

DEPARTMENT OF ZOOLOGY
SAVITRIBAI PHULE PUNE UNIVERSITY
GANESHKHIND, PUNE 411007



Syllabus

For

M. Sc. (Zoology)

(NEP 2023 Credit/Semester Based)

w.e.f. 1st July 2023

- (1) **Title of the Program:** M. Sc. (Zoology)
- (2) **Duration:** TWO years (Four semesters) Full-time Post - Graduate Degree Program
- (3) **Intake Capacity:** 32 students
- (4) **Total number of credits:** 88 credits (maximum)
- (5) **Preamble:** The Department of Zoology is one of the first departments to be established by the Savitribai Phule Pune University in 1950. During the last 60 years, the department has made its identity in the frontier areas of Life Sciences and now it has developed into a center of teaching and research in modern biology. The Department offers up-to-date and pertinent postgraduate programmes (M.Sc. and Ph.D.) in Zoology with emphasis on fundamentals as well as emerging areas of modern biology. Efforts of the Department in establishing unique and innovative teaching and training programmes are reflected in its recognition as a **Centre of Advanced Study (CAS) by the University Grants Commission (UGC)** since 2005 (**Phase, I, II & III**). The Department of Zoology has received funds from **UGC** and **DST** under various schemes (**COSIST, UPE, FIST and PURSE**). The department offers choice-based credit system (CBCS) for M.Sc. in Zoology with emphasis on hands-on practical training and continuous internal assessment. The department has successfully organized four short-term courses under the Global Initiative of Academic Networks (GIAN) programme sponsored by MHRD Government of India, in which the international scientists/professors were invited to encourage their engagement with the faculty and students of SPPU. The faculty members of the department have been actively engaged in research and have received extramural research grants from **UGC, CSIR, DRDO, ISRO, DBT, DST, DAE, SPARC and ICMR**, in addition to industry sponsored projects. In view of the paradigm shift in the way teaching and learning at the higher education institutes are envisaged in the National Education Policy 2020, the department has extensively revised and restructured its post-graduate syllabus to incorporate courses that will instill analytical and creative thinking and enhance the skills of students, which will in turn increase the competitive ability, innovative thinking and creativity of students thus increasing their employability. In addition, the post-graduate course provides them with in-depth knowledge of the subject and technical skills thus encouraging them to take up research work in the frontier areas of biology.
- (6) **Program Objectives:** Some of the objectives of M.Sc. (Zoology) Program are as follows:
 - a) To inculcate scientific acumen in students to enhance their creative and analytical skills.
 - b) To empower students with fundamental and advanced knowledge about animal sciences.
 - c) To inculcate entrepreneurship, students will be motivated to translate classical/modern Zoology into technology.
 - d) To stimulate students to explore interdisciplinary and trans-disciplinary applications of zoology.
- (7) **Program Outcomes:** After successful completion of 2 years of M.Sc. (Zoology) program from the Department of Zoology, Savitribai Phule Pune University,

- a) Students will have a thorough understanding of the fundamentals of Zoology and their relevance to the betterment of human health, biodiversity and conservation, ecological balance and other aspects of man-animal conflicts.
- b) Students will also acquire knowledge about applied zoology which will enhance their employability in both the academic and industrial sectors.
- c) Practical and research-based learning will provide opportunities for entrepreneurship.
- d) Students have acquired skills in analyzing research problems, formulating hypothesis, evaluating, validating the results and drawing meaningful conclusions
- e) Students will be able to apply their knowledge acquired while studying zoology for sustainable development and betterment of society.

(8) Program Structure of M.Sc. (Zoology): For M.Sc. (Zoology) Degree, a student has to earn the minimum 88 credits from at least FOUR semesters. The structure of the program is as follows:

- a) In each semester, the Department will offer at least 22 credits.
- b) In semesters I, II, and III, there will be mandatory theory courses of total 10 credits, practical courses of total 4 credits, and two elective courses of 2 credits each. In semester IV, there will be mandatory theory courses of total 8 credits, practical courses of total 4 credits, and two elective courses of 2 credits each.
- c) In addition to (b), there will be compulsory courses as follows: Semester I - Research Methodology (RM) - 4 credits.
- d) Semester II - On Job Training (OJT) - 4 credits. Semester III - Research Project (ZOO 600 RP) - 4 credits Semester IV- Research Project (ZOO 650 RP) - 6 credits.
- e) Each course of 2 credits comprises 2T or 2P
- f) A student has to attend 1-hour classroom teaching per week for one credit of theory and 2 hours' lab work/problem-solving session/ related activities per week for one credit of practical.
- g) Practical sessions (lab work/problem-solving session/related activity) will be conducted in batches. A batch for such sessions will be of size maximum of 12 students.
- h) The modus-operandi for the conduct and evaluation of a Research Project Course will be decided by the Departmental Committee from time to time as per the needs.
- i) The Department may conduct necessary lectures/workshops as a part of OJT.

(9) Exit Option: After earning 44 credits offered by the Department for the first two semesters successfully (First year – Semester I & II), a student will have the option of exit from the program. In this case, the student will be conferred with PG Diploma in Zoology.

(10) Evaluation Rules: Student evaluation will be done as per the general policy and rules of Savitribai Phule Pune University, and UGC.

- (a) Each course of 2 credits (T/P) will carry 50 marks and the evaluation of the course will be done separately. There will be Continuous Assessment (CA) of 25 marks and Semester End Examination (SEE) of 25 marks for each course.
- (b) The CA will be based on a minimum of two internal tests (IT). In addition, a teacher may assess the students using one of the following ways:
 - I. Home Assignment(s)
 - II. Seminar/Presentation (Individual / Group)
 - III. Laboratory assignment
 - IV. Group Discussions / Oral
 - V. Research Paper Review
 - VI. Technology Demonstration
- (c) For passing a course, a student must score a minimum of 30% marks in each of the CA and SEE separately and a minimum of 40% marks in the combined grading of CA and SEE. If a student fails to score a minimum of 30% marks in CA of a course, then the result of such a course will be FAIL.
- (d) For both OJT and RP, the CA will be based on grades awarded by guide/mentor while the SEE will be based on presentation/oral/discussion/ any other criterion decided by the departmental committee. Also, for RP, the dissertation will be compulsory.
- (e) If a student fails in a course (with a minimum score of 30% marks in CA), then he/she can improve the performance in CA of a “failed course” in any of the forthcoming semesters in which the course is subsequently conducted and, in this case, the student will have to appear for the SEE at the same time also for the said course.
- (f) Provision of (e) can be availed within the stipulated period as per UGC/SPPU norms.
- (g) The rules/directives issued by the Department/ Savitribai Phule Pune University/Govt. Maharashtra/any other competent authority from time to time will be applicable.

(11) ATKT Rules:

A student who wishes to take admission to the second year (register for third semester) of M. Sc. program must have earned at least 22 credits (50%) from the total credits of two semesters (44 credits) of the first year of M.Sc.

(12) Research Project (ZOO 600 RP & ZOO 650 RP):

Course outcome: Research Project(s) by the student(s) portray the culmination of a study toward the PG degree with a specialization in Zoology/Life Sciences at the Department of Zoology, Savitribai Phule Pune University. This offers an opportunity for the students to apply and demonstrate the knowledge gained from the core courses in Zoology, which ultimately would open the doors of applications and practicality of Zoology, undertake problem(s) identification, and formulation, and devise a mechanism to find an approximate or best-fit solution for it. Also,

a student is adept to take steps to bespeak his/her knowledge gained during the project period and demonstrate it as and when it is required in the professional career.

Procedures and guidelines for the conduct of the Research project:

Students are supposed to register for the course ZOO 600 RP & ZOO 650 RP individually.

- a) A student will carry out the academic activity for the course throughout the semester.
- b) The course is to be completed under the supervision and guidance of a teacher. Each teacher of the Department of Zoology, Savitribai Phule Pune University is expected to guide at least one group of students.
- c) The respective teacher is expected to engage a group of students for at least 4 hours/week for ZOO 600 RP and at least 6 hours/week for ZOO 650 RP.
- d) Every group will submit a dissertation at the end of the semester duly signed by all group members and the respective teacher.

(13) On Job Training (OJT): In this course, the students are expected to do the On-Job Training (OJT) in appropriate Industries/Government sectors/Institute etc. to get hands-on experience. The department may conduct necessary lectures/workshops/seminars as a part of OJT. The course will be conducted as per the guidelines of the Department/the University and the Government of Maharashtra.

(14) Completion of the Degree Program:

- a) In order to qualify for the award of M.Sc. (Zoology) Degree, a student has to earn a minimum 88 credits and also need to complete the compulsory audit courses as prescribed by the University from time to time.
- b) If a student fails in a course, then the said course will not be considered for calculation of SGPA/CGPA and overall grade. Only those courses in which the student has passed will be considered for calculating the SGPA/CGPA and overall grade.
- c) The applicable policies and procedures laid down by SPPU will be followed for the conduct of examinations, evaluations and declaration of the results.

(15) The Departmental Committee in its meeting with the majority may introduce/design additional course(s) and include/exclude/modify the existing course(s) to accommodate the then developments from time to time.

M.Sc. (Zoology) Part I Syllabus

SEMESTER I

Total no. of credits: 22 [Major core (14) + Major elective (4) + RM (4) + OJT/FP (0)]

Major Core Courses		
Code No.	Course Title	Credits
ZOO 501 MJ	Principles of Biochemistry	2C
ZOO 502 MJ	Cell Biology	2C
ZOO 503 MJ	Principles of Development	2C
ZOO 504 MJ	Animal Physiology	2C
ZOO 505 MJ	Entomology	2C
ZOO 506 MJP	Experiments in Biochemistry and Cell Biology- I	2C
ZOO 507 MJP	Experiments in Developmental Biology and Animal Physiology- I	2C
Total		14C

Major Elective Courses (Any Two)		
Code No.	Course Title	Credits
ZOO 511 OE	Fundamentals of Molecular Biology	2C
ZOO 512 OE	Toxicology: Principles and Practices	2C
ZOO 513 MJP	Experiments in Molecular Biology	2C
ZOO 514 MJP	Experiments in Entomology	2C
ZOO 515 MJP	Experiments in Biochemistry and Cell Biology- II	2C
ZOO 516 MJP	Experiments in Developmental Biology and Animal Physiology- II	2C
Total		4C

Other Courses		
Code No.	Course Title	Credits
ZOO 500 RM	Research Methodology	4C

M.Sc. (Zoology) Part I Syllabus

SEMESTER II

Total no. of credits: 22 [Major core (14) + Major elective (4) + RM (0) + OJT/FP (4)]

Major Core Courses		
Code No.	Course Title	Credits
ZOO 551 MJ	General Genetics	2C
ZOO 552 MJ	Biostatistics: Theory and Applications	2C
ZOO 553 MJ	Histology and Histochemistry	2C
ZOO 554 MJ	Analytical Techniques in Biology	2C
ZOO 555 MJ	Applied Entomology	2C
ZOO 556 MJP	Tools and Techniques in Biology - I	2C
ZOO 557 MJP	Experiments in Genetics and Applied Entomology – I	2C
Total		14C

Major Elective Courses (Any Two)		
Code No.	Course Title	Credits
ZOO 561 OE	Fundamentals of Immunology	2C
ZOO 562 OE	Genetic Information Flow and Processing	2C
ZOO 563 MJP	Practicals in Biostatistics	2C
ZOO 564 MJP	Experiments in Immunology	2C
ZOO 565 MJP	Tools and Techniques in Biology - II	2C
Total		4C

Other Courses		
Code No.	Course Title	Credits
ZOO 550 OJT/FP	On Job Training (OJT)/Field Project (FP)	4C

Exit option: 1 year, 2 semesters, PG Diploma (44 credits)

M.Sc. (Zoology) Part II Syllabus

SEMESTER III

Total no. of credits: 22 [Major core (14) + Major elective (4) + RM (0) + OJT/FP (0) + RP (4)]

Major Core Courses		
Course No.	Course Title	Credits
ZOO 601 MJ	Metabolic Pathways	2C
ZOO 602 MJ	Biosystematics and Biodiversity and Conservation	2C
ZOO 603 MJ	General and Comparative Endocrinology	2C
ZOO 604 MJ	Communicable and Non-Communicable Diseases	2C
ZOO 605 MJ	Insect Anatomy and Physiology	2C
ZOO 606 MJP	Experiments in Endocrinology	2C
ZOO 607 MJP	Laboratory and Field Exercises in Biodiversity and systematics	2C
Total		14C

Major Elective Courses (Any Two)		
Course No.	Course Title	Credits
ZOO 611 OE	Regulation of Gene Expression	2C
ZOO 612 OE	Integrated Pest Management	2C
ZOO 613 OE	Advanced Physiology	2C
ZOO 614 OE	Recombinant DNA Technology	2C
ZOO 615 MJP	Experiments in Parasitology and Pathophysiology	2C
ZOO 616 MJP	Advanced Techniques in Molecular Biology	2C
Total		4C

Other Courses		
Course No.	Course Title	Credits
ZOO 600 RP	Research Project	4C

M.Sc. (Zoology) Part II Syllabus

SEMESTER IV

Total no. of credits: 22 [Major core (12) + Major elective (4) + RM (0) + OJT/FP (0) + RP (6)]

Major Core Courses		
Course No.	Course Title	Credits
ZOO 651 MJ	Ethology and Evolution	2C
ZOO 652 MJ	Biology of Reproduction	2C
ZOO 653 MJ	Vertebrate and Invertebrate Embryology	2C
ZOO 654 MJ	Advanced Entomology	2C
ZOO 655 MJP	Image and Data Analysis: Software Applications	2C
ZOO 656 MJP	Laboratory and Field exercises in Ethology, Evolution and Advanced Entomology	2C
Total		12C

Major Elective Courses (Any Two)		
Course No.	Course Title	Credits
ZOO 661 OE	Analytical and Applied Genetics	2C
ZOO 662 OE	Genomics and Proteomics	2C
ZOO 663 OE	Stem Cells, Regenerative Medicine and Cancer	2C
ZOO 664 OE	Bioinformatics: Theory and Applications	2C
Total		4C

Other Courses		
Course No.	Course Title	Credits
ZOO 650 RP	Research Project	6C

2 years, 4 Semesters, PG Degree (88 Credits)

ZOO 501 MJ: Principles of Biochemistry

Course Objectives:

The objective of this course is to provide a thorough knowledge of the core principles and topics of biomolecules and their dynamics that sustain life through diverse functions, providing basic concepts of structure of carbohydrate, lipids, amino-acids, proteins and enzymes, their mechanism of folding and methods to engineer them for various applications. This course will enable students to acquire a specialized knowledge and understanding of the biochemical molecules and their significance in cellular integrity and functions.

Course Outcomes:

Upon completing this course, students will:

- Acquire insights into levels of biomolecule structures – their basic constituents, forces that stabilize the structures, their various modules, and arrangements.
- Learn how biomolecules fold during and following biological function and the consequences of improper folding.
- Acquire insight into enzyme structure-function relationship, learning the significance of protein structures in their ability to perform various functions.
- Get acquainted with different quantitative and methods of isolation of biomolecules.

ZOO 501 MJ: Principles of Biochemistry (2 Credits: 30 Lectures)		
01	Biomolecules: characteristic features: Water, structure of liquid water, water as ideal biological solvent. Problems and concepts related to mole, molarity, normality, buffers etc. Bioenergetics: Laws of thermodynamics, Gibbs free energy and equilibrium constant relationship, entropy, enthalpy, high energy bonds.	5L
02	Amino acids, peptides and polypeptides: Structure of amino acids, peptide linkage and its partial double bond nature, charge on amino acids. Determination of primary structure of polypeptide (N-terminal, C-terminal determination, method of sequencing of peptides). Secondary structures of proteins (α helical and β -pleated structures, turns and loops) Ramachandran plot and its significance. Tertiary and quaternary structures of proteins. Structure of collagen triple helix. Domain – basic unit of tertiary structure.	5L

03	<p>Carbohydrates: Composition, Structure and function of Carbohydrates. Monosaccharides and derivatives of sugars such as sugar alcohols, amino sugars, sugar acids, deoxy sugars. D-series, L-series, dextro, laevo-rotatory, reducing and non-reducing sugars. Asymmetric centre in sugars. Sugar isomers, anomers, epimers. Disaccharides and polyacrylamides, structure and function.</p>	5L
04	<p>Lipids: Classification of lipids according to chemical structure, fatty acids, saturated, unsaturated, branched, nomenclature system. Triacylglycerols, Sphingolipids, Glycerophospholipids, Cholesterol. Properties of Lipid Aggregates: Micelles and Bilayers, Liposomes, Bilayer dynamics. Membrane assembly and protein targeting: Lipid Distributions in Membranes, The Secretory Pathway, Vesicle Formation, Vesicle Fusion, Protein Targeting to Mitochondria.</p>	5L
05	<p>Nucleotides: Structure of bases, nucleosides, nucleotides, phospho-diester linkages, 5' phosphate, 3' hydroxyl polarity of nucleic acids, tautomeric forms of bases and their implication in pairing of bases, structure of DNA (A, B and Z forms), T_m value, detailed structure of tRNA, rRNA, and mRNA.</p>	5L
06	<p>Enzymology: Enzymes as Catalysts: A. Overview--proteins as catalysts, B. Enzyme characteristics and properties, C. Enzyme nomenclature/classification. D. Enzyme Purification and Assay. Activity measurements, enzyme units, turnover number and properties, purification and purity, initial velocity measurements, assay conditions, methods for measurement. Enzyme Kinetics: Reaction kinetic concepts, Michaelis–Menten kinetics, Briggs-Haldane steady-state treatment, Michaelis constant (K_m), specificity constant, graphical analysis. Enzyme inhibition: Classification, competitive, noncompetitive, uncompetitive, Suicide inhibition.</p>	5L

Reference Books:

- Fundamentals of Biochemistry: Life at the Molecular Level 5th Ed. (2016) Donald Voet, Judith G. Voet, Charlotte W. Pratt. Publisher: John Wiley & Sons Inc, New York.
- Biochemistry 9th edition (2019) Lubert Stryer, Jeremy Berg, John Tymoczko, Gregory Gatto Publisher: W. H. Freeman, New York.
- Lehninger Principles of Biochemistry, 8th edition, (2021) David L. Nelson; Michael M. Cox W. H. Freeman, New York.
- Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., Publisher: John Wiley and Sons, New York.

- Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.

ZOO 502 MJ: Cell Biology

Course Objectives:

The objectives of this course are to make students understand the basic concepts of cell biology, the structure, composition and function of plasma membrane in maintaining cell integrity, structure and function of cell organelles in maintaining cell homeostasis and, cell cycle and regulation of growth.

Course Outcomes:

Students will understand the structure, composition and functioning of plasma membrane. Similarly, they will get an in-depth knowledge of the structure and function of different cell organelles. Finally, they will get insights into how the cell cycle is regulated and the consequences of its dysregulation

ZOO 502 MJ: Cell Biology (2 Credits: 30 Lectures)		
01	An overview of cell, cell shapes and types.	2L
02	Plasma membrane and cell surface: Structure, chemistry, receptors, transport, pinocytosis and phagocytosis, cell junctions, membrane potential and synaptic transmission, glycocalyx and cell wall	8L
03	Mitochondria; Structure, function, Respiratory complexes; composition and organization; Components of electron transport chain (ETS) and their organization; Fo-F1 particles and ATP synthesis, Chloroplast – Photosynthesis; energy transduction and photoreduction, PS I and PS II system, cyclic and non-cyclic photophosphorylation, Calvin cycle and its regulation, water-splitting complex.	5L
04	Sub-cellular organelles: (a) Endoplasmic reticulum (smooth and rough), (b) Golgi complex, (c) Lysosomes, (d) Peroxisomes and glyoxysomes, (e) Nucleus	10L
05	Cell cycle: Phases of cell cycle, checkpoints of cell cycle, tools used in studying the cell cycle, regulation of cell cycle: M-phase kinase, its role in the regulation of cell cycle, Role of protein kinases and phosphatases in controlling the activity of M-Phase kinase, Cell cycle inhibitors and their significance, Rb protein and its importance in the regulation of cell cycle	5L

Reference Books:

- *The World of the Cell*, 8th edition (2010), Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin. Publisher-Pearson.
- *Molecular Cell Biology*, 8th edition (2016), Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, Paul Matsudaira. Publisher - W. H. Freeman and Co.
- *Molecular Biology of the Cell*, 7th edition, (2022), Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Publisher - WW Norton & Co.
- *The Cell: A molecular approach* 8th edition (2018). Geoffery M. Cooper Sinauer Associates Inc

ZOO 503 MJ: Principles of Development**Course Objectives:**

Objective of the course is to make students understand basic concepts of development using model systems and their significance in advancing the knowledge in development and differentiation. Similarly, cell-cell interaction including signaling molecules and their significance in cell adhesion, migration, and differentiation, growth and post-embryonic development will be taught. Finally, the role of evolution in development will be taught.

Course Outcomes:

- Students will understand and appreciate the significance of model organisms in advancing the knowledge of developmental biology
- Gain an insight into the role of autocrine, juxtacrine and paracrine signaling molecules and their pathways in regulating cell adhesion, proliferation, cell migration leading to organogenesis.
- Get to know how processes like differentiation, post-embryonic development, apoptosis and aging are regulated at the organismal, cellular and molecular levels.
- Students will understand the significance of evolutionary processes in development

ZOO 503 MJ: Principles of Development (2 Credits: 30 Lectures)		
01	Basic concepts of Developmental Biology: Model systems (Fish, Frog, Chick, Mouse, and <i>Drosophila</i>) and their significance in understanding and advancing development.	5L
02	Types of eggs and cleavage patterns:	5L

	Concepts in Pattern formation, animal vegetal axis, gradients, origin, and specification of germ layers.	
03	Cell–cell interaction and cell signaling: Cell–cell interaction and cell signaling during morphogenesis in the early embryo; gastrulation, neurulation, and primordial organ rudiments, Origin and the fate of neural crest cells.	5L
04	Differentiation: Cellular basis of differentiation, trans-differentiation, metaplasia and regeneration. Stem cells and their role in development	5L
05	Growth and post-embryonic development: Apoptosis: apoptotic pathways; cellular, biochemical, and molecular mechanisms, genetic basis, consequences of dysregulation; Aging and senescence: genetic and epigenetic regulation; molecular mechanisms regulating aging in different groups of animals, theories of aging, insulin signaling and regulation of aging abnormal development.	5L
06	Evolution and development confirmative study.	5L

Reference Books:

- Developmental Biology, XI edition (2016), S.F. Gilbert and Michael J. F. Barresi. Publisher - Sinauer Associates Inc.
- Principles of Development, VI edition (2019), Lewis Wolpert, Cheryll Tickle and Alfonso Martinez Arias, Publisher- Oxford University Press.
- An Introduction to Embryology, 5th edition (2012), B. I. Balinsky. Publisher - Thomas Asia Pvt. Ltd
- Developmental Biology, (2001), R. M. Twyman, Publisher - Bios Scientific Publishers LTD.

ZOO 504 MJ: Animal Physiology

Course Objectives:

The objectives of the course are

- To impart detailed information about the functions of organ systems and tissues in the human body.
- To provide a course of study on physiology, building on the knowledge of basic physiological principles and expanding on some areas touched in earlier levels of study.
- To provide students with a detailed understanding of the fundamental processes and mechanisms that serve and control the body's various physiological functions such as structure and function of muscular system, blood and circulation, respiration, digestion, nervous system, excretion, and osmoregulation.

- To understand how these systems interact to yield integrated physiological responses to challenges and maintain homeostasis in cells/ organs/ system and body.

Course Outcomes:

The students will

- Gain thorough insights into physiology of digestion, muscular system, excretion, respiration, composition of blood and its circulation, excretion and osmoregulation.
- Understand and appreciate the functioning of these systems and integration to maintain a physiological homeostasis.

ZOO 504 MJ: Animal Physiology (2 Credits: 30 Lectures)		
01	<p>DIGESTION: Overview of the Digestive System: Layers of the GI Tract; Neural Innervation Digestion in the mouth: Composition and functions of saliva, Mechanical and chemical digestion in the mouth Digestion in the stomach: Composition and functions of gastric juice, Mechanical and chemical digestion in the stomach. Digestion in the intestine: Composition and functions of pancreatic juice, Role and composition of bile, Role of Intestinal Juice and Brush-Border Enzymes, Mechanical and chemical digestion in the intestine, Digestion of Carbohydrates, Proteins, Lipids, Nucleic Acids Absorption:</p>	4L
02	<p>RESPIRATION: Respiratory System: Trachea, Bronchi, Lungs, Lobes, Fissures, Lobules & Alveoli, Blood Supply to the Lungs Pulmonary Ventilation: Pressure changes during pulmonary ventilation, Inhalation, exhalation Factors affecting Pulmonary ventilation, Surface tension of alveolar fluid, Lung Volume and Capacity; Exchange of Oxygen and Carbon Dioxide: Gas Laws, External and Internal Respiration; Transport of Oxygen and Carbon Dioxide: Oxygen Transport, Relationship Between Haemoglobin and Oxygen Partial Pressure, Factors Affecting the Affinity of Haemoglobin for Oxygen, Carbon Dioxide Transport. Gas Exchange and Transport in Lungs and Tissues; Control of Respiration: Respiratory Centre</p>	4L
03	<p>CIRCULATION: Anatomy of the Heart: Location, Layers of the Heart, Chambers of the Heart, Fibrous Skeleton of the Heart. Heart Valves and Circulation of Blood: Operation of the heart valves; Systemic and Pulmonary Circulations.</p>	4L

	Cardiac Muscle Tissue and the Cardiac Conduction System.; The Cardiac Cycle: Pressure and Volume Changes During the Cardiac Cycle; Heart Sounds; Cardiac Output; Regulation of heart rate	
04	MUSCLE PHYSIOLOGY: Types of skeletal muscle fibers, microanatomy of skeletal muscle, transmission of impulse across neuromuscular junction, sarcotubular system, role of calcium in contraction, Molecular mechanism of muscle contraction: The Contraction Cycle, Excitation–Contraction Coupling Calcium receptors, Calmodulin and calcium pump, muscle metabolism, proteins of sarcomere, Control of Muscle Tension, Types of contraction- isotonic and isometric contraction. Sliding filament theory of muscle contraction, Microscopic Anatomy of smooth and cardiac muscle	5L
05	OSMOREGULATION: Osmolarity, ionic composition in ECF and ICF, Osmoregulatory challenges and osmoregulation in freshwater, marine and terrestrial animals, role of chloride cells in osmoregulation of marine and freshwater teleosts, extreme regulators, osmoregulation in marine air breathing animals, salt glands in marine birds, nitrogenous wastes	4L
06	EXCRETION: Anatomy and Histology of Kidneys, Blood and Nerve supply, Structure of Nephron, Glomerular Filtration: The Filtration Membrane, Net Filtration Pressure, Glomerular Filtration Rate, regulation of GFR; Tubular Reabsorption & Secretion: Reabsorption Routes, Transport Mechanisms Regulation of Tubular Reabsorption and Tubular Secretion, Countercurrent Multiplication, Countercurrent Exchange, Urea cycle, Formation of Urine	4L
07	NERVE PHYSIOLOGY: Neurons: Structure of a neuron, structural diversity, Classification, Neuroglia of central (CNS) & Peripheral nervous systems (PNS) Organization of the Nervous System: CNS & PNS Electrical Signals in Neurons: Ion Channels, Resting Membrane Potential, Graded Potentials, Generation of Action Potentials, Depolarizing & Repolarizing Phases, After-hyperpolarizing Phase, Refractory Period. Propagation of Action Potentials: Continuous and Saltatory Conduction, Factors affecting Speed of Propagation Signal Transmission at Synapses: Electrical & Chemical synapses, Excitatory and Inhibitory Postsynaptic potentials, Neurotransmitter receptors: Ionotropic & Metabotropic receptors. Removal of Neurotransmitter, Spatial and Temporal Summation of Postsynaptic potentials, Axonal transport.	5L

Reference Books:

- *Principles of Animal Physiology*, 3rd edition (2015), C. D. Moyes and P. M. Schulte. Publisher - Pearson Education Inc.

- *Textbook of Medical Physiology* 13th edition (2015). A. C. Guyton and J. E. Hall. Publisher - W. B. Saunders Company, Philadelphia.
- *Principles of Anatomy and Physiology*, 16th edition (2020), G. J. Tortora and B. Derrickson. Publisher-John Wiley and Sons Inc.
- *The World of the Cell*, 8th edition, (2012), Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin., Publisher - Benjamin Cummings.

ZOO 505 MJ: Entomology

Course Objectives:

This course aims to familiarize students with the world of insects, their significance as a component of the ecosystem. The course examines the structure of insects, their development and function, and introduction to pertinent insect physiology, ecology, and behaviour. The course summarizes the systematic study of insect orders and their identification in addition to imparting in depth knowledge of their biology.

Course Outcomes:

The students will learn the following information during the course:

- Introduction and history of Entomology
- Nomenclature and classification of Insects
- Insect orders and identification of Insects
- Insect Internal organ system
- How insect show perception to various senses

ZOO 505 MJ: Entomology (2 Credits: 30 Lectures)		
01	Scope and importance of entomology	2L
02	Development of Insect (generalized insect), metamorphosis	2L
03	Taxonomy of insects up to family level	8L
04	Study of morphological features a. Head and its appendages b. Thorax and its appendages	6L

	c. Abdomen and its genitalia	
05	Collection, preservation and presentation of insects, rearing of insects	2L
06	Internal organ systems: Digestive, nervous, circulatory, respiratory and reproductive systems	6L
07	Sense organs and chemoreception	4L

Reference Books:

- *The insect structure and function*, 5th Edition (2012). Chapman, R.F. Publisher- Cambridge University Press London.
- *The Principles of Insect Physiology*, 7th edition (2012) Wigglesworth, V.B. Publisher- English Language Book Society and Methuen and Co. Ltd.
- *Physiological Systems in Insects*, 4th Edition (2022). Klowden, M. J. Publisher- Academic Press, New York.
- *Principles of Insect Morphology*, (2011). Snodgrass, R.E. Publisher- Tata McGraw Hill, Bombay.
- *The Insects: Structure, Function and Biodiversity*, (2015). Ambrose, D.P. Publisher- Kalyani Publishers, New Delhi.
- *The Science of Entomology*. 2nd edition (1998). Romoser, W. S. Publisher-MacMillan, New York.
- *General and Applied Entomology*. 2nd edition (2015). David, B. V. and Ananthakrishnan, T. N. Publisher- Tata McGraw Hill, New Delhi.
- *Arthropod Phylogeny with special reference to insects*, (1987). Boudreaux, H. B. Publisher- John Willey and Sons New York.
- *The Insects: An Outline of Entomology*, by P. J. Gullan (Author), P. S. Cranston, 5th edition (17 October 2014) Publisher-Wiley-Blackwell.

ZOO 506 MJP: Experiments in Biochemistry and Cell Biology-I

Course Objectives:

The course provides students with fundamental tools used in practical settings. Through this, students will gain the confidence, interest, and discipline needed to succeed in biochemistry practicals such as estimations of micro and macromolecules, enzyme kinetics, buffer preparations etc. The course will also provide hands-on training about the tools used in isolating different cell organelles and study and functions. Similarly, students will be trained in techniques used to study cell division and its mechanism

Course Outcomes:

Upon finishing the course, students will have the ability to:

- Operate basic laboratory equipment for conducting experiments.
- Perform calculations based on experimental results of enzyme kinetics and buffer preparations.
- Comprehend acid-base reactions and their importance in the life system.
- Recognize the significance of adhering to safety protocols during practical sessions.
- Estimations of biomolecules such as proteins, sugars, nucleic acids etc.
- Students will gain insights into the technical aspects of subcellular fractionation and its utility in understanding the functional aspects of cell organelles, understand the ultrastructure of cell organelles

ZOO 506 MJP: Experiments in Biochemistry and Cell Biology-I (2 Credits: 30 Hours)		
01	Preparation of Acid & Alkali solutions and acid-base titration.	1P
02	Concept of pH. Measuring pH of different solutions	1P
03	Preparation of buffers: Acetate, Phosphate and Tris buffers	2P
04	Estimation of inorganic phosphate	1P
05	Estimation of sugar (glucose)	1P
06	Study of enzyme kinetics (K_m and V_{max} determination)	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be taken.	
01	Distinction between Prokaryotic and Eukaryotic cells using different staining	2P
02	Subcellular fractionation: nuclei, mitochondria cytosol & assaying functional identification of mitochondria.	2P
03	Mitosis: Effect of colchicine on mitosis and polyploidy.	1P
04	Preparation of blood smears: Cell type identification and differential counts.	1P
05	To determine osmotic fragility using erythrocytes	1P
06	Determination of oxidative and reductive states of hemoglobin	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be taken.	

ZOO 507 MJP: Experiments in Developmental Biology and Animal Physiology-I

Course Objectives:

The objectives of the course are

- To help students acquire various basic laboratory techniques in physiology
- To develop powers of observation and data recording to assess physiological principles.
- To develop analytical and writing skills by conducting experiments and presenting them in a formal laboratory report format.
- To understand the pathophysiology of various systems learned in the theory of animal physiology.

Course Outcomes:

Upon completing this course, students can:

- Apply various laboratory techniques in understanding the physiology of different systems.
- Set up and use precision equipment to study physiological phenomena.
- Critically observe, qualitatively and quantitatively analyze, and apply knowledge to interpret experimental data.
- Write formal laboratory reports in a scientific format.
- Work and coordinate effectively in a group to accomplish laboratory-based tasks.
- Follow ethical laboratory practices such as safety and environmental protection.
- Evaluate and design laboratory experiments, interpret experimental data and write up the results in accordance with appropriate scientific conventions.
- Understanding of the pathophysiology of various systems learned in the theory of animal physiology based on the data acquired during experiments.

ZOO 507 MJP: Experiments in Developmental Biology and Animal Physiology-I (2 Credits: 30 Hours)		
01	Patterns of cleavages in starfish, <i>Amphioxus</i> , <i>Onepidula</i> , insects (slides)	1P
02	Study of embryonic and post-embryonic development using frog egg as a model system.	2P
03	Study of embryonic development using chick as model system (Gross anatomy of chick embryos till 96 h)	2P
03	Harvesting of chick embryos using filter paper ring preparation of permanent mounts	2P
04	Zebra fish as model system in studying development	

	* From the above list, any 5 practicals (equivalent to 15H) will be conducted	
01	Determination of Glomerular Filtration Rate by creatinine clearance in vertebrates	1P
02	Determination the effect of salinity on oxygen consumption of crab/fish	1P
03	Study of skeletal mass	1P
04	Study the structural and physiological abnormalities of heart by electrocardiogram / echocardiogram	1P
05	Separation and identification of pathophysiological proteins	1P
06	Effect of chemicals/ hormones on excretion	1P
07	Estimation of cholesterol in blood	1P
08	Study of structural components of animal house and their utility	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be conducted	

ZOO 511 OE: Fundamentals of Molecular Biology

Course Objectives:

The objective is to offer detailed knowledge of gene and genome structure and organization. The basic concepts of replication, recombination, and transposition of genes in the genome will be taught.

