DEPARTMENT OF ANIMAL SCIENCE

SCHOOL OF LIFE SCIENCES

BHARATHIDASAN UNIVERSITY

TIRUCHIRAPPALLI - 620 024

M.Sc., Zoology (Program Code: 2PSZOO)

Course Structure (CBCS)

From Academic year 2022-2023 onwards

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI

DEPARTMENT OF ANIMAL SCIENCE

M. Sc. Zoology Curriculum

(For the students admitted during the academic year 2022 - 23 onwards)

Program's General Objective

The Master of Zoology program curriculum is designed to enable them to deepen their knowledge of fundamental concepts and development in modern biology. There are no limits to their choice of learning, they can expand their knowledge in their favorite subject from online courses (MOOC, SWAYAM, NPTEL) through credit transfer system. This program train students in teaching and research projects and preparing them for a career in biology related fields, advancement from graduate students, teaching, public and private services. In addition, one full semester for dissertation-based program allows everyone to gain the desired experience, either at our department laboratories, which are fully- equipped for contemporary applications in modern biology, or in other academic, industries and governmental laboratories. After completing the program, they will have a specific competence profile and be able to analyze complex concepts in their field of study, as well as plan and carry out experiments. Finally, this program provides a solid foundation to respond to the challenges of the 21st century in the biological sciences.

Program Outcome (PO)

The M.Sc., Zoology program provides all essential components to the transformative learning that prepares our graduates to become alumni who make a significant contribution to the society. The courses build students' abilities to think critically, solve problems, generate new ideas and create knowledge and to make connections between academic disciplines. This program supports the broader University vision of national/ international recognition via interdisciplinary, extramurally-funded research and publications.

PO1	M.Sc., Zoology program is designed to develop comprehensive and deep knowledge of the field(s), in which the "one semester" thesis research is embedded.
PO2	The challenging, student-centered curriculum is research - based and technology - oriented and provides a foundation for life - long learning.
PO3	The program caters to students' interest in different domains of biology – from classical to modern, including varied specializations (Behavioural Neuroscience, Aquaculture Technology, Nano-biotechnology, Cancer Biology, Reproductive Technology and Stem Cells in Neuronal Disorders).
PO4	Training in specialized domain of biology is intended to prepare students to become qualified graduates to address biology-related issues at national and international levels.

PO5	Biology being evidence-based, the program is grounded with an equal number of laboratory courses in the formal practices of observation, experimentation, testing hypotheses and interpretation.
PO6	Biology relies on applications of quantitative analysis and mathematical reasoning; therefore, the curriculum is designed to train the students to apply descriptive and inferential statistical methods, design and analyse diverse data set and understand the underlying probability in the calculations.
PO7	The program provides training to the students to develop their knowledge and skills to communicate appropriate scientific content, formatting and presentation of data through scientific seminars.
PO8	The program trains the students to understand the relationship between science and society, which enhances their vision to apply their knowledge in health systems, economic growth and sustainable environment.
PO9	The 8-credit research-oriented course engages in rigorous and original research that advances knowledge in their chosen field of study within the discipline.
PO10	Upon successful completion of the M.Sc., Zoology program with grade 9.0 and above (CGPA), the students shall be able to summarize the major, central tenets in their disciplines; this will provide ample chances for them to qualify for national eligibility tests and professional development gained will lead them to be successful in their careers in academia / industry.

Program Specific Outcome (PSO)

PSO1	**Knowledge expansion:** Learn in-depth complex biological concepts at the cellular and molecular level, demonstrate their ability to explain and apply their knowledge.
PSO2	**Developing specialization:** Consistent in learning by earning extra credits in specialized courses within the field of biological sciences
PSO3	**Skill development:** All core courses with laboratory components will provide exposure to a wide range of research techniques, therein enhancing their understanding of the application of techniques.
PSO4	**Scientific information and technology:** Skill oriented courses will provide details on principles, conduct of proper calibration and use of scientific instrumentation and appropriate use of scientific techniques in experimental design
PSO5	**Application of knowledge:** Preparation of field reports helps them to present their results and discussion in a written format that is typically required for their future professions.
PSO6	**Critical thinking:** Field and academic visits will help students to develop observation skills, grasping ability, collect and interpret data and propose models that will help them to understand hypotheses and conclusions.
PSO7	**Communication:** Mandatory seminars will help them to develop oral communication skills from formal subject-based presentations and informal scientific discourse.
PSO8	**Numeracy:** Students will develop the ability to reason, apply numerical concepts, and equations in their fields of study for interpreting scientific data and drawing relevant scientific conclusions.
PSO9	**Development of competency:** Through the interactions, students will develop skills of critical reading of texts, identifying gaps in knowledge, formulating scientific questions, and on will recognizing the synthesis of new ideas.
PSO10	**Professional and Career Development:** Students undertaking a research thesis will have the opportunity to design, develop and execute their own research ideas in their experiments, thus expanding their knowledge of research methods and laboratory skills.

BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI - 620 024
DEPARTMENT OF ANIMAL SCIENCE
M.Sc., ZOOLOGY (Program Code: 2PSZOO)
Course Structure (CBCS)

From Academic year 2022-2023 onwards

Core	Course Code	Title of the Course	Credits	Hours / week		Maximum Marks		
				Theory	Practical	CIA	ESE	Total
SEMESTER - I								
(Any four core courses from I – V)								
Core I	22ZOOC11	Structure and Function of Invertebrates	4	4	-	25	75	100
Core II	22ZOOC12	Cell Biology	4	4	-	25	75	100
Core III	22ZOOC13	Biomolecules and Structural Biology	4	4	-	25	75	100
Core IV	22ZOOC14	Genetics and Evolution	4	4	-	25	75	100
Core V	22ZOOC15*	Wildlife and Conservation Biology	4	4	-	25	75	100
Core VI	22ZOOC16	Laboratory Course - I (Structure and Function of Invertebrates)	3	-	3	40	60	100
Core VII	22ZOOC17	Laboratory Course - II (Cell Biology)	3	-	3	40	60	100
Core VIII	22ZOOC18	Laboratory Course - III (Biomolecules and Structural Biology)	3	-	3	40	60	100
		Library, Colloquium, Seminar	-	2+2+1	-	-	-	-
		TOTAL	**25**	**21**	**9**			**700**
SEMESTER - II								
(Any four core courses from IX - XIII)								
Core IX	22ZOOC21	Comparative Anatomy of Vertebrates	4	4	-	25	75	100
Core X	22ZOOC22	Developmental Biology	4	4	-	25	75	100
Core XI	22ZOOC23	Molecular Biology	4	4	-	25	75	100
Core XII	22ZOOC24	Environmental Biology	4	4	-	25	75	100
Core XIII	22ZOOC25*	Ecotoxicology	4	4	-	25	75	100
Core XIV	22ZOOC26	Laboratory Course - IV (Comparative Anatomy of Vertebrates)	3	-	3	40	60	100
Core XV	22ZOOC27	Laboratory Course - V (Developmental Biology)	3	-	3	40	60	100
Core XVI	22ZOOC28	Laboratory Course - VI (Molecular Biology)	3	-	3	40	60	100
Core XVII	22ZOOC29	Laboratory Course - VII (Environmental Biology)	3	-	3	40	60	100
(Any one from the following)								
Major Elective - I	22ZOOME21/ 22ZOOME22/ 22ZOOME23	Aquaculture and Fisheries / Reproductive Technology / Animal Behaviour	2	3	-	25	75	100
Non-Major Elective - I	22ZOONME21/ 22ZOONME22	Sericulture Technology / Animals on Commercial Interest	2	3	-	25	75	100
		Library, Colloquium, Seminar	-	1+1+1	-	-	-	-
		TOTAL	**32**	**25**	**12**			**1000**

SEMESTER - III								
(Any three core courses from XVIII – XXI)								
Core XVIII	22ZOOC31	General Microbiology	4	4	-	25	75	100
Core XIX	22ZOOC32	Biology of Immune system	4	4	-	25	75	100
Core XX	22ZOOC33	Animal Physiology	4	4	-	25	75	100
Core XXI	22ZOOC34*	Neurophysiology	4	4	-	25	75	100
Core XXII	22ZOOC35	Laboratory Course -VIII (General Microbiology)	3	-	3	40	60	100
Core XXIII	22ZOOC36	Laboratory Course - IX (Biology of Immune system)	3	-	3	40	60	100
Core XXIV	22ZOOC37	Laboratory Course - X (Animal Physiology)	3	-	3	40	60	100
(Any one from the following)								
Major Elective II	22ZOOME31/ 22ZOOME32/ 22ZOOME33	Genomics and Proteomics / Cancer Biology / Research Methods	2	3	-	25	75	100
(Any one from the following)								
Non-Major Elective II	22ZOONME31/ 22ZOONME32/ 22ZOONME33	Techniques and Tools for Biology / Integrated Farming Management / Molecular Evolution	2	3	-	25	75	100
		Library, Colloquium, Seminar	-	1+2+1	-	-	-	-
		TOTAL	25	**22**	**9**	**9**		**800**
SEMESTER - IV								
PW	22ZOOPW41	Project Work	8	30	-	50	150	200
		TOTAL	**8**	**30**	**-**	**-**	**-**	**200**
GRAND TOTAL			**90**	**128**				**2600**

Extra Credit Courses:

Course Code	Title of the Course	Credits	Hours / week		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
SEMESTER - I							
22ZOOVC19**	Bioinstrumentation	2	3	-	25	75	100
SEMESTER - II							
22ZOOVC23**	Medical Parasitology (or)	2	3	-	25	75	100
	Swayam/MOOC/NPTEL	-	-	-	-	-	-
	Field Project / Internship#						
SEMESTER - III							
22ZOOVC33**	Biostatistics	2	3	-	25	75	100
	Field Project / Internship##						

*** Optional Core Courses**

**** Value added courses not included for Credit Calculations**

 # Field Project/Internship - To undergo during the semester holidays (End of the semester - II)

Field Project/Internship - To undergo during the semester holidays (End of the semester - III)

*** SWAYAM – MOOC – Online course should be for the duration of at least 4 weeks with minimum of 2 credits. The course is mandatory and should be completed within the third semester (i.e., before the start of the fourth semester).**

Program Summary

Core Credit Courses			Extra Credit Courses	
Total Courses	Total Credits	Total Marks	Total Courses	Total Credits
25	**90**	**2600**	**3**	**6**

For final grading and ranking, only the core credit courses will be accounted. However, for the award of the degree, completion of all the extra-credit courses is mandatory

SEMESTER - I

CORE I: STRUCTURE AND FUNCTION OF INVERTEBRATES

Course Code	22ZOOC11	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Fundamental knowledge in invertebrates								

Course Objectives:

- Analyze the salient features of invertebrate body organization
- Integrate the major and minor phyla in relation to metamerism
- Summarize concepts and principles of organization linking with coelom
- Comparative analysis of digestive system from lower to higher metazoans
- Compare the osmoionic regulation in invertebrate species
- Justify the evolutionary significance of function of excretory organs
- Emphasize the significance of larval development and ecological association of invertebrates

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the significance of invertebrate taxonomy in evolutionary basis	K1, K2
CO2	Integrate typical organism and its physiological adaptations with their habitat	K4, K5
CO3	Understand the evolutionary development of nervous system with their physiological function	K2
CO4	Analyze the significance of osmotic regulation with their habitats	K5
CO5	Develop a correlation between life cycle and social life	K3, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Organization and Locomotion** **8 Lectures**	Homology and analogy in organization - eucellular plan of structure. Movement and fibrils - flagellar and ciliary movement - amoeboid movement in protozoa. Movement and hydrostatics - principle of hydrostatic skeleton - coelenterate organization and its hydrostatic skeleton - limitations to sponges. Triploblastic structure in Platyhelminthes and Nematoda. Coelomic hydrostatic skeleton - significance of coelom - hydrostatic movement in Sipuncula - Entoprocta- Ectoprocta - Annelida-Mollusca - class Gastropoda and Cephalopoda - Echinodermata.

Unit II **Nervous system Movement and Metamerism** **7 Lectures**	Primitive nervous system - nerve nets in Coelenterates - Echinoderms and Hemichordates. Advanced nervous system - metameric nervous system and locomotion in annelids- Cephalopods. Metamerism - significance - locomotion in Oligochaetes - Polychaetes and leeches. Movement and arthropodization - skeleton of Arthropods - tagmata and head. Locomotion and Crustacean limb- terrestrial Arthropods and flight in insects.
Unit III **Nutrition and Digestion** **7 Lectures**	Feeding and digestion in Protozoa. Nutrition - food resources - microphagy and macrophagy in lower Metazoa. Filter feeding and digestion in sponges - Coelenterates - intracellular and extracellular digestion Platyhelminthes and Nemertinea - Polychaeta - Mollusca - Deuterostomia and Crustacea.
Unit IV **Respiration, Excretion, Osmotic and ionic regulation** **8 Lectures**	Physical structure - respiratory pigments - gills and lophophores - gills and trachea in arthropods. Excretion of nitrogen - excretory organs - coelom – coelomo-ducts - nephridia and Malpighian tubules - excretion of nitrogen. Osmotic and ionic regulation - marine invertebrates - protozoa and freshwater life - Metazoa and freshwater life - water to dry land.
Unit V **Reproduction, Life cycle, Larval forms and Ecological association** **10 Lectures**	Patterns of reproduction - protozoan life cycle - asexual reproduction and Polychaete life cycle. Embryology and phylogeny - origin and development of Metazoan. Protostomia and Deuterostomia. Modes of larval development - Protostome larvae - Crustacean larvae - Deuterostome larvae and origin of Vertebrates. Insect larvae. Colonial and social life – protozoan colonies - sponge - Coelenterate and Ectoproctan colonies. Asexual reproduction and colonial life in Urochordates - social life in insects. Interspecific associations - types of association - mutualism and nutrition - symbiotic algae - corals and symbiosis - host-parasite relationships.
Current Contour	Faunal diversity of Invertebrates - Identification of Invertebrates in the natural environment. Faunal diversity of India and States - ZSI (Zoological Survey of India) - Red Data Book. Status survey of threatened and endemic species. Fauna conservation areas of states and India.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	S	M	S	L	S
CO2	S	M	M	S	S	S	S	M	M	M
CO3	M	S	M	M	S	S	M	S	L	S
CO4	M	S	S	L	M	M	M	S	S	S
CO5	S	M	M	L	M	S	M	S	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Barrington EJW. 2021. Invertebrate Structure and Function (II Ed.). Affiliated East-West Press Pvt Ltd.
2. Kapoor VC. 2019. Theory and Practice of Animal Taxonomy and Biodiversity. (VIII Ed.). Oxford and IBH Publishing.
3. Tripathi RC. 2005. Biosystematics and Taxonomy. University Book House, Jaipur.
4. Simpson GG. 1961. Principle of Animal Taxonomy. Oxford and IBH Publ.
5. Cleveland H Jr, Lary R, Susan K, Allan L and David E. 2011. Animal Diversity. McGraw-Hill Company, Inc. New York.
6. Margulis L and Capman MJ. 2010. Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth. (IV Ed.). W.H. Freeman and Company, USA.
7. Mayr E. 1969. Principles of Systematic Zoology. McGraw-Hill Company, Inc. New York.
8. David E, Allan L, Susan K, Larry R and Cleveland H Jr. 2009, Animal Diversity. (V Ed.). Boston: McGraw-Hill Company, Inc. New York.
9. Barnes RD. 1982, Invertebrate Zoology. (IV Ed.). Holt Saunders International Edition.
10. Waterman AJ. 1971. Chordate Structure and Function. The Macmillan Company.
11. Hyman GH. The Invertebrates. 1940-1967. (Vol. I to VII). McGraw-Hill Company, Inc. New York.

