SIDHO-KANHO-BIRSHA UNIVERSITY

FACULTY OF SCIENCE

DEPARTMENT OF ZOOLOGY

SYLLABUS FOR TWO-YEAR POST GRADUATE COURSE OF ZOOLOGY UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

(With effect from the session 2022–2023)

PREAMBLE

The current era often has been dubbed as century of biology, resolution of structure of DNA, theoretical progress in evolutionary biology, easier and newer methodsof genome sequencing and gene manipulation, RNA interference techniques, RNA editing techniques as well as deeper understanding of biodiversity and ecological understanding has ushered a golden age of biology. Tremendous progress in aforementioned areas in biology has transformed animal science or zoology in to forefront of scientific discovery and has wide implications for the betterment of society. Path breaking discoveries has blurred the distinction between different fields of biology and has created a deeply interconnected web of information that encourages and necessitates a more multidisciplinary approach to learning process of biology that is also deeply entwined into the constitution of our society than ever before. Keeping the challenges of this information driven revolution in biology in mind, that now includes cutting edge discoveries and newer understanding of cognition, neurobiology, evolutionary psychology, genomics, proteomics, bioinformatics, imaging and various other fields, a modern learner of Zoology needs to have much wider conceptual base than ever before. Keeping the challenges of modern biology in mind and by adopting a balanced approach we have meticulously constructed the current syllabus to introduce learners to concepts and information encompassing a much wider array of topics, ranging from basic and classical understanding to most recent that will cater to the need of a present day post graduate student by strengthening their conceptual base as well as providing them with opportunity to learn cutting edge and applied methods that has direct implication for immediate career possibilities. We have included in our syllabus, core areas such as cell biology, genetics, biodiversity, biochemistry, evolution, taxonomy and their helpful applications for the advancement of humanity, which have been grouped together. Students, peers, and members of the corporate world all have a say in the development of the curriculum.

CONTENT

PROGRAMME OUTCOME

The curriculum of the department has been carefully crafted to give equal weight to both the traditional aspects of the study of Zoology and its many contemporary applications. The traditional components of zoology include taxonomy, biosystematics, histology, animal physiology, evolution, and ecology. On the other hand, the contemporary dimension of the course curriculum has attached the most significant components of molecular biology, genetics, biotechnology, bioinformatics, biochemistry, immunology, and biostatistics. The results and academic performance of current and former students, which is being reflected in their success in various competitions at the national and state level, indicate that the effort appears to be very fruitful. In order to keep up with the above-mentioned course curriculum, the department offered a total of four distinct special papers (Parasitology and Immunology, Fisheries and Aquaculture, Cell Biology and Genetics). These papers have made it possible for students at the University to receive proper recognition on a national level, as well as to obtain a variety of subject-based services. In addition, the outreach and extension programme that includes students in their practical education has made a significant contribution to the generation of livelihoods for marginalized people in the region. The curriculum of the programme as a whole has been meticulously crafted to ensure that students are well-prepared for competitive examinations such as CSIR NET, SET, GATE, and others, as well as for the writing of research proposals for grants.

Marks Distribution

1. In each course, 20% marks is allotted for Internal Assessment.
2. Marks distribution for each paper will be as follows:
   a. For 40 marks of UNIT based paper:
      UNIT I and **UNIT II** (Total Marks 20): **Four** questions (out of **Six**) of 1 mark each, **three** questions (out of **Five**) of 2 marks each and **two** question (out of **Four**) of 5 marks are to be answered

   b. For 40 marks of NON-UNIT based paper:
      Eight questions (out of **Twelve)** of 1 mark each, **six** questions (out of Nine) of 2 marks each and **Four** question (out of **Eight**) of 5 marks are to be answered

   c. Broad question may be of 5 marks or (4+1) marks or (3+2) marks

Internal assessment: Continuous evaluation through term paper, viva, written examination, assignments, tasks or group activity.

M.Sc. ZOOLOGY SEMESTER MARKSDISTRIBUTION

SEM	THEORY	PRACTICAL
I	200	100
II	200	100
III	200	100
IV	200	100
TOTAL	**800**	**400**

SYLLABUS
SUBJECT: ZOOLOGY
Total Marks:1200

SEMESTER	Course Code	Course title		Credit	Marks	No. of Class hr./week
SEMESTER- I	MZOOCCT101	Unit – I Non-Chordates Structures & Function	Unit – II Entomology	4	40+10	4
	MZOOCCT102	Chordates: Structures & Function		4	40+10	4
	MZOOCCT103	Unit-I Animal Physiology, Endocrinology and Reproductive biology	Unit-II Biochemistry, Biophysics and biophysical techniques	4	40+10	4
	MZOOCCT104	Unit-I Cell structure and Function	Unit II Developmental Biology	4	40+10	4
	MZOOCCS105	Practical		4	50	8
	MZOOCCS106	Practical		4	50	8

SEMESTER	Course Code	Course title		Credit	Marks	No. of Class hr./week
SEMESTER-II	MZOOCCT201	Unit-I Genetics	Unit – II Evolutionary Biology	4	40+10	4
	MZOOCCT202	Unit-I Behavioural Biology	Unit-II Ecology	4	40+10	4
	MZOOCCT203	Unit-I Parasitology and Microbiology	Unit-II Immunobiology	4	40+10	4
	MZOOCCT204	Unit-I Applied Entomology (Skill Development Course)	Unit – II Aquaculture (Skill Development Course)	4	40+10	4
	MZOOCCS205	Practical		4	50	8
	MZOOCCS206	Practical		4	50	8

SEMESTER	Course Code	Course title		Credit	Marks	No. of Class hr./week
SEMESTER III	MZOOCCT301	Unit-I Molecular Biology and Biotechnology	Unit – II Environmental Biology & Toxicology	4	40+10	4
	MZOOCCT302	Unit-I Bio Systematics	Unit-II Biodiversity, Wild life conservation and Ethnobiology	4	40+10	4
	MZOOMET303	Major Electives (Parasitology and Immunology/ Fisheries and Aquaculture/ Genetics and Cell Biology).		4	40+10	4
	MZOOOET304	Open Elective		4	50	4
	MZOOCCS305	Practical		4	50	8
	MZOOOPP306	Outreach Program		4	50	8

SEMESTER	Course Code	Course title		Credit	Marks	No. of Class hr./week
SEMESTER IV	MZOOCCT401	Unit-I Neurobiology	Unit – II Biostatistics, Introduction to Bioinformatics and Bioethics	4	40+10	4
	MZOOMET402	Unit-I	Unit-II	4	40+10	4
	MZOOMET403	Unit-I	Unit-II	4	40+10	4
	MZOOACT404	Add on Course		4	50	8
	MZOOMES405	Practical		4	50	8
	MZOOMEP406	Project		4	50	4

Semester-I
Paper –MZOOCCT101
Unit I
(Non-Chordates: Structure and function)

Total marks: 50 **No. of Class Hrs. 60**

Course Objective: It is required to generalize about certain things and to dismiss others because the field of invertebrate biology is so extensive and runs across so many disciplinary lines that it is necessary to generalize about some topics. Structure and function were chosen as the two primary focuses for the curriculum that we devised for studying invertebrates so that we could establish common threads of interest. The first topic that we cover is structure, through which students will understand the fundamentals of functional body architecture. The second set of themes focus on the degree to which the structure has been adapted over time to fulfil a specific function for the organism that bears it. As a result, the most important objective that we have set for ourselves is to pique the students' interest in learning about the mystical world inhabited by animals that do not possess any notochords.

1. General Organization:
1.1. Organelles in Protozoans- Cilia, flagella, pseudopodia, vacuoles, Kinetoplast, Pellicle and skeleton.

2. Feeding and Digestion:
2.1. Nutrition in Protozoa -Types and mode of feeding.
2.2. Feeding diversity in Rotifers, Bryozoans and Echinoderms (Selected major and minor phyla)- Structural diversities.

3. Movements:
3.1. Movements in Amoeba, Annelids (Earthworm); Echinoderms (Starfish).

4. Blood Circulation:
4.1. Circulation in Earthworm, and *Pila*.
4.2. Types of blood circulation (open and close types).

5. Excretion:
5.1. Structure and function of kidneys in cephalopods

6. Nervous System:
6.1. Brief introduction to Nervous Organization with special reference to Cephalopods

7. Reproduction:
7.1. Budding and regeneration in Hydra and Plannarians.
7.2. Invertebrate hormones of reproduction with special emphasis on Crustaceans.

8. Growth and Development:
8.1. Moulting in Crustaceans: Hormonal regulation
8.2. Larval forms in echinoderms and hemichordates.

Unit II

Entomology

1. Insect Diversity & Classification:

1.1. Insect diversity and adaptive features.

1.2. Outline classification of Insects up to the orders with examples (After Richards and Davies, 1977 with minor revision).

2. Integument of Insects:

2.1. Basic structure and functions; structure of cuticle, sclerotization, epidermis and basement membrane.

2.2. Structure and type of insect wing, Wing venation

3. Feeding mechanism and feeding structure in Insects:

3.1. Mouth parts of insect

3.2. Structure of the gut, digestion and absorption of food, & fat body.

4. Insect Blood Circulation:

4.1. Composition, Structure, and Function.

4.2. Diaphragm and heart, haemolymph and its functions

5. Photogenic Organ and Light Production in Insects.

6. Mechanism of Sound Production:

6.1. Types of insect sound; significance of sound production.

7. Introduction to Insect Nervous System.

7.1. Mechanism of impulse conduction.

8. Reproductive Mechanism:

8.1. Basic idea of Parthenogenesis, Viviparity, Polyandry, Hermaphroditism in Insects.

8.2. Hormonal regulation of reproduction in Insects.

9. Growth and Development:

9.1. Insect hormone

9.2. Metamorphosis, Diapause in insects; types and hormonal regulation.

Books Recommended:

1. Barrington, E. J. W. (2012). Invertebrate structure and Function. 2nd edition, Affiliated East-West Press Pvt. Ltd.-New Delhi.

2. Barnes, R. D. & Ruppert, E. E., (1996). Invertebrate Zoology. 6th ed. Brooks Cole.

3. Anderson, D.T. (2002). Invertebrate Zoology, 2nd edition, Oxford University Press.

4. Meglitsch, P.A., & Schram, F.R. (2020). Invertebrate Zoology, 3rd edition, Oxford University Press.

5. Pechenik, J. A. (2019). Biology of the Invertebrates, 7th edition, McGraw Hill Education.

6.Brusca, R.C., Moore, W., & Shuster, S.M. (2016). Invertebrates, 3rd edition, Sinauer Associates.

7. Schierwater&DeSalle (2018). Invertebrate Zoology, A Tree of Life Approach. 1st edition. CRC press, Taylor & Francis group, Garland Science.
8. Gillott, C. (2005). Entomology. 3rd ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book)
9. Chapman, R.F. (1998) The Insects: structure and function 5th edition, Cambridge University Press.
10. Imms, A.D., Richard, O.W., & Davies, R.G. (1977) IMMS' General Textbook of Entomology: (2 volumes), 10th edition, Springer.
11. Klowden, M. J. (2007). Physiological systems in Insects, 2nd edition, Elsevier.
12. Wigglesworth, V. B. (1984). Principles of Insect Physiology, 8th edition, Springer.
13. Gullan, P. J. and Cranston, P. S. (2014). The Insects – an outline of Entomology. 4th ed. Blackwell Publishing.

Course Outcome: As a result of this course, students will have a deeper understanding of the evolution of the systems that invertebrates rely on to survive and reproduce in their natural habitat. This course will also provide students the fundamental idea of insect biology and diversity.

SEMESTER I
Paper MZOOCCT102
Chordates: Structures and Functions
Marks: 50 **No. of Class Hrs. 60**

Course Objective: Chordate biology helps students gain an awareness and comprehension of scientific concepts that combine and reflect on how science works. As John A. Moore put it, science is the "way of knowing". The comparative anatomy of vertebrates reveals distinct differences and similarities between the organisms. Animal skeletons shed light on the basic anatomy of each vertebrate while evolution deals with the development of a complex, interconnected system of organs and their roles. When it comes to evolution, vertebrate anatomy gives a strong example of how an integrated organism could evolve, and theprocess of remodelling, change of a fundamental plan, is the most common method. Using this section of the lesson, students will learn about the exciting journey of vertebrates and how evolution has shaped them to fit the demands of their surroundings.

1. Protochordates
1.1. Ultrastructure and role of notochord and endostyle in Amphioxus and Ascidia with evolutionary significance.

2. Skeletal system
2.1. Origin of jaw and modification of jaw bones and jaw suspension.
2.2. Jaw kinetics in relation to feeding.

3. Respiratory system
3.1. Prerequisites of respiratory system and functional requirements
3.2. Ventilatory mechanisms in relation to diverse adaptations: aquatic and terrestrial

4. Circulatory system
4.1. Heart and Circulation in foetal and neonatal mammals.

5. Excretion
5.1. Evolution of urinogenital system in vertebrate series
5.2. Structure and functions of kidneys with special reference to fish and mammals

6. Nervous system
6.1. Functional organization of brain and evolution of cerebrum.
6.2. Functional association of CNS and information processing.

7. Sense organs
7.1. Diversity of sensory organs-Organs of olfaction and taste,
7.2. Vomeronasal organs in reptiles, electroreception in fish

8. Locomotion and movement
8.1. Aquatic
8.2. Evolution of land vertebrates
8.3. Kinetics of locomotory organs in land vertebrates: general requirements of cursors, design for economy of effort, mechanism of bipedal running
8.4. Aerodynamics-general requirements of flyers: lift, drag, flight and control.

Books Recommended:

1. Kent, G. C., &Carr, R. K. (2000) - Comparative Anatomy of the vertebrates, 9th edition, McGraw Hill Higher Education.
2. Hildebrand, M. (1995). Analysis of Vertebrate Structure, 4th edition, John Wiley & Sons, Inc., New York.
3. Pough, F. H., Heiser, J. B. & McFarland, W. N. (1996). Vertebrate life, 4th Edition, Prentice Hall.
4. Klug, A. G. (1977). Chordate Structure and function. 2nd edition, New York Macmillan.
5. Kardong, K. V. (2018). Vertebrates: Comparative Anatomy, Function, Evolution, 8th edition, McGraw-Hill Education.
6. Young, J. Z. (2004). The Life of Vertebrates, 3rd edition, Oxford University Press.
7. Romer, A. S. (1977). Vertebrate Body, 5th edition, Saunders.
8. Liem, K. F., Bemish, W., Walker, W., & Grande, L. (2001). Functional Anatomy of the Vertebrates: An Evolutionary Perspective, 3rd edition, S. Chand & Company.
9. Kingsley, J.S. (2016). Outlines of Comparative Anatomy of Vertebrates, Wentworth Press.
10. Colbert, E. H., Morales, M. and Minkoff, E. C. (2002). Colbert's Evolution of the Vertebrates: A history of the backboned animals through time, 5th edition, John Wiley Liss, Inc., New York.
11. Wolff, R. G. (1991). Functional chordate anatomy, D. C. Heath Canada, Limited. The University of Michigan.

Course Outcome: Students will find that having knowledge of the diversity, morphology, anatomy, and physiology of different chordate groups to be of immense help in both understanding the animal world and pursuing further studies and research that are directly linked to human welfare, such as disease control, animal husbandry, and functional studies. Students will also find that having such knowledge will help them understand the animal world.

Paper MZOOCCT103
Unit I
Animal Physiology, Endocrinology and Reproductive biology

Marks: 25 **No. of Class Hrs. 30**

Course Objective: The study of the structural and functional plans found in animals is known as animal physiology. Understanding how animals' function on all levels as a whole integrated organism, from cells to tissues to organs, can be aided by knowledge gained through the study of animal physiology. Clarifying the functions of all cells in all organs and all animals in relation to the neurological, respiratory, circulatory, muscular, cellular communication, and transport systems, as well as any other physiological systems, falls under the purview of the scientific discipline known as physiology. This course places a strong emphasis on the various physiological systems of creatures found across the animal kingdom, with a particular concentration on the human body. This course focuses not only on the working of the various physiological systems, but also on the molecular foundation of the functioning of the physiological systems. Molecular basis of the functioning of the physiological systems. There is a widespread belief that the fields of endocrinology and reproductive biology are overly technical and only apply to a small number of selected students. The study of hormones and the role they play in reproduction is known as endocrinology and reproductive biology. Our daily existence would be impossible without hormones. They regulate a wide range of physiological processes, including body temperature, sleep, mood, stress, and even our growth. As a rule of thumb, hormones can be found in all organisms that have more than one cell. Growth, development, puberty, alertness, blood sugar regulation and appetite are just some of the physiological processes they affect or control.

Animal Physiology

1. Size and Scale of Organisms

1.1. Size and surface area to volume ratio.
1.2. Scaling relationship between BMR and body mass
1.3. Metabolic rate as a function pf animal speed in Locust and Cheeta.

2. Thermal Physiology

2.1. Body temperature: physical, chemical and neural regulation.
2.2. Heat transfer between animal and environment.
2.3. Poikilothermy and homeothermy.

3. Physiology of Respiration

3.1. Respiratory pigments and mechanism of respiration in animals.
3.2. Respiratory adaptation in animals in oxygen deficient environment.
3.3. Regulation of blood pressure.

4. Physiology of Excretion

4.1. Physiology of urine formation and its regulation.
4.2. Renal regulation of water and electrolyte balance.

5. Physiology of Blood and Body Fluid

5.1. Haemopoiesis
5.2. Composition and functions of blood plasma and corpuscles in vertebrates.
5.3. Body fluid: Function and regulation.

6. Physiology of Muscles

6.1. Role of ATP and signal molecules in muscular contraction

6.2. Neural regulation in muscular contraction

Endocrinology

1. Mechanism of hormone action
1.1. Classification of hormones, General principles of hormone action, Receptor Biology and Signal transduction pathways
1.2. Synthesis, function, metabolism and structure of hormones

2. Hormones:
2.1. Hypothalamic hormones – their structure and functions.
2.2. Anterior pituitary cell ultra-structures, nature of hormones and their functions.