Course Outcomes:

- Students will learn the basic features of chromosomes and their assembly.
- Students will understand the mechanism of DNA replication (prokaryotes and eukaryotes), the enzymes involved in the replication process, significance of the Replisome and Primosome, and the assembly of Nucleosome after replication.
- The molecular mechanism of homologous recombination and the proposed models will be understood. Concept of strand invasion, Heteroduplex DNA, Holliday Junction, Branch migration and resolution, Proteins involved in recombination, Gene conversion and site-specific Recombination
- Different classes of transposable elements in prokaryotes and eukaryotes will be known.
- Students will learn the sources and basic mechanism of DNA damage and repair

	ZOO 511 OE: Fundamentals of Molecular Biology (2 Credits: 30 Lectures)	
--	---	--

01	<p>Genome organization: C value paradox and genome size, Cot curves, repetitive and non-repetitive DNA sequence, Pseudogenes, Gene families, Gene clusters, Super-families, Organelle genome Structure of chromatin, nucleosome, chromatin organization and remodeling, higher order organization - chromosome, centromere, telomere Histone and its effect on structure and function of chromatin</p>	12L
02	<p>DNA Replication: DNA replication in <i>E. coli</i>, Origin of replication, types of <i>E. coli</i> DNA polymerases, details of replication process, regulation of replication, the connection of replication to cell cycle. Different replication models for linear and circular DNA, replication features of single-stranded phages. Eukaryotic DNA replication, multiple replicons, eukaryotic DNA polymerases, ARS in yeast, Origin Recognition Complex (ORC), regulation of replication</p>	4L
03	<p>DNA Damage and Repair: Different types in DNA damages, Different DNA repair systems: Nucleotide excision repair, Base excision repair, mismatch repair, recombination repair, Double-strand break repair, transcriptional coupled repair</p>	4L
04	<p>Recombination: Homologous and site-specific recombination models for homologous recombination: The Holliday model, double-strand break repair model. Proteins involved in recombination: RecA, Ruv A, B, C Gene conversion.</p>	5L
05	<p>Mobile DNA elements: Transposable elements in bacteria, IS elements, composite transposons, replicative, non-replicative transposons, Mu transposition, Controlling elements in Tn A and Tn 10 transposition, SINES and LINES. Retroviruses and retrotransposon</p>	5L

Reference books:

- Molecular Biology of the gene, 7th edition (2013), James D Watson, Pearson publication.
- Gene XII, Benjamin Lewin, 12th edition (2017), Jones and Bartlett Publishers.
- Molecular Biology of the Cell, 7th edition (2015), Bruce Alberts, Rebecca Heald, Alexander D. Johnson, David Morgan, Martin C. Raff, et.al. Garland Science, Taylor and Francis Group.
- Molecular Cell Biology, 6th edition (2007), Lodish Berk, Matsudaira, Kaiser, Krleger. W.H. Freeman & Company, New York.
- Fundamentals of Molecular Biology, (2009): J.K. Pal, S. Ghaskadbi; Oxford University Press India.

ZOO 512 OE: Toxicology: Principles and Practices

Course Objectives:

The toxicology course encompasses many toxic agents. The focus is on detection, measurement and detoxification of harmful toxins.

Course Outcomes:

During the course the students will learn about dose-response relationships, how chemicals enter the body, how they are metabolized, and how they are eliminated from the body are some of the fundamental concepts of toxicology. Other fundamental principles include the fundamentals of physiology, toxicokinetics, and cellular toxicology.

ZOO 512 OE: Toxicology: Principles and Practices (2 Credits: 30 Lectures)		
01	Definition, history, scope & sub-divisions of toxicology.	1L
02	Dose-effect and dose-response relationship- acute toxicity, chronic toxicity reversible & irreversible effects.	2L
03	Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins.	3L
04	Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms.	4L
05	Absorption and distribution of toxicants- portals of entry- skin, gastrointestinal tract, gills and respiratory system. Bio-distribution, biomagnification biotransformation of xenobiotics- Introduction to Phase-I and Phase-II reactions.	10L
06	Genetic Toxicology: Mutagenic agents in environment & application of genetic toxicology to human & environmental monitoring, screening of chemicals for genotoxic potential and common assays for testing mutagenicity using microbes and animals; Mutagenicity screening methods using animal models	10L

Reference Books:

- The Dose Makes the Poison: A Plain-Language Guide to Toxicology 3rd edition (2011). Patricia Frank and M Alice Ottoboni, Wiley.
- Pharmacotherapy Handbook (India Special edition) 11th edition (2021). Joseph T. DiPiro, Gary C. Yee, L. Michael Posey, Stuart T. Haines, & 2 More. McGraw Hill Medical
- Casarett & Doull's Toxicology: The Basic Science of Poisons, 9th edition (2018) Editor -Curtis D. Klaassen, The McGraw-Hill Companies

- Essentials of Toxicology, 4th edition (2021) A & L LANGESERIES) 2021
- Barile's Clinical Toxicology: Principles and Mechanisms. 3rd edition (2019) Frank A. Barile. CBS Publishers & Distributors Pvt. Led. New Delhi.
- Principles of Genetic Toxicology, 2nd edition (1987), David Brusick, Publisher-Plenum press.

ZOO 513 MJP: Experiments in Molecular Biology

Course Objectives:

This practical course offers hands-on training in various molecular techniques and their applications in the isolation/extraction of DNA/protein from prokaryotic/eukaryotic cells to the students.

Course Outcomes:

Upon completing this course, students can

- understand hypo- hyperchromic effect using spectrophotometric analysis of nucleotides.
- isolate Bacterial/ eukaryotic DNA from the given sample and quantify it
- extract and quantify Proteins from given samples
- have hands-on experience with agarose and polyacrylamide gel electrophoresis

ZOO 513 MJP: Experiments in Molecular Biology (2 Credits: 30 Hours)		
01	Spectrophotometric analysis of nucleotides and amino acids.	2P
02	Extraction of DNA from bacterial/animal cells.	2P
03	Quality & quantity estimation of DNA by agarose gel electrophoresis and Nanodrop	1P
04	Demonstration of plasmid DNA in <i>E. coli</i> .	1P
05	Restriction Endonuclease digestion and mapping.	2P
06	Protein gel electrophoresis a) SDS-Polyacrylamide gel electrophoresis. b) Native Polyacrylamide gel electrophoresis.	2P
* From the above list, any 6 practicals of 5 h each (equivalent to 30H) will be conducted		

ZOO 515 MJP: Experiments in Biochemistry and Cell Biology-II

Course Objectives:

The aim of the basic biochemistry laboratory is to familiarize students with the fundamental tools used in practical settings. Through this, students will gain the confidence, interest, and discipline needed to succeed in biochemistry practicals. This course also provides an overview of cell biology techniques. The course will also provide hands-on training about the tools used in isolating different cell organelles and study and functions. Similarly, students will be trained in techniques used to study cell division and its mechanism

Course Outcomes:

Upon finishing the course, students will have the ability to:

- Operate basic laboratory equipment for conducting experiments.
- Perform calculations based on experimental results.
- Comprehend acid-base reactions.
- Recognize the significance of adhering to safety protocols during practical sessions.
- Create solutions and reagents.
- To estimate inorganic phosphate sugar (glucose) Amino acid (Tyrosine), Nitrogenous Base (Guanine)
- Students will gain insights into the technical aspects of subcellular fractionation and its utility in understanding the functional aspects of cell organelles, and understand the ultrastructure of cell organelles.

ZOO 515 MJP: Experiments in Biochemistry and Cell Biology-II (2 Credits: 30 Hours)		
01	Estimation of Base (Guanine)	1P
02	Estimation of Amino acid (Tyrosine)	1P
03	Estimation of inorganic phosphate	1P
04	Determination of Blue value of Starch	1P
05	Estimation of Proteins	1P
06	Estimation of nucleic acids (DNA)	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted		
01	Study of Phagocytosis / Pinocytosis.	2P

02	Electron micrographs – interpretation of cellular ultrastructure	1P
03	Determination of cell viability by vital staining	1P
04	To study lipid solubility of membranes.	1P
05	Study of meiosis I & II using grasshopper testes	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted		

ZOO 514 MJP: Experiments in Entomology

Course Objectives:

This course offers detailed knowledge of anatomical modifications of the insect body. This will help students to understand how these structural modifications help the insect to survive and perform various functions in their habitat.

Course Outcomes:

After successfully finishing this course, students will have authentic training of handling and dissecting various insects' body regions to understand their structural modifications among various orders. Students can also identify insect orders based on their morphological parameters.

	ZOO 514 MJP: Experiments in Entomology (2 Credits: 30 Hours)	
01	Study of head sclerites and mouth parts in insects	1P
02	Study of insect segmentation, various tagmata, and their appendages.	1P
03	Observation of permanent mounts of different body parts/organs and their taxonomic importance.	1P
04	Rearing and preservation of insects.	1P
05	Study of symbionts from insects.	1P
06	Study of sting apparatus and legs in honeybees.	1P
07	Study of different types of wings and insects	1P
08	Field visits to identify insects of different orders using taxonomic keys.	1P
09	Structural and functional characterization of insect midgut.	2P
10	Identification of flight muscle mitochondria	1P
* From the above list, any 5 practicals (equivalent to 15H) will be taken.		

ZOO 516 MJP: Experiments in Developmental Biology and Animal Physiology-II

Course Objectives:

The course's objectives are

- To help students acquire various basic laboratory techniques in physiology
- To develop powers of observation and data recording to assess physiological principles.
- To develop analytical and writing skills by conducting experiments and presenting them in a formal laboratory report format.
- To understand the pathophysiology of various systems learned in the theory of animal physiology.

Course Outcomes:

Upon completing this course, students can:

- Apply various laboratory techniques in understanding the physiology of different systems.
- Set up and use precision equipment to study physiological phenomena.
- Critically observe, qualitatively and quantitatively analyze, and apply knowledge to interpret experimental data.
- Write formal laboratory reports in a scientific format.
- Work and coordinate effectively in a group to accomplish laboratory-based tasks.
- Follow ethical laboratory practices such as safety and environmental protection.
- Evaluate and design laboratory experiments, interpret experimental data and write up the results in accordance with appropriate scientific conventions.
- Understanding of the pathophysiology of various systems learned in the theory of animal physiology based on the data acquired during experiments.

ZOO 516 MJP: Experiments in Developmental Biology and Animal Physiology-II (2 Credits: 30 Hours)		
01	Gross anatomy and histology of chick embryos till 96 h (Slides)	2P
02	Experiments in regeneration in Hydra or Planaria.	1P
03	Study of cell death during limb morphogenesis in chick embryo.	1P
05	Effect of thyroxin on development and metamorphosis of amphibian tadpoles	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be conducted	
01	Body size and oxygen consumption in aquatic animals (crab/fish).	1P
02	Study of nitrogenous waste products of animals from different habitats.	1P
03	Study of the cardiac cycle of frogs and its response to temperature.	1P

04	Effect of salinity on oxygen consumption of crab.	1P
05	Effect of exercise on heart rate and lactic acid in human blood.	1P
06	Estimation of Chloride content of the crab blood.	1P
07	Effect of starvation on liver and muscle glycogen of mouse.	1P
08	Effect of adrenaline on liver and muscle glycogen of mouse.	1P
09	Measurement of tidal volume and vital capacity.	1P
10	Induction of diabetes in mouse.	1P
11	Lipid profile in vertebrates.	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be conducted	

ZOO 500 RM: Research Methodology

Course Objectives:

- To know about the research perspective in Zoology
- To understand the research hypothesis formulation and testing
- To develop writing skills in scientific communications
- To Provides students the systematic Structure of research and research methodology
- To enhance the research quality in future research generation
- To help students to formulate research problems, derive better solutions and inculcate logical and systematic thinking
- To understand significance of scientific programs in Zoology

Course Outcomes:

Students would learn

- The procedure or plan of action for conducting research. Students will have the skills and technical ability to formulate hypotheses, design and run experiments using instruments to test their hypotheses, and analyze and interpret the results
- The tools and techniques to collect, analyze, and interpret the data to find solutions.
- The accurate sources from where data should be extracted for studying, thereby improving the quality of research.
- To develop a better understanding of the research problem. Students will have the knowledge base and intellectual framework to use reasoning and problem-solving skills to read critically, evaluate support for competing hypotheses, and critique experimental design.
- To develop the logical thinking ability of individuals.
- To present the research findings in a proper format. Students can communicate biological ideas from literature or their laboratory investigations to audiences of biologists and non-biologists in various formats, including written reports, posters, and oral presentations.

- The ethical values in research and Biosafety measures to be observed during research. Students will recognize the importance of scientific integrity and ethical research and applications of biology to science policy

ZOO 500 RM: Research Methodology (2 Credits: 30 Lectures)		
01	Foundation of Research	3L
02	Defining Research Problem	2L
03	Literature survey, Bibliography and Scientism databases	5L
04	Research Design and Estimation	3L
05	Sampling Design	4L
06	Measurement and Scaling	3L
07	Data Collection, Analysis and Presentation	10L
08	Manuscript writing and research publications.	5L
09	Research ethics, animal ethics and human ethics	4L
10	Intellectual property rights and patents	3L
11	Scientific presentations	3L
12	Research paper presentations	15L

Reference Books.

- John W. Creswell (2014) Research Design: Qualitative, Quantitative and Mixed Methods Approaches 4th Edition, SAGE Publications
- Sharan B. Merriam and Elizabeth J. Tisdell (2015) Qualitative Research: A Guide to Design and Implementation 4th Edition, John Wiley & Sons publications
- Wayne C. Booth, Gregory G. Colomb and Joseph M. Williams (2008) The Craft of Research, Third Edition (Chicago Guides to Writing, Editing, and Publishing) Third Edition, University Of Chicago Press.
- William M. K. Trochim and James P. Donnelly (2006) The Research Methods Knowledge Base, 3rd Edition 3rd Edition, Atomic Dog publication
- John W. Creswell (2012) Qualitative Inquiry and Research Design: Choosing Among Five Approaches Third Edition, SAGE Publications, Inc; Third edition
- Judith Bell (2010) Doing Your Research Project (Open Up Study Skills) Fifth (5th) Edition
- Uwe Flick (2015) Introducing Research Methodology: A Beginner's Guide to Doing a Research Project Second Edition, SAGE Publications Ltd.

- O'Leary and Zina (2009) *The Essential Guide to Doing Your Research Project 2nd*. SAGE Publications Ltd.
- Louis Cohen, Lawrence Manion and Keith Morrison (2011) *Research Methods in Education 7th Edition*. Routledge Publication
- Norman K. Denzin and Yvonna S. Lincoln (2011) *The SAGE Handbook of Qualitative Research Fourth Edition*, SAGE Publications, Inc.
- Yvonna S. Lincoln and Egon Guba (1985) *Naturalistic Inquiry First Edition*. SAGE Publications
- Michael J Crotty (1998) *The Foundations of Social Research: Meaning and Perspective in the Research Process First Edition*. SAGE Publications Ltd
- Fred C. Lunenburg and Beverly J Irby (2007) *Writing a Successful Thesis or Dissertation: Tips and Strategies for Students in the Social and Behavioral Sciences 1st Edition*. CorwinPublisher.
- Carol Roberts and Laura Hyatt (2018) *The Dissertation Journey: A Practical and Comprehensive Guide to Planning, Writing, and Defending Your Dissertation Third Edition* Corwin Publisher.
- Elizabeth A. Wentz (2013) *How to Design, Write, and Present a Successful Dissertation Proposal 1st Edition*. SAGE Publications, Inc.
- Joshua O. Miluwi & Hina Rashid (2015) *Research methodology, principles, methods & practices*. Mangalam Publications Delhi

ZOO 551 MJ: General Genetics

Course Objectives:

The objective is to offer detailed knowledge of Mendelian and non-Mendelian (Linkage and cytoplasmic) inheritance patterns. Basic concepts of population and microbial genetics and gene mapping will be taught.

Course Outcomes:

- Students will learn about inheritance patterns and genome mapping.
- Students will understand the effect of genetic and environmental factors on the inheritance of traits
- Students will learn how multiple allele genes are inherited.

ZOO 551 MJ: General Genetics (2 Credits: 30 Lectures)		
01	Review of Mendelian & Non-Mendelian Inheritance: Mono/dihybrid inheritance, types of dominance, multiple allelism, Pleiotropy, epistasis, inheritance related to sex, probability and exercises for solving genetics problems.	5L
02	Quantitative Genetics: Polygenic traits and mode of inheritance, analysis of variation: genetic and environmental factors, Heritability, Inbreeding and consequences, Coefficient of inbreeding and consanguinity.	5L
03	Linkage and mapping in eukaryotes: Detection of linkages, construction of linkage maps in diploids and their characteristics, Coefficient of Coincidence, Outline of other mapping techniques.	5L
04	Cytogenetics: Variation in chromosomal structure and number and genetic consequences	2L
05	Cytoplasmic inheritance:	3L
06	Microbial Genetics: Recombination in bacteria and gene mapping, Transformation, Conjugation, Transduction (Generalized and Specialized), Fine structure mapping of genes, General principles and genetics of (a) bacteriophages (T-even and T-odd) (b) RNA phage c) Mu and transposons	5L
07	Population Genetics: Basic concepts, terminologies, Hardy-Weinberg principles and applications, Changes in allelic frequencies, Exercises for solving population genetics problems.	5L

Reference Books:

- *Concepts of Genetics*, 11th edition (2019), William S. Klug, Michael R. Cummings, Charlotte Spencer, and Michael A. Palladino, Publisher-Benjamin Cummings
- *Genes XII*, 12th edition (2017), Benjamin Lewin, Publisher-Jones and Bartlett Publishers Inc.
- *Principles of Genetics*, 6th edition, (2011), Snustad D. Peter and Simmons J. Micheal, Publisher - John Wiley and Sons. Inc.
- *Principles of Genetics*, 8th edition (2006), Eldon J. Gardner, D.P. Snustad, M.J. Simmons, and D. Peter Snustad Publisher-John Wiley and Sons. Inc.
- *Microbial Genetics*, (1990), David Freifelder, Publisher-Jones & Bartlett
- *Genetics*, 3rd edition, Monroe W. Strickberger, (2015), Publisher - Macmillan Publishing Co.

ZOO 552 MJ: Biostatistics: Theory and Applications

Course Objectives:

The objectives are to impart in depth knowledge about different statistical tools (both descriptive and inferential) and their utility in representation, description and analysis of biological data.

Course Outcomes:

Students will become thorough with the theory and practice of various statistical tools such as sampling, description and presentation of biological data in addition to the use of inferential statistics in the analysis of data.

