical course.
- Minimum 80% practical from each core subjects are required to be completed.
- Certified Journal is compulsory for appearing at the time of Practical Exam

NOTE: To pass the examination, attendance is compulsory in both Internal & External (Theory + Practical) Examinations.