3. Biosynthesis, functions and metabolism of hormones:
3.1. Thyroid hormone structure and functions.
3.2. Adrenocortico-medullary hormones -- structure and functions.
3.3. Endocrine pancreas: cell types, hormone structure and their role in glucose homeostasis.
3.4. GI tract hormones: source, composition and functions.

4. Hormone Bioassay.
4.1. RIA and ELISA

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Reproductive Biology

1. Development of male and female genital systems in rat/human.
1.1. Biosynthesis and metabolism of androgens.
1.2. Hormonal control of spermatogenesis, Sertoli-cell-spermatid interaction and sperm induction.
1.3. Influence of androgens on extra-gonadal tissues.
1.4. Biosynthesis and metabolism of ovarian hormones.
1.5. Interrelationship between ovarian hormones and ovarian follicles, uterus and vagina.
1.6. Hormonal control of folliculogenesis, ovulation and oocyte maturation.
1.7. Physiological role of ovarian steroids on extragonadal tissues.

2. Endocrine physiology of gestation, parturition and lactation.

3. Control of fertility:
3.1. Modes and methods of male and female fertility control.
3.2. Endocrine malfunction induced male and female infertility.

Books Recommended:

Animal Physiology & Reproductive Biology:

1. Ganong, W. F. (2003). Review of Medical physiology. 21st e2d. McGraw Hill.
2. Hall, J. E. (2015). Guyton and Hall Textbook of Medical Physiology (Guyton Physiology), 13th edition, Elsevier.
3. Sherwood, L. (2004). Human Physiology: From cells to systems. 5th ed. Thomson Brooks Cole.
4. Willmer, P. et al. (2001). Physiological Adaptations. W. H. Freeman.
5. Hill, R., Wyse, G. A., & Anderson, M. (2012). Animal Physiology. 3rd Edition, Sinauer Associates.
6. Tortora, G. J., Derrickson, B. (2011). Principles of Anatomy and Physiology: Organization, Support and Movement, and Control Systems of the Human Body, 13th International Student Edition, Wiley.

7. Randall, D., Bergren, W., French, K. (2001). Eckert Animal Physiology: Mechanism and Adaptation, 5th Edition. W.H. Freeman.

Endocrinology:

1. Melmed, S., Polonsky, K. S., Larsen, P. R., & Henry, M. (2012). William's Text Book of Endocrinology. 12th edition, Saunders.
2. Halt, E. H., Lupsa, B., Lee, G. S., Bassyouni, H., & Perry, H. (2021). Goodman's Basic Medical Endocrinology, 5th edition, Elsevier.
3. Endocrinology-- L. J. De Groot and J. L. Jameson (ed.), 2005, W.B. Saunders Co. Philadelphia, USA. (3 Volumes)
4. Rumsby, G. & Furrow, S. (1997). Molecular Endocrinology: Genetic Analysis of Hormones and their Receptors, 1st edition, Routledge.
5. Gardener, D. G., &Shoback, D. (2003). Greenspan's Basic & Clinical Endocrinology. 10th edition, LANGE.
6. Norris, D. O., &Carr, J. A. (2020). Vertebrate Endocrinology. 6th edition. Academic Press.
7. Bentley, P. J. (2019). Comparative Vertebrate Endocrinology, 3rd edition, Cambridge University Press.
8. Hadley, M. E. (1999). Endocrinology, 5th edition, Prentice hall. International Edition.

Course Outcome: After completing this course, the students will have a better understanding of how the various systems in animals' function as well as how the biology of these species is influenced by the various settings. The students will get the opportunity to investigate a novel question in the field of animal physiology. The students will develop an appreciation for the molecular composition of the physiological systems and a comprehension of what makes up the systems and enables them to function. This program is intended to give students a comprehensive understanding of the endocrinology of vertebrates. The many different types of hormones, where hormones come from, how hormones are produced and synthesized, which tissues hormones target and their receptors, the mechanisms by which hormones function and are regulated, and the techniques used in endocrinology will be covered in this course. The traditional endocrine systems will be the topic of discussion in both the lectures and the assigned readings from the main literature. Students will get a better understanding of how a person's reproductive system evolves over the course of a lifetime. Pregnancy hormones and the processes that can lead to reproductive system dysfunction along with male and female fertility control will be discussed.

SEMESTER- I
Paper MZOOCCT103
Unit II

Biochemistry, Biophysics and Biophysical techniques

Marks: 25 **No. of Class Hrs. 30**

Course Objective: Students in this advanced course in biochemistry and metabolic processes will learn about thermodynamics, interplay, catalysis and how cellular reactions are possible in living systems and how important metabolic pathways: regulation and inter-dependence of the pathways on one another their roles in both health and disease are studied. Enzymes, enzyme kinetics of first- and second-order processes, inhibitions, and regulators are all topics covered in the course. Biochemistry courses in undergraduate programmes expose students to advanced topics including free radicles and their roles inliving systems, vitamins and minerals, and other aspects of their own biochemistry as well. Lastly this course provides some of the most important and fundamental biophysical technique that will engorged the students with technical knowledge that could help them in better understanding of biological processes in broad range. This course is intended for students who have already studied biochemistry at the undergraduate level and want a deeper understanding of the subject at the graduate level.

1. Introduction to Biochemistry

1.1. Thermodynamics, Gibbs free Energy, Biomolecules structure: Nucleic Acid, Protein, Lipid, and Carbohydrate

1.2. Proteins: Protein folding and protein stability

1.3. Carbohydrates: Glycolysis, glycogenolysis, gluconeogenesis, TCA cycle, Digestion and absorption.

1.4. Lipids: Biosynthesis and transport of cholesterol.

1.5. Amino- acid metabolism: Krebs-Henseleit Urea cycle, basic idea of transamination & deamination.

2. Enzymes

2.1. Kinetic analysis of enzyme – catalyzed reaction

2.2. Regulation of enzyme activity.

2.3. Co-enzymes and isoenzymes.

3. Bioenergetics:

3.1. Energy production and utilization, redox potential, electron transfer and oxidative phosphorylation.

4. Free radicals and antioxidants.

5. Membrane Transport-Biophysical aspect.

6. Biophysical Techniques:

6.1. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties)

6.2. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif andfolds), stability of proteins.

6.3. Conformation of nucleic acids [helix (A, B, Z), t-RNA, micro-RNA], stability ofnucleic acid

6.4. Microscopy: SEM, TEM, Confocal, Phase-Contrast, DIC, FRET, Fluorescence.

6.5. Imaging Technique: PET, CT, MRI.

6.6. Electro-measurement: ECG, EEG.
6.7. Principle and applications of Spectroscopy, & Elementary Crystallography.

Books Recommended:

1. Berg, J. M., Tymoczko, J. K. &Stryer, L. (2007). Biochemistry.6th ed. W. H. Freeman & Company.
2. Metzler, D. E. (2003). Biochemistry: The Chemical reactions of living cell. Vol. 1 & 2. Academic Press.
3. Murray, R. K., Granner, P., Mayes A. &Rodwell, V. W. (2003). Harper's Illustrated Biochemistry. 25 ed. McGraw-Hill.
4. Nelson, D. L. & Cox. M. M. (2004). Lehninger's Principles of Biochemistry. 2nd ed., Macmillan Worth Publishers.
5. Switzer, R. L. & Garrity, L. F. (1999). Experimental Biochemistry. W. H. Freeman & Company.
6. Voet, D., Voet, J. G. & Pratt C. W. (1999). Fundamentals of Biochemistry. Upgrade edition. John Wiley & Sons.
7. Mathews, C. K., Van Holde, K. E., Appling, D. R., & Anthony-Cahill, S. J. (2012). Biochemistry. 4th Edition. Pearson Education.

Course Outcome: Students who successfully complete this course will have a better understanding of how various metabolic pathways interact and play a key role in biological systems. As a result, the students will be able to forecast and comprehend which particular pathway will work under a certain scenario. When metabolic pathways fail, they will be able to foresee what the future holds. That means that students will learn how to locate compounds that influence metabolic pathways so that they can eventually build medications as a result of this course. Students will also gain a thorough understanding of techniques commonly used in biological research and clinical understanding. They will be able to understand and analyze the basic principles of methods and experiments used in understanding the molecular mechanisms of cellular processes after completing the course.

SEMESTER - I
Paper MZOOCCT104
Unit I

Cell, Tissue Structure and Function

Marks: 25 marks **No. of Class Hrs. 30**

Course Objective: The chemistry of cells is incredibly complicated, and any list of cell parts and their interactions, no matter how comprehensive, will leave large gaps in our understanding. We now understand that generating convincing explanations of cell behaviour will necessitate quantitative information about cells combined with sophisticated mathematical/computational approaches, some of which have yet to be invented. As a result, one emerging goal for cell biologists is to focus their research on quantitative evaluation.

1. Ultrastructure of cellular membranes:

1.1. Basic structure of organelles: Golgi, mitochondria, lysosome.

2. Cell membranes and their functions:

2.1. Membrane pumps, carriers, channels.

2.2. Transport across membrane: Active and Passive transport, Facilitated transport.

3. Cell adhesion molecules:

3.1. Extracellular matrix molecules, Cellular adhesion, Intercellular junctions, Connective tissues, microtubules and cytoskeleton (RBC cytoskeleton as a model).

4. Cell signaling:

4.1. G- protein and signal transduction.

4.2. Signal hypothesis, Intracellular protein trafficking.

5. Cytoskeleton and cellular motility:

5.1. Motor proteins: Actin and myosin binding proteins.

5.2. Cytoskeletal structures: microtubules, microfilaments, & intermediate filaments.

6. Cell to cell communication:

6.1. Basic structure of extracellular matrix.

6.2. Fundamental idea of: Tight Junctions, Gap junctions, Desmosomes, Hemidesmosomes, Focal adhesion.

7. Cell cycle:

7.1. Cell cycle check-points, role of cyclins and CDKs.

7.2. Functional role of the following proteins:
APC, Mcm, Aurora and Polo like Kinase, Condensins, & Kinesins.

8. Somatic cell fusion:

8.1. Human – rodent hybrid cells, radiation hybrid mapping.

9. Programmed cell death:

9.1. Regulators of programmed cell death, cell death pathways, relationship with cancer.

9.2. Apoptotic cell detection: Annexin V Assay.

10. Histology and histological methods:

10.1. Types & Organization of Tissues.

10.2. Principle and methods of staining.

10.3. Histological stains (Haematoxylin & Eosin).

10.4. Types of fixatives & chemistry of fixation.

10.5. Tissue processing (Dehydration, Clearing, & Embedding).

10.6. Microtomy: Types of microtome, sectioning & paraffin blocks.

Books Recommended:

1. Alberts, B. et al. (2008). Molecular Biology of the Cell. 5th edition, Garland Science.

2. Becker, W. M. et al. (2009). The World of the Cell. 7th edition. Benjamin-Cummings.
3. Cooper, G. M., & Hausman, R. E. (2004). The Cell-A molecular approach. 4th edition, Sinauer Associates
4. Townsend-Nicholson, A. et al. (2022). Cell Biology: A Short Course, 4th edition, Wiley-Blackwell.
5. Harvey, L. et al. (2004). Molecular Cell Biology. 5th edition. W.H. Freeman.
6. Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments. 5th edition, John Wiley.
7. Ploper, G., Sharp, D., & Sikorski, E. (2013). Lewin's CELLS, 3rd edition, Jones &Bratlett.
8. Bancroft, J. D. & Stevens, A. (2002). Theory and Practice of Histological techniques, Churchill-Livingstone.
9. Bloom, W. and Fawcett, D. W. (1998). A Textbook of Histology. 12th edition, CRC Press.
10. Junqueira, L. C. and Carneiro, J. (2005). Basic Histology: Text and Atlas. 11th edition, McGraw Hill Lange Med. Pub.
11. Ross, M, H., Reith, E. J. and Romell, L, J. (1998). Histology: a text and atlas. 2nd edition, Williams and Wilkins.

Course Outcome: The student will understand the core concept that underlies how cellular functions works. The importance of well-coordinated cellular activity to the continued existence of a living organism.

SEMESTER - I
PAPER MZOOCCT104
Unit II

Developmental Biology

Marks: **25** **No. of Class Hrs. 30**

Course Objective: If Dobzhansky said "nothing in biology makes sense except in the light of evolution", Scott F. Gilbert rightly said, "nothing in morphological evolution makes sense without knowledge of development." Education is sometimes referred to as "development," and there are many similarities between education and embryology. The two fields have exchanged metaphors constantly for the past two centuries, and two German words that have been used for both development and education—*Bildung* and *Entwicklung*—connote education by experience and education by instruction, respectively. Both work in different situations. Changes in adult anatomy and physiology are predicated on changes in morphogenesis and differentiation during development. This course of Developmental Biology is specifically designed to develop the basic fundamental idea of development among students.

1. Basic principles of differentiation, potency, morphogenetic gradients

2. Stem cells

2.1. Properties and classification.
2.2. Niche, regenerative and restoration biology.
2.3. Stem cell therapeutics.

3. Gametogenesis, fertilization and early development.

3.1. Primordial germ cells and development of sex organs.
3.2. Production of gametes, pre-requisite of fertilization.
3.3. Gastrulation and formation of germinal layers.

4. Organogenesis

4.1. Axis specification
4.2. Organizer formation and mesoderm specification

5. Environmental regulation of gene expression during development.

5.1. Importance of symbionts in mammalian development.
5.2. Genetic errors of human development, teratogenicity.

6. Aging and senescence

6.1. Mitochondrial control of aging.
6.2. Role of telomere.

Books Recommended:

1. Arias, A. M. & Stewart, A. (2002). Molecular Principles of Animal Development, OUP Oxford.
2. Balinsky, B. I. (2004). An Introdution to Embryology, 5th edition, Thompson Brooks Cole.
3. Gilbert, S. F. (2006). Developmental Biology. 8th edition, Sinauer Associates.
4. Nusslein-Volhard, C. (2006). Coming to Life: How Genes Drive Development, Kales Press.
5. Moody, S. A. (Ed.) (2007). Principles of Developmental Genetics. Academic Press.

6. Tickle, C. & Wolpert, L. (2012). Principles of Development. 4th edition, Oxford University Press.
7. Slack, J. M. W. (2021). Essential Developmental Biology, 4th edition, Wiley-Blackwell.
8. Gilbert, S. F. &Epel, D. (2015). Ecological Developmental Biology: The Environmental Regulation of Development, Health, and Evolution, 2nd edition, OUP Oxford.

Course Outcome: Students will be able to write confidently and concisely about developmental biology at the postgraduate level as well as in layperson terms, having mastered the theoretical underpinnings that defines the fields of developmental biology. They will be able to explain the molecular, biochemical, and cellular events that regulate the development of specialized cells, tissues, and organs during embryonic development, as well as explain the morphological processes that transform a fertilized egg into a multicellular organism. Identify model organisms used in developmental biology research and compare the developmental programmes of various organisms. They will be able to identify critical unresolved issues in cell and developmental biology.

Semester - I
Paper – MZOOCCS105
(Practical: Non-chordate structure and function / Entomology/ Chordate structure and function)

Marks -50 **No. of Class Hours: 60**

Course Objective: This practical course is designed to give students a hand on experience on Non-Chordate and Chordate anatomy.

Laboratory Course

1. Non-Chordate Anatomy

1.1. Comparative anatomy of excretion, nervous system in arthropoda&mollusca (Demonstration/ Model)

1.2. Special structure – stomatogastric nervous system in cockroach, sting apparatus of honey bee/ant, mounting of mouth parts of mosquito, haltere in housefly, mouth parts of house fly

1.3. Distinctive features and identification of non-chordate from museum specimen

1.4. Demonstration of live protozoa and Rotifer (free living and parasitic) under microscope.

1.5. Identification of different larval stages of mosquito.

2. Entomology: Collection, preservation and identification of insects. Submission of properly preserved insect species of at least 5 orders.

3. Chordate anatomy

3.1. Comparative anatomy of circulatory and urinogenital system in Fish and mammals (Demonstration/ Model)

3.2. Special structures – olfactory apparatus and otolith in culturable fish, Weberian ossicles and swim bladder in carp.

3.3. Distinctive features of chordate from museum specimens.

3.4. Identification of bones: axial and appendicular skeleton of marsupials (*Osphranter*sp.), eutherian mammals (*Tachyglossus* sp.), birds (*Columba* sp.), amphibians (*Bufo* sp.), reptiles (*Varanus* sp.) including snake (*Python* sp., *Heterodon*sp., &*Ophiophagus* sp.)

C) Internal assessment

D)Viva voce

Course Outcome: Student will able to dissect, demonstrate chordate and non-chordate anatomy.

Semester - I
Paper – MZOOCCS106
(Practical: Endocrinology & Reproductive Biology/Biochemistry / Cell Structure & Function/ Developmental Biology)

Marks-50 **No. of Class Hours: 60**

Course Objective: The Endocrinology & Reproductive Biology course is designed to equip students to know about endocrine glands practically. This course includes various types of reproductive and endocrine gland demonstration and androgen bioassay.
The biochemistry practical course is specifically designed to provide the hand on experience to student regarding biochemical analysis of protein, amylase activity, K_M of the enzyme. The Cell Structure & Function practical is specifically designed for students to have the hand on experience on cell separation techniques, primary cell culture, and determination of cell size and granularity. The Developmental Biology practical course is designed for students to know the techniques behind preparation of different stages of chick embryo and developing stages of fish embryo characteristics.

Laboratory Course

1. Endocrinology & Reproductive Biology:

1.1. Demonstration of endocrine glands (Thyroid, Pancreas, Adrenal, Gonads) in mice.
1.2. Demonstration of Oestrous stages of mice.
1.3. *In vitro* study of motility of epididymal spermatozoa.
1.4. Histology of endocrine glands of mammals.
1.5. Androgen bioassay (demonstration)

2. Biochemistry

2.1. Determination of Protein by Folin Lowry method
2.2. Determination of activity of amylase enzyme
2.3. Determination of Km of an enzyme

3. Cell Structure and Function

3.1. Cell separation techniques
3.2. Primary culture of Cells
3.3. Determination of cell size and granularity.
Annexin V staining by flowcytometry/fluorescent imaging.
DAPI nuclear blabbing imaging.