Related Online Contents:

1. http://www.iaszoology.com/
2. https://royalsocietypublishing.org/doi/10.1098/rspb.2013.2683
3. http://faunaofindia.nic.in/
4. https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species
5. https://wii.gov.in/nwdc_aboutus

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SEMESTER - I

CORE II: CELL BIOLOGY

Course Code	22ZOOC12	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Knowledge about cellular organelles and functions								

Course Objectives:

- List the cellular components in prokaryotic and eukaryotic cells
- Summarize inter- and intra-cellular transport mechanisms
- Analyze and compare the different types of cell division and mechanisms
- Connect molecular signaling in responses to physiological changes
- Generalize signaling pathways in cellular communications
- Explain cellular response to pathogens and its interactive mechanisms
- Understand the symptoms of infection and host response

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the membrane transport and complexity of cell specialization.	K1, K2
CO2	Analyze the nature of polymers and their integrity in cell structure and importance of cellular lipid recycling.	K4, K5
CO3	Describe the mechanism of external signals amplified within the cells and integration of cell to cell communications.	K2, K7
CO4	Relate the role of kinetochore formation and cell cycle mechanism and its influencing factors.	K4, K7
CO5	Explain the significance of host-pathogen interactions.	K4
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I **Cell membrane structure and function** **6 Lectures**	Basic properties of cell - chemical composition - structure and function of cellular membrane. Dynamic nature of plasma membrane - diffusion active / passive transport and ion channels. Cell junctions - cell to cell adhesion - extracellular matrix and integrins.
Unit II	Structure and function of cytoskeleton - microfilaments - motor

Cell compartments and Organelles **8 Lectures**	proteins - actin filament and myosin - intermediate filament - microtubules - cilia and flagella. Endoplasmic reticulum - ribosomes – centriole - Golgi complex - lysosomes - peroxisomes and microsomes - vacuoles - mitochondria - nucleus - nucleosomes and chromosomes.
Unit III **Cell division and Growth** **12 Lectures**	Cell cycle - types of cell division - mitosis and meiosis. Control and regulation of cell cycle - cell volume - size - internal / external checkpoints in G1 - G2 - S and M. Positive regulators - cyclin A - B - D and E - Cdks and cyclin-Cdk complex. Negative regulators - Rb protein - E2 Factors - p53 - and p21. Extracellular control system - survival factors and growth factors. Programmed cell death - apoptosis - aging and its theories.
Unit IV **Cell communication and Signaling** **10 Lectures**	General principles of cell communication - membrane receptors - cytosolic receptors and nuclear receptors. Extracellular messengers and their receptors - structure and mechanism of G protein linked cell surface receptors (GPCR) - Cytokine - tyrosine kinases - (TGF)-β receptors - Hedgehog - Wnt and Notch. Enzyme linked cell surface receptors - cyclic AMP dependent protein kinase - Inisitol phosphates - Ca^{2+}/ CaMKII - proteolysis.
Unit V **Cell biology of infection** **4 Lectures**	Introduction to cell pathogen - interactions - protective barriers - membrane fusion - pore formation and disruption. Signs and symptoms of infection - host response - mechanism of bacteria or virus invasion into cell - exploitation of host cell mechanism - colonization and preventive mechanism of host cells.
Current Contour	Recent developments in cellular function through research articles referred from PubMed.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	M	S	M	S	S
CO2	M	S	M	S	L	M	M	S	L	M
CO3	S	S	M	M	S	L	L	M	S	S
CO4	M	L	S	M	M	S	M	S	M	S
CO5	S	M	M	M	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Lodish H, Berk A, Chris AK, Kreiger M, Bretscher A, Ploegh H, Amon A and Kelsey CM. 2021. Molecular Cell Biology (IX Ed.). WH. Freeman and Company, New York.
2. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Richard L. 2014. Molecular Biology of the Gene (VII Ed.). Pearson Education Inc.
3. Bruce A, Alexander J, Julian L, Martin R, Keith R and Peter W. 2016. Molecular Biology of the Cell (VI Ed.). Garland Science Publ.
4. Alberts B, Hopkin K Johnson A, Morgan D, Raff M, Roberts K and Walter P. 2019. Essential Cell Biology. WW Norton & Co.
5. Gerald K, Janet I and Wallace M. 2019. Cell and Molecular Biology (IX Ed.). Wiley Press.
6. Jocelyn EK, Elliot SG and Stephen TK. 2017. Lewin's Genes XII. Jones and Bartlett Publ.
7. Geoffrey MC and Robert EH. 2015. The Cell: A Molecular Approach, (VII Ed.). Sinauer Associates Inc.
8. George MM. 2008. Friefelder's Essentials of Molecular Biology. (IV Ed.). Jones and Bartlett Publ.
9. Stella P and Michael K. 2013. The Molecular Biology of Cancer: A bridge from bench to bedside. (II Ed.). Blackwell Publ.
10. Arunima M. 2009. Cell Biology: Fundamentals and Applications. Oxford Book Company.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC520841/
2. http://www.wiley.com/college/pratt/0471393878/student/animations/signal transduction
3. https://pubmed.ncbi.nlm.nih.gov/32943426/
4. https://www.ncbi.nlm.nih.gov/books/NBK26869/
5. https://www.nature.com/subjects/cell-biology

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SEMESTER - I

CORE III: BIOMOLECULES AND STRUCTURAL BIOLOGY

Course Code	22ZOOC13	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Knowledge in biomolecules and its role in biochemical pathways								

Course Objectives:

- Understand the basic concepts of biomolecules and its biochemical interactions
- Integrate the structural and functional significance of carbohydrates and its polymers
- Categorize and relate the molecular relationships of lipids, nucleic acids and vitamins
- Interpret the structure and interaction of proteins and its composition
- Discuss the catalytic action of enzymes and its regulatory pathways
- Practice and apply on equations / plots related to enzyme kinetics
- Know the concept of biomolecular interactions in the living system

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Acquire the basic knowledge regarding the maintenance and perpetuation of living systems	K6
CO2	Understand the bonding, stability and interactions of molecules	K1, K2
CO3	Able to relate the biochemical pathways in association with physiological changes	K4
CO4	Develop some perspective ideas on the complexity of biomolecules and describe the underlying theories on enzymatic mechanisms in the living system	K6
CO5	Learn the available tools and implementing in biochemical applications	K2, K3

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Fundamentals of biomolecules** **7 Lectures**	Introduction - origin and scope of biochemistry - molecular basis of life - structure - properties - importance of water - acids - bases - pH and buffers. Properties of covalent - non-covalent - hydrogen bonds and their importance in biological systems. Types of biochemical reactions - oxidation - reduction - condensation - hydrophilic - hydrophobic - nucleophilic and electrophilic substitution reaction.
Unit II	Classification - structure and function of monosaccharides - glucose - fructose - mannose and galactose. Disaccharides -

Carbohydrates **8 Lectures**	sucrose - lactose and maltose - trisaccharides and polysaccharides - starch - glycogen - cellulose - chitin and peptidoglycan. Structure and conformation of sugars – stereoisomerism - optical isomerism - bacterial cell wall polysaccharides - O- linked and N- linked oligosaccharides.
Unit III **Lipids, Nucleic acids and Vitamins** **10 Lectures**	Classification and types of lipids - structure - properties and biological functions of fatty acids - esters of fatty acids - cholesterol - phospholipids - glycolipids - sphingolipids - lipoproteins - High Density Lipoprotein (HDL) - Low Density Lipoprotein (LDL) - Very Low-Density Lipoprotein (VLDL) - steroids and bile acids. Structure of nucleic acids - duplex stability - hybridization - structure of nitrogenous bases - nucleosides and nucleotides. Structure and classification of vitamins - water soluble and fat-soluble vitamins.
Unit IV **Amino acids and Proteins** **6 Lectures**	Structure and classification of amino acids - essential and non-essential amino acids. Orders of protein structure - primary structure and its importance - secondary structure - α-helix - β-pleated sheet and super secondary structure - tertiary structure - unfolding/refolding - quaternary structure - haemoglobin.
Unit V **Enzyme kinetics** **9 Lectures**	Structure and classification of enzymes - general principles of catalysis - quantification of enzyme activity and efficiency. Enzyme action - mechanism of enzyme catalysis - Michaelis Menten equation - Lineweaver–Burk plot and Hanes-Woolf plot. Inhibition kinetics – competitive - uncompetitive and non-competitive - allosteric - cooperative - cumulative and feedback inhibition - concept of catalytic antibodies - catalytic strategies - proteases - carbonic anhydrases - regulatory strategies - isozymes.
Current Contour	Advanced studies to identify the structure and functions of DNA - RNA and protein by using biophysical techniques. Research articles on disease mechanism by the function of the biological macromolecules. PubMed and other online resources - role of biomolecules in metabolism of living systems.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	L	S	S	S	S	S
CO2	M	M	S	S	S	M	L	S	S	M
CO3	M	S	S	L	M	S	M	L	S	M
CO4	M	M	L	S	S	S	S	M	M	S
CO5	S	M	M	M	S	M	M	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Victor WR, David AB, Kathleen MB, Peter JK, and Anthony PW. 2018. Harper's Illustrated Biochemistry (XXXI Ed.). McGraw-Hill Publ.
2. David LN and Michael M. Cox. 2021. Lehninger's Principles of Biochemistry. (VIII Ed.). MacMillan Publ.
3. Jerry M. Berg, John LT and Stryer L. 2015. Biochemistry, (V Ed.). W.H. Freeman Company.
4. Wilson K and Walker J. 2010. Principles and Techniques of Practical Biochemistry. (VII Ed.). Cambridge University Press.
5. Donald V, Charlotte WP, Judith GV. 2011. Biochemistry, (IV Ed.). International student version. John Wiley and Sons, Asia Pvt Ltd.
6. Nitin S. 2010. Molecular Biology and Biochemistry. Oxford Book Company.
7. Hames BD, Hooper NM. 2011. BIOS Instant Notes in Biochemistry. Taylor & Francis.
8. Chatterjee MN, Shinde R. 2012. Textbook of Medical Biochemistry. (VIII Ed.). Jaypee Publ.
9. Chandel R, Chatterjee G. 2016. Postgraduate Biochemistry Companion (I Ed. 2016). IP Innovative Publication Pvt. Ltd.
10. Upadhye SP. 2020. Textbook of Biochemistry. Dream tech Press.

Related Online Contents:

1. https://www.enzyme-database.org/class.php
2. http://biochem.du.ac.in/web/uploads/43%20Enzyme%20Kinetics.pdf
3. https://www.ncbi.nlm.nih.gov/books/NBK21139/
4. https://www.britannica.com/science/protein/General-structure-and-properties-of-proteins
5. http://med.fau.edu/students/md_m1_orientation/Overview.pdf
6. https://pubmed.ncbi.nlm.nih.gov/16892270/

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SEMESTER - I

CORE I: GENETICS AND EVOLUTION

Course Code	22ZOOC14	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Basic knowledge in classical genetics and concepts in evolution								

Course Objectives:

- Learn the basic principles of inheritance at the molecular, cellular and organismal levels
- Understand and evaluate causal relationships between molecule/cell level phenomena (modern genetics) and organism level patterns of heredity (classical genetics)
- Identify and relate the gene defects for disorders and its therapies
- Understand the evidence that living species share descent from common ancestry
- Ancestral character inheritance explains the traits of living species
- Significance of transposition and the evolutionary role in prokaryotes and eukaryotes
- Origin and evolution of higher order and adaptations to variation

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understanding phenotype and genotype	K1, K4
CO2	Can relate genetic status of population using genetic drift/ bottle neck effect	K3, K7
CO3	Evaluate the inherent traits in pedigree	K1, K4
CO4	Relate horizontal gene transfer with examples from natural environment	K2
CO5	Can discuss the evolutionary significance in physiological context	K1, K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Classical genetics** **8 Lectures**	Mendelian principles - concept of gene - allele - multiple alleles - pseudoallele - penetrance and expressivity - epistasis - pleiotropy - phenocopy - linkage and crossing over. Sex-linked genes - genetic disorders - compensation of x-linked genes. Inheritance of complex traits - multiple factor hypothesis. Non-mendelian inheritance - polygenic inheritance - multifactorial trait - threshold trait - genetic susceptibility and risk factors - mitochondrial genome and disorder.
Unit II **Chromosomal theory** **8 Lectures**	Chromosomal theory - chromosome rearrangements - duplication - deletion - inversion - translocation - fragile sites. Chromosomal variations - aneuploidy - types - effect - disomy - trisomy - mosaicism. Polyploidy - autopolyploidy - allopolyploidy - significance. Chromosome structure - prokaryotes and eukaryotes. Chromosome mapping - physical mapping - molecular mapping - RAPD - RFLP - microsatellites - SNPs. Chromosome walk - epigenetics - types of epigenetics - epigenetic inheritance - effect of epigenetics on genome structure - epigenomes.
Unit III **Genetic disorders** **8 Lectures**	Genetic disorders - classification - single gene disorders - cystic fibrosis, Marfan's syndrome. Multifactorial disorders - disease identification and genetic tests - thalassemia - fanconi anemia - sickle cell anemia - fragile - X syndrome - alzheimer's disease - Duchenne muscular dystrophy/Becker's muscular dystrophy - Huntington's disease. Allelic susceptibility test for multifactorial disorders - neural tube defect - cleft lip and palate - cardio vascular disorder - male infertility. Treatment and management of genetic disorders - genetic counseling - principles of genetic counseling - ethical and legal issues in genetic counseling.
Unit IV **Origin of life and Speciation** **8 Lectures**	Origin of life on the earth - molecules - membranes - proto cells. Concept of Oparin and Haldane-Miller. Origin of prokaryotes - RNA world - chemiautotrophs and heterotrophs - bacteria and archaea - cyanobacteria - eukaryotic cells - endosymbiosis - membrane infolding - protist - Sporozoa - Sarcodina - Zoomastignia - Euglenophyta - Chrysophyta - Pyrrophyta - slime and molds. Horizontal-vertical gene transfer - evolution of eukaryotes. Genetics of speciation - variation in individuals - populations and evolutions - continuation of variations. Coevolution. Speciation - sympatric and allopatric speciation - hybridization - gene flow and genetic drift.
Unit V **Mechanism of genome evolution**	Transposition - retroposition - transposable elements - theories - classification and structure - prokaryotic and eukaryotic transposons - genetic and evolutionary significance.

8 Lectures	Chromosomal evolution - comparative mapping - genome duplication, origin of introns, domain shuffling and genome project. Evolution of man - human phenotype and haplotype variation - degeneration of Y-chromosome - geographical distribution. Genetic disease - simple and complex. Telomere – structural arrangement - functions and its evolutionary significance.
Current Contour	History of test and measurement of evolution - current test and measurements.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	S	S	L	M	S
CO2	S	M	M	S	S	S	S	S	M	M
CO3	M	S	S	M	S	M	S	S	S	M
CO4	M	S	M	S	S	M	M	M	S	S
CO5	M	S	S	M	S	M	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Hartwell L, Hood L, Goldberg M, Reynolds AE and Silver L. 2000. Genetics (IV Ed.). McGraw-Hill Publ.
2. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R, Inglis CSHLP. 2008. Molecular Biology of the Gene. (VI Ed.). Benjamin Cummings Publ.
3. Powar CB. 2007. Genetics. (Vol I and II). Himalaya Publ. House.
4. Gardner EJ, Simmons MJ, Snustad DP. 2006. Principles of Genetics. (VIII Ed.). Wiley India Pvt Ltd.
5. Strickberger MW. 2008. Principles of Genetics. Phi learning Publ.
6. Klug WS and Cummings MR. 2005. Essentials of Genetics (V Ed.).
7. Wen-Hsiung Li. 1997. Molecular Evolution. Sinauer Associates Publ.
8. Graur D and Wen-Hsiung Li. 1991. Fundamentals of Molecular Evolution. Sinauer Associates Publ.
9. Barton NH, Derek EG Briggs, Eisen JA, Goldstein DB and Patel NH. 2007. Evolution. CSHL Press.
10. Hall BK and Hallgrimsson B. 2014. Strickberger's Evolution. Jones and Bartlett Publ.
11. Jobling MA, Hurles ME and Tyler-Smith C. 2007. Human Evolutionary Genetics. Garland-Science Publ.
12. Strachan T and Read A. 2019. Human Molecular Genetics (V Ed.). Garland Science.

Related Online Contents:

1. https://www.sciencedaily.com/news/fossils_ruins/evolution/
2. https://www.livescience.com/topics/evolution
3. https://www.nature.com/subjects/evolution
4. https://link.springer.com/article/10.1007/s00239-020-09932-6
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4517414/

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SEMESTER - I

CORE V: WILDLIFE AND CONSERVATION BIOLOGY

Course Code	22ZOOC15	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Understanding the importance of wildlife and its conservation								

Course Objectives:

- List the different Wildlife Protection Act and its importance
- Summarize different wildlife sanctuaries and their importance in India
- Demonstrate different methods adopted in Population survey
- Scrutinize the special management program for wild animals in India
- Describe the wildlife conservation approaches and limitations
- Merits and demerits of wildlife census technique
- Assess the salient features of fauna and adaptation with special reference to tropical forest

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the importance of the wildlife protection Act and management	K2
CO2	Evaluate the richness of the species diversity in the different sanctuaries in India	K5, K7
CO3	Analyse the different habitat and species diversity	K1, K4
CO4	Assess the present status and recommend the strategy to improve the habitat	K7
CO5	Describe the methods to create awareness about wildlife conservation	K1, K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to wildlife conservation** **5 Lectures**	Conservation strategies - past and present. Emerging conservation movements. Biogeographic classification of India. Wildlife management in India - concept - importance - and perspectives. Wildlife ecology and biodiversity - habitat - climate and food availability - Indian forests - characteristics - composition and distribution with reference to major types of vegetation.