ZOO 552 MJ: Biostatistics: Theory and Applications (2 Credits: 30 Lectures)		
01	Introduction to Biostatistics: Importance of statistics in biology, samples and populations, variables in biology, Accuracy and Precision. Collection and Condensation of data, types of biological data and tabular and graphical representation of the data (graphs like Histogram/Ogive curve/frequency curve etc.).	5L
02	Descriptive Statistics: Measures of central tendency: Mean, Mode, Median. Concept of variation, Measures of variation such as variance, standard deviation, and coefficient of variation.	5L
03	Introduction to Probability Distribution:	5L

	<p>Elements of probability, Definition, relative frequency approach.</p> <p>Binomial and Poisson distribution</p> <p>Normal Distribution: frequency distributions of continuous variables, properties of normal distribution, applications of normal distribution, fitting a normal distribution to observed data</p>	
04	<p>Regression and Correlation Analysis, Curve Fitting:</p> <p>Pearson's correlation coefficient, regression coefficient and regression line equation, Spearman's correlation coefficient, hypothesis testing and 95 % CI of Pearson's correlation coefficient.</p>	5L
05	<p>Statistical Hypothesis Testing:</p> <p>Tests of simple hypothesis using normal and t-distribution, Types of errors</p> <p>Tests of significance: Parametric and non-parametric tests</p> <p>t-tests (One sample t-test, Two sample t-test, Paired t-test)</p> <p>Chi-square test for goodness of fit</p> <p>F-test for comparing variance, One-way ANOVA</p> <p>Mann-Whitney test, Kruskal- Wallis test</p>	10L

Reference Books:

- *Biometry*. 3rd edition (2001). R. R. Sokal and F. J. Rohlf. W. H. Publisher-Freeman and Company.
- *Introduction to Biostatistics* 2nd edition (2009). F. J. Rohlf, Mathematics and R. R. Sokal
Dover Publications Inc
- *Biostatistical analysis*. 5th edition (2014). J. H. Zar. Publisher-Pearson Education India.
- *Design* 2nd edition (1980). G. M. Clarke. Publisher-Edward Arnold Ltd.
- *Statistical Methods in Biology* 1st edition (2015). S.J. Welham, S.A. Gezan, S.J. Clark, A. Mead
Publisher-Chapman and Hall.
- *Biostatistics: A foundation for analysis in Health Sciences*. 11th edition (2018). W. W. Daniel and
Chad L Cross. Publisher-John Wiley & Sons.
- *Introduction to Biostatistics and Research Methods*, 5th edition (2012) P.S.S. *Sundar Rao* and J.
Richard, Publisher- PHI Learning Pvt. Ltd.

ZOO 553 MJ: Histology and Histochemistry

Course Objectives:

The objectives are to make students understand how to use different histological and histochemical procedures to understand the structure and functioning of different types of tissues and how these histochemical and biochemical parameters change in histopathology

Course Outcomes:

- Explain the method of tissue preparation for histological examination.
- Outline the principles of histochemistry and immunohistochemistry.
- Describe the function of the different types of microscopy utilized in histology.

ZOO 553 MJ: Histology and Histochemistry (2 Credits: 30 Lectures)		
01	Fundamentals of histology: Epithelial, connective, muscular, nervous and other specialized tissues.	5L
02	Tools in histology: Principles, design and functioning of microtomes, automated microtomes, ultramicrotome, cryostat, problems and troubleshooting	3L
03	Techniques in histology: Sample preparation, obtaining tissue samples, handling reagents, fixatives, processing of fixed samples, dehydration, embedding, block making, staining, dyes and dye-binding reactive groups, mordants and mordanting	7L
04	Histochemical principles: Principles of chemical reactions used in histochemistry and cytochemistry, detection of carbohydrates, lipids and nucleic acids, proteins, hydrolytic and oxidative enzymes, Use of inhibitors, detection and localization of calcium.	7L
05	Cytochemistry and quantitation: Cytochemical detection techniques, principles and technique of autoradiography, cytophotometry, microspectrophotometry, and other morphometric methods.	5L
06	Histopathology: Principles, techniques and applications	3L

Reference Books:

- Histochemistry in focus: A source Book of techniques and research needs. (2019), K. Shyamasundari and K. Hanumantha Rao. Publisher - M. J. P. Publishers Chennai, India
- Histochemistry (Vol I–III). 4th Edition (1991), Stoward, P. J. & Pearse, A. G. E. Publisher – Churchill Livingstone Edinburgh, London

- Histological and Histochemical methods: Theory and Practice. 5th edition (2015), J. A. Kiernan Publisher – Scion Publishing Ltd. Oxfordshire.
- Colour Atlas of Histology. 3rd edition (2000). L. P. Gartner and J. L. Hiatt Publisher – Lippincott-Williams & Wilkins, Baltimore.
- Histology: A textbook and Atlas. 2nd edition (1989). M. H. Ross, E. J. Reith and L. J. Romrell Publisher - Williams & Wilkins, Baltimore.

ZOO 554 MJ: Analytical Techniques in Biology

Course Objectives:

This course offers detailed knowledge of various analytical techniques used in modern biology. This will help students to understand and design various experiments.

Course Outcomes:

The course combines lectures with corresponding laboratory experiments to make students competent with common laboratory procedures. After completing the course, students can:

- Understand the principle of light, fluorescence, scanning, and transmission electron microscope.
- Understand the principle of centrifugation, various types of Centrifugation, rotors, and their applications
- Understand the principle and differences between various chromatography techniques
- Know about agarose and polyacrylamide gel electrophoresis.
- Students will learn different quantitative and isolating methods of biomolecules.

ZOO 554 MJ: Analytical Techniques in Biology (2 Credits: 30 Lectures)		
01	Fundamentals of optical microscopy: Introduction to optics scales of magnification & limits of resolution, microscope designs and types, imaging components and image formation. Abbe's theory of microscopic resolution. Microscopic aberrations and remedial lens system	2L
02	Contrast in Microscopy: Fundamentals of contrast modulation in bright-field and dark-field, Concept of phase differences, Phase contrast microscopy, Differential Interference contrast (Nomarsky) microscopy, Polarizing microscopy and Birefringence. Video enhanced contrast microscopy, Applications	2L
03	Fluorescence Microscopy: Principle of Fluorescence, Fluorescent dyes, Conventional Fluorescence Microscopy and imaging, Confocal imaging, Specialized Fluorescence imaging and applications	2L
04	Electron Microscopy and Scanning probe microscopy techniques: Principles, Transmission Electron microscope, Scanning Electron Microscope, Specialized Electron microscopes (STEM, HVEM, Cryoelectronic microscopy etc.), Scanning Tunneling Microscopes, Atomic Force Microscopes, New generation advanced probe microscopes	2L

05	Microscopic image documentation: Photomicrography, Microscopic image acquisition, documentation, and analysis techniques, Advanced imaging techniques of Biomedical applications.	2L
06	Chromatography: Principles, Adsorption chromatography, Partition chromatography, Ion-exchange chromatography, affinity chromatography, Molecular exclusion chromatography, thin layer chromatography, HPLC, FPLC, selection of chromatographic system.	4L
07	Spectrophotometry: Principles, UV-visible light spectroscopy, Spectrofluorimetry, Infrared and Raman spectroscopy, Nuclear magnetic resonance spectroscopy, Applications in biology	4L
09	Immunological Techniques: Immunodiffusion, Immunoelectrophoresis, ELISA, Studying antigen-antibody interactions, Immunofluorescence, Flow cytometry	5L
10	Electrophoretic Techniques: General principles, Support media, electrophoresis of proteins and nucleic acids, Capillary electrophoresis.	4L
11	Centrifugation: Basic principles of sedimentation, Types of centrifuges, Analytical Centrifugation, Preparative centrifugation.	3L

Reference Books:

- Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson, John Walker, Cambridge University Press; 8th edition (2018)
- Basic Techniques in Biochemistry and Molecular Biology by R.K. Sharma, S.P.S. Sangha; Dreamtech Press (2020); Dreamtech Press
- Clinical Chemistry: Techniques, Principles, Correlations, by Bishop, Fody, Schoeff; Wolters Kluwer India; 8/E edition (2018).

ZOO 555 MJ: Applied Entomology

Course Objectives:

The basic purpose of this course is to meet the present-day challenges in the field of applied entomology, specifically in developing and establishing agro-based industry in the country. The content of this course at a glance reveals its value and utility to increase crop protection efforts, and control of various vectors of medical, and veterinary importance. To make students aware of the applications of entomology in economic losses and benefits of insects.

Course Outcomes:

The course combines lectures with corresponding laboratory experiments to investigate the habits and life histories of beneficial as well as harmful insects. The ultimate object of such work is to provide the requisite knowledge upon which to base those remedial or preventive measures. Upon completion of the course, students will be able to learn how to maintain these beneficial insects, how to regulate the pest population of many harmful pest species, and to produce natural products, etc.

ZOO 555 MJ: Applied Entomology (2 Credits: 30 Lectures)		
01	Fundamentals of Agricultural, Forest, Medical and Veterinary Entomology.	2L
02	General biology of important pests cultivated in Maharashtra and in India	3L
03	Measures to control the vectors of medical, veterinary importance	2L
04	Household and stored grain pests and their control.	3L
05	Principles of Mechanical, Biological and chemical control.	4L
06	Useful insects of economic importance.	1L
07	Uses of sex attractants, Pheromones and hormones in insect control.	5L
08	Introduction of Lac culture, Life cycle of the lac insects; Lac cultivation, Composition & uses of Lac.	4L
09	Introduction to sericulture: Life cycle of the silk moth, cultivation, composition and uses of silk.	3L
10	Introduction to Apiculture: Types of honey bees, social organization, Life history of honey bee, Bee keeping, economic importance of honey bee.	3L

Reference Books:

- Boudreau, (1987): “*Arthropod Phylogeny with Special Reference to Insects*”. John Wiley & Sons, New York.
- *Applied Entomology*, 2nd edition, (2009), P G Fenemore, Alka Prakash, Publisher: New Age International.
- *General and Applied Entomology*, 2nd edition, B. V. David and T. N. Ananthkrishnan (2015), Publisher: Tata McGraw Hill
- *Text Book of Applied Entomology*, K. P. Shrivastava (2020), Publisher: Kalyani Publishers
- *Introduction to General and Applied Entomology*, 3rd edition, V. B. Awasthi (2017), Publisher: Scientific Publishers India Jodhpur.
- *Insect pests of crops*, S. Pradhan (1969), Publisher: National Book Trust of India, New Delhi
- *The insect structure and function*, 5th Edition (2012). Chapman, R.F. Publisher- Cambridge University Press London.
- *Biological control by natural enemies*, Bebach P. and David R. (1991), Publisher: Cambridge University Press.

ZOO 556 MJP: Tools and Techniques in Biology-I

Course Objectives:

This course offers detailed knowledge of various analytical techniques used in modern biology. This will help students to understand and design various experiments.

Course Outcomes:

On completing the course, students will be able to:

- Understand various components of light and inverted microscopy.
- Perform Density Gradient Centrifugation.
- understand and perform gel-filtration chromatography
- Perform ion exchange chromatography

ZOO 556 MJP: Tools and Techniques in Biology-I (2 Credits: 30 Hours)		
01	Fixation, dehydration, embedding, sectioning, staining, permanent mounting of tissues and histology	4P
02	Microscopic measurements of histological samples using micrometers and planimeters	1P
	PAS reaction, Alcian blue reaction, and detection <u>in situ</u>	1P
03	Histochemical localization of Carbohydrates using PAS/Alcian blue staining	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted		
01	Microscopy lab exercise: Components of optical systems in upright & inverted microscope, episcopic & diasopic illumination	1P
02	Demonstration of Molecular exclusion/Gel-filtration chromatography	2P
03	Density gradient centrifugation	2P
04	Ion exchange chromatography	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted.		

ZOO 557 MJP: Experiments in Genetics and Applied Entomology-I

Course Objectives:

This course offers detailed knowledge of various insect-rearing techniques, including rearing of *Drosophila*, setting up the mono- and Di-hybrid crosses to study autosomal gene inheritance patterns. The practical portion is planned to direct students toward the collection, identification, and mode of

damage of insect pests of crops, fruits, vegetables, stored grains, and households. The use of insecticides, different formulations, and their computation and application. This course also encompasses the practicals based on population genetics, cytogenetics and microbial genetics.

Course Outcomes:

Students who complete the course will be able to

- Learn mass-rearing techniques of beneficial and harmful insects.
- Understand the scientific techniques used in commercial Apiaries and Silkworm rearing Units. Determine LD/LC concentrations.
- To setup culture of important entomopathogenic fungi and checking its efficacy.
- The practical course will also help students to perform practicals based on population genetics, cytogenetics and microbial genetics.

ZOO 557 MJP: Experiments in Genetics and Applied Entomology-I (2 Credits: 30 Hours)		
01	Use of <i>Drosophila</i> in genetics and laboratory handling and rearing of flies, mutant identification, sexing of pupae for virgin isolation for crosses, setting up genetic crosses using <i>Drosophila</i> mutants and wild type.	2P
02	Study of autosomal gene inheritance (monohybrid crosses and dihybrid crosses using vestigial and sepia mutants along with wild-type flies for F1 and F2 generations) and Chi-square analysis of data of progeny.	2P
03	Estimation of gene frequencies in human population and analysis of heterozygote frequencies	1P
04	Cytogenetic studies using Polytene chromosomes.	1P
05	Cytogenetic studies and preparation of metaphase chromosome spreads using eukaryotic cells	1P
06	Study and characterization of normal and abnormal karyotypes from human subjects	1P
07	Isolation and purification of bacterial strain	1P
	* From above practicals, any 5 practicals (equivalent to 15H) will be taken.	
01	Mass rearing of Insects/natural enemies/breeding of various biocontrol agents,	1P
02	Project document preparation for establishing a viable mass-production unit /insectary	1P
03	Visit to commercial Apiaries and Silkworm rearing Units.	1P
04	Effect of Biopesticides on insect immunological aspects: Phenol oxidase, Oxidative stress, Phagocytosis index	
05	Study of pollinators, weed killers and scavengers	

06	Study of Insecticides and their toxicity; Determination of LD/LC concentrations	2P
07	To set up a culture of important entomopathogenic fungi and check its efficacy.	1P
08	Study of haemocytes by using various staining techniques.	2P
09	Extraction of sericin and study of its antioxidant potential	2P
10	To demonstrate the heart beat in cockroach and effect of cardiac inhibitors and accelerators	1P
11	Binary food choice assays in insects.	1P
	* From the above list, any 5 practicals (equivalent to 15H) will be conducted	

ZOO 561 OE: Fundamentals of Immunology

Course Objectives:

The objectives of this course are to learn about structural features of components of the immune system as well as their function. The primary emphasis will be on the development of the immune system and the mechanisms by which our body elicits immune responses. This will be imperative for students as it will help them predict the nature of the immune response that develops against bacterial, viral, or parasitic infection and prove it by designing new experiments.

Course Outcomes:

On completion of this course, students should be able to:

- Evaluate the usefulness of innate and adaptive immune response and their mechanisms,
- Core understanding of immune function with respect to self and non-self-immune tolerance,
- Apply their knowledge and design immunological experiments to demonstrate innate, humoral responses and figure out the type of immune responses in the setting of infection (viral or bacterial).

ZOO 561 OE: Fundamentals of Immunology (2 Credits: 30 Lectures)		
01	Overview immune system: Historical perspective, Innate and acquired immunity, antigens, antigenicity and immunogenicity. Cells and organs of the Immune system.	5L
02	Generation of B-cell and T cell responses: B and T cell epitopes, structure and function of antibody, Antigen-antibody interactions, activation and differentiation of B and T cells, receptors of B and T cells. Antigen processing and presentation.	8L

03	Immune effector mechanisms: Cell-mediated and humoral effector functions, complement system pathways, inflammation, cytokines.	8L
04	Immune system in Health and Diseases: Immunological Tolerance and autoimmunity, Immunity against infectious diseases, vaccines,	9L

Reference Books:

- *Kuby Immunology*, 8th edition (2019), Jenni Punt; Sharon Stanford; Patricia Jones; Judy Owen, Publisher: W.H. Freeman and Company.
- *Immunobiology: The Immune System in Health and Diseases*, 6th Edition (2005), Charles A. Janeway, Publisher: Garland Science.
- *Roitt's Essential Immunology*, 11th Edition (2006) Peter Delves, Seamus Martin, Dennis Burton, Ivan Roitt, Publisher: Wiley-Blackwell.
- *Cellular and Molecular Immunology*, 6th Edition (2008) Abul K. Abbas, Andrew H. Lichtman, and Shiv Pillai, Publisher: Elsevier, USA.
- *Prescott, Harley, Klein's Microbiology* 7th edition (2009), Joanne M Willey, Christopher J Woolverton, Linda M Sherwood, Publisher: McGraw-Hill.

ZOO 562 OE: Genetic Information Flow and Processing

Course Objectives:

The course addresses molecular details of how coded information in the DNA is decoded to make all of our proteins and that RNA is a messenger that carries this information to the ribosomes.

Course Outcomes:

On the successful completion of the course, the student will be able to:

- Understand the process of Transcription both in prokaryotes and eukaryotes with reference to enzymes involved in details, Transcriptional unit, Transcription factors, and machinery, nuclear export of mRNA.
- Understand the Genetic Code, ribosome structure, Formation of initiation complex in translation followed by elongation and termination of translation in prokaryotes and eukaryotes, and Transport of Proteins and molecular Chaperons.