4. Developmental Biology

4.1. Preparation of different stages of developing Chick embryo (24hr, 48 hr, 72 hr, 96 hr)
4.2. Developing stages of fish embryo-characteristics and documentation.

5. Internal assessment

6. Viva voce

Course Outcome: After completion of this course student will able to demonstrate endocrine and reproductive gland practically, they will have a hand on experience in determining protein concentration, activity of salivary amylase, and lastly determine the K_M. Students will also have a practical experience in some of the essential methods of cell structure and function. The developmental biology practical training would assist in proper understanding of the theoretical knowledge and equip them with hands on experience in the area**.**

SEMESTER - II
PAPER MZOOCCT 201
Unit I
Genetics

Marks: 25 marks **No. of Class Hrs. 30**

Course Objective: Genetics is one of the fastest-moving fields of science, with new discoveries being made every month. If you go to a major news source, you're likely to see articles on genetics: the sequencing of new genomes like those of the king cobra or minke whale; the revelation of genes that affect major diseases like multiple sclerosis, anxiety, and cancer; or the analysis of DNA from long-extinct organisms like a 700,000-year-old Pleistocene horse. Advertising for genetic testing to find out a person's ancestry or the lineage of your dog is commonplace. The study of genetics is timely, important, andfascinating because of the many new discoveries and applications of genetics that have substantial economic and ethical implications.

1. Organization of Eukaryotic Chromosomes:

1.1. Basic concept of chromosome condensation: nucleosomes, solenoid, protein scaffold, metaphase chromosome.

1.2. Role of telomere in eukaryotic DNA replication**.**

2. Fine Structure of Gene:

2.1. Fundamental idea of cistron, recon, muton.

3. Gene activity in Polytene and Lampbrush chromosomes.

4. Sex determination and dosage compensation in *Drosophila* and humans.

5. Human karyotypic disorders:

5.1. Down's Syndrome, Edward's Syndrome, Klinefelter's Syndrome and Turner's syndrome.

6. Mendelian Inheritance of Man:

6.1. Huntington's disease, Sickle cell anemia, Cystic fibrosis.

6.2. Haemophilia, Muscular dystrophy.

7. Genomic imprinting, DNA methylation, Prader-Willi and Angelman syndromes.

8. Gene mapping, & human genome project.

Books Recommended:

1. Brown, T. A. (2020). Gene Cloning & DNA Analysis, 8th edition, Wiley-Blackwell.
2. Hartl, D. L. & Jones, E. W. (2006). Essential Genetics: a genomics perspective, 4th edition, Jones and Bartlett Publishers, Boston.
3. Harvey, L. et al. (2004). Molecular cell Biology, 5th edition, W.H. Freeman.
4. Alberts, B. et al. (2008). Molecular Biology of the Cell. 5th edition, Garland Science.
5. Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments, 5th edition, John Wiley.
6. Griffiths, A. J. F. et al. (2020). Introduction to Genetic Analysis, 12th edition, Macmillan.
7. Pierce, B. (2020). Genetics: A Conceptual Approach, 7th edition, W. H. Freeman.

8. Lewin, B. (2008). Genes IX. Jones & Bartlett Publishers.
9. Weaver, R. F. (2012). Molecular Biology, 5th edition, McGraw-Hill Education.
10. Clark, D. P., Padzernik, M., & McGehee, M. (2018). Molecular Biology, 3rd edition, Academic Press, Elsevier.

Course Outcome: Students will understand the fundamental concept of chromosome condensation, as well as the fine structure of recombination, cistrons, and mutons. In addition to this, students investigate the make-up of two giant chromosomes. They will havean understanding of the fundamental mechanism behind the determination of sexual orientation, as well as the karyotype of chromosomes that carry anomalies. In addition to this, they will have an understanding of the numerous genetic diseases, as well as genetic imprinting, methylation pattern, gene mapping, and the human genome project.

Unit II
Evolutionary biology

Marks: 25 marks **No. of Class Hrs. 30**

Course Objective: Evolutionary biology has had to establish its validity more than any other field of study. This means that to educate students on evolution is to educate them on science itself, as well as on how to think critically about claims and evidence. For this reason, we believe it is critical for students to learn about the nature of science and how it operates, as well as the reasons why this method of knowledge has been deemed so reliable. This vital purpose can best be served by evolutionary biology. Even if the fields of organismal biology such as paleobiology and ecology, as well as the study of animalbehaviour and physiology, remain crucial to evolutionary theory, the genomic revolution, new analytical methodologies, and new evolutionary theories are enhancing these fields.

1. Natural selection:
- 1.1. Basic Concept, Types, Selection Pressure, Selection co-efficient, Reproductive fitness.
- 1.2. Absolute Fitness versus Relative Fitness, Frequency dependent selection.
- 1.3. Sexual selection (examples), Handicap Principle.

2. Moto Kimura's Neutral Theory of Evolution v natural selection

3. Hardy –Weinberg Principle and Gene Frequency.
- 3.1. Effect of selection, mutation, inbreeding, migration on gene frequency,
- 3.2. Evolution by Sewall Wright effect or genetic drift**.**

4. Isolating Mechanism & Speciation
- 4.1. Basic idea of various types of reproductive barriers (prezygotic & postzygotic)
- 4.2. Concepts of species and modes of speciation: allopatric, sympatric, and parapatric.
- 4.3. Punctuated equilibrium and its role in peripatric speciation.

5. Sexual selection:
- 5.1. Types of Mating system and Mate choice.
- 5.2. Male-male competition.

6. Evolution of Eusociality:

6.1. Keen selection, Hamilton's rule

6.2. Evolution of haplo-diploid system with special emphasis on honey bee colony.

7. Coevolution:

7.1. Red Queen hypothesis and Evolutionary Arms Race

7.2. ESS and Game Theory.

8. Pattern and Trends in Evolution:

8.1. Molecular phylogeny: definition, construction of phylogenetic tree through nucleotide sequence change, methods of maximum parsimony, concept of molecular clock.

9. Origin and evolution of Primates:

9.1. Evolution of Anthropoid Primates.

9.2. The first hominids and origin of modern man.

Books Recommended:

1. Bowler, P. J. (1989). Evolution: History of An Idea, Revised edition, California University Press.
2. Mayr, E. (1997). Evolution and the Diversity of Life, reprint edition, Harvard University Press.
3. Jones, S. et al. (1994). The Cambridge encyclopedia of Human Evolution, reprint edition, Cambridge University Press.
4. King, M. (1995). Species Evolution: The Role of Chromosome Change, revised edition, Cambridge University Press.
5. Futuyma, D. J. & Kirkpatrick, M. (2017). Evolution, 4th edition, Sinauer Associates.
6. Colbert, E. H. (2015). Evolution of the Vertebrates, 3rd edition, Scientific publishers, Jodhpur.
7. Moody, P. A. (2004). An Introduction to Evolution. 3rd edition, Kalyani Publishers.
8. Strickberger, M. W., Hall, B. K., & Hallgrimsson, B. (2007), Strickberger's Evolution, 4th edition, Jones & Bartlett.
9. Ridley, M. (2003). Evolution, 3rd edition, Wiley-Blackwell.
10. Wen-Hsiung, L. &Graur, D. (1991). Fundamentals of Molecular Evolution, 2nd edition, Sinauer Associates.

Course Outcome: According to Theodesius Dobzhansky, "nothing in biology makes sense except in the light of evolution". The idea of evolution is the scientific paradigm for biology and should be taught to all students of life sciences, according to this widely-quoted and widely-agreed-upon statement. The Evolutionary Biology section of the course has been thoroughly revised and updated to meet the specific needs of post graduate students. It is intended to provide students with a foundation in Taxonomy so that they may go out and investigate and evaluate biodiversity and ecosystem health.

SEMESTER - II
PAER MZOOCCT202
Unit – I
Behavioural biology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Animal Behavior has been the associated with educational for introductory courses in biological science for more than 40 years. When it comes to studying animal behaviour, a more integrated approach is needed to stay up with developments in the field. This course emphasizes research that links behaviour to the brain, genes and hormones as well as to environmental and social factors. It also aims to test out fresh theories on how animal behaviour has evolved. Finally, its fundamental objective is to provide students with a window into the multiple levels of analysis that researchers employ to explain why all living things behave, often in complex ways.

1. Principles of Animal Behavior:

1.1. Basic conceptual approaches: Niko Tinbergen's four why?
1.2. Innate behaviours with examples.
1.3. Proximate and ultimate causation.

2. Learning:

2.1. What animals learn? Individual learning, social learning.
2.2. Associative learning, Habituation, Conditioning and Imprinting.
2.3. Cultural transmission.

3. Foraging:

3.1. Optimal foraging theory, foraging and group living, predation and foraging.

4. Aggression:

4.1. Aggressive behaviour. Home range, territoriality and territory defence.
4.2. Hierarchy and social stratification.
4.3. Female hyena, naked mole rat and langur society: hierarchy, display and dominance relationship.
4.3. Models and strategies in conflict resolution. Bourgeoisie strategy, war of attrition and zero sum games.
4.4. Sibling rivalry, parent offspring conflict and infanticide.

5. Communication and Animal Signals:

5.1. Communication.
5.2. Evolution of animal signals.

6. Chronobiology and Behavioural genetics

6.1. the concept of Average, amplitude, phase and period, Adaptive significance of biological clocks
6.2. Biological rhythms and endocrine and receptor influence. Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.
6.2. Drosophila circadian rhythm genetics.

6.3. Courtship behaviour, pair bonding and parenting: vasopressin and oxytocin signalling in prairie voles as model.

Books Recommended:

Ethology:

1. Alcock, J. & Rubenstein, D. (2019). Animal Behaviour, 11th edition, Sinauer-Oxford.
2. Drickamer, L. C. &Vessey, S. H. (2001). Animal Behavior: Mechanisms, Ecology, Evolution, 5th edition, McGraw-Hill Education.
3. Mannig, A. & Dawkins, M. S. (2012). An Introduction to Animal Behaviour, 6th edition, Cambridge University Press.
4. Breed, M. & Moore, J. (2021). Animal Behaviour, 3rd edition, Elsevier.
5. Gadagkar, R. (1998). Survival Strategies: Cooperation and Conflict in Animal Societies, revised edition, Harvard University Press.
6. Krebs, J. R., Davies, N. B., & West, S. A. (2012). An Introduction to Behavioural Ecology, 4th edition, Wiley-Blackwell.
7. Goodenough, J., McGuire, B. & Jakob, E. (2009). Perspectives on Animal Behavior, 3rd edition, Wiley.

Ethnobiology:

1. Kumar, N.C. (2004). An Introduction to Medical botany and Pharmacognosy, Emkay Publications, New Delhi.
2. Rao A. V. (1999). Herbs that heal. Diamond Pocket Books (P) Ltd., New Delhi.
3. Pal, D. C. & Jain, S.K. (1998). Tribal medicine, Naya Prakash, 206, Bidhan Sarani, Calcutta.
4. S.K. Jain, S.K. (2001). Contribution to Indian ethnobotany, 3rd edition, Scientific publishers, Jodhpur, India.

Course Outcome: Students will be expected to have a thorough understanding of animal behaviour by the end of this course. They will comprehend the proximate controls of behaviour, such as the roles of hormones, genotype, and environment in the development of behaviour. Much of our work will be evolutionary in nature, so students will have a thorough understanding of the adaptive significance of behaviour, with a focus on animal communication, social behaviour, territoriality, sexual selection, and mating systems.

SEMESTER - II
PAPER MZOOCCT202
Unit –II

Ecology

Marks: 25 **No. of Class Hrs. 30**

Course Objective: "Ecology" refers to the study of interrelationships between organisms and their physical surroundings. There are various ways in which these relationships can affect the natural environment, such as how creatures are distributed and abundance, the variety of species living together, and the flow of energy in nature. Since environmental change is occurring at a rapid rate in the early twenty-first century it is vital that we better comprehend the ecology of the planet. While most people associate ecologists with fieldwork, ecologists who develop theoretical models or do laboratory research have made some of the most significant contributions to ecological theory. We can clearly see that our simplistic description of ecology does not adequately convey its vastness or the diversity of its practitioners. Let's talk at this course to have a better grasp of what ecology is all about.

1. Introduction to ecosystem concept.

1.1. The Ecosystem: Gaia hypothesis, cybernetic nature and stability of the ecosystem, ecosystem management and optimization. Macroecology: concept and consequences. Principles of Thermodynamics, energy flow and ecological energetics.

1.2. Niche theory: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. (Lotka-Volterra model, Isoclines, Niche prediction).

2. Population growth and regulation

2.1. Age structured population growth and empirical projections

2.2. Deterministic and stochastic growth models, time lags and limit cycles, Oscillations, Chaos.

2.3. Regulations on population size: Density Dependence (types and nature)

2.4. Discrete time population models: Beaverton-Holt and Ricker model.

3. Metapopulation

3.1. Metapopulation concept

3.2. Levin's model of metapopulation and development of theories. Comparison of metapopulation and logistic population model.

4. Community organization

4.1. Nature of communities, analysis of community structure. Gradient analysis and Ordination.

4.2. Competition theory, modelling competitive exclusion and coexistence.

5. System concept

5.1. Fixation, generation and cycling of energy across the food web.

5.2. Measuring ecosystem productivity, patterns in primary and secondary production. Factors affecting primary and secondary production.

6. System structure and Function

6.1. Ecological processes in wet land and mangrove ecosystem.

7. Ecology of biological and industrial invasion

7.1. Eutrophication in freshwater, coastal and marine ecosystem, faunal interaction and changes, remediation.

7.2. Acidification in aquatic and terrestrial environment, effects & remedies.

Books Recommended

1. Begon, M., Harper, J. L. & Townsend, C. R. (2005). Ecology: Individuals, Populations and communities. 4th edition, Blackwell Publishing.
2. Chapman, R. L. & Reiss, M. J. (2000). Ecology: Principles & Application. Cambridge University Press.
3. Faurie, C., Ferra, C., Medori, P. &Devaux, J. (2001). Ecology: Science and Practice, 1st edition, Oxford & IBH Publishing Company Pvt. Ltd.
4. Kormondy, E. J. (2002). Concepts of Ecology, 4th Indian Reprint edition, Pearson Education.
5. Krebs, C. J. (2001). Ecology: The Experimental Analysis of Distribution and Abundance, 5th edition, Benjamin Cummings.
6. Leveque, C. (2003). Ecology: from Ecosystem to Biosphere, 1st edition, CRC Press.
7. Odum, E. P. & Barret, G. W. (2005). Fundamentals of Ecology, 5th edition, Thompson Brooks-Cole.
8. Smith, T. M. & Smith, R. L. (2006). Elements of Ecology. 6th edition, Pearson Education.
9. Ricklefs, R. E. & Miller, G. L. (1999). Ecology, 4th edition, W. H. Freeman.
10. Molles, M. (2015). Ecology: Concepts and Applications, 7th edition, McGraw-Hill Education.
11. Bowman, W. D., Hacker, S. D. (2020). Ecology, 5th edition, Sinauer-Oxford.

Course Outcome: Individuals may be given lecture outlines with vocabulary words and study questions that you need to know in order to meet the goals of the course. Individuals should use these outlines as guides to help you decide what to study. The student will describe basic information about ecology and figure out how to use it. The following is part of this information: population growth and the factors influencing this growth; ecological succession and the role of environmental disturbance in this process; water, watersheds, and the hydrologic cycle; soil, its characteristics and formation, ecosystems, including their structure (trophic relationships, abiotic factors, and biomes) and function (energy flow and biogeochemical cycles).

SEMESTER - II
PAPER MZOOCCT203
Unit 1
Parasitology and Microbiology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Few people realize that there are far more kinds of parasitic than nonparasitic organisms in the world. Even if we exclude viruses and rickettsias, which are all parasitic, and the many kinds of parasitic bacteria and fungi, parasites are still in the majority. The bodies of free-living plants and animals represent rich environments, which have been colonized innumerable times throughout evolutionary history. In general, the parasitic way of life is so successful that it has evolved independently in nearly every phylum of animals, from protistan phyla to arthropods and chordates, as well as in many plant groups. At the same time, the world of microbes is very much fascinating since time immemorial. It is no wonder that the science of parasitology has developed out of efforts tounderstand parasites and their relationships with their hosts. This course of parasitology and microbiology is designed to evoke the basic fundamental knowledge of parasitic and microbial world within students.

1. Basic concept of Parasitism.

2. Morphology and ultrastructure of *Plasmodium* sp. and integuments of nematode.

3. Life cycle and host-parasite interactions in:

3.1. *Giardia* sp.;
3.2. *Entamoeba* sp.;
3.3. Leishmania sp.;
3.4. *Ancylostoma*sp.;

4. Major malaria vectors in India:

4.1. Distribution, bio-ecology, potentiality and present sustainability status; resurgence of malaria in India

5. Acarines of medical importance:

5.1. Soft tick and hard ticks - external morphology;
5.2. Ticks as disease transmitter;
5.3. House dust mites - general account and importance.
5.4. Scabies: Vector, pathogenicity and transmission.

6. Bacteria:

6.1. Structure and function of capsule, pili and flagella.

7. Virus:

7.1. Structural organization.
7.2. lytic cycle of bacteriophage with reference to *E. coli*.

8. Microbial genetics:

8.1. Bacterial gene transfer: transformation, conjugation, transduction.

9. Medical Microbiology:

9.1. Transmission, pathogenicity and prevention of air borne (Tuberculosis), food and water borne (Typhoid) and arthropod borne (Dengue) diseases.

10. Environmental Microbiology:

10.1. Soil microbiology, role of microbes in N_2 fixation.

10.2. Microbes as indicator of water quality.

11.**Industrial microbiology:**

11.1. Microbial fermentation;productionandcommercialization.

Books Recommended

1. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th edition, John Wiley & Sons.
2. Cheng, T. C. (1986). General Parasitology, 2nd edition, Academic Press.
3. Cox, F. E. G. (1993). Modern Parasitology, 2nd edition, Blackwell Scientific Publications.
4. Hati, A. K. (2001). Medical Parasitology: protozoology and helminthology, Allied Book Agency, Kolkata.
5. Schmidt, G. D. & Roberts, L. S. (2001). Foundation of Parasitology, 3rd edition, McGraw-Hill Education.
6. Marr, J., Nilsen, T. W., &Komuniecki, R. W. (2002). Molecular Medical Parasitology, 1st edition, Academic Press.
7. Roberts, L. &Janovy, J. Jr. (2008). Foundations of Parasitology. 8th edition, McGraw-Hill Education.
8. Bogitish, B., Carter, C, &Oeltmann, T. (2005). Human Parasitology, 3rd edition, Elsevier.