Unit II **Wildlife habitat** **8 Lectures**	Characteristics of fauna and adaptation with special reference to tropical forest. Protected area concept - national parks - sanctuaries and biosphere reserves - cores and buffers - nodes and corridors. Community reserve and conservation reserves - management of wildlife distribution status. Habitat utilization pattern - threats to survival of slender loris - musk deer - great Indian bustard and olive ridley turtle.
Unit III **Wildlife in India** **10 Lectures**	Live capturing and marking techniques of birds and mammals. Zoological parks and sanctuaries in India. Threats to wildlife - Wildlife Protection Act (1972) and its amendments. Wildlife wealth of India - threatened wildlife and its depletion in India. Wildlife conservation approaches and limitations - special management program of wild animals in India - project tiger, operation rhino and project elephant.
Unit IV **Wildlife and Biodiversity** **7 Lectures**	IUCN threat categories - Red Data Book - threats to biodiversity - major causes - extinctions and vulnerability of species to extinction. Strategies for biodiversity conservation - principles of biodiversity conservation - *In-situ* and *Ex-situ* conservation strategies - theory of reserve design. Restoration of biodiversity - acceleration of ecological succession - reintroduction of biota.
Unit V **Wildlife tools, techniques and practices** **10 Lectures**	Wildlife census techniques - objectives - direct and indirect methods. Pug-marking and line transect method - technique - merits and limitations. Bird census methods - call count and point count. Telemetry - types - instrumentations - techniques and limitations. GIS - instrumentation - application - merits and limitations.
Current Contour	World - track on wild animals. Invasion of exotic animals.
Total Lectures - 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	S	M	M	S	M	M	M	M
CO2	S	S	S	M	S	S	S	S	S	M
CO3	S	M	S	M	S	S	S	S	S	S
CO4	S	M	S	M	M	S	S	S	S	S
CO5	L	S	M	M	L	M	M	M	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bist BS, Joshi R and Pathak K. 2022. A Textbook of Wildlife Conservation and Protected Area Management. Heritage Publishers and Distributors Pvt Ltd.
2. Sodhi NS and Ehrlich PR. 2011. Conservation Biology For All. Oxford University Press.
3. Raymond FD. 1964. Wildlife Biology. John Wiley, New York.
4. Hunter Jr ML and Gibbs J. 2007. Fundamentals of Conservation Biology. Wiley Blackwell Publ.
5. Eric GB and William LR. 2002. Wildlife Ecology and Management (V Ed.). Pearson Publ.
6. Thomas EA and Harold EB. 2015. Forest Measurements (V Ed.). Waveland Press, Inc.
7. Silvy NJ. 2012. The Wildlife Techniques Manual Research - Vol I. (VII Ed.). The Johns Hopkins University Press, Baltimore.
8. Silvy NJ. 2012. The Wildlife Techniques Manual Management -Vol II. (VII Ed.) The Johns Hopkins University Press, Baltimore.
9. Bolen EG and Robinson WL. 1995. Wild Life Ecology and Management. Prentice Hall.
10. Ranjitsinh MK. 2017. A Life with Wildlife - From Princely India to the Present. HarperCollins.

Related Online Contents:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/wildlife-management
2. https://india.gov.in/wildlife-protection-act-1972-3
3. https://www.wcs.org/our-work/solutions/wildlife-management
4. https://wii.gov.in/
5. https://www.nwf.org/Educational-Resources/Wildlife-Guide/Threats-to-Wildlife/Invasive-Species
6. https://defenders.org/blog/2020/07/wildlife-tracking-thats-totally-out-of-world
7. https://nhpbs.org/wild/tracking.asp
8. https://www.iucnredlist.org/

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SEMESTER – I

CORE VI: Laboratory Course I – STRUCTURE AND FUNCTION OF INVERTEBRATES

Course Code	22ZOOC16	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Basic knowledge on invertebrate species								

Course Objectives:

- Understand the morphological differences within phyla
- Gain the knowledge about morphological resemblance between phyla
- Demonstrate the arrangement of internal organs through virtual platform
- Summarize the level of diversity through field visit

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Integrating the general habit and habitat of fauna	K5
CO2	Describe the significant differences in morphology related to feeding habits	K1, K2
CO3	Design and develop a miniature of endangered species	K5, K6
CO4	Impart the knowledge on metamorphosis stages	K1, K2
CO5	Identify the species based on their taxonomical hierarchy	K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Study of animals in their natural habitats in relation to morphological, ecological and evolutionary diversity.
2. Assigning animals to their respective taxonomic position up to order, based on morphological characters.
3. Preparation neural gland complex (ganglion and neurons).
4. Metamorphosis stage- Butterfly/Honeybee.
5. Observe the specifying characters of earthworm.
6. Dissection of cockroach: Digestive, reproductive and nervous systems.
7. Taxa, identification techniques: Butterfly/ dragonfly body parts and venation.
8. Simple identification of any 20 animals (local which represent all taxa): Common name and scientific name.

9. Field study (compulsory):
    a. Visit biodiversity hotspots
    b. Report on local biodiversity conservation efforts

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	S	M	M	S	S	M	S	M	S
CO2	M	S	S	S	S	M	S	M	L	M
CO3	S	S	S	M	S	S	M	M	L	M
CO4	M	S	S	S	M	S	M	M	L	S
CO5	M	S	S	M	M	S	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Verma PS. 2010. A Manual of Practical Zoology: Invertebrates, Chand Publ.
2. Wallace RL, Taylor WK. 2002. Invertebrate Zoology Lab Manual (VI Ed.). Pearson Publ.
3. Wallace RL, Taylor WK, Litton JR. 1989. Beck and Braithwaite's Invertebrate Zoology: A Laboratory Manual (IV Ed.), Macmillan Publisher.
4. Verma PS, Srivastava PC. 2012. Advanced Practical Zoology. S Chand Publisher.
5. Dales RP, Cox FEG. 1981. Practical Invertebrate Zoology: A laboratory manual for the study of the major groups of invertebrates. New York, Wiley.

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SEMESTER – I

CORE VII: Laboratory Course II - CELL BIOLOGY

Course Code	22ZOOC17	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Ability to understand the techniques in cell biology								

Course Objectives:

- Familiarize students with techniques used in cell biology
- Train students in handling the instruments related to cell culture techniques
- Ability to understand the cell structure and its organelles
- Experimenting and observing the phases of mitotic division and regulation
- Imply the role and significance of banding pattern in polytene chromosome
- Identification and quantification of cells and its viability
- Understanding cell lines and its importance

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Handle the equipments related to different microscopic and cell culture techniques	K3
CO2	Observe and identify the cell lines and their differentiation	K6
CO3	Understand the different methods of preservation of cells	K2
CO4	Relate the cancer cell lines and its pathogenic effect	K7
CO5	Discuss the functional significance of polytene chromosome	K2, K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Mitotic stages and mitotic index in onion root tip.
2. Gram staining
3. Polytene Chromosomes in Chironomus larva
4. Plasma membrane permeability in erythrocytes
5. Barr body in oral mucosa
6. Aseptic techniques for cell culture.
7. Trypsinization and subculturing of monolayer cultures.
8. Quantification of cells and viability percentage by Trypan blue dye exclusion test.
9. Identify the morphological changes of by AO/EtBr dye.

10. Study the effect of toxic chemicals on cultured cells by MTT assay.
11. Identification and study of types of cancer, cancer cells by permanent slides/ photographs.
12. Cryopreservation of cancer cell cultures and cell lines.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	M	M	S	S	S
CO2	S	M	S	M	S	M	M	S	M	M
CO3	L	S	M	S	M	S	M	M	M	S
CO4	S	L	S	S	S	M	S	S	S	S
CO5	S	L	M	M	S	S	L	S	L	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Heidcamp WH. Cell Biology Laboratory Manual. Gustarus Adolphus college, Saint Peter, Minnesota, USA.
2. Manju Y. 2008. Development of Chick. Discovery Publ. House Pvt Ltd.
3. Freshney RI. 2016. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell Publ.
4. Verma PS. 2010. A Manual of Practical Zoology: Invertebrates, Chand Publ.
5. Lal SS. 2017. Practical Zoology: Invertebrate. Rastogi Publications.

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SEMESTER - I

CORE VIII: Laboratory Course III – BIOMOLECULES AND STRUCTURAL BIOLOGY

Course Code	22ZOOC18	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Ability to understand the principles and applications in biochemical techniques								

Course Objectives:

- Make them practice on estimation of biomolecules in biological samples
- Demonstrate the separation of biomolecules using chromatographic techniques
- Interpret the different enzymatic assays and usage of bioelectronics
- Provide and familiarize hands-on training in electrophoresis

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the working principles in instrumentation, calculation and plotting of biochemical values	K4
CO2	Enhance knowledge on basic interpretation and significance of biomarkers	K7
CO3	Acquire the techniques on the separation of biomolecules using chromatography	K3
CO4	Generalize the quantification methods of biochemical components	K7
CO5	Associate the enzymatic activity and its significance	K2, K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Estimation of total protein by using Lowry's method/ Bradford method
2. Estimation of carbohydrate by using Anthrone method
3. Estimation of total lipid by using Folch's method
4. Estimation of free fatty acids
5. Chromatographic techniques - Thin layer chromatography and paper chromatography
6. Estimation of chlorophyll content
7. Bioelectronic-instruments in biomedical science (Glucometer, ECG)
8. Enzyme assay- Determination of α-amylase activity
9. Determination of antioxidant enzyme activity
10. Polyacrylamide gel electrophoresis

Demonstration

GC-MS (Gas Chromatography Mass Spectrometry)

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	M	S	M	M	M	M
CO2	L	S	S	M	S	S	M	M	L	M
CO3	S	S	S	L	S	S	M	M	M	M
CO4	L	S	S	M	S	S	S	S	S	S
CO5	M	M	M	M	S	S	S	S	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bonham AJ, Anna MD, Elkins KM. 2013. Biochemistry laboratory manual. Metropolitan State University of Denver.
2. Ramakrishnan S and Sulochana KN. 2012. Manual of Medical Laboratory Techniques (I Ed). JP Medical Ltd.
3. Plummer DT. 2018. An introduction to practical biochemistry (III Ed.). Tata McGraw-Hill Education.
4. Wilson K and Walker J. 2000. Principles and techniques of practical biochemistry (V Ed.). Cambridge University Press.
5. Chawla R. 2014. Practical Clinical Biochemistry: Methods and Interpretations (IV Ed.). JP Medical Ltd.

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SEMESTER: II

CORE IX: COMPARATIVE ANATOMY OF VERTEBRATES

Course Code	22ZOOC21	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Fundamental knowledge on vertebrates								

Course Objectives:

- Demonstrate and compare the musculoskeletal system in vertebrates
- Describe the formation and structure of digestive system according to their food and feeding habits
- Compare and integrate the respiratory and circulatory system in different organisms
- Assess the evolutionary significance of renal system of vertebrates in different habitats.
- Describe the development of genital organs and their accessory glands
- Summarize the sensory receptors and their differentiation in vertebrates
- Illustrate the nervous system and their integration in vertebrates

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the musculoskeletal evolutionary development	K1, K2
CO2	Discuss the digestive system and their adaptive feeding habits	K2, K4
CO3	Interpret the structural modification of respiration, circulation among vertebrates	K3, K4
CO4	Elucidate the renal and reproductive differentiation among organisms	K6
CO5	Differentiate and compare the nervous system and sensory receptor adaptation in vertebrates	K2, K3

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Integumentary and Skeletal system** **8 Lectures**	Integumentary and skeletal system (Fishes, Amphibians, Reptiles, Birds and Mammals) - integument and mammary glands. Skeleton - exoskeleton - endoskeleton - vertebral column - ribs and sternum (skull - visceral skeleton and bones) - appendicular skeleton - fins and limbs.
Unit II **Digestive system** **8 Lectures**	Anatomy and function of digestive system (Fishes, Amphibians, Reptiles, Birds and Mammals) - general structure - mouth - oral cavity - accessory organs of oral cavity - gastrointestinal tract.
Unit III **Respiratory and Circulatory system** **8 Lectures**	Respiratory system (Fishes, Amphibians, Reptiles, Birds and Mammals) - types of respiration and respiratory organs - respiratory pigments - gills - swim-bladder and lungs. Organs of circulatory system (Fishes, Amphibians, Reptiles, Birds and Mammals) - origin and development of blood vessels - arterial system - venous system - development of heart. Lymphatic system.
Unit IV **Urinogenital system** **8 Lectures**	Urinogenital system (Fishes, Amphibians, Reptiles, Birds and Mammals) - structure and development of nephridia - male and female generative ducts and gonads - urinogenital organs.
Unit V **Nervous system and Sensory organs** **8 Lectures**	Nervous system and sensory organs (Fishes, Amphibians, Reptiles, Birds and Mammals) - central and peripheral nervous system. Sensory organs - integument - somatic receptors - photoreceptors - mechanoreceptors - chemoreceptors and accessory sensory organs.
Current Contour	Finding evolutionary relationship of organ and functional development and organ dysfunction.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	M	M	S	L	L	L
CO2	S	M	S	M	S	S	M	S	M	M
CO3	S	S	M	M	M	S	S	M	S	M
CO4	S	M	M	S	M	S	M	S	M	S
CO5	M	S	S	S	M	S	M	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Parker WN. 1907. Comparative Anatomy of Vertebrates. (III Ed.). MacMillan & Co. Ltd. London.
2. Kardong KV. 2012. Vertebrates – Comparative Anatomy, Function and Evolution. (VI Ed.). McGraw-Hill Publ. New York.
3. Simpson GG. 1961. Principle of Animal Taxonomy. Oxford and IBH Publ.

4. Cleveland H Jr, Lary R, Susan K, Allan L and David E. 2011. Animal Diversity. McGraw-Hill Company, Inc. New York.
5. Margulis L and Capman MJ. 2010. Kingdoms and Domains: An Illustrated Guide to the Phyla of Life on Earth. (IV Ed.). W.H. Freeman and Company, USA.
6. Mayr E. 1969. Principles of Systematic Zoology. McGraw-Hill Company, Inc. New York.
7. David E, Allan L, Susan K, Larry R, Cleveland H Jr. 2009, Animal Diversity. (V Ed.). Boston: McGraw-Hill Company, Inc. New York.
8. Barnes RD. 1982, Invertebrate Zoology. (IV Ed.). Holt Saunders International Edition.
9. Waterman AJ. 1971. Chordate Structure and Function. The Macmillan Company.
10. Hyman GH. 1940-1967. The Invertebrates. (Vol. I to VI). McGraw-Hill Company, Inc. New York.

Related Online Contents:

1. http://www.iaszoology.com/
2. https://royalsocietypublishing.org/doi/10.1098/rspb.2013.2683
3. http://faunaofindia.nic.in/
4. https://www.iucn.org/resources/conservation-tools/iucn-red-list-threatened-species
5. https://wii.gov.in/nwdc_aboutus

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SEMESTER - II

CORE X: DEVELOPMENTAL BIOLOGY

Course Code	22ZOOC22	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				1	3	-	4		
Pre-requisite	Understanding the concept in embryonic development								

Course Objectives:

- Comprehend the organization of male and female gametes
- Understand the molecular regulation of fertilization and post fertilization development
- Integrate the mechanism of gene regulation with organization and development of organs
- Describe the experimental studies in organization and its significance in organ formation and differentiation
- Summarize the post-embryonic developments with examples
- Apply theoretical knowledge on inductive and interactive signals during embryo development
- List and discuss the impact of teratogens in embryonic development

Expected Course Outcomes:

On completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the evolutionary relationship of patterning / symmetry with development	K1, K2
CO2	Summarize the process of gastrulation from lower order to higher order vertebrates	K2, K7
CO3	Illustrate the process of polarization of embryo development	K3
CO4	Combine and integrate the different forms of regenerative abilities	K2, K5
CO5	Assess and grade the different teratogens and their impact in embryonic development	K4, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Concepts in Developmental biology** **8 Lectures**	Scope and importance - Basic concepts - potency - commitment - specification - induction - competence - determination and differentiation - morphogenetic gradients and cytoplasmic determinants. Cell fate and cell lineages. X chromosomal inactivation - embryonic stem cells - stem cell lineages and imprinting.