ZOO 562 OE: Genetic Information Flow and Processing		
(2 Credits: 30 Lectures)		

01	RNA synthesis and processing: Prokaryotic transcription- RNA Polymerase, Transcription unit, Initiation- promoter recognition, Elongation, Termination- rho dependent and rho independent.	7L
02	Eukaryotic Transcription: RNA Polymerases I, II and III, Transcription unit for each polymerase, Transcription factors, Processing of transcripts.	8L
03	Regulation of transcription: Concept of Operon, Positive and Negative regulation, Regulation by attenuation, Phage strategies to regulate transcription, antitermination.	5L
04	Protein synthesis and processing: Prokaryotic translation – Genetic code, deciphering genetic code, codon usage, altered code in mitochondria. rRNA and ribosome structure, the active center of ribosome tRNA – the structure of tRNA, modified bases of tRNA, Activation of tRNA Initiation – the role of initiation factors, Shine Dalgarno sequences, Elongation – Role of elongation factors, translocation of ribosomes, Termination – termination codons, role of release factors, GTP as an important source of energy for translation, Fidelity of translation	6L
05	Eukaryotic translation and regulation: Initiation, elongation and termination, role of chromatin in regulating gene expression and gene silencing.	4L

Reference books:

- Molecular Biology of the gene, 7th edition (2013), James D Watson, Pearson publication.
- Gene XII, Benjamin Lewin, 12th edition (2017), Jones and Bartlett Publishers.
- Molecular Biology of the Cell, 7th edition (2015), Bruce Alberts, Rebecca Heald, Alexander D. Johnson, David Morgan, Martin C. Raff, et.al. Garland Science, Taylor and Francis Group.
- Molecular Cell Biology, 6th edition (2007), Lodish Berk, Matsudaira, Kaiser, Krleger. W.H. Freeman & Company, New York.
- Fundamentals of Molecular Biology, (2009): J.K. Pal, S. Ghaskadbi; Oxford University Press India

ZOO 563 MJP: Practicals in Biostatistics

Course Objectives:

The course will provide hands-on training in using various statistical tools in presenting, describing and analyzing biological data and its interpretation

Course Outcomes:

On the successful completion of the course, the student will be able to:

- use and apply descriptive statistics to describe and present biological data
- understand the apply inferential statistics to analyze biological data
- to interpret experimental data to draw meaningful conclusions

ZOO 563 MJP: Practicals in Biostatistics (2 Credits: 30 Hours)		
01	Introduction to Excel, Graphical Representation of the data and Frequency distribution	2P
02	Measures of Central Tendency and Dispersion	2P
03	Correlation and Regression Analysis	3P
04	Hypothesis Testing: t-tests (One sample t-test, Two-sample t-test, Paired and unpaired t-test), Chi-square test, One-way ANOVA, Mann-Whitney test, Kruskal-Wallis test	6P
* From the above list, any 10 practicals (equivalent to 30H) will be conducted Practicals will be conducted using computers on the above topics giving examples from biological data. In the lectures, practical emphasis is given on biological situations wherein Statistics can be used.		

ZOO 564 MJP: Experiments in Immunology

Course Objectives:

This course will provide the knowledge and understanding of immunology and the way it is applied in diagnostic and therapeutic techniques and research.

Course Outcomes:

On the successful completion of the course, the student will be able to:

- Use of Immunological techniques for disease diagnosis.
- Various techniques to understand antigen-antibody reactions.

ZOO 564 MJP: Experiments in Immunology (2 Credits: 30 Lectures)		
01	Immune cells and organs	1P
02	Antibody detection, Immunoelectrophoresis, Ouchterlony technique	2P
03	Purification of Immunoglobulin G with DEAE Column Chromatography	2P
04	Western blotting and antigen detection	2P
05	ELISA for antigen or antibody detection	2P
06	Immunohistochemical detection and localization of specific antigens.	2P
* From the above list, any 10 practicals (equivalent to 30H) will be conducted		

ZOO 565 MJP: Tools and Techniques in Biology-II

Course Objectives:

This course offers detailed knowledge of various analytical techniques used in modern biology. This will help students to understand and design various experiments.

Course Outcomes:

On completing the course, students can:

- Understand various light and phase contrast microscope components.
- Perform HPLC based estimation of biomolecules
- Perform Thin Layer Chromatography

ZOO 565 MJP: Tools and Techniques in Biology-II (2 Credits: 30 Hours)		
01	Histochemical localization of Alkaline phosphatase/dehydrogenase	1P
02	Histochemical localization of DNA using Feulgen reaction	1P
03	Sudan black B staining for lipids	1P
04	Methyl green – Pyronin G method of detection of nucleic acids	1P
05	Millon's reagent and histochemical detection of Basic proteins	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted		
01	Microscopy lab exercise-2: interpupillary distance adjustment, diopter ring adjustment, Köhler adjustment of microscope, Use of Phase contrast and dark viewing	2P
02	HPLC based estimation of biomolecule	2P
03	Thin layer chromatography	1P
* From the above list, any 5 practicals (equivalent to 15H) will be conducted		

M.Sc. (Zoology) Part II Syllabus

SEMESTER III

Total no. of credits: 22 [Major core (14) + Major elective (4) + RM (0) + OJT/FP (0) + RP (4)]

Major Core Courses		
Course No.	Course Title	Credits
ZOO 601 MJ	Metabolic Pathways	2C
ZOO 602 MJ	Biosystematics and Biodiversity and Conservation	2C
ZOO 603 MJ	General and Comparative Endocrinology	2C
ZOO 604 MJ	Communicable and Non-Communicable Diseases	2C
ZOO 605 MJ	Insect Anatomy and Physiology	2C
ZOO 606 MJP	Experiments in Endocrinology	2C
ZOO 607 MJP	Laboratory and Field Exercises in Biodiversity and systematics	2C
Total		14C

Major Elective Courses (Any Two)		
Course No.	Course Title	Credits
ZOO 611 OE	Regulation of Gene Expression	2C
ZOO 612 OE	Integrated Pest Management	2C
ZOO 613 OE	Advanced Physiology	2C
ZOO 614 OE	Recombinant DNA Technology	2C
ZOO 615 MJP	Experiments in Parasitology and Pathophysiology	2C
ZOO 616 MJP	Advanced Techniques in Molecular Biology	2C
Total		4C

Other Courses		
Course No.	Course Title	Credits
ZOO 600 RP	Research Project	4C

M.Sc. (Zoology) Part II Syllabus

SEMESTER IV

Total no. of credits: 22 [Major core (12) + Major elective (4) + RM (0) + OJT/FP (0) + RP (6)]

Major Core Courses		
Course No.	Course Title	Credits
ZOO 651 MJ	Ethology and Evolution	2C
ZOO 652 MJ	Biology of Reproduction	2C
ZOO 653 MJ	Vertebrate and Invertebrate Embryology	2C
ZOO 654 MJ	Advanced Entomology	2C
ZOO 655 MJP	Image and Data Analysis: Software Applications	2C
ZOO 656 MJP	Laboratory and Field exercises in Ethology, Evolution and Advanced Entomology	2C
Total		12C

Major Elective Courses (Any Two)		
Course No.	Course Title	Credits
ZOO 661 OE	Analytical and Applied Genetics	2C
ZOO 662 OE	Genomics and Proteomics	2C
ZOO 663 OE	Stem Cells, Regenerative Medicine and Cancer	2C
ZOO 664 OE	Bioinformatics: Theory and Applications	2C
Total		4C

Other Courses		
Course No.	Course Title	Credits
ZOO 650 RP	Research Project	6C

2 years, 4 Semesters, PG Degree (88 Credits)

OO 601 MJ: Metabolic Pathways (2 Credits: 30 L)

Course Objectives:

The objective of this course is to provide a thorough knowledge of metabolic pathways by which all cells synthesize and degrade carbohydrates, lipids, amino acids and nucleotides. The main emphasis will be on structural details and enzymes/cofactors involved and regulation of catabolic and anabolic pathways. The topics will be discussed taking into consideration how energy is derived from the breakdown of nutrients and how diseases arise from defects in metabolic pathways and altered metabolism.

Course Outcomes:

Upon completing this course, students will:

- Learn the characteristics of metabolic pathways.
- Learn regulation of catabolic and anabolic pathways involved in metabolism of carbohydrates, lipids, amino acids and nucleotides.
- Acquire insight into structural details and enzymes/cofactors involved in metabolism of carbohydrates, lipids, amino acids and nucleotides.
- Learn about different diseases that arise from defects in metabolic pathways.

ZOO 601 MJ: Metabolic Pathways (2 Credits: 30 Lectures)		
01	Fundamental concepts of Metabolism: i. Concept of catabolism and anabolism: metabolic strategies, organization, Thermodynamics and direction of metabolic pathways. Vitamins and minerals assist metabolic reactions. Characteristics of metabolic pathways. Experimental approaches to study metabolism. ii. Regulation of Metabolic Pathways: controlling the amount of enzymes, catalytic activity, hormonal coordination, feedback inhibition, energy charge, phosphorylation potential, compartmentalization to segregate opposed reactions, controlling the flux of substrates.	5L
02	Carbohydrate metabolism: i. Glycolysis and Gluconeogenesis, Pentose Phosphate Pathway, Glycogen metabolism (emphasis on regulation). ii. The Citric acid cycle: Cyclic overview and reactions. Metabolic sources of acetyl CoA. Regulation and amphibolic nature of the cycle. iii. Dark reactions of Photosynthesis: CO ₂ fixation: C ₃ , C ₄ and CAM pathways.	10L
03	Amino acid metabolism: Ubiquitin tags proteins for degradation, proteasomes, amino acid deamination, urea cycle, fates of carbon skeletons of amino acids. Amino acid biosynthesis (essential and non-essential amino acids).	5L

04	Lipid Metabolism Lipid digestion, absorption and transport (triacylglycerols, lipoproteins). Fatty acid oxidation: linkage to Coenzyme-A, role of carnitine, β -oxidation, oxidation of unsaturated fatty acids, oxidation of odd-chain fatty acids (propionyl-CoA), peroxisomal and mitochondrial β -oxidation, Ketone bodies Fatty acid biosynthesis, Regulation of fatty acid metabolism, cholesterol metabolism.	5L
05	Nucleotide Metabolism: Salvage and <i>de novo</i> pathways of purine and pyrimidine nucleotide biosynthesis. Formation of deoxyribonucleotides, origin of thymine, nucleotide degradation.	5L

References:

- Fundamentals of Biochemistry: Life at the Molecular Level 5th Ed. (2016) Donald Voet, Judith G. Voet, Charlotte W. Pratt. Publisher: John Wiley & Sons Inc, New York.
- Biochemistry 9th edition (2019) Lubert Stryer, Jeremy Berg, John Tymoczko, Gregory Gatto Publisher: W. H. Freeman, New York.
- Lehninger Principles of Biochemistry, 8th edition, (2021) David L. Nelson; Michael M. Cox W. H. Freeman, New York.
- Biochemical Calculations, 2nd Ed., (1997) Segel Irvin H., Publisher: John Wiley and Sons, New York.
- Enzymes: Biochemistry, Biotechnology & Clinical chemistry, (2001) Palmer Trevor, Publisher: Horwood Pub. Co., England.

ZOO 602 MJ: Biosystematics, Biodiversity and Conservation (2 Credits: 30 L)

Course Objectives:

The course aims to provide a comprehensive picture of the existing organic diversity on earth. It provides information about studying biodiversity & biosystematics and their importance in sustainable development. It also provides a thorough knowledge about tools and techniques used in studying biodiversity. Further, the course emphasizes on the ways to study diversity of different organisms in different ecosystems. Finally, the course also provides information about the importance of conserving biodiversity and different ways of conservation.

Course Outcomes:

Upon completing this course, students will:

- Acquire insights into the importance of biodiversity and biosystematics in sustainable development.
- Get acquainted with the tools and techniques used in biodiversity studies in different ecosystems.
- Acquire knowledge about interaction of animals with their surroundings.
- Gain insights into different methods of conserving biodiversity.

ZOO 602 MJ: Biosystematics, Biodiversity and Conservation (2 Credits: 30 Lectures)		
01	Kingdoms of Life : General outline of kingdoms including Monera & Protista; Broad outline and Diversity in Animalia	5L
02	Biotic community & interrelationships: Zoogeographical relations of species and population, interrelationships among organisms including parasitism, symbiosis & commensalism; Diversity of adaptation in animals: adaptive radiation	5L
03	Biosphere: Biodiversity characterization, generation and maintenance, Biosphere reserves, resources and management, Global diversity hotspots, Effect of anthropogenic activities in alteration of environment and Biospheres.	5L
04	Fundamental of systematics: Biological classification, hierarchy of categories and higher taxa, Taxonomic characters – procedures and keys, species concepts: varieties, subspecies, sibling, species, race etc. International code of Zoological nomenclature.	5L
05	Methodologies in systematics: Morphology based taxonomy, Numerical taxonomy, Cyto-taxonomy and chemotaxonomy, Molecular systematics, DNA fingerprinting & Molecular markers for detection/evaluation of polymorphism, RFLP, RAPD etc.	5L
06	Conservation : Objective of Conservation, strategies of conservation, Global programmes and concept of endangered species, Modern tools and techniques to assess biodiversity.	5L

References:

- This is Biology: The Science of Living World, Mayr, M. (1997), Universities Press Ltd.
- Evolution, 3rd edition, Strickberger, M. W. (2000), Jones and Bartlett Publishers London.
- J.R.B. Alfred and Ramakrishna (2004) Collection, Preservation and Identification of animals. Zoological Survey of India Publications.
- N.A. Campbell and J.B. Reece (2004) Biology, 7th edition, Benjamin Cummings Publ. [8th edition (2009)]
- P.D. Sharma (2005) Ecology and Environment, Rastogi Publications
- N.H. Barton et al. (2007) Evolution. Cold Spring Harbor Lab. Press.

ZOO 603 MJ: General and Comparative Endocrinology (2 Credits: 30 L)

Course Objectives:

The course aims to provide a thorough knowledge about the structure of vertebrate endocrine organs and their significance in regulating developmental, physiological and behavioral processes. Further the course aims to provide methodologies to study endocrine glands, their synthesis and secretion. The course also provides a thorough knowledge about the interaction of the central nervous system with

peripheral endocrine organs to transmit environmental signals to bring about changes in development, physiology and behavior. Finally, the course also provides thorough knowledge about pathophysiology of hypo and hyper-secretion of these hormones.

Course Outcomes:

Upon completing this course, students will:

- Acquire knowledge about the structure and organization of the endocrine system of vertebrates.
- Get acquainted with the tools and techniques used in studying the endocrine system.
- Acquire knowledge about the comparative aspects of endocrine organs of vertebrates including the human body and their physiological significance.
- Gain insights into the role of the central nervous system (CNS) in mediating the effect of extrinsic (environmental) factors to the endocrine system.

ZOO 603 MJ: General and Comparative Endocrinology (2 Credits: 30 Lectures)		
01	Organization of vertebrate endocrine system: Types of chemical messengers, types of hormone receptors, Biosynthesis, chemistry and metabolism of hormones, mechanisms of hormone action.	5L
02	Endocrine hypothalamus; Structural organization, Hypothalamic hormones, Regulation of hormone secretion, biological actions, Feed-back mechanisms. Pineal gland; structural organization, hormonal secretion and functions.	5L
03	Pituitary hormones – Comparative developmental anatomy and structural organization of pituitary, Adenohypophysis: Peptide & Glycoprotein hormones, regulation of hormone secretion and biological functions, Neurohypophysis: Hormones, Regulation of secretion and biological functions.	5L
04	Pancreatic hormones, Thyroid hormones, Glucocorticoids and regulation of Carbohydrate, Protein and Lipid metabolism.	5L
05	Hormones of Adrenal gland: Comparative aspects of adrenal structure, synthesis and secretion of Corticosteroids, Osmoregulatory hormones; mineralocorticoids, renin-angiotensin system, natriuretic peptides and sodium homeostasis, Catecholamines; biosynthesis, synthesis, secretion and metabolism.	6L
06	Gastrointestinal hormones and their physiological significance, Hormonal regulation of Calcium/phosphate homeostasis.	4L

References:

- Endocrinology (V Ed.). Mac. E. Hadley and John E. Levine. Publisher - Pearson Education Inc. and Dorling Kindersley Publishing Inc. 2008
- Comparative Vertebrate Endocrinology. (III edition) P. J. Bentley. Publisher - Cambridge University Press, Cambridge UK. (1998)

- Vertebrate Endocrinology. (V Ed.) D. O. Norris and J. A. Carr. Publisher- Academic Press: An imprint of Elsevier, California, USA. 2013.
- Vertebrate Endocrinology: Fundamentals and Biomedical implications (Volume I to III). P. K. T. Pang and M. P. Schreibman Publisher - Academic Press Inc. Orlando Florida (1986).
- An Introduction to General and Comparative endocrinology. E.J.W. Barrington. Publisher - Clarendon Press Oxford 1975
- Handbook of Endocrinology (II edition) Volume I & II. G. H. Grass and H. M. Kaplan. Publisher - CRC Press, New York. 1996
- William's textbook of Endocrinology. (XI Ed.) H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen. Publisher - Saunders, Elsevier Inc. (2009).

ZOO 604 MJ: Communicable and Non-Communicable Diseases (2 Credits: 30 L)

Course Objectives:

The course aims to provide a thorough knowledge about different parasites (unicellular and multicellular), their morphology, physiology, life history, adaptations and behaviour, highlighting their impact on hosts. Further, it enables students to understand the etiology and risk factors associated with various non-communicable diseases, injury mechanisms and strategies to prevent them. Moreover, it aids in understanding age related consequences and causes for diseases.