Course Outcome: Students learn about parasite biology, life cycles, transmission methods and pathology in this course. A number of significant diseases and the numerous protozoans, helminths, worms, and arthropods that cause them will be explored by students throughout the course. As part of this course, students will learn about a variety of diseases and the various protozoans, parasites, and arthropods that cause them. Another part of the course has been designed to help students comprehend how our immune system works in a logical way when it comes to protecting us from invading viruses or parasites.

SEMESTER– II
PAPER - MZOOCCT203
Unit- II
Immunobiology

Marks-25 **No. of Class Hrs. 30**

Course Objective: As a firm believer in the premise that immunology is best taught and learnt through conceptual methods, this course has been designed to provide just that. As a department, we strive to help students understand how important discoveries were achieved, what issues remain, and how they might best be answered after completing a course in immunology. It is our belief that this method helps students gain a firm grasp on basic immunological principles, absorb the idea that immunology is a dynamic and continuous process, and cultivate the responsibility to participate to new discoveries. With this in mind, this syllabus has been thoroughly revised to reflect the most recent advancements in the field across the board.

1. Immune system:

1.1. Innate and adaptive immunity**.**

1.2. Cells and organs of the immune system in mammals**.**

2. Antigen:

2.1. Immunogenicity and antigenicity.

3. MHC, antigen processing and presentation

3.1. Organization and inheritance of major histocompatibility complex (MHC)

3.2. Structure and functions of MHC

3.3. Antigen presenting cells: dendritic cell, macrophage

3.4. Antigen processing and presentation

4. Antigen receptor complex

4.1. Immunoglobulin super family: I_g types and structure

4.2. Structure and arrangement I_gG cluster

4.3. Generation of antigen receptor diversity and clonal selection

5. Humoral immunity

5.1. B-cell maturation, activation and differentiation

5.2. B-cell receptor complex

5.3. Diseases related to B-cell malfunction

5.4. Complement system.

6. Cell mediated immunity

6.1. T-cell maturation, activation and differentiation

6.2. T-cell receptor complex

6.3. Diseases related to T-cell malfunction

7. Cytokines

7.1. Cytokine receptors and antagonists

7.2. Cytokine Secretion by TH_1 and TH_2 Subsets

8. Hypersensitivity and autoimmune diseases

8.1. Types of hypersensitivity.
8.2. Mechanisms of induction of autoimmunity.
8.3. Immunodeficiencies.

Books Recommended:

1. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2006). Cellular and molecular Immunology. 6th edition. Saunders.
2. Chakraborty, A. K. (2003). Immunology II, 2nd edition. Oxford Univ. Press/N. L. Publishers Siliguri.
3. Khan F. H. (2009). The Elements of Immunology, 1st edition, Pearson Education, India.
4. Kindt, T., Goldsby, R. Osborne, B. (2007). Kuby Immunology. 6th edition, W.H. Freeman.
5. Male, D., Brostaff, J., Roth, D. &Roitt, I. (2006). Immunology. 7th edition, Mosby.
6. Roitt, I. M. & Delves, P. J. (2001). Roitt's Essential Immunology. 10th edition, Blackwell Science.
7. Abbas, A. K., Lichtman, A. H. & Pillai, S. (2019). Basic Immunology: Functions and Disorders of the Immune System, 6th edition, Elsevier.

Course Outcome: This course aims to teach students about immunology, infectious illnesses, and vector molecular biology in a comprehensive manner. As part of their education, students will study about the vital parts of the immune system. Learn about how infectious agents can evade our natural defences and cause disease in this course. Natural defences against infectious diseases and the type of immunity they activate will also be shown to students.

SEMESTER – II
PAPER MZOOCCT204
Unit I:
Applied Entomology (`Skill Development Course`)

Marks: 25 **No. of Class Hrs. 30**

Course Objective: The study of insects and their dual nature (beneficial and detrimental to humans) is the focus of the field of applied entomology. It offers specific information on insect orders that are significant to the economy, including the characteristics that are unique to each of those orders. In addition to this, it discusses insect metamorphosis, as well as the most effective ways in which beneficial insects, such as silkworms, honey bees, and lac insects, might be utilized for the benefit of humankind. In addition, the primary focus of this subfield of entomology is on the utilization of predators and parasitoids for the control of pest insects and pollinators in order to increase crop yields. In addition to that, it includes a comprehensive report on the control of dangerous insects through the application of a variety of techniques

1. Economic decision levels for pest population

1.1. Concepts
1.2. Dynamics of economic injury levels
1.3. Calculation of economic decision levels using economic levels.

2. Pest Management theory and practice

2.1. The concept of pest management
2.2. Kinds of Pests and likely Strategies
2.3 semiochemicals and pest management

3. Pests and their managements

3.1. Sugarcane pests – Biology, bionomics and management.
3.2. Mango pests - Biology, bionomics and management.

4. Beneficial insects

4.1. Lac culture: Lac insects, composition of lac, lac host plants, Diseases and pests of lac insects.; processing of lac and its uses. Problems and prospects of lac culture in India.
4.2. Sericulture: Kinds of silk worm, host plant and improvement of their variety. Brief idea on non-mulberry silk. Life history and rearing of *Bombyx mori*. Harvesting and processing of cocoon. Reeling and extraction of silk.; Disease and pests of mulberry silkworm; Biotechnology in sericulture. Scope and future of sericulture in India.
4.3. Apiculture: Types of honey bee, modern methods of apiary management, products and its use. Problems and prospects of apiculture in India. Diseases and pests of honey bee;
4.4. Bee pollination: (honey bees and solitary bees); prospects and problems in bee pollination.

5. Natural enemy diversity in India and their potentialities in pest management.

6. Insects of commercial importance:

6.1. Medicinal, Dye, Resin, food and food product producing insects: Diversity and uses.

Books Recommended:

1. Atwal, A.S. & Dhaliwal (2005). Agricultural Pest of India and Sour-East Asia. Kalyani Publishers.

2. Pedigo, L.P. & Rice, E.M. (2009). Entomology and Pest Management. Pearson / Prentice Hall.
3. Vincent H. Resh& Ring T. Carde (2003). Encyclopedia of Insects. Elsevier.
4. Srivastava, K. P. & Dhaliwal, G. S. (2010). A Textbook of Applied Entomology (Vol. I & II), 2nd edition, Kalyani Publishers.
5. Metcalf, C. L. & Flint, W. P. (1962). Destructive and useful insects: Their habits and control, McGraw Hill Education.

Course Outcome: After completion of this course, student will know about the identification of major insect pests of agricultural and urban sectors, their control methods and pesticide application equipment and also the importance of entomological cottage industries and other beneficial aspects of insects.

Unit – II
Aquaculture (Skill Development Course)

Marks: 25. No. of Class Hrs. 30

Course Objective: The students will become familiar with the Origin, Evolution, and Distribution of the Major Groups of Fishes, as well as Ornamental Fish Culture, Fish Nutrition, and Aquaculture Methods in this course.

1. Aquaculture of carps
- 1.1. Qualities of cultivable indigenous and exotic species
- 1.2. Preparation and management of Nursery and Rearing ponds
- 1.3. Management of Grow out pond and polyculture

2. Biotechnology in improvement of live stock
- 2.1. Fish induced breeding and hybridization
- 2.2. Sex reversal in fish

3. Air breathing fish culture
- 3.1. Breeding of *Clariasbatrachus*
- 3.2. Larval rearing and culture of *Clariasbatrachus*

4. Integration of aquaculture
- 4.1. Rationale of integrated farming of fish and live stock
- 4.2. Rice-field aquaculture and Makhana cum fish culture
- 4.3. Aquaponics

5. Ornamental fish and their management
- 5.1. Common ornamental fish species (Indian and exotic)
- 5.2. Breeding and rearing of some common ornamental fishes
- 5.3. Marketing of ornamental fishes

Books Recommended:

1. Jhingran, V. G. (1991). Fish and Fisheries of India, 3rd edition, John Wiley & Sons.
2. Lowe, H. (2005). Beginner's Guide to Aquarium Fish and Fish Care, 1st edition, Abhisek J. press.
3. Pillay, T. V. R. (1993). Aquaculture: Principles and Practices, New edition, Wiley-Blackwell.

Course Outcome: Aquaculture is now regarded as a viable option for increasing fish production, as it plays an important role in ensuring food security in India. Aquaculture informatics is the scientific application of information technology to biological concepts in order to increase the productivity and economic viability of aquaculture sectors. Advances in electronic communication, combined with targeted cooperative efforts, should be used to boost regional information exchange. It is the responsibility of the nation to educate fish farmers through community-based organizations and to provide a low-cost information system to meet their needs.

SEMESTER – II
Paper MZOOCCS205
(Practical Genetics /behavioural biology/ Ecology)

Marks: 50

Course Objective: This hands-on course will offer the student with the experience, methodology, and analysis of some of the most essential and basic procedures in the fields of Genetics, Ethnobiology, and Ecology.

A. Genetics:

1. Identifying certain mutations (Cy, w, vg, etc.) of Drosophila.
2. Human pedigree analysis
3. Karyotype analysis from the metaphase chromosomes of human/Rat/Mice.
4. Chironomas /giant chromosome or bone marrow preparation.

B. Behavioural biology

1. Foraging behaviour in ants: orientation and cues and ant trail.
2. Light dark cycle of *Daphnia* movement.
3. Observation of nesting in social insects.
4. Study and actogram construction of locomotor activity in cockroach/fish/mice
5. Flocking behaviour in pigeons.
6. Mate choice copying in Guppy.

B. Ecology

1. Quantitative and qualitative estimation of zooplankton communities
2. Estimation of total hardness, total alkalinity and salinity of water
3. Estimation of Primary productivity and assessment of nutrient status of water bodies
4. Qualitative analysis of sampled terrestrial community

C. Internal Assessment

D. Viva voce

Course Outcome: Student will have a clear-cut idea of the basic methods that often used in the fields of Genetics, Ethnobiology, and Ecology.

SEMESTER – II
Practical (Parasitology and Microbiology / Immunobiology/ Applied Entomology/Aquaculture)

Course Objective: The purpose of the lab course is to acquaint students with fundamental staining and impregnation techniques so that they can effectively plan and carry out experiments. Additionally, students will leave the course with the knowledge necessary to identify a variety of parasites, which will facilitate their future careers. This course is also designed to give students their first taste of scrutinizing insects and to provide them with the opportunity to gain practical experience in explaining the anatomy and physiology of specimens they have handled. Students will receive hands-on experience on microbiology, applied entomology, and aquaculture through the course.

A. Parasitology and Microbiology

1. Collection, preparation, preservation, identification and submission of ectoparasites, endoparasites and vectors.
2. Identification of larval stages of mosquito.
3. Gram staining bacteria.
4. Preparation and staining of *Lactobacillus*.

B. Immunobiology

1. Antigen antibody interaction (Blood groups)
2. Identification of histological slides of lymphoid (Thymus/ spleen) tissues.
3. Demonstration of macrophages.
4. Bone marrow smear preparation and staining.
5. Immunostaining for flowcytometry.

C. Applied Entomology

1. Identification and Calculation of damage in stored grain.
2. Silk content estimation; cocoon diversity study.
3. Lac insect; Identification of lac insects; Estimation of phenolics from lac insect secretion.
4. Vegetable, Sugarcane and Mango pests: Collection and identification.
5. Visit to Lac kuthi/ sericulture/ apiculture farm.
6. Identification of economically important insects.

D. Aquaculture

1. Collection, preservation of pituitary gland; preparation of extract; administration of pituitary extract.
2. Identification of aquatic weeds, predatory and weed fishes

E. Internal Assessment

F. Viva voce

Course Outcome: Following successful completion of this course, students will have a comprehensive understanding of the procedures, methods, identification, and demonstration of the topics listed above.

SEMESTER– III
Paper – MZOOCCT301
Unit – I
Molecular Biology & Biotechnology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: During the next half-century, our knowledge of how living organisms' function at the molecular level will grow in ways we are only just beginning to comprehend. In today's world, we know far more about genes than we did when Mendel first hypothesized them over a century ago. DNA molecules contain encoded information in the form of DNA fragments known as genes. Even genes are now chemical reagents that can be used in the laboratory. This course notably stresses that molecular biology is useful to more than simply human medicine and health because of the ongoing interest in applying molecular biology to an ever-widening range of topics. As a result, students must have a basic knowledge of molecular biology. Biotechnology has transformed the planet. Many inherited disorders may now be traced back to their genetic roots because to advances in biotechnology. People may now live in considerably higher population densities thanks to biotechnology's ability to provide more food per acre. As a result of advances in genetics and current molecular biology, we now know more about genomes of a wide range of creatures, from viruses to trees to people. Science has been transformed from a descriptive to a variety of fields that generate new items such as pharmaceuticals, vaccines, and meals thanks to the application of this knowledge. This course is designed to flash the spotlight of Molecular biology and Biotechnology on student to make them equipped with the modern science.

Molecular Biology

1. Nucleic Acid and Beyond:

1.1. Structure of DNA and RNA.

1.2. DNA replication: semiconservative mode of replication, Meselson-Stahl experiment, role of DNA polymerase III, II, & I, chromosome end replication problem in eukaryotes.

1.3. DNA damage (due to UV, ionizing radiation) and repair (base excision repair, photoreactivation repair, mismatch repair, SOS repair).

2. Recombinant DNA:

2.1. Restriction endonucleases, rDNA technology, cloning of DNA.

2.2. DNA libraries & Vectors: (plasmid, cosmid, retro- and adenoviruses, BAC and YAC, shuttle and expression vectors).

2.3. Promoter analysis and characterization: Deletion mapping, DNase I Footprinting

3. Mechanism of Transcription:

3.1. Mechanism of prokaryotic & Eukaryotic Transcription.

3.2. Post transcriptional modification: mRNA processing via capping, tailing, splicing, RNA editing (guide RNA & without guide RNA mediated), catalytic RNA, nuclear transport of processed mRNA, post-transcriptional gene silencing, RNA interference.

4. Translation and Gene Regulation:

4.1. Mechanism of translation: Formation of initiation complex, Elongation and termination.

4.2. Role of ribosomes and tRNAs

4.3. Operon: Lac, trp, arabinose.

5. DNA polymorphism:

5.1. Macro and microsatellites, VNTR, RFLP, AFLP, STS, EST, RAPD, FISH and GISH.

5.2. Molecular basis of Trinucleotide repeat disorder.

6. Cancer biology:

6.1. Hallmark features of cancer.

6.2. Tumor progression: Clonal Selection Theory, Angiogenesis, Metastasis.

6.3. DNA repair genes and genomic instability, Oncogenes and proto-oncogene, p53, tumor-suppressor genes, retinoblastoma, Philadelphia chromosome.

7. DNA microarray.

Biotechnology

1. Biotechnological production of living organism:

1.1. Oil- eating and solid waste degrading bacteria, oncomouse; their uses and patenting.

2. *In vitro* fertilization and ART:

2.1. Embryo sexing, animal cloning, practical application.

3. Genetically engineered insulin, growth hormones

4. Transgenesis and knock- out procedures

5. Gene targeting in mammalian cells *in vitro* and *in vivo*.

6. Gene Therapy in:

6.1. homologous recombination, viruses, antisense technology, ribozyme,

7. Pharmacogenomics:

7.1. Tailor-made medicines,

7.2. Drug-delivery systems.

8. Nuclear and mitochondrial DNA based protocols:

8.1. Forensic (disputed percentage, rapist identity),

8.2. Multilineage familial inheritance and human evolution.

8.3. DNA fingerprinting and ELSI.

Books Recommended:

Molecular Biology.

1. Alberts, B. et al. (2008). Molecular Biology of the Cell, 5th edition, Garland Science.
2. Brooker, R. J. (2017). Genetics: Analysis and Principles, 6th edition, McGraw-Hill.
3. Hartwell, L. et al. (2001). Genetics: From genes to Genomes, 4th edition, McGraw Hill Education.
4. Primrose, S.B. & Twyman, R.M. (2007). Principles of Gene Manipulation and Genomics, 7th edition, Blackwell Publishing.
5. Russel, P. J. (2016). iGenetics: A Molecular Approach, 3rd edition, Pearson.
6. Pierce, B. (2020). Genetics: A Conceptual Approach. 7th edition, W. H. Freeman.
7. Watson, J. D., Baker, T. A. & Bell, S. P. (2007). Molecular Biology of the Gene. 6th edition, Benjamin Cummings.
8. Snustad, D. P. & Simmons, M. J. (2006). Principles of Genetics, 4th edition, John Wiley and Sons.
9. Klug, W., Cummings, M., Spancer, C., Palladino, M. (2015). Concepts of Genetics. 11th Edition, Pearson.

Biotechnology:

1. Amendt, J. et al. (2010). Current Concepts in Forensic Entomology, 10th edition, Springer.
2. Singh, M. & Srivastava, A. E. (2012). Development of Vaccines: From Discovery to Clinical Testing, 1st edition, Wiley.
3. Kaufmann, S. H. E. (1996). Concepts in Vaccine Development, De Gruyter Publications.
4. Glick, B. R. & Patten, C. L. (2022). Molecular Biotechnology: Principles and Applications of Recombinant DNA, 6th edition, ASM Press.
5. Clark, D. and Pazdernick, N. (2015). Biotechnology, 2nd edition. Academic Press, Elsevier.

Course Outcome: The primary objective of this class is to provide students with a foundational understanding of the structural and functional features of biological macromolecules such as DNA, RNA, and proteins. The students will be able to use this information in their scientific disciplines and higher education after completing the course.