Unit II **Gametogenesis and Fertilization** **8 Lectures**	Spermatogenesis and oogenesis - vitellogenesis - chemo-differentiation. Organization of cell cytoplasm. External and internal fertilization - cell surface molecules in sperm-egg recognition - essence of activation - sperm in the egg interior - changes in the organization of the egg cytoplasm - zygote formation. Parthenogenesis - types - natural - haploid - diploid - special types of natural and artificial parthenogenesis and significance. Polarity and symmetry - anterior-posterior and dorso-ventral patterning - genes in patterning and signaling (Drosophila, Amphibia and Chick).
Unit III **Early development** **8 Lectures**	Storage and transmission of genetic information by the generative cells - transmission of genetic information during replication - control of protein synthesis. Cleavage - types - mechanism - chemical and molecular changes during cleavage. Role of cytoplasm and nucleus during early development. Morphogenetic movements - presumptive areas and fate maps. Gastrulation - metabolic events during gastrulation - integration of gastrulation and formation of germ layers.
Unit IV **Organogenesis and Differentiation** **6 Lectures**	Organogenesis - concept of organizers and induction - eye lens induction - neural tube formation. Vulva formation in *Caenorhabditis elegans.* Development of kidney - ureteric bud development and mesenchymal tubules. Vertebrate limb development. Differentiation - types - morphological - physiological and chemical basis of differentiation. Changing pattern of protein synthesis - factors causing differentiation – dedifferentiation. Cell aggregation and differentiation in *Dictyostelium discoideum.*
Unit V **Post embryonic development, Regeneration and Teratogenesis** **10 Lectures**	Metamorphosis – role of hormones in metamorphosis (insects and frog). Biology of ageing. Medical implications of developmental biology - genetic errors of human development. Sex determination - hormonal and environmental. Regeneration - laws of regeneration - types and mechanism - factors influencing regeneration - physiological and biochemical process involved in regeneration. Epimorphic regeneration in reptile (salamander limb) and amphibian (limb and tail) - requirement of nerves for proliferation of blastema cells. Teratogenesis and teratogens – genetic and environmental - developmental mechanism of teratogenesis. Teratogens - alcohol, thalidomide and retinoic acid.
Current Contour	Researches in Axolotl neoteny and regeneration - observe researches on hormonal regulation in metamorphosis in insects and amphibians and record the stages of development -

	embryonic signaling and its focus on pathology - articles related to *In vitro* advances, teratogenesis and its disorders in humans.

Total Lectures – 40

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	M	S	S	S	L	S
CO2	M	M	S	L	M	M	L	M	M	M
CO3	S	M	M	L	M	S	L	S	M	M
CO4	M	S	S	M	S	S	L	M	S	S
CO5	S	S	S	S	S	M	S	M	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Barresi MJF and Gilbert SF. 2019. Developmental Biology. (XII Ed.). Oxford University Press.
2. Gilbert SF. 2016. Developmental Biology. (XI Ed.). Sinauer Associates Inc.
3. Gilbert SF and Epel D. 2015. Ecological Developmental Biology. The Environmental Regulation of Development, Health, and Evolution. Oxford University Press.
4. Balinsky BL. 2012. An Introduction to Embryology. (V Ed.), Cengage Learning India.
5. Slack JMW and Dale L. 2021. Essential Developmental Biology. (IV Ed.). Wiley Blackwell Publ.
6. Slack JMW. 2012. Essential Developmental Biology. (III Ed.). Wiley Blackwell Publ.
7. Saunders W Jr. 1982. Developmental Biology - Patterns, Problems and Principles. Mac Millar, USA.
8. Wolpert L, Tickle C, Arias AM, Lawrence P and Locke J. 2019. Principles of Development. (VI Ed.). Oxford University Press.
9. Wolpert L and Cheryll T and Alfonso MA. 2015. Principles of Development. (V Ed.), Oxford University Press.
10. Shostak S. 1990. Embryology – An introduction to Developmental Biology. Longman Higher Education.
11. Goel SC. 1994. Principles of Animal Developmental Biology. Himalaya Publ. House.
12. Rugh R. 2012. Experimental Embryology: A manual of techniques and procedure. Ulan Press.
13. Wilkins AS. 2001. The Evolution of Developmental Pathways. Oxford University Press.

Related Online Contents:

1. https://biology.duke.edu/research/developmental-biology
2. https://pubmed.ncbi.nlm.nih.gov/31767146/
3. https://www.cell.com/current-biology/pdf/S0960-9822(18)30218-5.pdf
4. https://www.sciencedirect.com/science/article/pii/S2352320420300043
5. https://embryo.asu.edu/pages/teratogens
6. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/teratogenesis
7. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC117475/

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SEMESTER - II

CORE XI: MOLECULAR BIOLOGY

Course Code	22ZOOC23	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Basic knowledge in modern biology								

Course Objectives:

• Describe the concept of genome and its organization
• Summarize the molecular mechanism of transcription and translation
• Classify the different DNA modifying enzymes and discuss their application in molecular biology / genetic engineering
• Illustrate the importance of synthetic biology
• Connect the different elements in plasmids and their role in molecular regulation
• Integrate the different types of vectors and their applications
• Explain the importance of transgenic animals in understanding the complexity of gene regulations and their function

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the elements in genome, structure and their role in genome stability	K1, K2
CO2	Differentiate the mechanism behind regulations of transcription and translation	K4, K7
CO3	Design the strategy of cloning methods	K6
CO4	Acquire the knowledge in developing transgenic animals based on applications	K1, K2
CO5	Describe the type of viral vectors and their application in gene therapy	K2, K7
K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation		

Unit I **Concept of genome** **6 Lectures**	Structure and organization of genome - DNA packaging and managing - replication of DNA - theories and models. DNA polymerase - types and complex. DNA damage - instability - oxidation - alkylation - cross linking and mutagens. Genome to epigenome - reprogramming of genome. Synthetic genomes - synthetic biology approach to minimal genomes and their application.
Unit II **Transcription and its regulation** **12 Lectures**	Transcription - transcription complex - RNA polymerase – types - interaction with upstream factors - transcription factors – types - structure. Splicing - chemistry of RNA splicing - spliceosome machinery - splicing mechanism - self and alternative. RNAi /siRNA /miRNA mediated gene regulation - post-transcriptional process - mRNA transport - translation - localization - posttranslational modifications - trafficking.
Unit III **DNA modifying enzymes and Recombinant vectors** **8 Lectures**	DNA modifying enzymes and their application in genetic engineering. Strategies of cloning - sticky ends - blunt ends and homopolymeric tailing - adapters and linkers - ligation and transformation types. Host - vector system - Cosmids - plasmids - YACs - BACs. Host system - prokaryotes - insect cells - animal cells. Construction of recombinant vectors - fusion genes - expression vectors - transfection - expression of recombinant proteins - protein and protein interaction - one/two hybrid assay - coprecipitation. Protein engineering and their applications.
Unit IV **Viral vectors and its applications** **8 Lectures**	Biology of animal viral vectors - types of viral vectors - methods for the construction of recombinant viral vectors - first, second, third generations – vectors and application / significance in gene therapy - prospects and problems. Development of vaccine – live attenuated/inactivated - RNA - DNA - protein subunit vaccine - limitation and advantage - delivery system.
Unit V **Model organisms and Transgenic expression** **6 Lectures**	Model organism for genetic analysis - *Caenorhabditis elegans* - *Drosophila melanogaster* and *Mus musculus* / *Rattus norvegicus*. Chromosomal engineering - transgenic animals for genetic disorders - methods for generating transgenic animals - Cre/Loxp -system - conditional gene knock in/out - CRISPR/Cas-9 system - screening of transgene - controlling transgene expression and applications of transgenic animals.
Current Contour	Recent developments in genome analysis - markers and expression study.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	M	L	S	M	S
CO2	S	M	S	M	S	M	M	S	M	M
CO3	S	S	S	S	S	M	L	S	S	S
CO4	S	S	S	S	S	S	M	S	M	S
CO5	S	S	S	S	S	S	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Primrose SB, Twyman RM and Old RW. 2003. Principles of Gene Manipulation. Blackwell Scientific Publ.
2. Brown TA. 2001. Gene Cloning and DNA Analysis - An Introduction. Blackwell Scientific Publ.
3. Watson JD, Gilman M, Witowski J and Mark Zoller. 1992. Recombinant DNA. Scientific American Books.
4. Winnacker EL. 1987. From Genes to Clones: Introduction to Gene Technology. Wiley VCH
5. Moo-Young and Robinson CW 2004. Comprehensive Biotechnology (Vol I to IV). Robinson Howell. Elsevier Publ.
6. Watson JD, Baker TA, Bell SP, Gann AAF, Levine M and Losick RM. 2014. Molecular Biology of the Gene. (VII Ed.). Pearson Education Inc.
7. Bruce A, Alexander J, Julian L, Martin R, Keith R and Peter W. 2014. Molecular Biology of the Cell. Garland Science Publication.
8. Locelyn EK, Elliott SG and Stephen TK. 2011. Benjamin Lewin's Genes (XI Ed.). Oxford University Press.
9. Malacinski GM and Friefelder D. 2015. Essentials of Molecular Biology (IV Ed.). Jones and Bartlett Publishers.
10. Burton ET. 2008. Molecular Biology. Jones and Bartlett Publishers.
11. Gibson DG, Hutchison CA, Smith HO and Venter JC. 2017. Synthetic Biology: Tools for Engineering Biological Systems, Cold Spring Harbor Press.
12. Ronald WE. 1999. Combination vaccines: Development, Clinical Research and Approval. Humana Publ. Ltd.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5467957/
2. https://www.frontiersin.org/articles/10.3389/fendo.2018.00402/full
3. https://www.mmcmodinagar.ac.in/econtent/biotech/DNA-modifying-enzyme.pdf
4. https://www.sciencedirect.com/topics/medicine-and-dentistry/virus-vector

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SEMESTER – II

CORE XII: ENVIRONMENTAL BIOLOGY

Course Code	22ZOOC24	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	4		
Pre-requisite	Basic knowledge about ecosystem and its importance								

Course Objectives:

- Illustrate the basic concepts of environmental science and its laws
- Explain the different ecosystems and its biotic interactions
- Enhance the importance of population and community ecology
- Create the awareness on stability and management of complex ecosystem
- Import knowledge on the environmental resources and their significance
- Assess the environmental impact and risk factors due to various pollution
- Familiarize the Acts and summits related to ecological conservation

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the principle and scope of ecology	K1, K2
CO2	Enrich knowledge on biomes and its limiting factors	K4
CO3	Learn about different ecosystems with biotic interactions	K4, K7
CO4	Gain conscious on maintenance of stable ecosystem and their management	K2, K3
CO5	Compare and relate the global biodiversity conservation and their significance	K2, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to environmental science** **6 Lectures**	Introduction to environmental science - principles and scope of ecology. Environmental concepts - laws and limiting factors - ecological models. Characteristics of population - population size and exponential growth - limits of population growth - population dynamics - life history pattern - fertility rate and age structure. Biosphere - biomes - terrestrial and aquatic biomass - impacts of climate on biomes.
Unit II **Ecosystem structure and function**	Biotic and abiotic components - types of ecosystems - biomes - energy flow in ecosystems - energy flow models - food chains and webs - biogeochemical cycles - ecological succession -

8 Lectures	species diversity - edge effects - ecological habitats and niche - ecosystem stability and services - factors affecting ecosystem. Population ecology – characteristics - keystone species. Community ecology – concept and types of interaction – amensalism - commensalism - mutualism - predation - parasitism and competition and biological invasions.
Unit III **Dynamics of ecosystem** **10 Lectures**	Ecosystem dynamics and management - stability and complexity of ecosystem - environmental stress and climate change – national action plan - global warming - ozone layer depletion - sea level rise - acid rain and nitrogen deposition - strategies related to climatic variations. Biogeochemical cycles - carbon cycle - water cycle - sulphur cycle and phosphorus cycle.
Unit IV **Biodiversity and Conservation** **8 Lectures**	Biodiversity – definition - importance and threats. Hotspots – hotspots in India. Measures of biodiversity – species richness and abundances. Diversity indices – Shannon, Simpson and Fisher's Alpha. Biodiversity and various ecosystem services - strategies for biodiversity conservation - valuation of ecosystems and species. Wildlife conservation (*In situ* and *Ex situ* conservation), endemic species and its conservation status in India. Biopiracy and bioprospecting - restoration ecology. Wildlife conservation projects – project tiger - project elephant - crocodile conservation - white rumped vulture - Goi-UNDP sea turtle project - Indo-rhino vision. An overview of environmental laws in India amended from time to time.
Unit V **Environmental pollution and Ecotoxicology management** **8 Lectures**	Environmental pollution - water and soil pollution - causes - effects and control measures of pollutions. Environmental laws related to water - air - soil. Classification and assessment of toxicity - acute and chronic toxicity - LC_{50} and LD_{50} assessment - dose response relationship. Molecular mechanism of toxicant action - biomagnification - bioaccumulation of toxic use and risk assessment. Sewage and waste water treatment - aerobic and anaerobic treatment technologies - sources - causes and treatments of solid waste. Bioremediation - types - advantages and disadvantages.
Current Contour	Emerging threats to biodiversity - habitat loss-over harvesting - species invasion - climatic change. Environmental disasters - natural resources and their assessment - environmental education and awareness - environmental ethics - policies of the environment- environmental conventions and agreements.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	L	S	S	S	S	M	S
CO2	S	M	L	M	S	L	S	M	S	S
CO3	L	S	M	S	M	S	S	M	S	M
CO4	M	M	M	M	L	M	S	S	M	S
CO5	S	L	S	S	M	S	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Conklin AR Jr., 2004. Field Sampling: Principles and Practices in Environmental Analysis. CRC Press.
2. Fahey TJ and Knapp AK. 2007. Principles and Standards for Measuring Primary Production. Oxford University Press, UK.
3. Grant WE and Swannack TM. 2008. Ecological Modeling. Blackwell.
4. Wilkinson DM. 2007. Fundamental Processes in Ecology: An Earth system Approach. Oxford University Press, UK.
5. Allen HB. 1958. Principles of Field Biology and Ecology. Mc -Graw Hill Publisher.
6. Bhatia AL. 2013. Textbook of Environmental Biology. IK International Publishing House Pvt. Ltd.
7. Krishnamurthy KV. 2018. An Advanced Textbook on Biodiversity: Principles and Practice. Oxford & IBH Publishing Co Pvt. Ltd.
8. Matthew RF. 2021 Environmental Biology. Open Oregon Educational Resources.
9. Meetu G. 2018. Fundamentals of Environmental Biology. IK International Publishing House Pvt. Ltd.
10. Das PC. 2021. Environmental Biology. A.I.T.B.S. Publ.