Course Outcomes:

Upon completing this course, students will:

- Understand various protozoans and multicellular parasites, their biology, physiology, morphology, life history, and behaviour, highlighting their impact on hosts.
- Learn the etiology, background and risk factors for various NCDs and injury mechanisms and strategies to prevent them.
- Comprehend the age related consequences and causes for diseases

ZOO 604 MJ: Communicable and Non-Communicable Diseases (2 Credits: 30 Lectures)		
01	Introduction to parasitism: Host Parasite relationship. Parasitic adaptations, interrelationships between host and parasite.	5L
02	Unicellular parasites: Protozoans parasites (<i>Giardia</i> , <i>Entamoeba histolytica</i> , <i>Plasmodium</i> spp. <i>Babesia</i> spp., <i>Trypanosoma</i> spp. <i>Leishmania</i> spp. <i>Toxoplasma gondii</i> etc.), diagnosis and control of parasites	5L
03	Multicellular parasites: Platyhelminth parasites (tapeworm, blood fluke, liver fluke), nemathelminths (roundworm, hookworm, filarial worm), diagnosis and control of parasites Arthropods and Vector Biology, Myiasis, Neglected zoonotic diseases	5L

04	Metabolic Disorders: Diabetes, Cardiovascular disease: inborn errors of metabolism, epidemiology, characteristics, risk factors (modifiable and non-modifiable risk factors, behavioural risk factors, metabolic risk factors, environmental risk factors) prevention and control.	10L
05	Aging related disorders: Neurodegenerative disorders, dementia and osteoporosis: types, causes, symptoms, pathophysiology, biomarkers and diagnosis.	5L

References:

- Flik, G., & Wiegertjes, G. (Eds.). (2004). Host-parasite interactions. Taylor & Francis.
- Smyth, J. D., & Wakelin, D. (1994). Introduction to animal parasitology. Cambridge university press.
- Gunn, A., Pitt, S. J. (2012). Parasitology: An Integrated Approach. United Kingdom: Wiley.
- Parasite Communities: Patterns and Processes. (2012). Netherlands: Springer Netherlands.
- Parasitology Protozoology and Helminthology 13Ed (Hb 2019): (Protozoology & Helminthology)
- Krämer, A., Kretzschmar, M., Krickeberg, K. (2010). Modern Infectious Disease Epidemiology: Concepts, Methods, Mathematical Models, and Public Health. Netherlands: Springer New York.
- The Geohelminths: Ascaris, Trichuris and Hookworm. (2006). United Kingdom: Kluwer Academic.
- Sing, A. (Ed.). (2014). Zoonoses-Infections affecting humans and animals: Focus on public health aspects. Springer.
- Marquardt, W. H. (Ed.). (2004). Biology of disease vectors. Elsevier.
- Bondy, S., & Maiese, K. (Eds.). (2010). Aging and age-related disorders. Springer Science & Business Media.
- Almeida, C. A., & Barry, S. A. (2011). Cancer: basic science and clinical aspects. John Wiley & Sons.
- Jain, B. P., & Pandey, S. (Eds.). (2022). Understanding Cancer: From Basics to Therapeutics. Academic Press.
- Farooqui, A. A., & Farooqui, T. (Eds.). (2013). Metabolic syndrome and neurological disorders. Wiley-Blackwell.
- Gilbert-Barness, E., Barness, L. A., & Farrell, P. M. (Eds.). (2017). Metabolic diseases: foundations of clinical management, genetics, and pathology. IOS Press.

ZOO 605 MJ: Insect Anatomy and Physiology (2 Credits: 30 L)

Course Objectives:

The course is meant to provide a detailed outline of different systems and their physiological functions in insects. Further, it provides a thorough knowledge of biochemical molecules and processes to enable students to understand the structures and functions of the physiological systems.

Course Outcomes:

Upon completion of the course, the student will:

- become familiar with the physiological systems of insects and processes associated with them..
- Know how to determine the impact of hormonal and neuronal regulators on each system..
- Understand how physiology could affect important research subjects in the field of entomology.

ZOO 605 MJ: Insect Anatomy and Physiology (2 Credits: 30 Lectures)		
01	Endocrine Systems- Types of Hormone Release Sites in Insects, Early Experiments That Set the Stage for our Current Understanding, Types of Hormones in Insects, Prothoracicotrophic Hormone, Ecdysteroids, The Juvenile Hormones, Other Neuropeptides Found in Insects, Vertebrate-type Hormones in Insects.	4L
02	Reproductive Systems- Female Reproductive Systems, Vitellogenesis, Endocrinology of Female Reproduction, Ovulation, Fertilization, and Oviposition, Male Reproductive Systems, Unconventional Methods of Insect Reproduction, Mating Systems	4L
03	Behavioral Systems- Ways of Looking at Behavior, Genetic Basis of Insect Behavior, Physiology of Learning and Memory, Hormonal Regulation of Behavior, Physiology of Circadian Rhythms- Insect Sleep and Arousal Patterns, Physiology of- Synchronous Behavior, Polyphenisms, Metamorphosis, Ecolosion, Reproductive Behaviors, Behavioral Modulation by Parasites.	4L
04	Circulatory Systems- Structure of the Insect Circulatory System, haemolymph composition-organic/inorganic constituents, fat body and its functions, Immune Mechanisms in Insects, The Circulatory System and Temperature Variations.	4L
05	Excretory Systems, Major Excretory Products in Insects, Malpighian Tubules, Mechanisms of excretion, Hindgut and Rectum, Cryptonephridial System, Filter Chamber, Hormonal Control of Excretion and Osmoregulation, Storage Excretion.	4L
06	Respiratory Systems- The Tracheal System, Modifications That Increase Oxygen Uptake, Nonrespiratory Functions of Tracheal Systems, Discontinuous Gas Exchange.	4L
07	Nervous Systems- Overview of the Nervous System, Evolution and Structure of the Nervous System, Contents The Visceral Nervous System, Sensing the Environment, Visual Receptors, Visual Pigments, Magnetic Sensitivity.	3L
08	Communication Systems- Visual Communication, Acoustical Communication, Tactile Communication, Chemical Communication, Pheromones, Pheromone Synthesis and Release, Allelochemicals, Primer Pheromones.	3L

References:

- Insect Physiology and Biochemistry. James L. Nation. 2015
- The Insect: Structure and Function. R. F. Chapman. 2013
- Ecological and Environmental Physiology of Insects. Jon Harrison. 2012
- Klowden, M. J. (2013). Physiological systems in insects. Academic press

ZOO 606 MJP: Experiments in Endocrinology

Course Objectives:

The practical course provides hands-on training in handling laboratory rodents. It provides training on identification of endocrine and exocrine organs of the mammals and how to study histology to understand the structural organization of hormone secreting cells and their functional significance. It also provides an opportunity to study and understand the structural organization of the pituitary gland and its association with the central nervous system in mammals.

Course Outcomes:

Upon completing this course, students will:

- Be able to handle the laboratory and maintain rodents independently.
- Get acquainted with the tools and techniques used in studying the internal anatomy and histology of endocrine organs of mammals.
- Acquire knowledge about the invasive and non-invasive techniques used in quantifying steroid hormones
- Acquire insights into the role of hormones in controlling physiological processes.

ZOO 606 MJP: Experiments in Endocrinology (2 Credits)		
01	Dissect and display of endocrine organs of rat/mouse	1P
02	Studying histology of mammalian endocrine organs with emphasis on hormone secreting cells using rat as a model system	3P
03	Studying steroidogenesis by histochemical localization of 3 β -hydroxysteroid dehydrogenase enzyme 3 β -HSD in the adrenal and gonads.	2P
04	Studying the histology of the brain and pituitary of different vertebrates (Slides) to understand comparative aspects of structural organization and functional significance.	1P
05	Induction of diabetes and the role of insulin in glucose metabolism.	2P
06	Immunohistochemical demonstration of neuropeptides in the central nervous system.	2P
07	Quantification of steroid hormones using non-invasive enzyme immunoassay	2P
08	Staging of fish chromatophores and effect of epinephrine (<i>in-vivo</i> and <i>in-vitro</i>) and acetylcholine (<i>in-vitro</i>) esterase	1P
09	Effect of Thyroxine in amphibian metamorphosis	1P
	* From above practicals, any ten practicals (equivalent to 30 H) will be taken.	

ZOO 607 MJP: Laboratory and Field Exercises in Biodiversity and Systematics (2 Credits)

Course objectives:

The course aims to provide hands-on training in different sampling methods, tools and techniques used in studying biodiversity. Further, it provides hands-on training on how to study different biotic components of the ecosystem and their interaction in the transfer of energy from one trophic level to the next. Similarly, the course provides information about determining and maintaining ecosystem health by studying biological and chemical oxygen demand of a freshwater ecosystem. It also gives an opportunity for students to visit different state and national biodiversity museums, repositories, sanctuaries and parks to get first-hand information on different conservation methods.

Expected outcome:

Upon completing this course, students will:

- Get hands-on training in different sampling methods, tools and techniques in studying biodiversity.
- Get familiar with handling different organisms and their interaction with surroundings.
- Acquire knowledge about different methodologies of preserving animals for museum exhibition.
- Gain thorough insights into ex-situ and in-situ conservation methods and the importance of preserving biodiversity.

ZOO 607 MJP: Laboratory and Field Exercises in Biodiversity and Systematics (2 Credits)		
01	Study of freshwater plankton, collection, sorting, identification of samples of zooplankton: protozoans, rotifers, crustaceans (including study of permanent specimens)	2P
02	Study of biodiversity sampling using quadrat method: study of community in an ecosystem by determination of frequency density and abundance of different taxonomic groups (fauna only) present in the community.	2P
03	Study of biotic components of a pond ecosystem and grouping on the basis of their trophic position.	1P
04	Field visit to understand sampling methods to study biodiversity; different diversities and diversity indices	2P
05	Museum preservation techniques of selected vertebrates and invertebrates.	1P
06	Museum preservation techniques of selected vertebrates and invertebrates.	1P
07	Visit to ZSI Pune, Sanctuaries and National parks to understand biodiversity conservation methods	1P
* From above practicals, any 10 practicals (equivalent to 30 H) will be taken.		

ZOO 611 OE: Regulation of Gene Expression

Course Objectives:

The objective is to offer detailed knowledge of gene transcription and translation both in prokaryotes and eukaryotes. The basic concepts of central dogma, transcription and translation regulation will also be taught.

Course Outcomes:

- Students will learn the basic features of prokaryotic transcription and translation.
- Students will understand the experiments which led to the discovery of genetic code and how the information on mRNA is decoded.
- The detailed molecular mechanism of eukaryotic transcription and how it is different from prokaryotic transcription will be explained and the enzyme and its regulation level
- Different factors of eukaryotic translation and its regulation will be explained.

ZOO 611 OE: Regulation of Gene Expression (2 Credits: 30 Lectures)		
01	Activating transcription: Transcription activating factors, Different domains in transcription factors, Mechanism of transcription activation, response elements recognized by activators.	5L
02	RNA processing: Splicing: Nuclear pre-mRNA splicing - spliceosomes, alternative splicing, trans splicing tRNA splicing, rRNA splicing - autosplicing in group I and group II introns. Editing: types of editing gRNA mediated editing, enzyme mediated editing 3' processing: Polyadenylation, PARP, Poly (A) signal, mRNA stability 5' processing: Capping, importance of capping, mechanism of capping.	10L
03	Chromatin remodeling: alternative states of chromatin, mechanisms of modification	2L
04	Epigenetic effect: heterochromatin and euchromatin, inactive and active chromatin, mechanisms of X chromosome inactivation, genome imprinting, importance of imprinting.	5L
05	Translational regulation: mRNA stability, half-life- polyadenylation, polysome formation mRNA structure-3' and 5' UTRs CAP independent, CAP dependent translation, IRE sites, multiple ORFs, 5' and 3' structures formed, role of initiation and elongation factors Mechanism of global and mRNA specific regulation of translation: Initiation by eIF2, cap binding protein assembly, IRE mediated regulation, mRNPs –as trans regulating proteins, miRNA mediated regulation mRNA localization and regulation of translation, protein degradation and regulation of translation.	8L

Reference books:

- Molecular Biology of the gene, 7th edition (2013), James D Watson, Pearson publication.
- Gene XII, Benjamin Lewin, 12th edition (2017), Jones and Bartlett Publishers.
- Molecular Biology of the Cell, 7th edition (2015), Bruce Alberts, Rebecca Heald, Alexander D. Johnson, David Morgan, Martin C. Raff, et.al. Garland Science, Taylor and Francis Group.
- Molecular Cell Biology, 6th edition (2007), Lodish Berk, Matsudaira, Kaiser, Krleger. W.H. Freeman & Company, New York.
- Fundamentals of Molecular Biology, (2009): J.K. Pal, S. Ghaskadbi; Oxford University Press India.

ZOO 612 OE: Integrated Pest Management (2 Credits: 30 L)

Course Objectives:

The discipline provides key principles, methodologies, approaches, and practical examples of insect pest management in agriculture, horticulture, medical and veterinary entomology. It provides a broad outline of different ways used for controlling pests. This information continues to be essential in all aspects of insect pest management, applied entomology, crop protection, and medical and veterinary entomology.

Course Outcomes:

Upon completion of the course, the students will:

- Be able to monitor and forecast pest outbreaks, yield loss and impact assessments and all of the latest methods involved in the control and management of insects as well as socio-economic and research management aspects of developing integrated approaches to pest management.
- Gain insights into the key advances made in molecular biology, biochemistry and genomics related to insects and their management.
- The importance and role of biodiversity, climate change, precision agriculture, data management and sustainability of production and supply in delivering integrated management solutions.

ZOO 612 OE: Integrated Pest Management (2 Credits: 30 Lectures)		
01	Sampling, monitoring, and forecasting. Sampling, monitoring, and forecasting and an insight into some of the problems confronting scientists working in the field of pest management.	3L
02	Biological components of IPM: Biology, adaptation, host-seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., and their mode of action. Biological control of weeds using insects Scope of classical biological control and augmentative biocontrol; introduction and handling of natural enemies; nutrition of entomophagous insects and their hosts, dynamics of biocontrol agents	7L

	Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application, and evaluation.	
03	Biorational control Insect Growth Regulator, Chitin synthesis inhibitor, JH analogues, Anti JH, Moulting hormone, Pheromones Allelochemicals, Attractant, Repellent, Antifeedant, Chemosterilant, Sterile male release.	5L
04	IPM Programme design, management, and implementation IPM programme design, management, delivery of research results, implementation and adoption, Principles of sampling and surveillance Case histories of national and international programmes, their implementation, adoption, and criticisms, global trade and risk of invasive pests.	04
05	Legislation, codes of conduct, and conventions: Legislation, regulations, and voluntary codes used at national and international levels to ensure good practice in pest management Quality of food and other products that require treatment against pests and the introduction of exotic organisms across national boundaries Quarantine regulations, and regulation of pesticides and genetically modified organisms, convention on biological diversity.	4L
06	Challenges and needs of IPM: Dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation; strategies for pesticide resistance management.	4L
07	Prospects for IPM: The future of pest control technologies, systems approaches, the IT revolution, and the role of the general public are then addressed in an attempt to place integrated pest management in the context of modern developments in agriculture and the wider world.	3L

Reference Books

- Dent, D., & Binks, R. H. (2020). Insect pest management. Cabi.
- Pedigo, L. P., Rice, M. E., & Krell, R. K. (2021). Entomology and pest management. Waveland Press.
- Radcliffe, E. B., Hutchison, W. D., & Cancelado, R. E. (Eds.). (2009). Integrated pest management: concepts, tactics, strategies and case studies. Cambridge University Press.
- Walter, G. H. (2003). Insect pest management and ecological research. Cambridge University Press.
- Koul O & Cuperus GW. 2007. Ecologically Based Integrated Pest Management. CABI, London.

- Koul O, Dhaliwal GS & Curperus GW. 2004. Integrated Pest Management -Potential, Constraints and Challenges. CABI, London.
- Maredia KM, Dakouo D & Mota-Sanchez D. 2003. Integrated Pest Management in the Global Arena. CABI, London.
- Dhaliwal, GS & Koul O. 2007. Biopesticides and Pest Management. Kalyani Publ., New Delhi.
- Metcalf RL & Luckman WH. 1982. Introduction of Insect Pest Management. John Wiley & Sons, New York. Norris RF,
- Caswell-Chen EP & Kogan M. 2002. Concept in Integrated Pest Management. Prentice Hall, New Delhi. Pedigo RL. 1996. Entomology and Pest Management. Prentice Hall, New Delhi.

ZOO 613 OE: Advanced Physiology (2 Credits: 30 L)

Course Objectives:

- To understand the physiology of sense organs and receptor system
- To make students aware of various environmental conditions (hypobaric, hyperbaric, weightlessness) and response of various body systems
- To study the body's response to exercise.
- To study the mechanism of thermoregulation and cellular mechanism of stress response.

Course Outcomes:

- After completion of this course, students will be able to:
- Learn various receptors and their pathways
- Learn effects of hypobaric and hyperbaric conditions on physiology of various body systems and compensatory cellular mechanisms.
- Learn effects of weightlessness conditions on various body systems and exercise physiology and short term and long term response of body systems to the exercise
- Learn the mechanism of thermoregulation and cellular mechanism of stress response.

ZOO 613 OE: Advanced Physiology (2 Credits: 30 Lectures)		
01	Receptor Physiology & Pathways: Hearing and tactile response, Mechanoreceptors, Photoreceptors, Chemoreceptors. Reflexes and reflex arcs: the stretch reflex, the tendon reflex, the flexor and crossed extensor reflex	7L

02	High altitude Physiology: Atmospheric pressure variation with altitude, Acute Mountain Sickness, HAPE, HACE, pathophysiology of high altitude sickness, Biological Responses to Hypobaric Hypoxia, Cardiovascular Changes respiratory changes, Haematological Changes, Fluid Balance and Hormonal Response to high altitude. Mechanism of cellular response to hypobaric hypoxia. Genetics of adaptation to hypobaric hypoxia	4L
03	Aviation and Space Physiology: Effects of acceleratory forces on the body in aviation and space, “artificial climate” in the sealed spacecraft, weightlessness in space, physiological problems of weightlessness.	4L
04	Physiology of Deep-Sea Diving and Other Hyperbaric Conditions: Effect of High Partial Pressures of Individual Gases on the body, Scuba (Self-Contained Underwater Breathing Apparatus) Diving, Special Physiologic Problems in Submarines, Hyperbaric Oxygen Therapy	4L
05	Physiology of Exercise: Short term and long term effects of exercise on various systems of the body. Cardiovascular response to exercise, vascular shunt mechanism, Starling’s Law of the Heart. Effect of exercise on Skeletal muscle blood flow. Respiratory response to exercise, Endocrine response to exercise, Metabolic adjustments during exercise.	4L
06	Thermoregulation : Normal Body Temperatures, Regulation of Body Temperature- Role of the Hypothalamus, Abnormalities of Body Temperature Regulation.	3L
07	Cellular mechanism of stress response. ROS,RNS, Cell and tissue damage by ROS and RNS, Properties of free radicals, endogenous and exogenous sources of ROS, Molecular targets of free radicals, Free Radicals and Diseases, Antioxidant enzymes and their action mechanisms, Non-enzymatic antioxidants and their action mechanisms, Natural antioxidants	4L

Reference Books:

- Principles of Animal Physiology (2006), C. D. Moyes and P. M. Schulte. Publisher - Pearson Education Inc. and Dorling Kindersley Publishing Inc.
- Textbook of Medical Physiology 10th edition (2001), A. C. Guyton and J. E. Hall. Publisher - W. B. Saunders Company, Philadelphia. -
- Principles of Anatomy and Physiology, 11th edition (2006), G. J. Tortora and B. Derrickson. Publisher-John Wiley and Sons Inc.
- Endocrinology, 5th edition (2008), Mac. E. Hadley. Publisher-Pearson Education Inc. and Dorling Kindersley Publishing Inc.
- Comparative Vertebrate Endocrinology 3rd edition (1998), P. J. Bentley. PublisherCambridge University Press.
- Vertebrate Endocrinology 3rd edition (1997), D. O. Norris. Publisher- Academic Press: An imprint of Elsevier.
- The World of the Cell, 7th edition, (2005), Wayne M. Becker, Lewis J. Kleinsmith, Jeff Hardin., Publisher - Benjamin Cummings.