Unit – II

Environmental Biology and Toxicology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Environmental science is concerned with everything that surrounds an organism or community, as well as how they interact. Understanding and evaluating arguments that are based on scientific evidence, and make informed choices based on those evidence-based arguments, is critical for our future. Because of the complexity of environmental issues, finding and implementing solutions that lead to long-term environmental sustainability requires the participation of all of us. Toxicology is traditionally defined as "the study of poisons." Toxicology is defined as "the study of the adverse effects of chemicals or physical agents on living organisms." Adverse effects can take many forms, from immediate death to subtle changes that aren't noticed for months or years. There are a variety of ways in which they can manifest in the body, from an organ to an individual cell to a biochemical. As medical knowledge has advanced, so has our understanding of how toxic agents harm the body. Certain changes in the body's anatomy and functions can be traced back to previously unrecognized changes in specific biochemicals, according to new research. This course is designed to induce the interest of environmental biology and Toxicology within student.

Environmental Biology

1. Fundamental of environmental physiology
- 1.1. Physical & Chemical environnent, Macro & Micro environnent.
- 1.2. Major environment regimes of earth.

2. Extreme environmental adaptation
- 2.1. High altitude adaptation
- 2.2. Deep sea adaptation

3. Environmental pollution
- 3.1. Pesticides
- 3.2. Radio-active pollution

4. **Concept of Environment**:
- 4.1. Structure, radiation balance, UN movements on environment.

Toxicology

1. Toxins
- 1.1. Microbial Toxins
- 1.2. Mycotoxins and algal Toxins
- 1.3. Bioaccumulation and biomagnification
- 1.4. Metabolism of drugs, pesticides and toxins

2. Toxicity
- 2.1. Acute and chronic effects; factors influencing toxicity.
- 2.2. Food additives and contaminants
- 2.3. Hepatotoxicity, Nephrotoxicity, Neurotoxicity and Reproductive toxicity.

3. Dimensions of toxicological study
- 3.1. Industrial toxicology
- 3.2. Biomonitoring and biomarker study
- 3.3. Environmental Impact Assessment (EIP)

4. Biodegradation and Bioremediation Concept.
- 4.1. Bioremediation: Advantages of Bioremediation, types of bioremediation.
- 4.2. Monitoring the efficacy of Bioremediation. Bioaugmentation, biomagnifications and Biotransformation Bioventing.

4.3. Bioremediation for controlling oil spills.
4.4. Biosorption: Use of bacteria and fungi, Bioreaction for biosorption. Problems associated with disposal of xenobiotic compounds, hazardous wastes.
4.5. Biodegradation of xenobiotics: Persistent compounds, Degradation mechanisms, naphthalene, benzene, phenol, PCB's, propanil (Herbicide), urea.
4.6. Biodegradation of petrochemical effluents. Global environment problems: The Green House effect, Ozone depletion, UV radiation, Acid rain.

Books Recommended

Environmental Biology

1. Enger, E. D. & Smith, B. F. (2008). Environmental Science: A study of Interrelationships, 11th edition, McGraw-Hill Higher Education.
2. Mukherjee, B. (1996). Environmental Biology, 1st edition, Tata McGraw-Hill Publishing Ltd.
3. Raven, P. H. et al. (2015). Environment, 9th edition, Wiley.
4. Cunningham, W. P. & Cunningham, M. A. (2020). ISE Environmental Science: A Global Concern, 15th edition, McGraw-Hill education.
5. Martin, A. (1973). Biodegradation and Bioremediation, 2nd edition, Elsevier.
6. Bidoia, E. D. &Motangnolli, R. N. (2021). Biodegradation, Pollutants and Bioremediation Principles, 1st edition, Routledge, Taylor & Francis group.

Toxicology

1. Hodgson, E. (2010). A Textbook of Modern Toxicology, 4th edition, Wiley.
2. Duffus, J.H. & Worth H.G.J. (Ed.) (2006). Fundamentals of Toxicology. RSC publishing.
3. Klaassen, C. D. (Ed.) (1996). Casarett&Daul's Toxicology: The Basic Science of Poisons.5th edition, McGraw-Hill, New York.
4. Pandey, K., Shukla, J. P. & Trivedi, S. P. (2005). Fundamentals of Toxicology, New Central Book Agency (P) Ltd. Kolkata.
5. Plant, N. (2003). Molecular Toxicology, 1st edition, Bios Scientific Publishers.
6. Stine, K. E. & Brown, T. M. (2006). Principles of Toxicology. 2nd edition, CRC Taylor & Francis Group, New York.
7. Walker, C. H., Hopkin, S. P., Sibly, R. M. &Peakall, D. B. (2000). Principles of Ecotoxicology, 2nd Ed. Taylor & Francis, London.
8. Lu, F. C. (1996). Basic Toxicology: Fundamentals, Target organs and Risk Assessment, 3rd edition, Taylor and Francis.
9. Timbrell, J. (2002). Introduction to Toxicology. 3rd edition, Taylor and Francis, London.

Course Outcome: The course aims to provide students with knowledge of the effects of toxic substances on molecular and cellular levels, as well as on public health. The primary goal of the course is to familiarize students with essential toxicological concepts based on toxico-dynamics and toxico-kinetics in order to develop an understanding of drug/toxicant disposition, drug side effects, and environmental exposures to toxic substances, including carcinogens. The impact of lifestyle on cancer incidence is also being addressed, as this will assist students in developing knowledge of cancer prevention strategies.

SEMESTER– III
Paper MZOOCCT302
Unit I

Taxonomy

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Taxonomy is the science of classification in general, but more specifically the classification of living and extinct organisms—i.e., biological classification. The term comes from the Greek words taxis (arrangement) and nomos (law). Taxonomy is thus the methodology and principles of systematic botany and zoology that organizes plant and animal species into hierarchies of superior and subordinate groups. In 1813, the Swiss botanist Augustin Pyramus de Candolle proposed the term for plant classification. This course is designed to clear the basic fundamental idea regarding traditional and molecular taxonomy.

1.Taxonomic characters

1.1. Baic concept of taxonomy and systematics
1.2. Character and character states, Discrete and overlapping characters; polymorphic characters, character of special consideration; method for identifying plesiomorphic and apomorphic character states.
1.3. Microcharacters, Cryptic character and internal characters
1.4. Artifacts and behavioural characters.
1.5. Character State Transitions.

2. Taxa and Species

2.1. Phylogenetic groups: Monophyly, polyphyly; paraphyly.
2.2. Problems with parthenogenetic and asexual taxa.

3. Theories of Biological Classification

3.1. Classification and phylogeny
3.2. Types of classification, hierarchic classification

4. Phenetic method of classification

4.1. Numerical taxonomy and numerical phenetics.
4.2. Preparation of data matrix and similarity matrix using distance method (Manhattan distance and Euclidian distance); cluster analysis (different methods).

5. Cladistics and related methods

5.1. Differences in the application of phenetic and cladistic classification.
5.2. Cladistics and cladograms.
5.3. Cladistic methods.
5.4. Application of parsimony and Maximum Likelihood.

6. Taxonomic applications

6.1 Cytotaxonomy,
6.2. Biochemical taxonomy,
6.3. Immuno-taxonomy
6.4. Barcoding.

Books Recommended

1. Futuyma, D. J. & Kirkpatrick, M (2017). Evolution. 4th edition, Sinauer Associates.
2. Hall, B. K. & Harrington, B. (2013). Strickberger's Evolution, 5th edition, Jones & Bartlett.
3. Mayr, E. & Ashlock, P. D. (1991). Principles of Systematic Zoology. 2nd edition, McGraw-Hill.
4. Quicke, D. A. J. (1993). Principles and Techniques of Contemporary Taxonomy, 1st edition, Springer.
5. Simpson, G. G. (2012). Principles of Animal Taxonomy, Scientific Publishers (India).

Course Outcome: Students will have a better understanding of the diversity of all life forms and will be able to identify unknown taxa and make new discoveries if they learn the fundamental principles of biosystematics and taxonomy, the most important discipline in the field of biological science. This can be accomplished by studying the basic principles of biosystematics and taxonomy. As a result, students have the potential to make significant contributions to both society and the scientific community in their future endeavours as researchers and educators.

Unit II

Biodiversity and Wild Life Conservation and Ethnobiology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Due to the significant loss of biodiversity and deterioration of natural ecosystems, there is little room for argument that all life on Earth is currently in jeopardy. As a result, this course is available to all graduate students, regardless of their academic expertise, in order to make them aware of and sensitized to this survival dilemma. Students who complete this course will have gained a solid foundation in the importance of biodiversity and ecosystem services in supporting life on Earth, as well as an understanding of the dangers posed by people' careless behaviour.This course offers an introduction to the inter-disciplinary area of ethnobiology, which is the study of different human communities' knowledge and beliefs about the natural world (ethnos). The field of ethnobiology emerged from the study of ethnoscience within the academic discipline of anthropology. It encompasses a wide range of topic matters as well as theoretical approaches.

1. Concept of Biodiversity

1.1. Framework of Biodiversity; Biodiversity hotspots – Global and Indian and Biodiversity act.

1.2. Problems and scales of Biodiversity extinctions in time and space.

1.3. Levels and Measures of Biodiversity; Interrelationships between diversity measures; application and integration of diversity measures.

1.4. Process and pattern of local and regional biodiversity --- Niche assembly, unified Natural theory; Island biogeography model, Rain Forest.

1.5. Values of Biodiversity: ethical, aesthetic, intrinsic and Special (indicator species and Environmental monitoring).

2. Threats to Species diversity

2.1. Natural and human induced threats and vulnerability of species extinctions.

2.2. Biodiversity and Rarity, Endemism and Biodiversity.

2.3. Problem of genetic diversity loss over time; Bottleneck, Genetic drifts, Inbreeding depression.

2.4. Extinction Vortex.

3. Theory and analysis of conservation:

3.1. Stochastic perturbations, population viability analysis, recovery strategy for threatened species

3.2. Different approaches for conservation – in-situ and ex-situ, In-situ conservation-problems and prospects; Sanctuaries, National parks, Community Reserves and Conservation Reserves; Biosphere Reserve, EIA and EIS.

4. National and International efforts for conservation

4.1. Information on CITES, IUCN and PBR.

4.2. Regional and National approaches for biodiversity conservation.

5. Ethnobiology:

5.1. Overview, concept and scope.

6. Ethnomedicine:

6.1. Concept and overview, definition, history and its scope.

6.2. Interdisciplinary approaches of ethnobotany – collection of ethnic information.

7. Traditional Medicine in Chemoprevention and Therapeutics:

7.1. Cancer and diabetes.

Books Recommended

1. Jeffries, M. J. (2005). Biodiversity & Conservation, 2nd edition, Routlledge, Taylor & Francis group.
2. Gaston, K. J. & Spicer, A. I. (2003). Biodiversity: An introduction, 2nd edition, Wiley-Blackwell.
3. UNEP. (2005). Global Biodiversity Outlook 5, UN Convention of Biological Diversity.
4. Primack, R. B. (2012). A primer of Conservation Biology, 5th edition, OUP USA.
5. Kato, M. (2012). The Biology of Biodiversity, Springer.
6. Wilson, E. O. (1988). Biodiversity, John Wiley & Sons.

Course Outcome: Students who successfully complete this course will be able to define, monitor, and comprehend environmental systems using quantitative methods and the scientific method. They will also be able to identify how harmful chemicals used for various objectives affect ecosystems and human health. In the Ethnobiology course, student will able to emphasize the importance of ethnobiology in the current context. Learn about India's major and minor ethnic groups, as well as their lifestyles. Discover the Methodology of Ethnobiological Studies. Learn about the function of Ethnobiology's Place in Modern Medicine. Raise awareness about medicinal plant conservation practices.

SEMESTER – III
Paper – MZOOMET303 A
(Elective – Parasitology and Immunology)

Marks: 50. **No. of Class Hrs. 60**

Course Objective: This elective is aimed to nourish the student with the expertise of parasitology and immunology. Student will investigate the dynamicity of parasitic environment together with specific parasitic life cycles. They also engorged in the area of host-parasite interactions, parasitic ecology. Student will also explore General concept of parasitology. Knowledge of some parasitic diseases that could be transmitted between animals and man (Zoonotic diseases), knowledge how to protect man and domestic animals from parasites and their treatment. Basic knowledge of parasitism, the different biological inter-relationships and the host-parasite relationships. Knowledge of different parasitic examples from all phyla (Protozoa &Metazoa), their morphology, biology, life cycles, diagnosis, treatment & control. Dissemination of health awareness of these parasitic diseases.

Unit-I

Parasitism and Diversity of Parasites

1. Concept on animal association and parasitism.

2. General knowledge, diversity of parasites and their classification

2.1. Classification of protozoans with suitable examples up to subclasses following Levine et al. (1980).

2.2. Classification of Trematoda, Cestoda and Nematoda with examples up to orders.

2.3. Classification of parasitic insects, ticks and mites with examples up to orders.

3. Evolution of parasitism and parasites - protozoans and helminthes.

4. Parasitic ecology.

5. Vertebrate alimentary canal, blood and tissues as parasite's habitat.

6. Parasite - Host specificity.

Unit-II

Biology of Parasites

1. Life cycle pattern of trematodes, cestodes, and nematodes and their larval stages.

2. Life cycle stages and biology of following parasites of medical and veterinary importance

2.1. Protozoa (i) *Entamoeba histolytica*, (ii) tissue invading *Naegleria and Acanthoamoeba, (iii) Giardia intestinalis, (iv)Trypanosoma* and sleeping sickness, and Chagas disease, *(v) Leishmania* and visceral Leishmaniasis, *(vi) Toxoplasma* and Toxoplasmosis, *(vii) Plasmodium* and cerebral malaria, *(viii) Balantidium* and human colitis

2.2. Trematodes: (i) *Schistisoma haematobium* – the blood fluke, (ii) *Paragonimus westermani*– the lung fluke,

2.3. Cestods: *(i) Echinococcus granulosus*- and hydatid disease

2.4. Nematodes: *(i) Ancylostoma duodenale* and hookworm disease (ii) *Dracunculus medinensis* and Guinea worm disease, (iii) Human filariasis – a brief review of the parasites involved.

3. Brief idea on biology and life cycle of Acanthocephala.

Books Recommended

1. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th edition, John Wiley & Sons.
2. Cheng, T. C. (1986). General Parasitology, 2nd edition, Academic Press.
3. Cox, F. E. G. (1993). Modern Parasitology, 2nd edition, Blackwell Scientific Publications.
4. Hati, A. K. (2001). Medical Parasitology: protozoology and helminthology, Allied Book Agency, Kolkata.
5. Schmidt, G. D. & Roberts, L. S. (2001). Foundation of Parasitology, 3rd edition, McGraw-Hill Education.
6. Bogitish, B., Carter, C, &Oeltmann, T. (2005). Human Parasitology, 3rd edition, Elsevier.
7. Marr, J., Nilsen, T. W., &Komuniecki, R. W. (2002). Molecular Medical Parasitology, 1st edition, Academic Press.
8. Roberts, L. &Janovy, J. Jr. (2008). Foundations of Parasitology. 8th edition, McGraw-Hill Education.

Course Outcome: Students will leave this class with an awareness of significant human parasite illnesses, including their life cycles, vectors of transmission, distribution and epidemiology, pathophysiology and clinical symptoms, therapy, as well as prevention and control measures.

Semester III
Paper – MZOOMET303- B
(Elective- Aquaculture and Fisheries)

Marks: 50. **No. of Class Hrs. 60**

Course Objective: This elective is designed to induce the student to gain knowledge abouta thorough understanding of the various types of aquaculture and fisheries. Advancedaquaculture and fisheries techniques knowledge, knowledge of the National FisheriesDevelopment Board, the Department of Fisheries, the Ministry of Fisheries, AnimalHusbandry. Advanced techniques used in aquaculture and fisheries to increase the rate ofproduction of cultured as well as capture species in response to market demand. Taught howto use natural water resources to produce aquaculture-based organisms. Encourage people toadopt as a skill for employment by working directly as a farmer, researcher, or even aworker to improve their socioeconomic status.

Unit I - (Limnology & Oceanography)

1. Freshwater Resources

1.1. Rivers, ponds, lakes and reservoirs – zonations, characteristics and morphometry
1.2. Productivity in ponds, lakes and reservoirs
1.3 Manipulation of productivity for aquaculture

2. Stratification in Lakes and Reservoirs

2.1. Thermal stratifications and their modifications
2.2. Stratification and dynamics of oxygen, nitrogen, phosphorus and inorganic carbon

3. Water Quality

3.1. Water quality parameters necessary for aquaculture and their role in fish production

4. Costal and Marine Fishery Resources & Factors

4.1. Classification, topography of marine environment and salient features of different zones
4.2 Physical environmental factors (Temp, Light, Pressure, Tides and waves); Chemical environmental factors (Oxygen, CO_2, Carbonates, Salinity, pH, N_2).
4.3. Mangrove ecosystem and its interaction with fish resources.

5. Deep Sea Biology:

5.1. Environmental characteristics, Adaptations, Midwater community, Ecology. Zonation. Hydrothermal vents.

6. Earth and ocean floor:

6.1. Origin. Structure of earth. Continental Drift. Classification of marine environment: Continental shelves, slopes, rise.
6.2. Submarine canyons. Ocean trenches. Island arcs. Ocean Ridges, Upwelling and Downwelling. Eddies. Inertial currents. Longmuir circulation. Thermohaline circulation. Deep ocean circulation.

Books Recommended

1. Ananthakrishnan, T. A. (1982). Bioresources Ecology, 1st edition, CRC Press.
2. Powlowski, L. (1980). Physicochemical Methods for Water and Wastewater

Treatment, 1st edition, Elsevier.
3. Trivedy, R. K. & Goel, P. K. (1986). Chemical and Biological Methods for Water Pollution Studies, 1st edition, Environmental Publications.
4. Charles R. & Horne, A. J. (1994). Goldman's Limnology, 2nd edition, McGraw-Hill Higher Education.
5. Wetzel, R. (2001). Limnology: Lake and River Ecosystems, 3rd edition, Elsevier.

Course Outcome: Protecting our natural resources and ensuring the availability of fish populations for future generations will benefit from a sustainable approach to fishing and aquaculture. Overfishing, poor management, industrialization, and agricultural contamination have all contributed to the current decline in fish populations.