Related Online Contents:

1. https://nios.ac.in/media/documents/SrSec314NewE/Lesson-25.pdf
2. https://babel.hathitrust.org/cgi/pt?id=uc1.b4455744&view=1up&seq=1
3. https://www.pmfias.com/ecology-principles-organizations/
4. https://www.webpages.uidaho.edu/range357/notes/diversity.pdf
5. https://sciencemonk.com/bioremediation/
6. https://www.frontiersin.org/articles/10.3389/fpubh.2020.00014/full
7. https://scied.ucar.edu/learning-zone/earth-system/biogeochemical- cycles

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SEMESTER - II

CORE XIII: ECOTOXICOLOGY

Course Code	22ZOOC25	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Understand the impact of environmental chemicals								

Course Objectives:

• Explain the distribution and effects of pollutants in the environment
• Summarize the impact of environmental toxicants on ecosystems
• Generalize the classification of toxicants and route of delivery to human
• Explain the fundamental concepts of toxicology and its analytical methods of detection
• Imply the evolving techniques and analysis of toxicants
• Assessment of the basic components of environmental risks and routes for recovery
• Compare, interpret and evaluate health risks on exposure to varied toxicants

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Measure the sources of bioaccumulation and biotransformation of xenobiotics from the environment	K3, K7
CO2	Understand the deleterious effects of toxicants and its detoxification processes	K1, K2
CO3	Distinguish the environmental monitoring of chemical toxicants and its ADME profile	K1, K2
CO4	Analyze tracing methods of chemical toxicants in the bio-complex systems and analytical methods to detect environmental toxicants and its impacts	K4, K7
CO5	Summarize the risk and recovery of toxicants in the ecosystem and measures their risk assessment for the prospect of human health against potential toxic exposures	K2, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to environmental toxicology** **6 Lectures**	General principles and terminology - history - modern toxicology - classification of toxic substances. Toxic exposure and response - characteristic and types of toxic response - duration - frequency - route and site of exposure. Tolerance and addiction - evaluation of toxicity - dose response relationships - assumptions in deriving dose response - LC_{50} - LD_{50} - IC_{50} - TD_{50} and therapeutic index.
Unit II **Toxicants** **8 Lectures**	Classification of toxicants – metals - pesticides - xenobiotics - teratogens - food additives and contaminants. Target organ toxicity - toxic response of blood - liver - kidney - skin - immune system - respiratory system - nervous system - visual system and endocrine system. Mechanisms involved in formation and detoxification process.
Unit III **Environmental and Clinical toxicology** **6 Lectures**	Environmental assessment - environmental health and hazards - air pollutants - water pollutants - radioactive pollutants - soil and land pollutants - outdoor pollutants and photochemical oxidants. Toxicokinetics – absorption - digestion - metabolism - excretion - mutagenicity - carcinogenicity and teratogenicity (xenobiotics). Toxic compounds (DDT, mercury) in food chain - movement and effect - bioaccumulation and biomagnification.
Unit IV **Applied and Analytical toxicology** **6 Lectures**	Medical toxicology - mission of medical toxicology - comparative toxicology - toxicological database. Wildlife toxicology - susceptibility of wildlife to chemicals - acute ecological hazards - toxicology of chemicals in birds and mammals. Forensic toxicology - specimen sample collection - types of testing and detection of poisons. Diagnostic toxicology - laboratory animals - histopathology - spectrophotometer - electrophoresis and radiological techniques.
Unit V **Regulatory, recovery and risk assessment** **4 Lectures**	Regulatory toxicology - regulatory agencies - regulation of industrial chemicals in India - regulation of pesticides - pharmaceuticals and food additives. Basic components of a risk assessment - use and importance - frameworks - factors triggering - routes for recovery - recent regulatory approaches to contaminated sites and updating risk assessment.
Unit VI **Current Contour**	Recent progress and future prospects - Modernize database for toxicology of substances (TOXNET). Outline of recent update in toxins cause aging and etiology. Assessing alternatives to toxic chemicals in recent research.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	S	M	S	M	S	S	L	M	S
CO2	S	M	S	M	M	M	M	S	S	M
CO3	S	S	M	S	S	S	M	S	M	S
CO4	M	S	M	S	S	M	S	M	S	S
CO5	M	M	S	M	L	S	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Sharma PD. 1998. Environmental Biology. Rastogi Publications.
2. Klaassen CD (Ed.). 2008. Cassarett and Doull's Toxicology - The Basic Science of the Poisons. (VII Ed.). Mc-Graw Hill Publisher.
3. Klaassen CD and Watkins JB. 2015. Cassarett and Doull's Essentials of Toxicology. (III Ed.). Mc-Graw Hill Education/Medical.
4. Timbrell J. 2001. Introduction to Toxicology. (III Ed.). CRC Press. (Available ebook-Taylor and Francis Publ.).
5. Karen S and Thomas MB. 2006. Principles of Toxicology. (II Ed.). CRC press.
6. Byung-Mu, Sam K and Hyung SK. 2017. Lu's Basic Toxicology: Fundamentals Target Organ and Risk Assessment. (V Ed.). CRC Press.
7. Robert JF, Eva C, Hans HM and Robin WH. 2020. Fundamentals of Analytical Toxicology (II Ed.). John Wiley & Sons Ltd.
8. David AW and Pamela W. 2002. Environmental Toxicology. Cambridge University Press.
9. Jorgensen E. 2010. Ecotoxicology. (I Ed.). Elsevier.
10. John EE, Christine AB, Christy M. 2011. Wildlife Ecotoxicology: Forensic Approaches. Springer.

Related Online Contents:

1. https://www.nlm.nih.gov/toxnet/index.html
2. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3127354/
3. https://www.frontiersin.org/articles/10.3389/fpubh.2016.00148/full
4. https://www.epa.gov/international-cooperation/persistent-organic-pollutants-global-issue-global-response

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SEMESTER – II

CORE XIV: Laboratory Course IV – COMPARATIVE ANATOMY OF VERTEBRATES

Course Code	22ZOOC26	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Basic knowledge on chordates								

Course Objectives:

- Understand the external features among vertebrate species
- Gain the knowledge about morphological resemblance between phyla
- Demonstrate the arrangement of internal organs through virtual platform
- Summarize the level of development from lower to higher vertebrates

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Integrating the salient features of chordates	K5
CO2	Describe the significant differences in morphology related to adaptation	K1, K2
CO3	Develop an evolutionary changes among the animals	K5, K6
CO4	Impart the knowledge of poisonous and non-poisonous snakes	K1, K2
CO5	Identify the axial and appendicular skeletal system	K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Assigning animals to their respective taxonomic position up to order, based on morphological characters.
2. Understanding the anatomy of frog using an appropriate software package (Caroline TM; Biolab R- Frog); Dissection works - Frog; Pro-dissector- Frog; Virtual Frog).
3. Dissection of an available fish: General anatomy (Viscera).
4. Identification using keys: Fishes to rabbit/rat.
5. Observation of different kinds of feathers
6. Identifying fins to differentiate the species under Class Pisces
7. Modification of claw pattern from Pisces to Mammals.

8. Preparation and mounting of scales from fishes.
9. Examining of model for exoskeleton from Pisces to Mammals
10. Axial (skull and vertebral column) and appendicular (pectoral and pelvic girdle) skeleton.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	S	M	S	S	S	S	M	M
CO2	L	M	S	M	S	S	M	M	L	M
CO3	M	M	S	M	M	S	M	S	S	S
CO4	L	S	S	S	L	M	M	S	M	S
CO5	L	L	S	M	L	M	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Verma PS. 2010. A Manual of Practical Zoology: Invertebrates, Chand Publ.
2. Robert LW and Walter KT. 2002. Invertebrate Zoology Lab Manual (VI Ed.). Pearson Publ.
3. Gerardo D and Dino P. 2019. The dissection of Vertebrates, (III Ed.). Academic Press.
4. Poonam P and Loveena G. 2021. Practical Book of Zoology. Associated book company.
5. Lal SS. 2010. Practical Zoology Vertebrate. Rastogi Publ. Meerut.
6. Verma PS. 2000. A Manual of Practical Zoology Chordates. Chand Publ.
7. Verma PS, Srivastava PC. 2012. Advanced Practical Zoology. S Chand Publ.

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SEMESTER - II

CORE XV: Laboratory Course V - DEVELOPMENTAL BIOLOGY

Course Code	22ZOOC27	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Basic understanding about vertebrate's embryogenesis								

Course Objectives:

- Observe and understand the different developmental stages of vertebrate embryo
- Ability to understand and differentiate the metamorphic stages in fruit fly
- Microscopic examination of cellular organization in mammalian gametes
- Associating animal models / spotters on environmental regulation

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Compare the organ formation in different developmental stages in vertebrates	K4, K7
CO2	Familiarize in culturing and maintenance of different developmental stages of insects	K1, K2
CO3	Relate the developmental/ life cycle patterns observed in the environment	K2, K4
CO4	Understand the significance of placental interaction during embryo development	K1, K2
CO5	Explore environmental influence on sex determination in species	K6

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Incubation and identification of different stages of chick embryos – 24 hrs, 33 hrs, 48 hrs, 72 hrs and 96 hrs.
2. Study of life cycle of *Drosophila melanogaster* (fruit fly stock cultures).
3. Observation of developmental stages - sexual dimorphism in *Drosophila melanogaster*.
4. Examination of frog/ rat sperm and ova.
5. Effect of thyroxine on amphibian metamorphosis.
6. Amphibian regeneration.
7. Observe and study the sections of mammalian testis (sperm) and ovary (ova) showing the maturation stages.
8. Sections of placenta as spotter.
9. Observe the developmental stages in amphibian with the help of permanent slides or spotters - cleavage stages, blastula, gastrula, neural, tail bud stage, tadpole.
10. Influence of environment, temperature and teratogens on animal development as spotters.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	S	S	M	S	S	S
CO2	S	S	S	M	S	M	S	M	M	S
CO3	M	L	S	L	S	M	S	S	S	S
CO4	S	M	S	L	M	S	M	M	L	S
CO5	M	S	S	M	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Manju Y. 2008. Development of Chick. Encyclopedia of Developmental biology V. Discovery Publ. House.
2. Tyler MS and Kozlowski RN. 2011. DevBio Laboratory: Vade Mecum 3. An Interactive Guide to Developmental Biology. Oxford University Press.
3. Gibbs MA. 2003. A Practical Guide to Developmental Biology. Oxford University Press.
4. Oppenheimer SB and Chao RLC. 1994. Atlas of Embryonic development. Newton, MA: Allyn and Bacon, Inc.
5. Sylwester C and Nicolas G. 2013. Atlas of Drosophila morphology. Elsevier Inc and Academia Press Publ.
6. Patten BM. 1920. The early embryology of chick. Philadelphia: Blakiston's Son's and Co.
7. Van HF, Sharon K, Pierson ES, Janseen WLP and Van MZ. 2005. Early embryology of chicken: Development from 18 to 72 hrs after fertilization. Radbound University, Nijmegan.
8. Nieuwkoop PD and Faber J. 1994. Normal Table of *Xenopus laevis* (Daudin). A Systematical & Chronological Survey of the Development from the Fertilized Egg till the End of Metamorphosis. Garland Science, New York.
9. Verma PS. 2010. A Manual of Practical Zoology: Invertebrates. Chand Publ.
10. https://www.vcbio.science.ru.nl/en/virtuallessons/embryology/chicken-slides/

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SEMESTER - II

CORE XVI: Laboratory Course VI - MOLECULAR BIOLOGY

Course Code	22ZOOC28	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Basic knowledge about the chemical substance / materials used in experiments								

Course Objectives:

- Understand the function of different chemicals used in purification / isolation of DNA, RNA and protein
- Acquire the knowledge in principles behind the separation of DNA, RNA and protein using different methods
- Demonstrate the principles in transformation and identification of recombinant vector
- Explain the strategies in preparation and performing ligation of DNA fragment in cloning vector

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Explain the critical component in isolation of functional molecules	K1, K2
CO2	Analyze the quality and quantity of DNA, RNA and protein	K4, K7
CO3	Describe the importance of elements in cloning and expression vectors	K1, K2
CO4	Design and develop the requirement based vectors for experiments	K5, K6
CO5	Understand the principle mechanism of cloning vectors	K1, K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments	1.	Isolation, visualization and quantification of
	2.	genomic DNA from animal tissue.
	3.	Isolation of total protein from animal tissue.
	4.	Separation of total protein (SDS-PAGE).
	5.	Isolation of RNA from animal tissue.
	6.	Synthesis of specific cDNA from messenger RNA.
	7.	Amplification of specific part of gene
	8.	Preparation of Competent cell and transformation.
	9.	Isolation of plasmid.
	10.	Preparation of vector and DNA fragment for ligation.
	11.	Ligation of specific gene and transformation.
	12.	Screening recombinant DNA clone with marker gene expression.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	S	S	M	S	S	S
CO2	S	M	S	M	S	S	M	S	S	M
CO3	M	S	M	S	S	S	L	S	S	S
CO4	S	S	S	S	S	M	S	S	M	S
CO5	S	S	S	S	M	M	L	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Sambrook J, Russell DW. 2001. Molecular cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.
2. Maniatis T. 2001. Molecular Cloning - A Laboratory Manual. Cold Spring Harbor Laboratory Press, New York.
3. Michael RG and Howard H. 2012. Molecular Cloning - A Laboratory Manual (IV Ed.). Cold Spring Harbor Laboratory Press. New York.
4. Hasan NA. 2021. Basic Molecular Biology Laboratory Manual. 10.5281/zenodo.4541490.
5. Shad M and Hawnaz N. 2017. Molecular Biology Laboratory Manual. 10.13140/RG.2.2.10020.17285.
6. Carson S, Miller HB, Witherow DS and Srougi MC. 2019. Molecular Biology Techniques – A Classroom Laboratory Manual. (IV Ed.). Academic Press.

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SEMESTER - II

CORE XVII: Laboratory Course VII - ENVIRONMENTAL BIOLOGY

Course Code	22ZOOC29	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Comprehensive knowledge in ecosystems								

Course Objectives:

- Learn the techniques of monitoring environment pollutions
- Understand the problems related to the environment
- Analyze the various parameters of aquatic ecosystem
- Isolate and identify the microorganisms from different environmental habitats
- Estimate the biomass productivity of the ecosystem

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Acquire the methodology to collect the samples from polluted environment	K2, K4
CO2	Assess the analytical techniques of water quality parameters	K5, K7
CO3	Inculcate the importance and preservation of ecosystems	K2
CO4	Gain the knowledge of microbial population in the environment and techniques of identification	K2, K7
CO5	Compare the various ecosystem and their interaction in the environment	K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Sampling techniques of water and preservation of water samples.
2. Analysis of physical parameters - temperature, colour, pH, turbidity, conductivity, total solids, total dissolved solids and total suspended solids.
3. Analysis of chemical parameters - acidity, alkalinity, carbon dioxide, hardness, dissolved oxygen, Demonstration - COD and BOD.
4. Analysis of biological parameters - identification

counting of zooplanktons and phytoplankton's, estimation of productivity using algae.

5. Vegetation analysis - association, diversity, frequency, density, productivity (primary) indirect estimation of standing crop.
6. Aquatic ecosystems - survey, mapping and preservation.
7. Identification and abundance estimation of macrophytes, biomass and primary productivity - estimation of chlorophyll and temperature.
8. Isolation of microorganisms from air, water and soil.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	M	S	S	S	M	M	M
CO2	S	M	M	M	S	S	S	S	S	S
CO3	M	L	S	S	S	M	M	S	S	M
CO4	M	S	S	S	M	M	S	M	S	S
CO5	M	L	M	M	L	M	S	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Gupta PK. 2012 Methods in Environmental Analysis Water, Soil and Air. Agrobios (India), Jodhpur.
2. American Public Health Association (APHA). 2012 Standard Methods for the Examination of Water and Waste Water (XX Ed.). Washington. D.C.
3. Rina M, Renuka K. 2019. Practical Manual of Ecology and Environment Science. Prestige Publ.
4. Swarajya Lakshmi G, Prabhu Prasadini P, Ramesh T, Tayaru VNLV. 2010. Environmental Science: A Practical Manual. BS Publ. Hyderabad.
5. Lynn LM. 2010. Environmental Biology and Ecology Laboratory Manual. (VI Ed.). Kendall Hunt Publ. Co.

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SEMESTER - II

AQUACULTURE AND FISHERIES (Major Elective - I)

Course Code	22ZOOME21	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	2		
Pre-requisite	Fundamental knowledge about aquatic organisms								

Course Objectives:

- Enrich the knowledge about different farming system and maintenance of farms
- Impart knowledge and update about the recent developments in combating pathogenic diseases and its management
- Explain the nutritional requirements of fish and fish feed formulations
- Provide essential knowledge and skills regarding biotechnological tools for enhanced fish production
- Explore on the diverse commercially important cultivable fishes
- Illustrate the different challenges for seed production and hatchery management
- Develop the knowledge on seaweed cultivation and its economic values

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Know about the importance of fisheries and aquaculture resources for ensuring the food security and improving the livelihood which would lead to the development of blue economy of the country	K4
CO2	Learn how to manage a fish farm and realize his/her role in aquaculture enterprises, aquaculture consultancy and aquaculture related research	K2, K5
CO3	Enrich his/her knowledge in nutritional value of the fishes as it has an effective contribution in addressing multiple micronutrient deficiencies of poor people in developing countries	K2, K6
CO4	Develop as an entrepreneur through learned throughput techniques involving in aquaculture.	K4, K6
CO5	Understand the significance of live feed and the importance of induced breeding of several important aquaculture species for year around supply of seeds for farming practices	K2, K6