- Animal Physiology: Adaptation and Environment (1997) Knut Schmidt-Nielsen Publisher: Cambridge University Press.
- Principles of Animal Physiology (2nd Edition) (2007) Christopher D. Moyes , Patricia M. Schulte
- Animal Physiology, Third Edition (2012) Richard W. Hill, Gordon A. Wyse, Margaret Anderson
- Functional Anatomy and Physiology of Domestic Animals 4th Edition (2009) William O. Reece
- Animal Physiology 2nd Edition Richard W. Hill Publisher: Sinauer Associates, Incorporated
- Eckert's Animal Physiology (2004) Roger Eckert, D.J. Randall, Warren Burggren, Kathleen French Publisher: W.H.Freeman & Co Ltd
- Animal Physiology: Adaptation and Environment (1997) Knut Schmidt-Nielsen Publisher: CAMBRIDGE UNIVERSITY PRESS
- Principles of Animal Physiology (2013) Christopher D. Moyes, Patricia M. Schulte
- Publisher: Pearson Education Limited
- Environmental Physiology of Animals (2004) Pat Willmer, Graham Stone, Ian Johnston
- Publisher: Blackwell Publishing Ltd
- The Eye: A Very Short Introduction (2014) Michael F. Land Publisher: Oxford University Press
- Introduction to Animal Physiology (1998) Ian Kay Publisher: Bios Scientific Publishers Ltd

ZOO 614 OE: Recombinant DNA Technology

Course Objectives:

The objective is to offer detailed knowledge of gene manipulation techniques using prokaryotic and eukaryotic systems. The basic concepts of creating transgenic animals and plants will also be taught.

Course Outcomes:

- Students will learn the different cloning strategies.
- The different vectors, enzymes used in recombinant DNA technologies and their industrial application will be taught.
- Different methods of screening of transformants will be explained.
- Students will learn various gene transfer strategies in plants and animals along with their biotechnological relevance.

ZOO 614 OE: Recombinant DNA Technology (2 Credits: 30 Lectures)		
01	Introduction to Recombinant DNA Technology	1L
02	General strategy of recombinant DNA technology and gene cloning : genomic libraries, cDNA libraries, single gene cloning	4L
03	Isolation, identification and characterization of DNA fragments to be cloned, preparation of cDNA	3L

04	Vectors in gene cloning: types of vectors and choice of vectors: plasmids, cosmids, lambda phage vectors, shuttle vectors, YACs, BACs, Other advanced vectors,	5L
05	Methods of transferring recombinant DNA to different host cells	3L
06	DNA modifying and degrading enzymes used in recombinant DNA technology	2L
07	Screening for transformants, Characterisation of transformants: different hybridization techniques, probe preparation using radioactive and nonradioactive ligands detection of hybrids, DNA sequencing, site directed mutagenesis	6L
08	Genetic manipulation of animals	1L
09	Gene transfer to plants	1L
10	Various expression vectors in bacteria and eukaryotes, choice of appropriate hosts, induce expression, Expression of industrially important	4L

Reference books:

- Primrose S., Twyman R., Old D., Seventh Edition (2013) Principles of Gene Manipulation, Blackwell Science Ltd.
- Prirose S., Twyman R., Third Edition (2006) Principles of genome analysis and genomics., Blackwell Science Ltd.
- Alcamo I. Second Edition (2001) DNA Technology, the awesome skill, Harcourt Academic Press
- Brown T.A., Third Edition (2007) Genomes 3, Garland Science, Taylor and Francis Group.

ZOO 615 MJP: Experiments in Parasitology and Pathophysiology (2 Credits)

Course Objectives:

- To perform experiments to understand the physiology of various organs such as kidney, heart, liver, muscle and effect of stress on them.
- To study association of body mass and metabolism
- To understand the functioning of animal house
- To perform experiments to understand blood physiology
- To study unicellular and multicellular parasites, their life cycle, morphological and physiological adaptations.
- To study of forensically important vectors and parasites

Course Outcomes:

- Students will be able to distinguish and characterize multicellular and unicellular parasites.
- Students will learn to prepare blood smears and identify blood parasites

- Students will learn to culture *Leishmania*
- Students will learn to identify forensically important vectors and parasites
- Students will learn the biomarkers to understand the physiology of various organs such as kidney, heart, liver, muscle and effect of stress on them.
- Students will understand the association of body mass and metabolism
- Students will learn the functioning of animal house
- Students will learn the methods to understand blood physiology

ZOO 615 MJP: Experiments in Parasitology and Pathophysiology (2 Credits)		
01	Assay of ROS level/ antioxidants in biological sample	1P
02	Effect of chemicals and modifiers on cardiovascular functions	1P
03	Identification of pathological condition of heart from pattern of ECG	1P
04	Effect of body mass on unit of metabolism	1P
05	Effect of drugs/pesticides on serum parameters	1P
06	Study of structural components of animal house and their utility	1P
07	Analysis of Creatine phosphate in vivo/in vitro	1P
08	Determination of the efficiency of contraction in skeletal muscle fibers by rate of release of inorganic phosphate	1P
09	Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney	1P
10	Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Thyroid and Parathyroid	1P
11	Detection of blood by hemin crystals test	1P
12	3-D viewing of Acetylcholine, ion channel proteins using RasMol/ Deepview softwares/	1P
13	Determination of pack cell volume (P.C.V).	1P
14	Determination of mean corpuscular volume (M.V.C.)	1P
15	Preparation of thin and thick smears of blood parasites	1P
16	Culture of <i>Leishmania</i> and preparation of slides	1P
17	Observation and study of multicellular parasites	1P
18	Study of various stages of malarial parasite-	1P
19	Study of physiology of multicellular parasites	1P
20	Study of forensically important vectors and parasites	1P
	* From above practicals, any 10 practicals (equivalent to 30H) will be taken.	

ZOO 616 MJP: Advanced Techniques in Molecular Biology (2 Credits: 30 Hours)

Course Objectives:

This practical course offers hands-on training in various molecular techniques and their applications in Recombinant DNA Technology and gene expression profiling.

Course Outcomes:

Upon completing this course, students can

- understand how transformation experiments are carried out and how transformant over non-transformant bacteria colonies are selected.
- perform the restriction digestion and ligation experiments.
- have hands-on experience designing primers and setting up a PCR for a gene and its result interpretation.
- have hands-on experience in RNA isolation, estimation and demonstration of RT-PCR and fold change calculation.

ZOO 616 MJP: Advanced Techniques in Molecular Biology (2 Credits: 30 H)		
01	To study the transformation of <i>E.coli</i> cells with plasmid DNA.	2P
02	To study small scale extraction and purification of plasmid DNA.	1P
03	To set Restriction digestion reaction of pBR322 DNA	1P
04	Designing the PCR primer	1P
05	To Prepare a passenger DNA by PCR using <i>Taq</i> DNA Polymerase	1P
06	Linearization of T – vector	1P
07	Ligation of PCR product into T-vector	1P
08	Transformation of Ligated T vector	2P
09	RNA Isolation and estimation	1P
10	RT-PCR and analysis	1P

ZOO 600 RP: Research Project (4 Credits)	
	<p>Procedures and guidelines for the conduct of the Research project:</p> <ul style="list-style-type: none"> ● Students are supposed to register for the course ZOO 600 RP & ZOO 650 RP individually. ● A student will carry out the academic activity for the course throughout the semester. ● The course is to be completed under the supervision and guidance of a teacher. Each teacher of the Department of Zoology, Savitribai Phule Pune University is expected to guide at least one group of students. ● The respective teacher is expected to engage a group of students for at least 4 hours/week for ZOO 600 RP and at least 6 hours/week for ZOO 650 RP. ● Every group will submit a dissertation at the end of the semester duly signed by all group members and the respective teacher.

ZOO 651 MJ: Ethology and Evolution (2 Credits: 30 L)

Course Objectives:

The course aims to provide a broad outline of studying animal behaviour and evolutionary processes. Further, it also provides insights into the development of animal behaviour emphasizing on the genetic and neural basis of animal behaviour. The course provides a thorough understanding of the various strategies adopted by animals for maximizing reproduction, parental care and evolution of sociality. Similarly, the course provides comprehensive knowledge about different evolutionary processes emphasizing on the pre-Darwinian period, Darwin's theory and post-Darwinian concepts about evolution.

Course Outcomes:

Upon completing this course, students will:

- Acquire knowledge about animal behaviour and how to study animal behaviour.
- Get acquainted with the tools used in studying animal behaviour and also understand the genetic and neural basis of behaviour
- Acquire knowledge about various theories about evolution and how different types of evidence have provided support to the theory of evolution.
- Acquire insights into how the interaction between genes and environment drives evolution of different traits and adaptation.

ZOO 651 MJ: Ethology and Evolution (2 Credits: 30 Lectures)		
01	Introduction: Questions about behavior, Patterns of behaviour; Development of behavior: Genetic basis of behavior, Hormone- brain relationship, Bird song development; Neural basis of behavior: Stimulus filtering, Biological rhythms.	4L
02	Exploitation of resources: decision making, prey-predator interaction Communication and animal signals: Communication, Evolution of animal signals.	4L
03	Reproductive strategies and Parental care: Sexual selection, Mating systems, Parental care Social organization : Altruistic behavior and concept of inclusive fitness, Evolution of helpful behavior, Evolution of eusocial behavior.	7L
04	Darwinian & pre-Darwinian concepts of evolution: Concept of organic evolution, Lamarckian theories, Darwin's theory of natural selection : merits and demerits, Darwinian concepts and sources of variation.	3L
05	Origin of Universe (Big Bang Theory); Origin of life: coacervates, Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Urey and Miller; the first cell; evolution of prokaryotes; evolution of unicellular eukaryotes; anaerobic metabolism, origin of oxygen in atmosphere; evolution of metabolic pathways.	9L

	Evidences of Evolution: Evidences from fossils, geographic distribution, comparative anatomy & embryology, vestigial organs and biochemical evidences. Relative and radioisotope dating for fossil age determination.	
06	Post-Darwinian concepts of evolution: Gradualistic vs. non-gradualistic theories, Mayr's Founder Principle, Gould's punctuated equilibrium theory, Kimura's neutral theory, Endosymbiotic theory of Margulis contemporary views.	3L

Reference Books:

- This is Biology: The Science of Living World, Mayr, M. (1997), Universities Press Ltd.
- Evolution, Strickberger, M. W. (2000), III edition, Jones and Bartlett Publishers London.
- Biology, N.A. Campbell and J.B. Reece (2009), VIII edition, Benjamin Cummings Publications.
- Evolution. N.H. Barton et al. (2007). Cold Spring Harbor Lab. Press
- Evolution. Douglas Futuyama, Oxford University Press 2010
- Evolution. Douglas Futuyama and Mark Kirkpatrick, V edition, Oxford University Press 2022
- An introduction to animal behaviour. Aubrey Manning and Marian Stamp Dawkins. VI edition (2012). Cambridge University Press
- Animal Behavior: An evolutionary approach. John Alcock X edition (2013). Sinauer Associates, Inc. Publishers

ZOO 652 MJ: Biology of Reproduction (2 Credits: 30 L)

Course Objectives:

The course aims to provide a broad outline of patterns of productive cycles and the role of exogenous (environmental) and endogenous (hormones) factors in regulating reproductive processes in different mammals including humans. Further the course will provide a thorough knowledge about different endocrine axes and their role in regulating reproduction in mammals. Similarly, it also provides comprehensive knowledge about pregnancy, parturition and lactation including the molecular mechanisms and hormonal regulation. Finally, the course also provides information about the ways in which reproductive potential can be enhanced/suppressed.

Course Outcomes:

Upon completing this course, students will:

- Acquire knowledge about patterns of reproductive cycles in different mammals and the role of extrinsic and intrinsic factors controlling reproduction and reproductive behaviour.
- Get knowledge about the hypothalamus-pituitary-gonad axis in controlling reproduction and reproductive behaviours
- Acquire knowledge about molecular mechanisms regulating different aspects of pregnancy and lactation.
- Acquire insights into the tools and techniques used in enhancing/suppressing the reproductive potential.

ZOO 652 MJ: Biology of Reproduction (2 Credits: 30 Lectures)		
01	Reproductive organs: Male and female gonads: duct systems and sex accessories. Reproductive Patterns: Environmental factors and breeding, continuous and seasonal breeders. Reproductive Cycles: Puberty, Oestrous and Menstrual cycles. Ovulation (spontaneous and reflex), Cycling of non-pregnant uterus and vagina.	5L
02	Hormonal regulation: Hypothalamo-hypophysial–gonadal axis; Hypothalamic GnRH, Pituitary gonadotropins, behavioural effects. Testicular hormones, Inhibin. Ovarian hormones.	5L
03	Pregnancy: Conception and blastocyst formation, Implantation and delayed implantation, Placenta: formation, types and functions. Hormones of pregnancy.	6L
04	Parturition: Birth process and its neuroendocrine control. Lactation: Milk glands, milk synthesis and secretion, Hormonal regulation, Suckling reflex.	5L
05	Reproductive dysfunctions: Ageing and reproduction, Climacteric, anatomical, endocrine and genetic disorders. Immunological aspects. Environmental effects.	4L
06	Artificial control of reproduction: Enhancing reproductive potential: artificial insemination, In-vitro fertilization and embryo transfer, Induced breeding, Synchronization of Estrus and ovulation: Chemical and hormonal aspects. Limiting reproductive potential: Physical, physiological, surgical and chemical methods of contraception (male and female): Causes and treatment, hormonal aspects, Monitoring fetal development : Methods and implications.	5L

References:

- Knobil, Ernst and Neill, Jimmy D. (2005). Physiology of Reproduction Vol 1 – 3. Academic Press.
- Knobil, Ernst and Neill, Jimmy D. (1998). Encyclopedia of Reproduction. Vol 1-3. Academic Press.
- Clarke, J. R. (1988). Oxford Review of Reproductive biology. Oxford Science Publications.
- James, E. W. Jr. (1988). Vertebrate Reproduction. Wiley Interscience.
- Metz, C.B. and Monroy, A. (1985). Biology of Fertilization. Academic Press.
- Devaraj Sarkar, H. B. (1985). Principles of Vertebrate Reproductive Biology. Ganapathy Graphics.
- Guyton, A. C. and Hall, J. E. (2001). Text book of Medical Physiology. 10th edition. W. B. Saunders Company, Philadelphia.
- Tortora, G. J. and Derrickson, B. (2006). Principles of Anatomy and Physiology, 11th edition, John Wiley and Sons Inc.

ZOO 653 OE: Vertebrate and Invertebrate Embryology (2 Credits: 30 L)

Course Objectives:

The course aims to provide a detailed outline of embryonic development of vertebrates and invertebrates emphasizing on protostomes and deuterostomes. It enables students to understand the development of gametes and fertilization. It provides knowledge about processes like metamorphosis, regeneration and their hormonal control.

Course outcome:

Upon completing this course, students will:

- Comprehend the fundamental mechanisms underlying the embryonic development (both vertebrate and invertebrate) differentiation of its tissues, organs, and organ systems.
- Get a thorough knowledge about reproductive processes in invertebrates and vertebrates, as well as the theoretical and practical goals of descriptive embryology.
- Understand and appreciate the importance of basic embryological and developmental processes in understanding more complex processes like differentiation and ageing.

ZOO 653 OE: Vertebrate and Invertebrate Embryology (2 Credits: 30 Lectures)		
01	Overview of invertebrate development Basic patterns and model systems, Deuterostome and Proterostome developmental patterns, developmental origin of Coelom, body axis etc.	5L
02	Moulting and Post-embryonic metamorphosis in invertebrates. Insect development – Basic patterns.	5L
03	Developments of gametes, spermiogenesis and capacitation, Oogenesis and vitellogenesis.	5L
04	Mechanisms of Fertilization, Acrosome reaction, egg activation.	5L
05	Metamorphosis; hormonal control during amphibian Development Limb regeneration, positional effect and polarity.	5L
06	Molecular Mechanisms of competence and neural induction in frog and chick embryo.	5L

Reference Books:

- Developmental Biology (VIII edition) S. F. Gilbert. Sinauer Associates Inc. USA. 2006.
- Principles of Development (III edition) Lewis Wolpert Oxford University Press
- UK. 2007.
- An Introduction to Embryology (V edition). B. I. Balinsky. Thomas Asia PVT. LTD. Singapore.
- Developmental Biology: R. M. Twyman. Bios Scientific Publishers LTD. New Delhi (2001)

ZOO 654 MJ: Advanced Entomology (2 Credits: 30 Hours)

Course Objectives:

The discipline studies key principles, methodologies, approaches, and practical examples of Insect-Plant Interactions, Genes of interest in entomological research, and advanced Emerging Pest Management Strategies and Technologies. This important information continues to be essential in all aspects of insect pest management, applied entomology, crop protection, and medical and veterinary entomology.