Paper – MZOOMET 303C
(Elective-Genetics and Cell Biology)

Marks: 50. **No. of Class Hrs. 60**

Course Objective: Gene concept, behaviour of genes, genome organization, site-specific recombination and its applications, gene regulation, linkage and crossing over, sex determination, quantitative trait loci mapping, and signalling pathways and their hardware will be covered in this elective course, which has been designed specifically for the student to gain knowledge of these topics.

Gene structure and function

1. Behaviour of Genes:

1.1. Penetrance, Expressivity, Pleiotropy, Pseudo-alleles, phenocopy, co-dominance, epistasis.

1.2. Unique and repetitive DNA, Gene clusters, Super-families.

1.3. Euchromatin and Heterochromatin, Constitutive and facultative heterochromatin.

1.4. C–value paradox. DNA re-association kinetics, C_0t curves, T_m values.

2. Sex-determination (molecular aspect) and Dosage Compensation:

2.1. Molecular mechanism of sex determination and dosage compensation in *C. elegans*, *Drosophila* and Human.

2.2. Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

3. Linkage and Crossing Over:

3.1. Sterns experiment, Holliday model, Tetrad analysis.

4. Mutation:

4.1. Chromosomal aberration

4.2. Mutation induced by chemical agents and their repair mechanism.

5. Nucleic Acid and Chromosome Structure:

5.1. The Regular Backbone of DNA, Grooves in DNA and Helical Forms of DNA.

5.2. Dissociation and Reassociation of Base-paired Strands, Topological Considerations in DNA Structure, Generating DNA with Superhelical Turns, Measuring Super Helical Turns Determining Lk, Tw, and Wr,

5.3. DNA replication: Detail mechanism, enzymology and accessory proteins, Processivity and accuracy of DNA Polymerases.

6. Quantitative Genetics:

6.1. Polygenic inheritance, heritability and its measurements, QTL mapping.

7. Signaling mechanism and its Hardware:

7.1. RTKs, Receptor serine/threonine kinases, TNF, toll like receptors, Notch receptors, Hedgehog receptors.

7.2. Second messengers: NO, Ca^{2+}, IP_3, Lipid derived.

Books Recommended

1. Brown, T. A. (2020). Gene Cloning & DNA Analysis, 8th edition, Wiley-Blackwell.
2. Hartl, D. L. & Jones, E. W. (2006). Essential Genetics: a genomics perspective, 4th edition, Jones and Bartlett Publishers, Boston.
3. Harvey, L. et al. (2004). Molecular cell Biology, 5th edition, W.H. Freeman.
4. Alberts, B. et al. (2008). Molecular Biology of the Cell. 5th edition, Garland Science.
5. Karp, G. (2008). Cell and Molecular Biology: Concepts and experiments, 5th edition, John Wiley.
6. Griffiths, A. J. F. et al. (2020). Introduction to Genetic Analysis, 12th edition, Macmillan.
7. Pierce, B. (2020). Genetics: A Conceptual Approach, 7th edition, W. H. Freeman.
8. Lewin, B. (2008). Genes IX. Jones & Bartlett Publishers.
9. Weaver, R. F. (2012). Molecular Biology, 5th edition, McGraw-Hill Education.

Course Outcome: Students who choose to participate in this optional course will find that they have advanced significantly in their understanding of molecular genetics. They will have the ability to do the analysis in any of the aforementioned subject areas. They will be able to tackle difficulties relating to linkage mapping and quantitative trait loci mapping.

SEMESTER – III
Paper – MZOOOET304
Open Elective
Biodiversity and Wildlife Conservation

Marks: 50. **No. of Class Hrs. 60**

Course Objective: This course is designed in such a way that it will provide the students with an understanding of the origin and diversity of life, the ability to examine and study organismic diversity at various levels (species, genetic, and ecosystem), the valuation of biodiversity, the ability to measure and estimate biodiversity, the ability to assess wildlife treat status and issues, and the threats that are responsible for the decimation of biodiversity and wildlife, as well as the means by which to address issues of sustainability and conservation of biodiversity.

1. Concepts of Biodiversity:

1.1. Concepts and components of biodiversity, genetic diversity, species diversity and ecosystem diversity.

1.2. Biodiversity indices, values of biodiversity.

1.3. Indian and global biodiversity.

2. Biodiversity conservation:

2.1. Conservation of biodiversity, in-situ and ex-situ conservation.

2.2. Biodiversity hotspots in the world, national and global red data lists, categories of species and their management.

2.3. IPR of biodiversity and its products, patent protection and biopiracy.

3. Management of wildlife:

3.1. Distribution, status, habitat utilization pattern.

3.2. Threats to survival of Lion-tailed macaque, NilgiriTahr, Bengal vulture, Great Indian Bustard, Olive Ridley Turtle.

4. National and International Efforts for Conservation:

4.1. National and International efforts for conservation: CITES, IUCN, CBD.

4.2. Traditional Ethics and Role of Local Communities in Conservation.

4.3. Integrated Development of Wildlife Habitats, Recovery of Endangered Species

4.4. National Plan for Conservation of Aquatic Eco-System: Ramsar Convention on Wetland

4.5. National Conservation Strategy and Policy statement on Environment and Development.

(Practical: Biodiversity and Wildlife Conservation)

1. Biodiversity study of any ecosystem with biodiversity indices.
2. Quadrate analysis.
3. A study of habitat specificity in birds or small mammals on campus principally based on observations.
4. Field methods of studying diet. Examination and recording of stomach contents of some local insects or fishes.

Books Recommended

1. Agarwal, S. K. (1996). Biodiversity and environment. APH publication house.
2. Krishnamurthy, K. V. (2003). Textbook of Biodiversity, 1st edition, CRC Press.
3. Shrivastava, R. (2015). Biodiversity Conservation, Om Publications.

4. Jeffries, M. J. (2005). Biodiversity and Conservation, Routledge, Taylor & Francis Group.

Course Outcome: Students will have the information and abilities necessary to, upon successful completion of the course, articulate the reasons why society works to protect bio diversity. Determine which risks are the most significant to biodiversity and assess which management strategies are most likely to be successful in preserving it in a variety of diverse environments. Create acceptable policy alternatives for the preservation of biodiversity in a variety of different environments. Through the use of a variety of different mediums, articulate an informed critique or analysis of biodiversity conservation policies and practices.

SEMESTER – III
Paper – MZOOCCS305
Practical Course

Marks: 50

Course Objective: Students will learn the essential techniques utilized in molecular biologyand biotechnology, such as restriction enzyme-mediated cleavage and plasmid

DNAisolation, in this practical course. Toxicology, biodiversity, and wild life conservation arealso areas of expertise for them.

A. Molecular Biology and Biotechnology.

1. Restriction enzyme cleavage of DNA.
2. Agarose gel electrophoresis.
3. Plasmid DNA isolation.
4. Handling of PCR apparatus.
5. Use of EtBr for visualizing DNA bands.

B. Environmental Biology & Toxicology

1. Haemocytes from different models in different stress conditions.
2. Study of micronucleus in fish model in different stress conditions.
3. Determination of LC 50 of an environmental toxin in static water environment.

C. Taxonomy & Biodiversity and Wild Life Conservation

1. Study of salient taxonomic study: Insect and fish models
2. Recognition of taxa from museum study and preparation of taxonomic keys.
3. Biodiversity assessment: Aquatic and terrestrial communities, dominance diversity analysis; analysis of community indices.
4. Major Field study in any national park/marine ecosystem/forest ecosystem/ Mountain ecosystem and Submission of field reports.

D. Ethnobiology

1. Local field survey.
2. Identification of some medicinal plants used by the local tribal people and submission of herbarium of local medicinal plants.
3. Isolation and Purification of bioactive components from medicinal plants: Extraction, TLC, HPLC, & GCMS.

E. Internal Assessment

F. Viva voce

Course Outcome: After completion student will understand and have a hands-on experience in techniques of Molecular Biology, Biotechnology, Environmental biology,Toxicology, Taxonomy, Biodiversity, and wild life conservation and Ethnobiology

SEMESTER – III
Paper – MZOOOPP306
Marks:50
Outreach program

SEMESTER – IV
Paper – MZOOCCT401
Neurobiology, BiostatisticsandIntroduction to Bioinformatics
Unit – I
Neurobiology

Marks: 25. **No. of Class Hrs. 30**

Course Objective: Students will become familiar with the field of neurobiology as part of the course's overarching mission. Show that you have a solid understanding of the fundamentals of neuroanatomy as well as the function of the nervous system on a molecular, cellular, and systems level. Describe the primary subfields of neuroscience while demonstrating an in-depth knowledge of the primary research strategies, methodologies, and subject areas. The study of neurobiology encompasses a wide variety of subfields, ranging from the molecular organization of nerve cells to the philosophy of mind; however, we will not go into detail regarding all of these subfields. Rather, the goal of the lectures will be to first cover some of the most fundamental topics, such as the structure of neurons, action potentials, and sensory systems, cognitive neuroscience, and neurodegenerative disorder and then to investigate some of the most cutting-edge areas.

1. Fundamentals of Neurobiology.

1.1. Neurons: Histological structure and types. Molecular biology of neurons – membrane proteins, lipids cytoskeleton, regulation of axonal transport.

1.2. Neurological cells: Different types and functions.

2. Cellular Neurobiology and Neurochemistry

2.1. Synapse: Characteristics features of type- I and type- II synapses. Cell adhesion molecules in synapse. Synaptic vesicles. Glial influence on synaptic transmission. Neuromuscular junctions and neuromuscular transmission.

2.2. Action potential generation in postsynaptic neurons: Theories of neuronal information processing.

3. Neurosecretion and neurotransmitters.

3.1. Biosynthesis, storage and inactivation of classical neurohormones and neurotransmitters Acetylcholine, Catecholamines, GABA, Serotonin – Substance P, Enkephalins, NPY, Neurotensin.

4. Cognitive Neuroscience

4.1. Memory: Types of memory- Explicit, implicit. Long term and working memory. Molecular basis of early and late LTP.

5. Neurodegenerative disorder

5.1. Neurogenerative diseases: Parkinson’s disease, Huntington Chorea, Alzheimer’s disease.

5.2. Other diseases: Schizophrenia, Autism, Prion disease.

Books Recommended

1. Purves, D. et al. (2017). Neuroscience. 6th edition, Sinauer Associates.
2. Sheffard. G. M. (1994). Neurobiology, 3rd edition, OUP.
3. Mathews, G. G. (2000). Neurobiology: Molecules, Cells and Systems, 4th edition, Blackwell Publishing.
4. Barker, R., Barasi, S., & Neal, M. J. (2003). Neuroscience at a Glance, 2nd edition, Wiley-Blackwell
5. Nelson, C. A. & Luciana, M. (2008). Handbook of Developmental Cognitive Neuroscience, 2nd edition, MIT Press.

Course Outcome: After completing this course, students will have a better understandingof how neurons work and how neurons are connected in circuits to form sensory or motor systems; they will also have a better understanding of cognitive neuro science and neurodegenerative disorders; and they will learn how to read and evaluate research articles.

SEMESTER – IV

Paper – MZOOCCT401
Unit – II
Biostatistics, Introduction to Bioinformatics and Bioethics

Marks: 25. **No. of Class Hrs. 30**

Course Objective: The field of study known as biostatistics focuses on improving public health and medicine through planning, carrying out, analysing, and drawing conclusions from scientific research. The study of inventing and applying computing algorithms and analysis procedures to large amounts of biological data, such as genetic sequences, is the field of study known as bioinformatics. The students will be provided with an overview of the discipline of bioinformatics and given the tools necessary to comprehend the fundamentals of statistical analysis as it relates to biology. This section will also introduce ethical concerns and ethical conducts in molecular biology, genetic engineering and animal and human experimentation.

Biostatistics

1. Sampling, Data and Central Tendency:

1.1. Sampling, Frequency distribution, Calculation of Mean, Median, Mode, Range, Variance, Standard deviation, and Quartile deviation.
1.2. Concepts of Coefficient of Variation, Skewness and Kurtosis

2. Probability:

1.1. Definition: Classical and statistical definitions of probability, applications.
1.2. Random experiment, events, mutually exclusive, equally likely, exhaustive events.
1.3. Probability models: Bernoulli, Binomial, Poisson, Normal (without deviation), Mean variation), Mean, Variance (without variation).
1.4. Applications of the models using zoological data.

3. Testing hypothesis:

3.1. Hypothesis- null and alternative, two kinds of error.
3.2. Level of significance, p-value and variance.
3.3. Statistical tests: Tests of population mean and variance- one population, two populations (correlated and uncorrelated) under normal set up; test for $\rho=0$.
3.4. Chi-square test for goodness of fit, Heterogeneity Chi-Square, Odds ratio

4. Analysis of Variance (ANOVA):

4.1. Concept of ANOVA, one way and two way lay out.

5. Correlation & Regression:

5.1. Types of correlations, Measure of Correlation – Scatter diagram, Pearson's Correlation Coefficient, Spearman's Rank Correlation.
5.2. Regression: Types of Regression, Regression equation, Regression Coefficient.

6. Multiple comparisons:

6.1. Tukey's post hoc test, Bonferroni and Benjamini Hochberg test, Concept of multivariate analysis.

Introduction to Bioinformatics:

1. Genomics and Proteomics:

1.1. Database and search tool
1.2. Computational tools and biological databases
1.3. National centre for Biotechnology information (NCBI)
1.4. European Bioinformatics Institute (EBI)

2. Sequence alignment and database searching:

2.1. The evolutionary basis of sequence alignment
2.2. Database similarity searching
2.3. Sequence Similarity search tools: BLAST and FASTA.

3. Primer designing:

3.1. Si RNA and Sh RNA designing tools.
3.2. Genome browser for promoter recognition.

4. **Bioethics :**

4.1. Genetic engineering and ethical concern with genetically modified organisms.
4.2. Stem cell technology, embryonic stem cell and ethical consideration.
4.3. Human cloning, gene editing, designer baby and ethical considerations.
4.4.International and Indian laws regarding prevention of cruelty on animals.
4.5.Ethical considerations for animal experiments, SOP and guidelines of CPCSEA, India.
4.6.Medical experiments and human ethics.

Books Recommended

Biostatistics:

1. Batschelet, E. (1979). Introduction to Mathematics for Life Sciences, 3rd edition, Springer.
2. Sokal, R. R. & F J Rohlf, F. J. (1994). The Principles and Practice of Statistics in Biological Research, 3rd edition, Wiley.
3. Snedecor, G. W. & Cochran, W. G. (1989). Statistical Methods, 8th edition, Iowa State University Press.
4. R H Green, R. H. (1979). Sampling Design and Statistical Methods for Environmental Biologists, 1st edition, Wiley
5. D Das, D. & Das, A. (). Statistics in Biology and Psychology, 6th edition, Academic Publishers.
6. Gun, A. M., Gupta, M. K., & Dasgupta, B. (2013). Fundamentals of Statistics, Volume I, World Press Pvt. Ltd.
7. Gotelli, M. J. & Ellison, A. M. (2012). A Primer of Ecological Statistics, 2nd edition, OUP USA.
8. Homes, S. & Huber, W. (2019). Modern Statistics for Modern Biology, 1st edition, Cambridge.
9. Norman, G. R. (2002). Biostatistics: The Bare Essentials, 2nd edition, CBS Publishers and Distributors Pvt. Ltd.

10. Zar, J. H. (2014). Biostatistical Analysis, 5th edition, Pearson.

Bioinformatics:

1. Alterovitz, G. &Ramoni, M. (2010). Knowledge-Based Bioinformatics: From Analysis to Interpretation, 1st edition, Wiley.
2. Attwood, T. (2007). Introduction to Bioinformatics. 1st edition, Pearson Education.
3. Leks, A. M. (2014). Introduction to Bioinformatics, 4th edition, Oxford University Press.
4. Basu, A. &Thukral, S. K. (2007). Bioinformatics: Experiments, Tools, Databases, and Algorithms, Illustrated edition, Oxford University Press.
5. Ghosh, J. (2008). Bioinformatics: Principles and Applications, Illustrated edition, OUP India.

Course Outcome: Learn the theory behind fundamental bioinformatic analysis methods, be familiar with widely used bioinformatics databases, understand basic concepts of probability and statistics, be able to describe statistical methods and probability distributions relevant to molecular biology data, and be able to perform and interpret bioinformatics and statistical analyses.

SEMESTER – IV

Paper – MZOOMET402A
(Elective – Parasitology and Immunology)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: The purpose of this elective course is to equip the student with the knowledge and skills necessary to become an expert in the field of parasite immunology. Throughout the duration of this class, students will do a cursory investigation into the biochemistry and ultrastructure of various parasites. Gall caused by nematodes and its histology, in addition to the epidemiology of certain disorders. Students will have a basic understanding of zoonosis and myiasis. Students will receive lessons in molecular parasitology, vector biology, and host-parasite interaction in order to be ready them for the present molecular parasitological world.

Unit -I
FM=25
Structure, metabolism and pathophysiology of parasites

1. Ultrastructures
- 1.1. Different stages of malarial parasites
- 1.2. *Leishmania*
- 1.3. *Trypanosoma*
- 1.4. *Cryptosporidium*
- 1.5. Spores of *Nosema*
- 1.6. Integuments of trematodes, cestodes and nematodes.

2. Carbohydrate and Protein metabolism in *Plasmodium sp.* and *Ascaris sp.*

3. Nematode induced gall and their histopathology:
- 3.1. Gall and its Classification.
- 3.2. Systematics of gall producing nematodes; Life cycle stages of *Meloidogyne* sp.; Histopathological changes induced by *Meloidogyne* sp. during gall formation.

4. Epidemiology:
- 4.1. Definitions, classification, landscape epidemiology.
- 4.2. Epidemiology of malaria, leishmaniasis (Kala Azar) and filariasis.

5. General idea on different types of Zoonoses and Myiasis (classification & evolution etc.)

Unit-II
FM=25
Vector biology and Molecular parasitology

1. Vectors and its importance in transmission of Parasitic diseases:
- 1.1. General morphology of fleas, flies, ticks and mites.
- 1.2. Life cycle stages of(i) *Boophilus*sp. – the vector of *Babesia*,
  (ii) *Trombicula*sp. – the vector of *Rickettsia etc.*

(iii) *Xenopsyllacheopis*sp. - plague vector,
(iv) *Phlebotomus* sp. - *Leishmania* vector,
(v) *Glossina* sp.- vector of Gambian trypanosomiasis.