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to aquaculture** **8 Lectures**	History of aquaculture - classification of cultivable species - freshwater - brackish water and marine. Present global and national scenario. Culture and socio-economic basis. Water quality parameters - pH - salinity - temperature - ammonia - nitrate - nitrite etc. Sources of pollution and conflicts of different farming systems - extensive - semi-intensive - intensive - pond culture - pen culture - cage culture - monoculture, polyculture and integrated culture systems.
Unit II **Aquaculture and Nutrition** **10 Lectures**	Criteria for selection of site for hatchery and fish farm (culture) for fresh water and brackish water farms - construction of ponds and farming practices. Prawn and shrimp culture - (*Macrobrachium rosenbergii*, *Litopenaeus vannamei* and *Penaeus monodon*). Culture of Indian major carps - culture of pearl oyster and lobster. Nutrition and feed - nutritional requirements of cultivable finfish (Rohu, Mrigal and Catla) - shellfish - immunostimulants. Feed ingredients and their composition - feed formulation and preparation - forms of formulated feeds. Types of feeds - wet feed - moist feed - dry feed - mashes - pelleted feeds - floating and sinking pellets - microencapsulated diets. Live feeds (Artemia, Rotifers and live microalgae feed for hatchery) - advantages and disadvantages of live and artificial feed - anti-nutritional factors. Feed additives - binders - antioxidants - enzymes - pigments - growth promoters and feed stimulants - use of preservatives.
Unit III **Aquaculture biotechnology and Health management** **10 Lectures**	Cryopreservation of gametes - monosex culture - sex reversal - super males - transgenic fish - Genetically Improved Farmed Tilapia (GIFT). Fish breeding - types - induced breeding - cross breeding and selective breeding. Factors affecting fish breeding. Diseases and management in aquaculture - disease problems - important diseases caused by protozoan - bacteria and viruses. General preventive methods and prophylaxis against the disease. Nutritional and ecological diseases. Role of probiotic and prebiotics in aquaculture.
Unit IV **Introduction to fisheries** **5 Lectures**	Fisheries - scope and types of fisheries - fisheries resources of India - FAO's code of conduct of responsible fisheries. Seaweed – types - culture and types of seaweed cultivation - economical value of seaweed. Different types of crafts and gears - use of modern techniques and equipments for finding and capturing fish. Application of remote sensing in fisheries.
Unit V **Capture fisheries** **7 Lectures**	Inland and marine fisheries. Fisheries in major riverine systems - estuaries - reservoirs and lakes of India. Principal capture fisheries of India - fisheries regulations - factors affecting marine fisheries - constrain in capture fisheries. Fisheries extension - objectives and principles. Role of Fisheries institutes and

	authorities in India – Indian Council of Agricultural Research (ICAR) - Central Institute of Fisheries Education (CIFE) - Central Institute of Freshwater Aquaculture (CIFA) - Central Marine Fisheries Research Institute (CMFRI) - Central Institute of Brackishwater Aquaculture (CIBA) - National Fisheries Development Board (NFDB) - National Bureau of Fish Genetic Resources (NBFGR) - Central Institute of Fisheries Technology (CIFT) and Marine Products Export Development Authority (MPEDA).
Current Contour	Precision fish farming - introduction and scope - different elements and industrial applications of precision fish farming. Aquaponics - an overview of aquaponics - system components and types - benefits and limitations of aquaponics.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	M	S	S	S	S
CO2	S	M	S	S	S	L	S	S	S	S
CO3	M	S	M	S	M	L	S	S	S	M
CO4	M	M	M	S	S	S	M	S	S	S
CO5	S	M	S	M	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Pillay TVR. 2005. Aquaculture: Principles and Practices. (II Ed.). Wiley-Blackwell.
2. Halver JE. 1989. Fish Nutrition. Academic Press, San Diego, CA.
3. Srivastava CBL and Srivastava S. 2016. A Textbook of Fishery Science and Indian Fisheries. Kitab Mahal Publ.
4. Singh B and Dey A. 2017. Fish and Fisheries. Invincible Publ.
5. Gupta N and Gupta DK. 2015. Fisheries and Aquaculture. Discovery Publ. House.
6. Jhingran VG. 2007. Fish and Fisheries of India. Hindustan Publ. Corporation (India) New Delhi.
7. Felix S. 2007. Molecular Diagnostic Biotechnology in Aquaculture. Daya Publ. House.
8. Ribelin WE and Miguki G. 1975. The Pathology of Fishes. The Univ. of Wisconsin Press Ltd, Great Russel Street, London, UK.
9. Khanna SS, Singh HR. 2014. Text Book of Fish Biology and Fisheries. (III Ed.). Narendra Publ. House.
10. Krishnaveni G, Veerabh N, Veeranjeneyulu K. 2016. Recent Technologies in Fish and Fisheries. Rigi Publ.

Related Online Contents:

Aquaculture developments trends

1. http://www.fao.org/docrep/003/ab412e/ab412e16.htm

Precision Fish farming

2. https://www.sciencedirect.com/science/article/pii/S1537511017304488#sec5

Aquaponics

3. https://www.nal.usda.gov/afsic/aquaponics
4. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/live-feeds

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SEMESTER - II

REPRODUCTIVE TECHNOLOGY (Major Elective - I)

Course Code	22ZOOME22	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic knowledge on biology of reproduction								

Course Objectives:

- Describe the basic structure and functional mechanism of reproductive system
- Explain the hormonal regulation and feedback mechanism in reproduction
- Analyze the reproductive abnormalities and their impact
- Create awareness on reproductive diagnosis
- Illustrate the significance of micromanipulation techniques
- Analyze and identify the neonatal risk assessment
- Discuss the ethical legal issues related to Assisted Reproductive Technologies

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the male and female reproductive system and their functional mechanism	K1, K2
CO2	Summarize the anatomical and physiological importance of endocrine glands in reproduction	K2, K7
CO3	Assess the effective diagnostic procedures for examining the reproductive complications	K4, K7
CO4	Understand the acquired knowledge about reproductive disorders and list the various reproductive diagnostic techniques to manage the infertility problem	K2
CO5	Explain the new born error and their follow-up and create awareness on the principles and ethics of third party reproduction	K4, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Anatomy and functional mechanism of reproductive system** **6 Lectures**	Anatomy - functions of male and female reproductive system - reproductive cycle - menstrual phase - pre and post ovulatory phase - ovulation - mechanism of fertilization - molecular aspects of implantation.
Unit II **Reproductive endocrinology** **8 Lectures**	Anatomy of endocrine glands and hormones - basic mechanism of hormone action - endocrine interrelations - neuroendocrine reflexes (feedback mechanisms). Hormones - gonadotropins - prolactin - melatonin - estrogen - progesterone - testosterone - Thyroid Simulating Hormone (TSH) - cortisol - Dehydroepiandrosterone (DHEA). Hormonal regulation – pregnancy - parturition and lactation - pubertal changes - menopause and andropause.
Unit III **Reproductive disorders and Therapeutic approach** **8 Lectures**	Sexual differentiation and developmental abnormalities - male and female reproductive disorders - precocious - delayed or absent puberty. Amenorrhea - endometriosis - fibroids - congenital anomalies - Polycystic Ovary Syndrome (PCOS) - unexplained infertility - recurrent pregnancy losses - implantation failure and labour abnormalities. Hyperprolactinemia. Drug therapy - danazol - progestins - GnRH - agonist - combination oral contraceptives and aromatase inhibitors. Umbilical cord blood and stem cells regeneration therapy.
Unit IV **Clinical diagnosis and Micromanipulation technique for infertility** **10 Lectures**	Transvaginal sonography - scrotal sonography - transrectal sonography - sonohysterography – adenomyosis - color doppler imaging - sonosalpingography and falloposcopy. Micromanipulation techniques **–** *In vitro* Fertilization **(**IVF) - Intra Cytoplasmic Sperm Injection (ICSI) - Embryo Transfer (ET) - Gamete Intra Fallopian Transfer (GIFT) - Frozen Embryo Transfer (FET) - Zygote Intra Fallopian Transfer (ZIFT) - Peritoneal Ovum and Sperm Transfer (POST) - test tube babies - reproductive cloning and surrogacy.
Unit V **Neonatal diagnosis and Ethical legal issues** **8 Lectures**	Screening test - counselling - follow-up and management. Ethical issues - creation - selection - disposal of embryos - coverage and access. Counselling in Assisted Reproductive Technology (ART) - understanding of third-party reproduction - sperm - oocyte and embryo donor.
Current Contour	Case study - pedigree analysis - Sib pair linkage analysis - biomimetic sperm selection - analysis of pre ovulatory changes - Point of Care (POC) - Surrogacy (Regulation) Act, 2021.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	M	M	S	M	S	M	M
CO2	M	M	M	M	M	S	M	S	S	M
CO3	M	S	S	S	S	S	S	L	S	S
CO4	S	S	M	S	S	M	S	M	S	S
CO5	L	M	M	S	M	M	S	L	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Richard EJ. 1983. Human Reproductive Biology. (II Ed.). Academic press, New York.
2. James EG and Sergio RO. 1992. Text book of Endocrine Physiology. Oxford University Press.
3. Strauss JF, Barbieri RL and Gargiulo AR. 2018. Yen and Jaffe's Reproductive Endocrinology: Physiology, Pathophysiology and Clinical Management. (VIII Ed.). Amsterdam - Elsevier.
4. Kamini AR. 2009. The Infertility Manual. (II Ed.). Jaypee Publ. India.
5. Gerris J, Olivennes F and De Suter P. 2004. Assisted Reproductive Technologies. Taylor and Francis, London and New York.
6. Chakravarty BN. 2019. Clinics in Reproductive Medicine and Assisted Reproductive Technology. CBS Publ.
7. Rajender S. 2019. Molecular Signaling in Spermatogenesis and Male Infertility. CRC Press.
8. David KG, Ariel W, Colin MH, Zeev S. 2018.Textbook of Assisted Reproductive Techniques. CRC Press.
9. Nayana HP. 2020. Advances in Assisted Reproductive Technology. Jaypee Publ.
10. Samuel SC, Yen MD, Robert BJ, Jerome FS, Robert LB. 1999. Reproductive Endocrinology: Physiology, Pathophysiology, and Clinical Management. (IV Ed.). Saunders.

Related Online Contents:

1. https://onlinelibrary.wiley.com/doi/full/10.1002/fsn3.2523
2. https://www.who.int/reproductivehealth/topics/rtis/pocts/en/

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SEMESTER - II

ANIMAL BEHAVIOUR (Major Elective - I)

Course Code	22ZOOME23	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic knowledge about behaviour of animals								

Course Objectives:

- Classify the different types of behavior
- Discuss the different parameters used to evaluate the behaviour
- Illustrate the different sampling methods for different behaviour in population
- Integrate the communication signals and response in different category
- Compare the types of signals and mode of transmission for finding the food, shelter, foraging, and mating
- Explain the social behaviour and its role in anti-predators
- Design and develop the procedure for sampling the data and analysis

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Interpret the animal behavior with social context	K2
CO2	Describe the factors which influence their Dispersal and migration	K2
CO3	Summarize the characteristics of the mate selection for maintaining their community's genetic diversity	K2, K7
CO4	Discuss about the different types of parental care	K2, K4
CO5	Integrate the neuronal regulation of behavior, learning, memory and cognition	K2, K5

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **History of animal behaviour** **6 Lectures**	Founders of ethology - history and development - learned vs innate behaviour - instincts conditioning - habituation and reinforcement. Measuring behaviour - states and events. Measures of behaviour - sampling methods and constructing ethograms.

Unit II **Animal communication** **6 Lectures**	Modes of communication - advantages and disadvantages - functions of communication - types of signals. Finding food - foraging strategies - generalists vs specialists - marginal value theorem and patch residence time. Finding shelter - habitat selection - territoriality - dispersal and migration.
Unit III **Mating systems** **5 Lectures**	Mating behaviour - finding mates - male-male competition - sexual selection by female choice. Avoiding predators - antipredator behaviour - prey-predator interactions - red queen hypothesis.
Unit IV **Parental care** **7 Lectures**	Adaptive value - asymmetry in parental investment - offspring recognition - brood parasitism - parent-offspring conflict. Social behavior - animal societies - costs and benefits of group - living - cooperation and conflict - Kin-selection and inclusive fitness.
Unit V **Neuroethology and Behavioral genetics** **6 Lectures**	Development of behaviour - processing of sensory information - hormonal control of behaviour - learning - memory and cognition.
Current Contour	Technologies to observe animal behaviour and researches focusing on population studies and conservation of endangering and endemic species.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	S	M	M	S	M	M	S	L	L
CO2	M	M	S	L	M	S	M	M	S	S
CO3	M	S	S	S	S	S	M	M	M	S
CO4	M	S	S	S	S	S	M	M	S	S
CO5	L	M	M	S	S	S	M	S	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Alcock J. 2005. Animal Behaviour: An Evolutionary Approach. (VIII Ed.). Sinauer Associates, Inc.
2. Davies NB, Krebs JR and West SA. 2012. An Introduction to Behavioural Ecology. (IV Ed.). Wiley-Blackwell Publ.
3. Cloudsley - Thompson. JL. 1961. Animal Behaviour. McMillan Publ.
4. Tinbergen N. 2014. Social Behavior in Animals with Special Reference to Vertebrates. Martino Fine Books.
5. Shukla JP. 2021. Fundamentals of Animal behavior. Atlantic Publ.

6. Simmons P and Young D. 2010. Nerve cells and Animal Behaviour. Cambridge University Press.
7. Morgan CL. 2019. Animal behavior. Alpha Edition.
8. Manning A and Dawkins MS. 2016. An Introduction to Animal Behaviour. (VI Ed.). Cambridge University Press.
9. Agarwal VK. 2010. Animal Behaviour (Ethology). S Chand Publ.
10. Avital E and Jablonka E. 2000. Animal Traditions: Behavioural Inheritance in Evolution. Cambridge University Press.

Related Online Contents:

1. https://www.stlzoo.org/about/blog/2018/06/11/eyes-dont-have-it-using-technology observe-animal-behavior
2. https://www.sciencedirect.com/science/article/abs/pii/S0003347200916063
3. https://digitalcommons.unl.edu/libphilprac/4897/
4. https://www.jstor.org/stable/24101536
5. https://www.cabdirect.org/cabdirect/abstract/20093233129

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SEMESTER - II

SERICULTURE TECHNOLOGY (Non - Major Elective - I)

Course Code	22ZOONME21	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	2		
Pre-requisite	Basic knowledge and importance of sericulture								

Course Objectives:

- Understand essential fundamentals and scope of sericulture
- Emphasize research and extension activities by several Sericulture boards
- Demonstrate modern scientific technologies in moriculture and sericulture
- Familiarize the commercial races and its breeding technology
- Describe the basic and modern rearing technologies and their significance
- Analyze the cocoon reeling strategies and its marketing management
- Illustrate various practical problems in diseases and pest management

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOME	KNOWLEDGE LEVEL
CO1	Acquire fundamental and basic principles in sericulture	K1, K2
CO2	Knowledge on current research and extension activities	K2, K6
CO3	Understand the efficiency of modern scientific reeling technology	K2, K5
CO4	Know the commercial races and its rearing practices	K2, K3
CO5	Analyze various practical problems of disease control in sericulture	K4, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **History of sericulture and Research institutes** **6 Lectures**	History and importance of sericulture - silkroad. Institutes and organizations - Central Silk Board (CSB) - Central Sericultural Research and Training Institute (CSR & TI) - National Silkworm Seed Project (NSSP) - Central Sericultural Research and Training Institute (CSTRI) - Silkworm Seed Technology Laboratory (SSTL) - aims and Scope. Mulberry varieties in India - cultivation methods - propagation and maintenance - harvest and storing.

Unit II **Races, Morphology and Life cycle of silkworm** **6 Lectures**	Silk production in world and India - Silk producing organisms - non-mulberry and mulberry varieties. *Bombyx mori* - external morphology - silk gland proteins and life cycle. Indigenous and exotic races of *B. mori* - voltinism (uni, bi and multivoltine) - hybridization techniques.
Unit III **Grainage technology and Rearing of silkworm** **6 Lectures**	Breeding stations - grainage and its importance - storage and transport of eggs. Rearing facilities - rearing appliances. Harvesting methods - types - advantages and disadvantages.
Unit IV **Cocoon marketing and Silk reeling** **6 Lectures**	Cocoon characteristics - marketing methods. Reeling - types - reeling appliances - advantages and disadvantages. Re-reeling. Silk testing - methods and advantages. By-products of sericulture.
Unit V **Diseases and pests of mulberry and *Bombyx mori*** **6 Lectures**	Mulberry diseases - fungal (Root rot: *Rosellinia necatrix* - Stem canker: *Botryodiploida theobromae*; wilt disease - Leaf disease: *Phyllactinia corylea*) - bacterial (*Pseudomonas mori*) - viral (mosaic - ring spot - dwarf disease) - nematode (*Meloidogyne incognita*) and deficiency diseases. Pests of mulberry - leaf eating - sap feeders - borers and its control measures. Diseases of *Bombyx mori* - protozoan (pebrine - *Nosema bombycis*) - bacterial (Flacherie - *Bacillus bombycis* - Septicemia) - viral (IFV-Infectious Flacherie Virus - Gattine; Grasserie) - fungal (*Beauveria bassiana*) and adult moth disease (*Aspergillus flavus*) and control measures. Pests of *Bombyx mori* - Uzi fly - *Dermestid beetles* - *Pedicolus ventricosus* - ants - nematodes and other vertebrates.
Current Contour	Research activities - rearing and reeling advancements - collaborators - training centres and facilities.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	M	S	L	S	S	S	M
CO2	S	S	M	S	S	M	S	S	S	S
CO3	M	L	S	S	S	M	L	S	S	M
CO4	M	L	M	S	S	M	S	S	S	S
CO5	S	S	M	S	S	M	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Ganga G and Sulochana CJ. 2021. An introduction to Sericulture (II Ed). Oxford and IBH Publishing Co. (P) Ltd. New Delhi.
2. FAQ of United Nations. 1987. Silk Worm Rearing. (Volume- II-15/2), Rome.
3. Manjeet SJ. 1987. Appropriate Sericulture Techniques, CSRTI, Mysore.
4. Ullal and Narsimhanna. 1981. Hand Book of practical sericulture, CSB, Bangalore.
5. Srinivas P and Ramadevi. 2001. Silkworm Morphology and Seed Technology, SIVE, DIE, Hyderabad.
6. Srinivas P and Ramadevi. 2003. Non-Mulberry Silkworms and Mulberry Rearing Requirements SIVE, DIE, Hyderabad.
7. Krishnaswamy S. 1990. New Technology of Silkworm Rearing, CSB, Bangalore.
8. Hisao A. 1994. Principles of Sericulture. Oxford & IBH Publishing Co. (P) Ltd., New Delhi.
9. Ramakrishna Iyyar TV. 1984. Handbook of Economic Entomology for south India. New Delhi. International Books & Periodicals Supply Service.
10. NCERT. 1990. Sericulture Instructional cum Practical manual, Vol.II, New Delhi.
11. Tazima. 1992. Hand Book of Silkworm Rearing, Agriculture Technical Manual-1, Fuji Publishing Co. Ltd., Japan.
12. CSB. 1997. New Illustrated Sericulture Reader, Bangalore.