Course Outcomes:

In this course, students should aim to acquire the following skills:

- Deciphering the Plant-Insect interactions, Nitrogen Modulation on Plant Direct and Indirect Defenses, and all of the latest methods involved in the control and management of insects as well as socio-economic and research management aspects of developing integrated approaches to pest management.
- The key advances made in the disciplines of molecular biology, biochemistry and genomics related to insect research
- Emerging Pest Management Strategies and Technologies

ZOO 654 MJ: Advanced Entomology (2 Credits: 30 Lectures)		
01	Insect-Plant Interactions: Deciphering the Plant-Insect Phenotypic Arms Race, Insect Herbivory-Inducible Proteins Confer Post-Ingestive Plant Defenses, Inducible Direct Defense of Plants Against Insects, Host Marking and Host Discrimination in Phytophagous Insects, Nitrogen Modulation on Plant Direct and Indirect Defenses	7L
02	Genes of interest in entomological research Marker genes for sex identification, neuropeptides, JH esterase, St toxins and venoms, chitinase, CPTI; lectins, and proteases. Peptides and neuropeptides, JH esterase, St toxins and venoms, chitinase, Bt toxin, CPTI; trypsin inhibitors, lectins and proteases, neuropeptides. Transgenic plants for pest resistance and diseases.	8L
03	Advanced Insecticide Toxicology: Cytochrome P450s: Their Role in Insecticide Resistance and Strategies in the Isolation and Characterization, P450-mediated Insecticide Detoxification and Its Implication in Insecticide Efficacy, Metamorphosis of Cisgenic Insect Resistance Research in the Transgenic Crop Era, Resistance to Transgenic <i>Bacillus thuringiensis</i> Crops in Target Insect Pests: Current Status and Prospect, Potential Use of Proteinase Inhibitors, Avidin, and other Bio-reagents for Synergizing Bt Performance and Delaying Resistance Development to Bt.	7L

04	Emerging Pest Management Strategies and Technologies: Advances and Prospects of RNAi Technologies in Insect Pest Management, Anti-tick Vaccine Development: Status and Perspectives, Hymenopteran Parasitoids and Their Role in Biological Control of Vegetable pests, Development of an Integrated Greenhouse for pest management Program, Advances in Research on the Venom Chemistry of Imported Fire Ants, Utilization of Lignocellulose-feeding Insects for Viable Biofuels: An Emerging and Promising Area of Entomological Science.	8L
-----------	--	-----------

References:

- Jain, P. C., & Bhargava, M. C. (2007). Entomology: novel approaches. New India Publishing.
- Liu, T., & Kang, L. (2011). Recent advances in entomological research. Springer Berlin Heidelberg.
- Ishaaya, I., Nauen, R., & Horowitz, A. R. (2007). Insecticides design using advanced technologies (pp. 249-261). Berlin Heidelberg: Springer.
- Agarwal, V. M., & Rawal, D. (2022). Advanced Research and Review in Zoology & Entomology Sciences.
- Dyer, L. A. (2023). Essential Entomology.
- Waseem, M. A., Hazarika, S., Chandar, A. S., & Gupta, (2024) S. Recent Trends in Entomology.

ZOO 655 MJP: Image and Data Analysis: Software Applications (2 Credits)

Course Objectives:

This practical course offers hands-on training on various softwares used extensively in the field of biological research. The practical engagement and active participation of student is the prerequisite for this course.

Course Outcomes:

Upon completing this course, students will

- Be able to use various softwares for statistical analysis of the data.
- Learn to use softwares and web applications to create illustrations and analyse images.
- Learn to make publication quality graphical representation of the data.
- Learn to use citation management tools to generate references, citations and bibliographies in a whole range of journal styles.
-

ZOO 655MJP: Image and Data Analysis: Software Applications (2 Credits)		
01	ImageJ Software: ImageJ is a widely-used open-source software that allows users to visualize, inspect, quantify, and validate scientific image data.	2P
02	BioRender WebApp: BioRender is a web application that can be used to create scientific figures, diagrams, and illustrations from a scientifically accurate image library.	2P

03	SPSS Software: IBM SPSS Statistics, is a software package used for the analysis of statistical data.	2P
04	PAST/Origin-Pro Software: Past is free software for scientific data analysis, with functions for data manipulation, plotting, univariate and multivariate statistics. Origin-Pro offers advanced data analysis tools such as for peak fitting, curve fitting, statistics and signal processing.	2P
05	Mendeley/Endnote/Zotero Software tools: These are citation management tools that offers all the basic citation management features. These tools generate references, citations and bibliographies in a whole range of journal styles.	2P

ZOO 656 MJP: Laboratory and Field Exercises in Ethology, Evolution and Advanced Entomology (2 Credits)

Course objectives:

The course aims to provide hands-on training on how to study animal behaviour. Further, it emphasizes on understanding the animal behaviour in nature and how innate and acquired behaviours help organisms to adapt to the changing environment. It also provides an outline on the importance of studying animal behaviour in evolution and conservation biology

Course Outcomes:

After the completion of the course the student will:

- Gain insights into different aspects of animal behaviour including the tools and methods used in studying animal behaviour in nature
- Get acquainted with the use of different model systems to address different questions in ethology
- Gain knowledge of the importance of studying animal behaviour in evolution and conservation
- Learn about Codex guidelines on good practice in pesticide residue analysis as well as quality control of pesticide residue measurements and can evaluate their results
- Learn the rearing technique of important insect pests, their parasites and entomopathogenic fungi and can see their effect on the development and toxicity of insect pests
- Learn the effect of different pesticides on insect digestive and nervous system, detoxification process.

	ZOO 656 MJP: Laboratory and Field Exercises in Ethology, Evolution and Advanced Entomology (2 Credits)	
01	Laboratory and field experiments in animal behaviour: Recognition (Predator and Kin), Learning, foraging, Reproduction, Parental care,	1P

02	Studying the importance of Innate Vs Acquired behaviour using amphibian tadpoles as model systems	1P
03	Studies on Predator-Prey interaction- Recognition of predators by prey using amphibian tadpoles	1P
04	Study on Pavlovian conditioning and its effect on learning using amphibian tadpoles/rats/mice	1P
05	Studying caste systems in paper wasps, honey bees and termites to understand its significance in the evolution of eusociality in insects.	1P
06	Embryological, Anatomical and Fossil evidences for evolution	1P
07	Study of homology and analogy and their significance in evolution	1P
	* From above practicals, any 5 practicals (equivalent to 15H) will be taken.	
01	Codex guidelines on good practice in pesticide residue analysis	1P
02	Practical Sampling, extraction, clean-up and estimation of insecticide residues by various methods.	1P
03	Preparation and storage of reference standard solutions	1P
04	Rearing of insect pests and parasitism by Hymenopteran parasitoids	1P
05	Parasitism by Hymenopteran parasitoids on food consumption and development of insect pest.	1P
06	Effect of parasites/entomopathogenic fungi on the insect pest.	1P
07	Effects of various insecticides on the cytochrome P450 in insect pests	1P
08	Effects of juvenile hormone (JH) analog insecticides on larval development and	
09	JH esterase activity in insect pest	1P
10	Effects of different Proteinase inhibitors on the activity of proteases in midgut juices of insect pests	1P
11	Effect of different pesticides on insect nervous system.	1P
	* From above practicals, any 5 practicals (equivalent to 15H) will be taken.	

ZOO 661 OE: Applied and Analytical Genetics (2 Credits: 30 L)

Course Objectives:

The objective this course is to offer detailed knowledge of non-Mendelian (Linkage and cytoplasmic) inheritance patterns. Concepts of quantitative, polygenic genetics and applied cytogenetics along with developmental and population genetics will be taught.

Course Outcomes:

- Students will learn about non-Mendelian model organism.

- Students will understand the effect of genetic and environmental factors on the inheritance of traits, how do they influence/ regulate the innate behaviour and hence genetics of psychiatric disorders
- Students will learn how multiple allele genes are inherited.
- By the end of the course, students will learn about the techniques which help in diagnosing genetic disorders.

ZOO 661 OE: Applied and Analytical Genetics (2 Credits: 30 L)		
01	Non-mammalian model system in genetic studies: <i>Drosophila melanogaster</i> , <i>Caenorhabditis elegans</i> , <i>Danio rerio</i> (Suitability of salient features, scope, genetic methodologies, and applications of each model system)	3L
02	Quantitative Genetics & Polygenic inheritance-- Fundamentals and Applications: Polygenic inheritance and salient features (human and commercially important animals and plants), Heritability estimation and applications and partitioning of variance, Twin studies in human and heritability analysis of quantitative traits	5L
03	Advanced Population Genetics & Evolutionary genetics Implications of Hardy-Weinberg principle on gene pool and effect of genetic drift in a population, Artificial selection and application in animal breeding program, inbreeding depression, Mutation-selection balance: Balanced, Directional and Disruptive selection pressures and effect on genetic profile of population.	5L
04	Applied Cytogenetics: Molecular Cytogenetics and detection techniques for genetic disorders, Clinical cytogenetic nomenclatures : practices and applications, Polytene chromosome system and application in genetics	2L
05	Developmental Genetics: Genetic regulation of early embryonic development, cascade of gene action control of differentiation during development (<i>Drosophila</i> as model)	3L
06	Behavioural & Neurogenetics: Genetic methodologies for studying genes influencing / regulating innate behavioural traits, Mutants of cognitive functions, Genetic regulation of biological rhythms, Ion channel mutants affecting neural circuitry, Genetics of psychiatric disorders.	4L
07	Inherited Disorders & Clinical Genetics: Single gene, multifactorial disorders, loss of function and other mutations, , organelle based genetic disorders, Inherited disorders of metabolism of nucleic acids, proteins, carbohydrate and lipids, detection techniques of genetic disorders, family screening and counselling, risk assessment, conventional and contemporary prenatal diagnosis and pre-implantation diagnostic methods.	5L

08	Extrinsic & Intrinsic Factors & genetic consequences: Fundamentals of Epigenetics and genetics of cancer.	3L
-----------	---	-----------

Reference books:

- *Concepts of Genetics*, 11th edition (2019), William S. Klug, Michael R. Cummings, Charlotte Spencer, and Michael A. Palladino, Publisher-Benjamin Cummings
- *Genes XII*, 12th edition (2017), Benjamin Lewin, Publisher-Jones and Bartlett Publishers Inc.
- *Principles of Genetics*, 6th edition, (2011), Snustad D. Peter and Simmons J. Micheal, Publisher - John Wiley and Sons. Inc.
- *Principles of Genetics*, 8th edition (2006), Eldon J. Gardner, D.P. Snustad, M.J. Simmons, and D. Peter Snustad Publisher-John Wiley and Sons. Inc.
- *Microbial Genetics*, (1990), David Freifelder, Publisher-Jones & Bartlett
- *Genetics*, 3rd edition, Monroe W. Strickberger, (2015), Publisher - Macmillan Publishing Co.

ZOO 662 OE: Genomics and Proteomics

Course Objectives:

The objective is to offer detailed knowledge of structural, functional genomics and the various techniques that can be used to understand genetic potential or phenotype or protein and proteome expression. The basic concepts behind genome mapping and global gene and protein expression will also be taught.

Course Outcomes:

- Students will learn the genetic and physical mapping of the genome and the techniques used in mapping.
- Students will understand the global genome and proteome expression analysis techniques and its result interpretation.
- The details genome sequencing, 2D PAGE and MS techniques will be taught.

ZOO 662 OE: Genomics and Proteomics (2 Credits: 30 Lectures)		
01	Introduction to Genomics: structural genomics, Functional Genomics Genome projects: The Human genome project, HapMap Project, The 1000 genome project, and The ENCODE Project.	4L
02	Physical mapping: Restriction mapping, Fluorescent in situ hybridization, Radiation hybrid mapping and Sequence tagged site mapping. Structural genomics: Genome sequencing, Sanger sequencing, 2 nd and 3 rd generation sequencing. Assembly of a contiguous DNA sequence- shotgun method, clone contig method, and whole –genome shotgun sequencing	11L
03	Global expression profiling: Whole genome analysis of mRNA expression, RNA Seq and microarray analysis and their applications.	5L
04	Importance of proteomics Strategies in proteomics: 2D PAGE and Mass spectrometry Global protein expression profiling: Whole protein expression, microarray analysis and their applications. Applications of proteomics: Understanding mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins Database and search engines in proteomics.	10L

Reference books:

- Molecular Biology of the gene, 7th edition (2013), James D Watson, Pearson publication.
- Gene XII, Benjamin Lewin, 12th edition (2017), Jones and Bartlett Publishers.
- Molecular Biology of the Cell, 7th edition (2015), Bruce Alberts, Rebecca Heald, Alexander D. Johnson, David Morgan, Martin C. Raff, et.al. Garland Science, Taylor and Francis Group.

ZOO 663 OE: Stem Cells, Regenerative Medicine and Cancer (2 Credits: 30 L)

Course Objectives:

The course aims to provide a detailed outline of stem cells, types, characteristics and applications of stem cells in tissue remodeling and repair. Further, it enables the student to understand different factors controlling stem cell population and their proliferation. The course also provides a comprehensive knowledge about the applications of stem cells in regenerative medicine. The course provides a detailed outline on cancer and its development. It also provides information about the factors (genetic and non-genetic) contributing to tumorigenesis. Finally, it provides knowledge about the diagnostics used in cancer detection and therapies.

Course Outcomes:

After the completion of the course, the student will:

- Gain a comprehensive knowledge about stem cells, types and classification and their characteristics
- Get insights into the applications of stem cells in tissue repair and regenerative medicine.
- Become familiar with cancer, its hallmarks, factors contributing to its development.
- Get acquainted with the tools and techniques used in cancer diagnostics and therapies

ZOO 663 OE: Stem Cells, Regenerative Medicine and Cancer (2 Credits: 30 Lectures)		
01	Introduction to stem cells Definition and general characteristics; <i>In vitro</i> morphology and growth parameters; Surface markers; Differentiation potential; Immunomodulatory and wound healing potential.	3L
02	Classification of stem cells ; Classification based on origin - Mesenchymal stem cells; Hematopoietic stem cells, Neural stem cells, Cancer stem cells Classification based on source and potency - Embryonic stem cells, Adult stem cells, Induced pluripotent stem cells (iPSCs) Factors affecting <i>in vitro</i> behavior of stem cells microenvironment cues, mechanical forces, adhesion surfaces, growth factors.	6L
03	Application of stem cells Tissue Engineering and Regeneration; Osteogenesis - Osteoarthritis, Osteoporosis; Chondrogenesis: Rheumatoid arthritis, Degenerative disc disease; Angiogenesis: Myocardial infarction, Coronary heart diseases; Neurogenesis: Spinal cord injuries; Parkinson's disease; Other disorders: Diabetes Mellitus, Muscular dystrophy [Note: For each representative disease few case studies and animal models can be discussed]. For disease modeling, Development of 3D <i>in vitro</i> culture models/ organoid systems for replicating disease pathology and physiology. Stem cell derived Microvesicles/ Exosomes- Characterization and applications.	10L
04	Limitations for large scale cultivation of stem cells; Stem cell research: Risks and ethics; Regulatory guidelines for stem cell therapy.	3L
05	Cancer Biology Introduction: types and classification, Hallmarks, Tumor viruses, Cellular oncogenes, growth factors, receptors and cytoplasmic signaling in cancer. Tumor suppressor genes: pRb and control of cell cycle, p53 and apoptosis: master regulator of cellular immortalization and tumorigenesis; Maintenance of genomic integrity and tumorigenesis, Tumor immunology; Angiogenesis and cancer, Invasion and metastasis, Diagnostics and therapies.	8L

Reference books

1. Culture of Human Stem Cells. Ed. R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach. *John Wiley & Sons*. <https://doi.org/10.1002/9780470167526>

2. Essentials of Stem Cell Biology. Ed. Robert Lanza and Anthony Atala. *Elsevier, Academic Press*. <https://doi.org/10.1016/C2012-0-06957-8>

3. Human Stem Cell Manual: A Laboratory Guide. Ed. Jeanne F. Loring, Robin L. Wesselschmidt and Philip H. Schwartz. *Academic Press*. <https://doi.org/10.1016/B978-0-12-370465-8.X5000-5>

4. The biology of Cancer. Robert Weinberg, II edition, Garland Publishing 2013

ZOO 664 OE: Bioinformatics: Theory and Applications (2 Credits: 30 L)

Course Objectives:

To provide detailed knowledge regarding computational analysis of biological data. To provide knowledge regarding structural biology.

Course Outcomes:

- Students will learn different biological databases and data retrieval.
- Students will understand different algorithms for sequence alignments, gene prediction and annotation.
- Protein structure function relationship will be taught.
- Various methods for construction of Phylogenetic tree and its application will be taught.

ZOO 664 OE: Bioinformatics: Theory and Applications (2 Credits: 30 L)		
01	Introduction to Bioinformatics, Concepts and applications Biological Databases- Concept, types, specialization, limitations, DBMS Data retrieval from various databases, homology searching and their applications Sequence Alignments- Algorithms, Scoring Matrices, Multiple Sequence Alignment (MSA)	10L
02	Structural bioinformatics: Protein structure basics, Ramachandran plot, Protein structure- function relationship, SCOP and CATH	5L
03	Phylogenetic analysis and tree construction methods, Gene Annotation- Introduction Sequence and Structure based predictions- Simulation of Molecular interactions Comparative Genomics	15L

Reference books:

- Introduction to Bioinformatics. Arthur M. Lesk (3rd ed.). Oxford University Press.
- Bioinformatics: Sequence and Genome Analysis. David Mount (2nd ed.). Cold Spring Harbor Laboratory Press.

- Bioinformatics for Geneticists: A Bioinformatics Primer for the Analysis of Genetic Data. Michael R. Barnes (2nd ed.). John Wiley & Sons Inc.
- Bioinformatics Tools and Applications. David Edwards, Jason Eric Stajich, David Hansen, Springer, 2009.
- Bioinformatics: Methods and Applications. S C Rastogi, N Mendiratta and P Rastogi, ISBN: 978-81-203-4785-4, PHI Learning Private Limited, 2015.

ZOO 650 RP: Research Project (6 Credits)	
	<p>Procedures and guidelines for the conduct of the Research project:</p> <ul style="list-style-type: none"> ● Students are supposed to register for the course ZOO 600 RP & ZOO 650 RP individually. ● A student will carry out the academic activity for the course throughout the semester. ● The course is to be completed under the supervision and guidance of a teacher. Each teacher of the Department of Zoology, Savitribai Phule Pune University is expected to guide at least one group of students. ● The respective teacher is expected to engage a group of students for at least 4 hours/week for ZOO 600 RP and at least 6 hours/week for ZOO 650 RP. ● Every group will submit a dissertation at the end of the semester duly signed by all group members and the respective teacher.