1.3. Mosquito as vector

2. Host-parasite interaction:

2.1. Recognition and entry process of different pathogen and parasites in the host cell/body.

2.2. Alteration of host cell behavior by pathogens.

3. Molecular parasitology:

3.1. Molecular basis of antigenic variation and diversity of parasites.

3.2. Molecular organization and gene structure in *Plasmodium*

3.3. Strategies of molecular cloning and protection against malaria.

Books Recommended

1. Chandler, A. C. & Read. C. P. (1961). Introduction to Parasitology, 10th edition, John Wiley & Sons.
2. Cheng, T. C. (1986). General Parasitology, 2nd edition, Academic Press.
3. Cox, F. E. G. (1993). Modern Parasitology, 2nd edition, Blackwell Scientific Publications.
4. Hati, A. K. (2001). Medical Parasitology: protozoology and helminthology, Allied Book Agency, Kolkata.
5. Schmidt, G. D. & Roberts, L. S. (2001). Foundation of Parasitology, 3rd edition, McGraw-Hill Education.
6. Bogitish, B., Carter, C, &Oeltmann, T. (2005). Human Parasitology, 3rd edition, Elsevier.
7. Marr, J., Nilsen, T. W., &Komuniecki, R. W. (2002). Molecular Medical Parasitology, 1st edition, Academic Press.
8. Roberts, L. &Janovy, J. Jr. (2008). Foundations of Parasitology. 8th edition, McGraw-Hill Education.

Course Outcome: The course's goal is to supplement a more traditional approach to parasites and related diseases, in which students are exposed to the realm of parasites. To present a basic overview of these diseases from epidemiology to diagnostics, the course is organized to focus on current hot themes such migrations, new technology, outbreaks, and treatment resistance. Teaching parasitology focuses on the specific host-parasite relationship for pathogens to humans, the biological danger that hosts face, the significant endemic parasitic diseases, and the public health aspects of their control in endemic areas. The instructors will also do their best to impart the knowledge they've learned through years of experience working in areas where parasites are widespread as parasitologists and international health specialists.

SEMESTER – IV

Paper – MZOOMET402- B
(Elective –Aquaculture and Fisheries)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: The purpose of this programme is to provide participants with the knowledge and technical abilities necessary to comprehend the dynamic nature of the current Fisheries & Aquaculture industry. Additionally, it is intended to equip students with the knowledge necessary to comprehend the most recent tendencies and challenges faced by farming societies in the field of Fisheries & Aquaculture and to infuse in them the self-assurance necessary to work on various types of aquaculture practices. The curriculum has been organized in such a way that the learners will become familiar with both the fundamental and the applied parts of Fisheries and Aquaculture thanks to the program's structure.

Unit I
Freshwater Aquaculture; Coastal and Marine Water Fisheries

1. Fisheries of Lakes and Reservoirs:

1.1. Distribution, commercial exploitation of major freshwater lakes and reservoirs, brackish water lakes.

1.2. Major threats to freshwater systems, including pollution and sand mining. Impact of large dams and fragmentation on river ecology and fishery.

1.3. River continuum concept. Environmental flow. Pollution and eutrophication.

1.4. Climate change implications on freshwater systems. Biomonitoring.

2.Cold water fisheries:

2.1. Definition, principal zones of cold-water fisheries of India, important cold-water fisheries of India, food and feeding habit.

3. Aquaculture of carps

3.1. Breeding of fish, Hormonal interactions for fish breeding

3.2. Modern hatcheries and management

3.3. Site selection, culture system, preparation and management of ponds for culture

3.4. Transportation of fish seeds

3.5. Major diseases in aquaculture, control and management

4. Fish Nutrition and Growth

4.1. Nutritional requirements, Digestive energy in fish feed and Energy flow through fish; Feed formulation

5. Aquaculture of Freshwater prawns

5.1. Major cultivable species of prawns.

5.2. Reproduction and larval rearing of prawns, site selection, construction of farms, grow out.

6. Fish pathology and diseases

6.1. Major diseases in aquaculture, control and management.

6.2. Immune protection in fish systems

7. Non-conventional aquaculture system

7.1. Raceways, Flow through & recirculation technology in aquaculture, Pens andCage aquaculture.

Unit-II:
Coastal and Marine Water Fisheries

1. Mariculture

1.1. Breeding and larval rearing of shrimps and management.

1.2. Different shrimp culture system, construction of farm, selection of larvae, water and feeding management, harvesting and disease management.

1.3. Culture of mud crab.

1.4. Edible oyster farming.

2. Marine fisheries

2.1. Exclusive economic zone – potentialities, exploitations &problems

2.2. Modern devices of exploitation (different crafts and gears used in Indian capture fishery)

2.3. Major fisheries of Indian coasts: Bionomics and production of Hilsa, Sardine, Bombay duck, Pomfret.

3. Survey of marine fisheries: offshore, deep sea, divisions.

4. Coastal fisheries: Coastal zones, features, EEZ, CRZ.

Books Recommended

1. Ananthakrishnan, T. A. (1982). Bioresources Ecology, 1st edition, CRC Press.
2. Powlowski, L. (1980). Physicochemical Methods for Water and Wastewater Treatment, 1st edition, Elsevier.
3. Trivedy, R. K. & Goel, P. K. (1986). Chemical and Biological Methods for Water Pollution Studies, 1st edition, Environmental Publications.
4. Charles R. & Horne, A. J. (1994). Goldman's Limnology, 2nd edition, McGraw-Hill Higher Education.
5. Wetzel, R. (2001). Limnology: Lake and River Ecosystems, 3rd edition, Elsevier.

Course Outcome: After this curriculum is completed, students will have a good grasp of the numerous aquatic species that can be used to produce healthy food for human consumption in an environmentally friendly manner. Students will be able to pursue a variety of research and employment opportunities as a result of the programme. For better management of culture ponds and hatcheries, students would be well-versed in employing applicable tools and procedures, including those related to water quality; illnesses; nutrition and supplementary feeds; as well as fish processing, marketing, and distribution. Upon completion of this programme, students will be well-prepared to start their own aquaculture business or work in a variety of aquaculture-related fields such as farms, hatcheries, analytical labs, the feed industry, the fish processing industry, marketing, and so on They would be extremely successful because of their wide range of skills and deep expertise in the field.

SEMESTER – IV
Paper – MZOOMET 402C

(Elective-Genetics and Cell Biology Special)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: The objective of this class is for each student to come away with a clearer grasp of the cellular environment and a deeper appreciation for the ways in which molecular interactions control various cellular functions. The mechanisms and regulation of genome maintenance and gene expression will be taught to the students. The course will place an emphasis on how molecular structure influence's function, explain why energy is necessary, and highlight the multiple layers of regulation involved in the flow of genetic information. The culmination of this information will be a better understanding of the role that these molecular systems play during the development of organisms.

Regulation of gene function.

1. Regulation of gene expression in prokaryotes:

1.1. overview, Operons (Lac, tryptophan and arabinose operon)

2. Regulation of gene expression in eukaryotes:

2.1. Regulation at transcriptional level: Transcription factors, leucine zipper, helix turn helix, helix loop helix, enhancers and silencers, Chromatin-remodelling complexes.

2.2. RNA interference (RNAi), shRNA, sno RNA

2.3. Regulation at translational level.

2.4. Regulation at chromosomal level: chromatin remodeling, histone modification.

2.5. Translation: Nature and Properties of Genetic code, Wobble; Prokaryotic and eukaryotic translation - The translational machinery, Mechanisms of initiation, elongation and termination; Regulation of translation, Co-and post-translational modifications of proteins

3. Genetic Imprinting:

3.1. Imprinting of genes, Epigenetic regulation by DNA methylation, Epigenetic control of gene expression.

4. Human genetics:

4.1. Pedigree analysis, lod score for linkage testing, genetic disorders.

5. Oncogenesis:

5.1. Transformation and Oncogenesis by Damaging the Chromosome, identifying a Nucleotide Change Causing Cancer.

5.2. Retroviruses and Cancer,

5.3. Tumor Suppressors-p53, Rb,

5.4. Programmed cell death, apoptotic and necrosis, proapoptotic and antiapoptotic proteins, ras-fos-jun Pathway.

5.5. Directions for Future Research in Molecular Biology.

Books Recommended

1. Alberts, B. et al. (2008). Molecular Biology of the Cell, 5th edition, Garland Science.
2. Brooker, R. J. (2017). Genetics: Analysis and Principles, 6th edition, McGraw-Hill.
3. Hartwell, L. et al. (2001). Genetics: From genes to Genomes, 4th edition, McGraw Hill Education.
4. Primrose, S.B. & Twyman, R.M. (2007). Principles of Gene Manipulation and Genomics, 7th edition, Blackwell Publishing.
5. Russel, P. J. (2016). iGenetics: A Molecular Approach, 3rd edition, Pearson.
6. Pierce, B. (2020). Genetics: A Conceptual Approach. 7th edition, W. H. Freeman.
7. Watson, J. D., Baker, T. A. & Bell, S. P. (2007). Molecular Biology of the Gene. 6th edition, Benjamin Cummings.
8. Snustad, D. P. & Simmons, M. J. (2006). Principles of Genetics, 4th edition, John Wiley and Sons.
9. Klug, W., Cummings, M., Spancer, C., Palladino, M. (2015). Concepts of Genetics. 11th Edition, Pearson.

Course Outcome: After finishing this course, students will have a solid understanding ofthe fundamental concepts underlying molecular genetics and cell biology. They will have a fundamental comprehension of the mechanism underlying genomic imprinting as well as oncogenesis. They will have the ability to comprehend pedigree analysis, lod score linkage tests, as well as genetic abnormalities.

SEMESTER – IV
Paper – MZOOMET403A
(Elective – Parasitology and Immunology)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: This elective is intended to provide students with the knowledge necessary to comprehend advanced topics in immunology & immune-parasitology, including treatments pertaining to immunity. The student will leave this class with an understanding of the theoretical framework behind the molecular mechanisms that control immune activity and immunological methods. In addition to this, they will understand tolerance, immunodeficiency and vaccination, immunology of transplantation, the immunology of tumors, immunomodulation, and immunopharmacology.

Unit-I
FM=25
Immunology and Immuno-parasitology

1. Concept of immunity and development of immune system in vertebrates:

1.1. Cells, tissues and molecules of the human immune system.

2. Molecular mechanism of Immune function:

2.1. Concept of lipid raft and local signaling. Signaling cascades during T and B cell maturation.

2.2. Generation of TCR and BCR diversity, class switch.

2.3. Signal transduction during BCR and TCR activation, & costimulatory pathways.

3. Overview of Inflammation:

3.1. Global regulator of inflammation: IL10, IL1 and Th17 subset. Cytokine storm, sepsis shock and inflammatory cascade.

4. Immunity and host defense:

4.1. Hypersensitivity reaction to helminth.

4.2. Mechanism of inflammation and inflammatory mediators from parasites.

4.3. Malaria and sickle cell anemia, co evolution of host defense

4.4. MHC and co-evolution of host immune system.

5. Immunotechniques:

5.1. Concept of flowcytometry and FACS, Si RNA and Sh RNA: Application in immunological research and therapeutics.

5.2. Concept of immunohistochemistry, population markers. ELISA.

Unit-II
FM=25
Immunity and Therapeutics

1. Tolerance and Autoimmunity

1.1. Peripheral and Central Tolerance of T and B cell, Clonal anergy.
1.2. Negative and positive regulation of immune system.
1.3. Molecular mechanism of autoimmunity.
1.4. Concept of autoimmunity: Type 1 diabetes, Multiple sclerosis, Arthritis.

2. Immunodeficiency and Vaccination:

2.1. Congenital Immunodeficiency, acquired Immunodeficiency.
2.2. Principles and Significance of Vaccine production, types of vaccines (subunit, killed, attenuated etc.), & future trend and target of vaccination.

3. Transplantation Immunology

3.1. Molecular basis of graft vs host reaction, acute, hyperacute and chronic graft rejection.
3.2. Modern techniques of transplantation (e.g., BMT, liver, cornea etc.).

4. Tumor Immunology

4.1. Immune surveillance theory, mechanism of Immune evasion by tumor, anti-tumor immune response.
4.2. Role of regulatory components of immune system in tumor establishment.
4.3. Targeted Immunotherapy of Cancer.

5. Immunomodulation and immunopharmacology

5.1. Mechanism of action of common immunosuppressant drugs.
5.2. Immuno-boosters, nutrition and immune system.
5.3. Mouse-human hybrid antibodies, anti-idiotype vaccines, antibody mediated drug delivery.

Suggested Readings:

1. Roberts, L. &Janovy, J. Jr. (2008). Foundations of Parasitology. 8th edition, McGraw-Hill Education.
2. Schmidt, G. D. & Roberts, L. S. (2001). Foundation of Parasitology, 3rd edition, McGraw-Hill Education.
3. Smyth, J. D. (1994). Animal Parasitology, 3rd edition, Cambridge University Press
4. Cheng, T. C. (1999). General Parasitology, 2nd edition, Academic Press, Inc.
5. Chatterjee, K. D. (2009). Parasitology: Protozoology, And Helminthology in Relation to Clinical Medicine, 13th edition, CBS Publishers And Distributors Pvt. Ltd., New Delhi
6. Mehlhorn, H. (2007). Parasitology in Focus (Encyclopedic Approach). 3rd edition, Springer-Verlag, Germany
7. Levine, N. D. (1985). Veterinary Parasitology. Iowa State University Press,
8. A. Mukhopadhyay, A. & De, A. K. (2002). Perspectives in Environmental Health: Vector and Water Borne Diseases, Section-I, ORIGINALS D.K. Publishers Distributors(P) Ltd, New Delhi-110002

9. Beaglehole, R., Bomita, R., &Kjelstorm, T. (1993). Basic Epidemiology. Orient Longman In Collaboration With WHO, Geneva.
10. Peters, W. & Killick-Kendrick, R. (1987). The Leishmaniasis In Biology and Medicine. Academic Press (Inc), Ltd.
11. Schmid-Hempel, P. (2011). Evolutionary Parasitology, Oxford University Press.
12. Palmer, S. R., Soulsby, L., & Simpson, D. I. M. (1998). Zoonoses, Oxford Medical Publication
13. Sherman, I. W. (1998). Malaria Parasite Biology, Pathogenesis and Protection. ASM Press, Washington, D.C.
14. Dawes, B. (1963). Advances in Parasitology, Vol-1-42. Academic Press.
15. Beaver, P. C., Jung, R. C., &Cupp, E. W. (1984). Faust's Clinical Parasitology 9th edition. Lea &Fabeiger, Philadelphia.
16. Soulsby, E. J. L. (1982). Helminths, Arthropods and Protozoa of Domesticated Animals. 7th edition.The English Longman Book Society and Bailliere tindall, London.
17. Krier, J. P. (1978). Parasitic Protozoa,2nd edition. Vol-1-12. Academic Press.
18. Garcia, L. S. (2010). Diagnostic Medical Parasitology, 5th edition. ASM Press.
19. Hyde, J. (1996). Molecular Parasitology, Open University Press.
20. Marr, J. &Mullar, M. (1995). Biochemistry & Molecular Biology of Parasites, Academic Press.
21. Brand, T. (1973) Biochemistry of Parasites. 2nd edition. Academic Press
22. Barret, J. (1981). Biochemistry of Parasitic Helminthes, Macmillan Publishers Ltd.
23. Kierszenbaum, F. (1994). Parasitic Infections and The Immune System, Academic Press.
24. Chakravarty, A. K. (2006). Immunology and Immunotechnology, Oxford University Press
25. Ingale, A. (2010). Basic Immunology, New Central Book Agency (P) Ltd. Kolkata - 700009
26. Kindt, T. J., Goldsby, R. A., & Osborne, B. A. (2007). Kuby's Immunology, 6th edition, W.H. Freeman.
27. Abbas, A. K. &Litchman, A. H. (2003). Cellular & Molecular Immunology, 5th edition, Saunders.

Course Outcome: After completion of this elective, student will understand the basicfundamentals of molecular mechanism behind immunity. They will have a vast knowledgeof many immunological techniques that include immunohistochemistry, ELISA, FACSetc. They will simply gain the basics of tolerance, autoimmunity, immunological diseaseand cancer immunology. They will also understand the basic idea of immunomodulationand immunopharmacology.

SEMESTER – IV
Paper – MZOOMET403- B
(Elective – Aquaculture and Fisheries)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: The purpose of this Fisheries & Aquaculture programme is to provideparticipants with the knowledge and technical abilities necessary to comprehend thedynamic nature of the current Fisheries & Aquaculture industry. Additionally, it is intendedto equip students with the knowledge necessary to comprehend the most recent tendenciesand challenges faced by farming societies in the field of Fisheries & Aquaculture and toinfuse in them the self-assurance necessary to work on various types of aquaculturepractices. The curriculum has been organized in such a way that the learners will becomefamiliar with both the fundamental and the applied parts of Fisheries and Aquaculturethanks to the program's structure.

Unit-I
FM=25
Fish genetics, Biotechnology, microbiology, fish processing and conservation

1. Sex determination in fish

2. Technique of stock improvement

2.1. Cryopreservation, cryoprotection and gamete banking
2.2. Production of Monosex and Sterile fish and their significance in aquaculture
2.3. Production of hybrids in captivity – techniques, inter specific and intergeneric hybrids, application of successful hybrids, limitations
2.4. Polyploidy in fish
2.5. Production of sex reversed fish – different techniques, identification of successful sex reversed fish, process of preparation of steroid hormone treated feed & application, sex reversion in *Tilapia.*
2.6. Production of transgenic fish – mechanism, example, advantages and limitation

3. Waste water recycling through aquaculture.

4. Fish intestinal microbiota, Pathogenic bacteria, Probiotics

Unit-II
FM=25
Fish processing, Marketing, and conservation

4. Processing, preservation & curing

4.1. Fish spoilage and methods of preservation
Spoilage (causes, changes in protein, amino acid and breakdown products)
Preservation (Drying, salting, smoking, freezing and canning, IQF etc.)
4.2. Fish by-products
4.3. Shrimp processing technology- processing, packaging, HACCP, ISI standard, problems & precautions.
5. Marketing: fish markets in India, strategy, structure, price formation.
6. Cooperative societies: principle, organization and function.