Related Online Contents:

1. http://www.csrtimys.res.in/sites/default/files/ebooks/2019-1.pdf
2. https://www.academia.edu/7988066/1_SILK_REELING
3. https://infonet-biovision.org/AnimalHealth/Mulberry-Silkworm
4. https://silks.csb.gov.in/coochbehar/wp-content/themes/common_district/coochbehar/dpm-frame2.html
5. https://digitallibrary.un.org/record/167892/files/ST_ESCAP_888-EN.pdf

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SEMESTER - II

ANIMALS ON COMMERCIAL INTEREST (Non - Major Elective - I)

Course Code	22ZOONME22	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	2		
Pre-requisite	Basic knowledge on commercial animals								

Course Objectives:

- List out the economically important farm animals
- Summarize the importance of farm products in Indian economy
- Apply the modern rearing technologies and their advantage
- Illustrate the advantage of vermicompost than chemical fertilizer
- Design the value-added dairy products to enhance farmer's economy and public health
- Develop the skill for the prediction and forecast of disease outbreak in poultry farming
- Explain the importance of integrated farming

Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the economic importance of different farming practices	K2
CO2	Identification of suitable farming based on the local environment and marketing	K2
CO3	Develop the skill for self-employment in sericulture, apiculture, and poultry farming	K4, K6
CO4	Appraise in implementing, practicing organic farming and its importance	K3, K4
CO5	Summarize the advantage of integrated farming	K2, K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Livestock in Indian economy** **6 Lectures**	Basic concepts - role of livestock in economy and poverty alleviation. Enterprise integration - agriculture and livestock - livestock and agrarian scenario - trends in numbers - growth - composition and exports and imports. Entrepreneurship in livestock - institutional structure in livestock production. Processing and marketing - co-operatives - contract farming and self-help groups. Case studies - success and failures - from the state - country and other countries.

Unit II **Sericulture and Apiculture** **6 Lectures**	Types of silk - species of silkworms and their host plants - mulberry silk worm culture - agricultural aspects of mulberry plant cultivation - extraction and reeling of silk. Diseases of silkworm and their control. Cost-benefit analysis of sericulture. Species of honey bees in India - life history of Apis - apiculture technique - bee products and their uses. Diseases of honey bee and their control - cost-benefit analysis of apiculture.
Unit III **Vermiculture** **6 Lectures**	Earthworms - classification - morphological and anatomical characteristics - reproduction. Ecological groups of earthworms. Vermicompost - characteristics and advantages. Vermicomposting - principle - participating organisms - process and required physical conditions. Acquiring skill of identification of worms. Application of vermicomposting in agricultural and horticultural practices. Microbes and earthworms. Economics of vermiculture.
Unit IV **Dairy and dairy breeds** **6 Lectures**	Scope of dairy farming - dairy breeds of India - breeding and management of sheep - goat - cows - buffaloes - exotic cows - systems of breeding. Live-stock diseases - viral - fungal - bacterial diseases. Dairy technology and marketing - milk - composition and nutritive value - pasteurization and spoilage of milk - techniques to detect milk adulteration. Value added milk products.
Unit V **Poultry farming** **6 Lectures**	Poultry breeds (fowl) - types of breeds. Diseases - types - pathogens - symptoms and control measures. Poultry industry in India - a survey - choosing commercial layers and broilers. Poultry housing - the deep litter system - cage rearing - cost-benefit analysis. Emu farming in India and current status.
Current Contour	Recent trends and future prospects - technologies for integrated and sustainable farming in India.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	S	S	M	S	S	L	M
CO2	S	M	M	S	S	S	M	M	M	M
CO3	M	M	M	S	S	M	M	S	M	S
CO4	S	M	M	M	M	S	M	M	L	S
CO5	M	M	M	L	S	L	M	L	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Ganga G and Sulochana Chetty J. 2021. An Introduction to Sericulture (II Ed.). Oxford and IBH Publishing Co. (P) Ltd. New Delhi.
2. FAO. 1972. Sericulture Manual: Vol III - Silk Reeling. FAO Agricultural Services Bulletin 15/3, FAO, Rome.
3. Ranganathan LS. 2006. Vermicomposting Technology - From Soil health to Human Health. AgroBios.
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5. Sasting NSR and Thamas CK. 1976. Farm Animal Management. Vikas Publishing House Publ.
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7. David Vasantharaj B and Ramamurthy VV. 2016. Elements of Economic Entomology. (VIII Ed.). Brillion Publ.
8. Dayib M. 2018. A Text-book of Economic Entomology (ebook). Somali Natural Resource Research Centre.
9. Das D, Das BC and Nayak N. 2021. Text Book on Poultry Management. Narendra Publ. House.
10. Gaur HK. 2018. Dairy, Livestock and Poultry Farm Practices. Random Publ.
11. Yadav DS. 2017. Organic Agriculture Practices: A Training Manual. Westville.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935116/
2. https://www.fao.org/animal-production/en
3. https://assets.publishing.service.gov.uk/media/57a08cac40f0b6497400136c/PPLPIwp10.pdf
4. https://www.frontiersin.org/articles/10.3389/fsufs.2020.00113/full
5. https://www.fao.org/3/u7600t/u7600T07.htm

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SEMESTER - III

CORE XVIII: GENERAL MICROBIOLOGY

Course Code	22ZOOC31	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Basic knowledge in microbiology								

Course Objectives:

- Explore the fundamental concepts, history and development of microbiology
- Enumerate the classification of microorganisms and their nutritional requirements
- and factors affecting their growth
- Understand the classification and physiology of different microorganisms
- Enable the students to learn the concepts of mutation and related bacterial genetics
- Educate the students to understand the tools and techniques in genetic engineering
- Learn how the microorganisms can be utilized for industrial products
- Signify and associate the role of microorganisms in recombinant technology

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Relate the basic understanding on taxonomical classification of microbes	K2
CO2	Compare the impact of microbes in life at the individual and ecological levels.	K4
CO3	Understand the different aspects of microbial genetics and its applications	K2
CO4	Learn to apply the principles of genetic engineering through microbes for the betterment of nature	K6
CO5	Gain knowledge on patents in new products and methods	K6

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Fundamentals of microbiology** **8 Lectures**	Brief history of microbiology - theory of spontaneous generation - germ theory of diseases - Koch's postulates - contribution of Leuwenhoek - Louis Pasteur - Robert Koch - Edward Jenner - Joseph Lister - Winogradsky - Waksman and John Tyndall. Scope of microbiology - salient features of different groups of microorganisms - bacteria - fungi - protozoa - algae - morphological features - mode of reproduction and cell cycle. Microbial interaction - mutualism - commensalism - synergism -

	parasitism - predation and competition - classification of biomedically important bacterial species.
Unit II **Microbial classification and Physiology** **7 Lectures**	Whittaker's five kingdom concept - Carl Woese's three domain concept - classification of bacteria according to Bergey's Manual of Systemic Bacteriology (a brief account). Structure of bacterial flagella - pili - gas vesicles - magnetosomes - capsule - slime - cell inclusion and endospores. Membrane structure and function - microbial growth - measurement of cell growth and numbers - factors affecting microbial growth - bacterial reproduction and growth - nutritional requirements and nutritional types of bacteria.
Unit III **Microbial genetics and Genomics** **9 Lectures**	Nuclear materials (DNA and RNA) - transduction (generalized and specialized transduction) - conjugation (discovery and mechanism). Bacterial transformation - mutation - reverse mutation - back mutation - suppressor mutation - advantage and application of mutation. Microbial genomics - genome project of *Escherichia coli* and yeast. Metagenomics evolutionary significance - applications in industry - medicine and environmental management. Microbial control - physical and chemical agents.
Unit IV **Agricultural microbiology** **8 Lectures**	Biofertilizers - history - source and significance - characteristics of biofertilizers - Rhizobium - Acetobacter - Azospirillum - Bluegreen algae - Azolla - strain selection - sterilization and quality control - applications and commercialization. Pest control (bio pesticides and bio insecticides). Genetically modified microorganisms. Bioremediation - principles and applications.
Unit V **Industrial microbiology and Intellectual property** **8 Lectures**	Fermentation - history - overview - isolation - screening - bioreactor - design and components - types of reactors - lab scale to industrial scale up process - down process - process of industrial fermenters - product purification - types of purification - end product - waste processing. Screening of microbial culture - primary and secondary metabolites of microbes. Microbial based production of alcohol - antibiotics (Penicillin, cephalosporins, chloramphenicol, tetracyclines and streptomycin) - dairy products - cheese and yogurt, organic acids (Lactic acid and citric acid) - vitamins (Vitamin B12 and β-carotene) and industrial enzymes (Amylase and proteinase). IPR - introduction - importance of patenting (biological materials, implication of patenting and issues) - copyright and trademarks.
Current Contour	Space microbiology - an overview - monitoring of astronaut's microbial flora. Effects of microgravity. Life detection methods a) Evidence of metabolism (Gulliver) b) Evidence of photosynthesis (autotrophic and heterotrophic).
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	M	S	M	S	L	S
CO2	S	M	S	S	M	S	S	S	S	M
CO3	M	S	S	M	S	M	S	S	S	S
CO4	S	M	L	S	S	S	S	M	M	S
CO5	M	M	S	S	S	M	M	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Atlas RM. 1987. Microbiology: Fundamentals and Applications, MacMillan, USA.
2. Madigan MT, Martink MJ, Bender KS, Buckley DH and Stahl DA. 2017. Brock's Biology Microorganisms. (XIV Ed.). Pearson Publ.
3. Prescott LM, Harley JP and Klein DA. 2004. Microbiology. (VI Ed.). McGraw-Hill Publ. New York.
4. Schlegal HG. 2006. General Microbiology. (VII Ed.). Cambridge University Press.
5. Tortora GJ, Funke BR and Case CL. 2019. Microbiology - An Introduction. (XII Ed.). Pearson Publ.
6. Kreig NR. 1984. Bergey's Manual of Systematic Bacteriology. Vol I: Sneath PHA (Ed.). 1986, Vol II: Staley JT (Ed.). 1989, Vol III: William ST (Ed.). 1989, Vol IV: William and William, Baltimore.
7. Moat AG and Fosters W. 2011. Microbial Physiology. (IV Ed.). Wiley India Pvt Ltd.
8. Brown TA. 2016. Gene Cloning and DNA Analysis: An introduction (VII Ed.). Wiley-Blackwell Publ. USA.
9. Glick BK and Patten CK. 2017. Molecular Biotechnology: Principles and Applications of Recombinant DNA. (V Ed.). Taylor and Francis.
10. Neelima R and Dilip Kumar M. 2006. Agricultural Applications of Microbiology. APH Publ.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2832349/
2. https://www.nasa.gov/sites/default/files/files/Microbial-Observatory-Mini-Book-04-28-14-508.pdf
3. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1086.2035&rep=rep1&type=pdf
4. https://www.frontiersin.org/articles/10.3389/fgene.2015.00348/full

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SEMESTER - III

CORE XIX: BIOLOGY OF IMMUNE SYSTEM

Course Code	22ZOOC32	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Fundamental knowledge in antigen, antibody and immune response								

Course Objectives:

- Classify and emphasize the importance of immune system
- Summarize the salient features of antigens, antibodies, and their interaction
- Illustrate the diversity of the complement system and their roles in host defense mechanism
- Connect the pathogenic infection with activation of immune signaling.
- Explain the role of cytokines in the suppression of antigen action
- Summarize the mechanism and emergence of spectrum of autoimmune diseases
- Illustrate the principles in techniques involved in qualitative and quantitative analysis of antibody, antigen and antigen-antibody complex.

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the types of antigens, antibodies, and their interaction using models and miniatures etc.,	K2
CO2	Classify the haplotypes of HLA and its clinical implications	K5
CO3	Explain the complement system in detail and also distinguish the first line of defense and cell-mediated immune response against the pathogens	K5
CO4	Reveal the knowledge on how to clear the pathogens from the host immune system	K4
CO5	Analyze and interpret which type of cytokine may influence the disease outcome	K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Outlines of immunology** **8 Lectures**	Historical perspectives and overview of immune system - invertebrate immune system - GPCRs in innate immunity - immune system from self/non-self-evolution of immune system – antimicrobial - DNA/RNA/histone in immunity - immunosenescene. Innate and acquired immunity - humoral and cell mediated

	immunity - active - passive and adaptive immunity - idiotypic network. Organs and cells involved in immune responses - central and peripheral lymphoid system - hemopoietic stem cells - macrophages - B and T lymphocytes - dendritic cells - natural killer (NK) cells and haematopoiesis. Immunological memory - differentiation of lymphocytes - lymphocyte trafficking - clonal selection theory.
Unit II **Antigens, antibodies and complements** **8 Lectures**	Antigens - structure - types and function of antigen - requirements for antigenicity and immunogenicity. Immunoglobulins - structure - types - antibody specificity - regional variation of antigen binding site - CDRs - function - immunoglobulin genes - Ig gene rearrangement - abzymes - antibody engineering. Antigen-antibody interaction - nature of the antigen-antibody interaction - primary and secondary bonds - precipitation - agglutination - agglutination inhibition - important features of soluble and membrane bound antibodies. Complement system - biological role of complement components - sequential proteolytic cascade - complement activation - classical - alternative and lectin pathways.
Unit III **Immune response** **8 Lectures**	Immunity to infection - immunity to pathogens such as bacteria - viral - fungal and parasitic infection. Hypersensitivity reactions - type I - II - III and IV. Cell mediated immune response - primary and secondary response - phagocytosis - role of T cells - macrophages and NK cells - subtypes of T cell and their functions - cytotoxic T cells - helper T cells - suppressor T cells and regulatory T cells. Cell mediated cytotoxicity - T cell receptor - activation and regulation. Chemokine and cytokine - structure - types - biological role. Apoptotic regulation in antigen elimination - non-specific immunity. MHC and its significance - class I and class II MHC in antigen processing and presentation.
Unit IV **Autoimmune diseases and Immunologic disorders** **8 Lectures**	Autoimmune diseases - spectrum of auto immunes diseases - mechanism - rheumatoid arthritis - psoriasis/psoriatic arthritis - multiple sclerosis - Systemic Lupus Erythemotsus (SLE) - inflammatory bowel disease - Addison's disease - Graves's disease - Sjogren's syndrome - Hashimoto's thyroiditis - Myasthenia gravis - autoimmune vasculitis - treatment for autoimmune diseases. Immunologic disorders - immune deficiency diseases - congenital and acquired immunodeficiency diseases - immuno-prophylaxis and immunotherapy.
Unit V **Immunotechnology** **8 Lectures**	Immunological techniques - one- and two-dimensional single radial immunodiffusion - Ouchterlony immunodiffusion - Rocket Immunoelectrophoresis (RIEP) - Enzyme Linked Immuno-Sorbent Assay (ELISA) - hybridoma technology and monoclonal/polyclonal antibody production. Transplantation immunology - tissue matching - serotyping and HLA typing by polymerase chain reaction -

	Sequence-Specific Primers (PCR-SSP) and direct sequencing.
Current Contour	Recent investigations on host - pathogen and environment interactions - knowledge on reverse vaccinology.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	L	S	S	L	S	M	M	M	S
CO2	M	L	S	S	S	S	M	M	M	M
CO3	S	M	S	M	S	S	S	S	M	S
CO4	M	S	S	M	S	S	S	M	M	M
CO5	S	L	M	M	M	S	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Jenni P, Sharon AS, Patricia PJ and Judith AO. 2018. Kuby's Immunology (VIII Ed.). W.H. Freeman and Company, New York.
2. Rao CV. 2017. Immunology: A Textbook. (III Ed.). Alpha Science International, Limited, UK.
3. Abul KA, Andrew HL and Shiv P. 2017 Cellular and Molecular Immunology. (X Ed.). Elsevier –Asia Ed.
4. Delves PJ, Martin SJ, Burton DR and Roitt IM. 2016. Roitt's Essential Immunology. (XIII Ed.). Wiley-Blackwell Publ. UK.
5. Rich RR, Fleisher TA, Shearer WT, Schroeder Jr, HW, Frew AJ and Weyand CM. 2012. Clinical immunology: Principles and Practice. (IV Ed.). Elsevier Health Sciences.
6. Cruse JM and Lewis RE. 2013. Atlas of Immunology. Springer Science & Business Media.
7. Parham P. 2014. The Immune System. Garland Science.
8. Alyaa AF. 2015. Immune system structure and function. Scholars' Press.
9. Charles AJ, Paul T, Mark W and Mark JS. 2001. Immunobiology. (V Ed.). Garland Science.
10. Philipp D. 2021. Immune: The Journey into the mysterious system that keeps you alive. Hodder & Stoughton.