7. Conservation of fishery resources

7.1. Sustainability of Fisheries development.

7.2. Open water stocking & ranching programme.

8. Fisheries act and environment act.

9. Stock Assessment and Management:

9.1. Marking, Tagging and Population enumeration, Length-weight relationship, Age and growth, Fecundity estimation, Application of statistical methods in fisheries.

Books Recommended

1. Bal, D. V. & Rao, K. V. (1984). Marine Fisheries. Tata McGraw Hill Pub. C Ltd.
2. Bardach, J. E. &Ryther, J. H. (1972). Aquaculture. John Wiley and Sons.
3. Beaumont, A. R. & Hoare, K. (2003). Biotechnology & Genetics in Fisheries and Aquaculture. Blackwell Publishing.
4. Dodson (2005). Introduction to limnology, 2005, McGraw-Hill.
5. Chaudhuri H L (1990). Induced breeding of carps, ICAR.
6. Jhingran, V. G. (1991). Fish and Fisheries of India.3rd ed., Hindusthan Pub. Corp. John Wiley & Sons.
7. Kent, (1990). Reservoir limnology: ecological perspectives, 1990, John Wiley Sons.
8. Khanna, S. S. & Singh, H. R. (2003). A Text Book of Fish Biology & Fisheries. Narendra Publishing House. New Delhi.
9. Midlen& Redding, (1998). Environmental management for aquaculture, Springer.
10. Philip Kotler, Marketing management, Prentice Hall, India.
11. Pillay, T. V. R. (1993). Aquaculture. Fishing News Books.
12. Ruttner et al. (1974). Fundamentals of limnology, University of Toronto Press.
13. Srivastava, C. B. L. (2006). A Text Book of Fishery Science & Indian Fisheries. Kitab Mahal, Allahabad. Publishing House. New Delhi.
14. Tundisi, (2012). Limnology, Taylor & Francis.
15. Wetzel (1995), Limnology, Saunders.
16. Wetzel, (2001). Limnology: lake and river ecosystem, Academic Press
17. Dutta Munshi and Hughes: Air Breathing Fishes of India.

Course Outcome: After this curriculum is completed, students will have a good grasp of the numerous aquatic species that can be used to produce healthy food for human consumption in an environmentally friendly manner. Students will be able to pursue a variety of research and employment opportunities as a result of the programme. For better management of cultureponds and hatcheries, students would be well-versed in employing applicable tools and procedures, including those related to water quality; illnesses; nutrition and supplementary feeds; as well as fish processing, marketing, and distribution. Upon completion of this programme, students will be well-prepared to start their own aquaculture business or work in a variety of aquaculture-related fields such as farms, hatcheries, analytical labs, the feed industry, the fish processing industry, marketing, and so on They would be extremely successful because of their wide range of skills and deep expertise in the field.

Paper – MZOOMET 403C
(Elective-Genetics and Cell Biology Special)

Marks: 50 **No. of Class Hrs. 60**

Course Objective: The study of the cell as a case study is extremely helpful for elucidatingthe operational logic underlying living systems. Cells are the basic structural units of everyliving organism. The fundamentals of cell biology will be investigated throughout theduration of this class. We have high hopes that students will cultivate a profound intuitionthat will allow them to comprehend the operational logic of a cell. We will discuss cellulardisorders and the associated health implications in the human society as a means of drawingattention to the critical role that cell biology plays in our everyday lives.

Molecular cell biology and techniques

1. Membrane Structure and Dynamics:

1.1. Overview of membrane structure and its components.
1.2. Regulation of fluidity, Various modes of attachment of membrane proteins
1.3. Membrane Pumps- Diversity of Membrane Pumps.
1.4. Membrane Carriers-Diversity of Carrier Proteins, Carrier Physiology and Mechanisms- Uniporters, Antiporters, Symporters
1.5. Membrane Channels - Channel Diversity and activity, Channel Structure.
1.6. Vesicular transport-cis trans.

2. Organization of plant cell wall and vacuole.

3. Stress Physiology:

3.1. Response of animals to different stressors

4. Genetic control of Biological rhythm

5. Cytoskeleton and Cellular Motility:

5.1. Microtubules- structure and composition, microtubule-associated proteins, dynamic properties of microtubules.
5.2. Microfilaments and intermediary filaments- intermediate filament assembly and disassembly.
5.3. Movements along Microtubules, Movement of Cytoplasm Driven by Actin and Myosin

6. Extracellular matrix:

6.1. Basal membrane and laminin, Collagen, Proteoglycan, Fibronectin.
6.2. Interaction of cells with extracellular matrix: Integrins. Focal adhesion and hemidesmosomes.
6.3. Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins, Adherens Junctions and desmosomes. Tight junctions, Gap junctions andPlasmodesmata.

7. Cellular Movement:

7.1. Motility and Contractility- intracellular microtubule-based movement: kinesin and

dynein, microtubule-based motility: cilia and flagella, actin-based cell movement: the myosins, filament-based movement in muscle, actin-based motility in nonmuscle cells

8. Secondary metabolites:

8.1. Synthesis function and their role.

8.2. C3 C4 and CAM pathways.

9. Transposable elements in Prokaryote and eukaryote:

9.1. Transposable elements in bacteria, IS elements, composite transposons, replicative, non-replicative transposons.

9.2. Transposable Elements in Eukaryotes, SINES and LINES, retro-transposon. Evolutionary significance of Transposition.

10. Cell and Molecular Biology based Instrumentation:

10.1. Centrifugation, TEM, SEM, AAS, GC-MS, RIA, Radioactive tracer techniques, AFM, fluorescent microscopy, Electrophoresis & blotting, 2D Electrophoresis, HPLC, FPLC, NMR, ESR, Flow Cytometry, RT-PCR, FISH, GISH; DNA finger printing.

10.2. Automated karyotyping, Chromosome painting.

Books Recommended

1. Schleif, R. (1993) Genetics and Molecular Biology, The Johns Hopkins University Press Baltimore and London.
2. Brooker RJ. (2009) Genetic Analysis and Principles, 3rd Edition, McGraw-Hill, New York.
3. Pierce BA. (2012) Genetics a Conceptual approach, 4th Edition, Freeman and Co. New York.
4. Snustad DP, Simmons MJ. (2012) Principles of genetics, 6th Edition, John Wiley & Sons Inc.
5. Lewin B. (2006) Essential Genes, Published by Pearson Education, Inc.
6. Russell, P. J. (2010), i-Genetics: a molecular approach. 3rd Edition.
7. Pollard TD and Earnshaw WC. (2008) Cell Biology.
8. Lodish, Bark, Keiser et al. Molecular Cell Biology. 7th Edition.
9. Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. (2014) Essential Cell Biology, 4th Edition. Garland Science
10. Reilly, M. J. (2018). Bioinstrumentation, CBS Publishers.
11. Srivastava S. (2010). Molecular Techniques in Biochemistry and Biotechnology, 1stedition, New Central Book Agency
12. Bajpai, P. K. (2010). Biological Instrumentation and Methodology, S Chand.
13. Sharma, R. K. & Sangha, S. P. S. (2013). Basic Techniques in Biochemistry and Molecular Biology, I K International Publishing House Pvt. Ltd.

Course Outcome: Students will be able to explain the structural characteristics of the structure, properties, and functions of membrane and membrane proteins in cells, and the intricate relationship between various cellular organelles and their corresponding functions after completing the course. They will also be able to explain the structure and function ofthe ECM and explain membrane physiology, including transport mechanisms, membrane potentials, and action potentials, and explain how specific components of the cytoplasmic cytoskeleton are structured and function. They will examine the mechanisms underlying cellular movements and transposable element. Finally, they will gain the knowledge behind instrumentation and techniques behind cellular and molecular biology.

SEMESTER – IV
Paper – MZOOACT 404
Health, Hygiene, Sanitization

Marks: 50

Course Objective: The students will get an understanding of fundamental concepts related to health, hygiene, and sanitation through this course. The course begins with an overview of the classification of microorganisms, and then moves on to discuss the diseases that are caused by each individual agent. In addition to this, it discusses the essential understanding that is behind the management and elimination of germs. Because it is important to have a fundamental understanding of themes such as community health and lifestyles, environmental hygiene, nutrition, and mental health, the final section of this course is devoted to these areas of study.

1. Microbiology and Parasitology:

1.1 Classification and Characteristics of microorganisms

1.2. Common diseases, causing microorganisms and their characteristics – AIDS, Leprosy, Malaria, Filaria

1.3. Activities of microorganisms in relation to the environment and the human body, Immunity

1.4. Basic principle of control and destruction of microorganisms

i) Vaccination, Sterilization, Disinfection

ii) Chemotherapy and antibiotics

iii) Control of spread of infection

iv) Pasteurization

v) Bio safety and waste management

2. Community Health and life style diseases:

2.1. Definition of Health, Health assessment - Characteristics of healthy individual

2.2. Definition and aims of epidemiology

2.3. Disease cycle

2.4. Disinfection

2.5. Life style diseases such as Obesity, Diabetes, Cardiac diseases, Cancer

3. Environmental Hygiene:

3.1. Components of environment

3.2. Importance of environmental health

3.3. Water – i) Potable and non-potable ii) Water pollution iii) Water borne diseases iv) Water purification

3.4. Air- Air pollution, prevention and control of air pollution

3.5. Waste- Health hazards, Waste treatment

3.6. Noise-Source, effect and control

3.7. Arthropod and Rodents of Public health importance: Mosquitoes, housefly, sandfly, rodents, Control measures

4. Nutrition:

4.1. Classification of food

4.2. Common foods in health and diseases

4.3. Adulteration of Food

5. Mental Health:

5.1. Substance and Abuse

5.2. Depressive orders

5.3. Alzheimer's, Parkinson's, Autism.

Books Recommended

1. Sumbali, G. & Mehrotra, R. S. (2009). Principles of microbiology, 1st edition, McGraw-Hill Education.
2. Sharma, P. D. (2010). Microbiology, 1st edition, Rastogi Publications.

Course Outcome: When students have successfully completed this course, they will have a comprehensive understanding of health, hygiene, and sanitation. They will be familiar with the fundamental factors that contribute to some of the most lethal diseases, the organism that is accountable for it, as well as the treatment and prevention strategies. In addition to this, they will get a comprehensive awareness of the behaviours that contribute to community health, as well as environmental hygiene, nutrition, and mental health.

SEMESTER – IV
Paper –MZOOMES405-A
(Elective – Practical –Parasitology and immunology)

50 Marks

Course Objective: This hands-on class will teach students how to identify a wide range of parasite species so that they can have a better understanding of the world around them. In addition to this, it incorporates a number of strategies and procedures that are typical in the fields of experimental parasitology and immunology. The biostatistics component of the course is intended to provide the student with an understanding of the fundamental statistical principles that underpin fundamental biological phenomena.

1. Identification of the prepared slides:
   Trypanosoma, Leishmania sp, (Promastigote and amastigote), *Opalina*sp.,
   Nyctotherus, Sicuophora, Balantidium,
   Stomatophora, Monocystis, Giardia,
   Entamoeba histolytica, Gregarina, Eimeria,
   Haemoproteus, Plasmodium (vivax &falciparum species*), Conchophthirus,*
   Myxobolus, Taenia solium, Taenia saginata,
   *Raillietina*sp., (mature proglottid and scolex), *Echinococcus, Fasciola,*
   Isoparorchis, Paramphistomum, Ascaris male and female,
   Argulus, Pediculus, Phthirus,
   Cimax, Xenopsylla, Ctenocephalids,
   Boophilus, Phlebotomus, mosquitoes (adult male & female, mouth parts of *Anopheles, Culex,* and *Aedes*)

2. Cell counting and cell viability

3. Mononuclear leukocyte separation

4. Preparation of serum and Isolation of Spleen, Thymus and Bone marrow cells

5. Peritoneal Lavage / Macrophage Activity

6. Primary culture of PBMC

7. Immunodiffusion (Radial and/or Ochterlony), ELISA, SDS PAGE AND Western Blot

8. Primer design for reverse transcriptase and normal PCR.

9. RT-PCR, qRT-PCR.

10. Histological preparation: spleen, thymus, and bursa of Fabricious and them identification and drawing in the laboratory note book and submission of prepared slides

11. Preparation of media, maintenance of Leishmania sp. in *in vitro* culture and preparation of growth curve.

12. Post-mortem examination, fixation, preservation, staining and preparation of permanent slides of available protozoans, helminths, insects and ticks of medical importance and submission of at least 12 prepared slides during examination for evaluation.

13. Visit to the slaughter house and poultry farm, collection of specimens and submission of collections and reports.

Biostatistics (Common for any elective) (Marks=30)

1. Statistical Analysis:

a. t test
b. Chi-square test
c. Population analysis

2. Internal assessment (Field study, Laboratory Note Book and class records). 10

3. Viva-voce examination, submission of prepared slides, field note book and practical records. 10

Course Outcome: When students have successfully completed this course, they will have a solid foundation in the fields of experimental parasitology, immunology, and biostatistics.

Paper – MZOOMES405-B
(Elective – Practical – Aquaculture and Fisheries)

Marks 50

Laboratory Work Full Marks: 25

Course Objective: The students will be provided with up-to-date information on fisheriesand aquaculture practices through participation in this practical elective course. In order forthe students to have a solid foundation in their advanced knowledge, they will investigate a variety of hands-on methodologies, statistical analysis, and field research pertaining to these two fields.

1. Analysis of important water & soil parameters.
2. Histological studies of different fish tissues and their identification.
3. Dissection of different organ systems (digestive system, urinogenital system, accessory respiratory organs).
4. Techniques of induced breeding (Collection of pituitary gland, preparation of extraction And administration)
5. Estimation of maturity and fecundity of fish specimens.
6. Estimation of relative gut length, hepato-somatic index and interpretations
7. Zooplankton sampling: methods of collection, preservation, identification and interpretations
8. Benthos of diverse biotopes
9. Identification of fresh water and brackish water fish fauna.
10. Identification of aquatic weeds, predatory fishes and aquatic insects
11. Fish Physiology Experiment-Digestive enzymes, biochemical composition of fish.
12. Microbiology: a)Preparation of liquid media (broth) and solid media for routine cultivation of bacteria, Preparation of slant and stab.
    b) Pure culture techniques: Spread plate, pour plate and streak plate.
    c) Biochemical tests for characterization: Catalase, Nitrate reduction, Indole production, Methyl red and Voges–Proskauer test.
13. Statistics of aquaculture data
14. Field study and submission of field report **10**
15. Internal Assessment (Field study, Laboratory Note Book and class records). **10**
16. Viva-voce. **5**

Course Outcome: Student will have a strong practical knowledge in the field of fishery and aquaculture.

MZOOMES 405C
Practical (Major Elective)
(Elective – Practical – Genetics and Cell Biology)

50 Marks

Course Objective: This elective practical course is designed to impart knowledge of laboratory techniques and methods in relation to genetics and cell biology. Student will also explore histological techniques of various tissue preparation of mice/rats. Lastly, institutional visit will provide the environment of research within students. The biostatistics component of the course is intended to provide the student with an understanding of the fundamental statistical principles that underpin fundamental biological phenomena.

1. Handling of Drosophila, Culture techniques, Handling techniques, Study of mutant phenotypes of Drosophila and genetic crosses.
2. Preparation and study of polytene chromosomes
3. Preparation and study of metaphase chromosomes: mitotic and meiotic from mice/rats
4. Chromosome banding (C, G, NOR banding).
5. Preparation of human/mice karyotype and study of chromosomal aberrations
6. Isolations of genomic DNA from bacteria/mouse/rat liver.
7. Measurement of absorption-spectrum of DNA, RNA, and nucleotides.
8. Separation of amino acids by paper chromatography and TLC
9. Separation of proteins and DNA – SDS PAGE and Agarose and western blot
10. Study of mitotic indices, micronuclei, and sperm head abnormality in mice/rat/fish
11. Quantitative estimation of Acid/Alkaline phosphatase/GGT/creatinine/cholesterol/ SOD/catalase/GPX/GST/GSH/cAMP
12. Histological sections of tissues from mice/rats (liver/kidney/spleen/testis/ovary), and comparison between treated and untreated sets.
13. Demonstration of RT-PCR and qRT-PCR/GC-MS
14. Visit to any Institute

Course Outcome: Students after completion of this this course will possess a breadth of knowledge, they will have gained a wealth of knowledge in the procedures that are utilized in genetics and cell biology. Students will develop an interest in research as a result of their visit to the institution, and they will choose to participate in research in order to advance their academic career.

Biostatistics (Common for any elective) Marks=30

1. Statistical Analysis:
   a. t test,
   b. Chi-square test,
   c. Population analysis

16. Internal assessment (Field study, Laboratory Note Book and class records). 10

17. Viva-voce examination, submission of prepared slides, field note book and practical records. 10

SEMESTER – IV
Paper – MZOOME6 405A

Project Objective: When it comes to developing research skills, projects serve essentially as the foundational building blocks for any student. As a result of the work on the project, the students will be able to conduct high-quality research, design research experiments, write procedures, and give speeches in front of academic audiences. Project work will also amplify

the critical thinking skills among students, promoting them to a stage where they will be able to cope with good scientific problems. This program is primarily intended to fulfil the aforesaid goals and objectives.

405AProject of Parasitology and immunology.

Marks 50

1. Contents 10
2. Methodology, experiment design and results 15
3. Presentation 15
4. Interaction 10

Paper- MZOOMES406-B
Project of Fisheries and Aquaculture

Marks 50

1. Content 10
2. Methodology, experiment design and results 15
3. Presentation 15
4. Interaction 10

Paper – MZOOMEP-406C
Genetics and Cell Biology

Marks: 50

1. Content 10
2. Methodology, experiment design and results 15
3. Presentation 15

4. Interaction 10

Project Outcome: After finishing the course, students will have the option to further their academic careers and will have developed a solid foundation for conducting research within oneself**.**