Related Online Contents:

1. https://www.ebi.ac.uk/ipd/imgt/hla/
2. https://currentprotocols.onlinelibrary.wiley.com/doi/10.1002/0471142735.im0629s61

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SEMESTER – III

CORE XX: ANIMAL PHYSIOLOGY

Course Code	22ZOOC33	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Basic knowledge in general physiology								

Course Objectives:

- Demonstrate the musculoskeletal system and their functional role among the animals
- Compare and integrate the gaseous exchange and circulation in different organisms
- Differentiate the feeding habits and their metabolic process in vertebrates
- Assess the evolutionary significance of renal function of vertebrates in different habitats.
- Describe the development of genital organs and their hormonal role in reproduction
- Summarize the sensory physiology and their role in chordates
- Illustrate the neuromuscular system and its integration in vertebrates

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Discuss the musculoskeletal system and their mechanisms	K1, K2
CO2	Interpret the mechanism involved in respiration and circulation of various physiological process	K2, K4
CO3	Discuss about the endocrine regulatory mechanism and various nutritive habits and their regulatory process	K2
CO4	Elucidate the renal and reproductive regulations	K6
CO5	Differentiate the neurons and its neurotransmitter regulations.	K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Musculoskeletal system** **8 Lectures**	Skeletal system - skull - vertebral column - thoracic cage - axial system - appendicular skeleton (pectoral and pelvic girdle, bones of upper and lower limb) and joints (classification of joints, fibrous, cartilaginous and synovial joints) - types of body movements. Muscular system - mechanism of muscle contraction and relaxation - molecular and neuronal control of skeletal muscles.
Unit II **Respiratory and Circulatory system**	Mechanism and regulation of respiration - transport of gases (Co_2 / O_2 - oxygen dissociation curve) - hypoxia - physiology of high altitude - atmospheric pressure. Circulatory system - composition and function of blood - plasma protein - hemoglobin - erythrocytes - leucocytes - platelets - coagulation of blood - lymphoid tissues and lymph. Conduction and regulation of heart beat. Cardiac cycle - Electro Cardio Gram (ECG).
Unit III **Endocrine system and Digestive system** **10 Lectures**	Endocrine system - structure and function of pituitary gland - thyroid - parathyroid - adrenal - pancreas - thymus and pineal gland. Digestive system - anatomy of gastrointestinal tract (GIT) - physiology of salivary secretion - mouth - esophagus - pancreas - liver and gall bladder - small and large intestine. Digestion and absorption - hormones in GIT.
Unit IV **Excretory and Reproductive system** **8 Lectures**	Excretion - anatomy of kidney - mechanism and formation of urine - regulation of volume and concentration of body fluids - biochemical mechanism - flow - ultrafiltration - reabsorption and secretion. Hormonal regulation and detoxification pathways. Reproduction - physiology of reproduction - male and female reproductive system - secretion of endocrine glands - mechanism and regulation of hormones (male and female) pregnancy - foetus development - parturition and lactation.
Unit V **Nervous and Sensory system** **8 Lectures**	Structure of brain - organization of nervous system – reflexes - neural transmission - sleep. Sensory organs - function and mechanism of somatic receptors - photoreceptors - mechanoreceptors - chemoreceptors and accessory sensory organs. Role of sensory organs in biological rhythm.
Current Contour	Collection of data – WHO - FAO - nutritional requirements and dietary regulations of all age groups. Finding novel molecular mechanical pathway relevant with various physiological function.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	M	S	S	M	L
CO2	S	M	L	M	S	S	M	S	M	S
CO3	S	L	M	M	M	S	S	M	S	M
CO4	S	M	M	M	S	S	M	S	M	S
CO5	M	S	M	S	M	S	M	S	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Dantzler WH 1997. Comparative Physiology (Handbook of Physiology): (Vol I and II). (I Ed.). Oxford University Press, New York, USA.
2. Hoar WS. 1983. General and Comparative Physiology. Prentice Hall, New York,
3. Nielsen KS. 1997. Animal Physiology: Adaptation and Environment. (V Ed.). Cambridge University Press, Cambridge, UK.
4. Randall D, Burggren W and French K. 2001. Eckart Animal Physiology. W. H. Freeman & Company.
5. Randall D, Burggren W and French K. 2002. Eckert Animal Physiology: Mechanisms and Adaptations (V Ed.). W.H. Freeman & Company.
6. Hoar WS. 1983. General and Comparative Physiology. Prentice Hall, New York.
7. Randall D, Burggren W and French K. 2001. Eckert Animal Physiology. W. H. Freeman & Company.
8. Rankin JC and Jensen FB. 2012. Fish Ecophysiology. Springer, Chapman and Hall, London.
9. Richard WH, Gordon AW and Margaret A. 2004. Animal Physiology. (IV Ed.). Sinauer Associates Inc.
10. John EH and Michael EH. 2020. Guyton & Hall Textbook of Medical Physiology. (III Ed.). Elsevier Health Science.

Related Online Contents:

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2. https://www.sciencedirect.com/topics/medicine-and-dentistry/altitude-acclimatization
3. https://www.fao.org/nutrition/en/
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7884906/

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SEMESTER - III

CORE XXI: NEUROPHYSIOLOGY

Course Code	22ZOOC34	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Basic knowledge on neuronal structure and function								

Course Objectives:

- Classify the different types of neurons based on the architecture
- Describe the anatomy of brain structure and region-specific function
- Summarize the different types of neurotransmitters and their role in cognition
- Discuss types of ion channels and their role in communication
- Integrate electrical and chemical communication in synapse
- Explain the different types of genetic defects based on neuronal disorders
- Analyze importance of electrophysiology and its applications

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the basic structure of neurons and their types	K2
CO2	Describe the motor co-ordination and behavior	K2
CO3	Demonstrate the action of ion channels during induction of electrical stimulus	K3
CO4	Develop the knowledge on role of neurotransmitters and its synaptic regulation	K6
CO5	Explain the current advancements in diagnosis and therapies for neuronal disease	K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Basics of nervous system** **4 Lectures**	Brain - structure - types and functions - central and peripheral nervous system - cerebrum - cerebellum - medulla - pons - basal ganglia - spinal cord - thalamus and hypothalamus.
Unit II **Neuron and its Classification** **8 Lectures**	Neuron - functional architecture. Classification of neuron - nerve fiber. Nerve impulse - propagation of nerve impulse - resting and action potentials - voltage gated ion channels - sodium and potassium channels - calcium channels.
Unit III **Synaptic transmission and Neurotransmitters** **12 Lectures**	Structure and classification of synapse - mechanism of synaptic transmission - neuro-muscular junction. Neurotransmitters - types - biosynthetic pathway of neurotransmitter - acetylcholine - serotonin - dopamine - norepinephrine - glutamic acid - γ -amino butyric acid (GABA) - glycine - histamine and neuropeptides - cholecystokinin and neurotensin - storage and release.
Unit IV **Signaling and stimulation** **8 Lectures**	Single cell signaling - basics in cellular recording. Cell and electrode - types of electrodes. Cell patching - inside out patch - outside patch. Whole cell recording and cellular stimulation.
Unit V **Disorders and treatments** **8 Lectures**	Neurological disorders - causes - symptoms and treatment of Alzheimer's disease - cerebral arteriosclerosis - epilepsy - multiple sclerosis - muscular dystrophy - myasthenia gravis - Parkinson's disease.
Current Contour	Current advancements in structural and functional brain imaging - pathogenesis of the neurodegenerative diseases - therapeutic advancements in some form of previously 'untreatable' conditions in neurological disorders.
Total Lectures – 40	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	M	S	M	L
CO2	S	M	S	L	M	S	M	S	M	M
CO3	M	L	M	S	M	M	S	M	M	S
CO4	S	M	S	M	M	S	S	M	S	S
CO5	S	M	M	M	S	S	M	L	S	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bear MF, Connors BW, Paradiso MA and Paradiso M. 2015. Neuroscience: Exploring the Brain (IV Ed.). Lippincott Williams and Wilkins Publ.
2. Kandel ER, Schwartz JH and Jessell TM. 1995. Essentials of Neural Science and Behavior. McGraw-Hill Publ.
3. Longstaff. A. 2011. Neuroscience. (III Ed.). Taylor and Francis Publ.
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6. Ellen C and Matt C. 2015. Basic Electrophysiological Methods. Oxford University Press.
7. Johnston D and Wu SMS. 2022. Foundations of Cellular Neurophysiology. MIT Press.
8. Hille B. 2001. Ionic Channels of Excitable Membranes (III Ed.). Sinauer Associates, Inc. Oxford University Press, USA.
9. Levitan IB and Kaczmarek LK. 2015. The Neuron – Cell and Molecular Biology. (IV Ed.). Oxford University Press.
10. Dunecan M, Nick C and Imran N. 2022. Carpenter's Neurophysiology: A Conceptual Approach. (VI Ed.). CRC Press.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3225087/
2. https://thebrain.mcgill.ca/flash/capsules/outil_bleu13.html
3. https://pubmed.ncbi.nlm.nih.gov/15459709/
4. https://pubmed.ncbi.nlm.nih.gov/17599115/
5. https://www.frontiersin.org/articles/10.3389/fphar.2019.00724/full

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SEMESTER - III

CORE XXII: Laboratory Course VIII - GENERAL MICROBIOLOGY

Course Code	22ZOOC35	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Basic knowledge on microbes and their impacts								

Course Objectives:

- Familiarize the various instruments used in a microbiology laboratory
- Demonstrate the practical skills on using modern tools and techniques in microbiology
- Learn the methods of culturing of microorganisms under laboratory conditions
- Providing hands-on skills in culturing industrially important microbes

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Learn the skill for cultivation of microorganisms in laboratory	K6
CO2	Equipped with required skill to carry out laboratory work under aseptic conditions, after completion of practical prescribed in the Laboratory course	K3
CO3	Explore the techniques of transfer of genes *in vitro*	K2, K5
CO4	Gain knowledge of industrially important microbes for large scale production	K2, K7
CO5	Assess the knowledge on antibiotic sensitivity microbes	K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Preparation and maintenance of microbial culture.
2. Identification of microbial cells by using Gram staining
3. Bacterial motility
4. Determination of antibiotic sensitivity.
5. Replica plating techniques.
6. Isolation of industrially important microorganisms (amylase, pectinase, cellulase) for microbial process.
7. Isolation of coliforms from water.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	M	S	S	S	S	M	M
CO2	S	M	S	M	S	S	S	S	M	L
CO3	S	L	S	L	S	S	M	S	L	M
CO4	S	S	S	S	M	S	S	S	M	S
CO5	S	L	S	M	L	S	S	S	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Cappucino JG and Sherman N. 2013. Microbiology: A Laboratory Manual, (VI Ed.). (I Indian Reprint). Pearson Education (Singapore) Pvt. Ltd.
2. Dubey RC and Maheswari DK. 2002. Practical Microbiology. (I Revised Ed.). S. Chand and Company Ltd.
3. Microbiology Society. 2016. Basic Practical Microbiology - A Manual published by the Microbiology Society, London, UK.
4. Apurpa SS, Sandhya BK. 2018. Essentials of Practical Microbiology. Jaypee Brothers Medical Publ.
5. Upasana B. 2021. Competency based Practical Manual for Microbiology as per Competency Based Curriculum (MCI). Jaypee Brothers Medical Publ.

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SEMESTER - III

CORE XXIII: Laboratory Course IX - BIOLOGY OF IMMUNE SYSTEM

Course Code	22ZOOC36	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
					1	2	3		
Pre-requisite	Basic knowledge about immune organs								

Course Objectives:

- Classify to identify the lymphoid organs
- Demonstrate and train to perform the different immunological test
- Explain the production of monoclonal and polyclonal antibodies
- Analyse and interpret the obtained results and convince the outcome

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Acquired the knowledge about the properties and action of different reagents which is used in the experiments	K2
CO2	Identification of the location of immune organs.	K2, K3
CO3	Examine and interpret the ABO blood groups and Rh factor	K5, K7
CO4	Determine antigen-antibody interaction	K7
CO5	Quantify the pathogen load, levels of antibody and antigen-antibody bound complex in the biological sample	K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Identification of lymphoid organs and lymph nodes.
2. Determination of ABO blood groups and Rh typing from human blood samples.
3. A rapid screening test for the diagnosis of pregnancy.
4. Serological Widal test in diagnosis of typhoid and paratyphoid fever.
5. Restraints and routes of inoculation in mice.
6. Production of monoclonal and polyclonal antibodies.
7. Immunoelectrophoresis (CCIE and RIE).
8. Immunodiffusion for antigen and antibody precipitation (Ouchterlony Double immunodiffusion Technique).
9. Western blot for antigen determination.
10. ELISA for antibody titre.

11. ELISpot assay for quantifying cytokines.
12. Immunophenotyping of T cells from human blood sample.
13. Latex agglutination test for diagnosis of rheumatoid arthritis in serum and synovial fluid.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	L	M	S	S	M	M	S
CO2	M	S	M	M	S	M	S	M	M	M
CO3	S	S	M	M	S	S	S	S	S	S
CO4	S	S	M	L	M	M	S	S	S	S
CO5	S	S	M	M	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Hay FC and Westwood OMR. 2002. Practical Immunology (IV Ed.). Blackwell Science.
2. Fischbach RN, Talaska F and Margaret A. 2017. Fischbach's a Manual of Laboratory and Diagnostic Tests. Lippincott Williams & Wilkins Publ.
3. Stevens CD and Miller LE. 2016. Clinical Immunology and Serology: A Laboratory Perspective. (IV Ed.). FA Davis.
4. Estridge BH and Reynolds AP. 2011. Basic Clinical Laboratory Techniques (VI Ed.). Cengage Learning.
5. Turgeon ML. 2015. Linne & Ringsrud's Clinical Laboratory Science. (E-Book: The Basics and Routine Techniques (VII Ed.). Elsevier Health Sciences).
6. Sam-Yellowe T. 2020. Immunology: Overview and Laboratory Manual. Springer Publ.
7. http://cshprotocols.cshlp.org/immunology

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SEMESTER – III

CORE XXIV: Laboratory Course X - ANIMAL PHYSIOLOGY

Course Code	22ZOOC37	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				-	1	2	3		
Pre-requisite	Knowledge on the physiological function of vertebrate systems								

Course Objectives:

- Understand the fundamental scientific concepts relating to a comparative animal physiology
- Demonstrate the functional mechanism of animals in their environments
- Examine the human blood parameters
- Analyze pathological tissues by histological process
- Measure and calculate their own physiological activity

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Discuss the comparative analysis of physiology	K1, K2
CO2	Analyze and collect their physiological data.	K4
CO3	Demonstrate blood composition by hematological study	K3, K5
CO4	Describe physiological tool with respective physiological experiment	K1, K2
CO5	Design and concise their laboratory experimental report	K5, K6

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Experiments

1. Study of salivary amylase activity of human with reference to pH.
2. Preparation of Haemin crystals of the blood fish and rat.
3. Estimation of Haemoglobin by haemometer.
4. Enumeration of RBC and WBC counts by haemocytometer.
5. Determination of rate of respiration in rat / fish.
6. Estimation of blood sugar (glucose) by ortho-toluidine method.
7. Calculation of BMI in human.
8. Microscopic slide preparation of uric acid crystals from Reptiles/Chick.
9. Estimation of urea in blood sample.
10. Study of estrous cycle by vaginal smear in rat/mouse.
11. Determining fertile period in reproductive female by salivary fern pattern.
12. Identification of male and female reproductive system and accessory reproductive glands of rat.
13. Sperm biology - motility, viability and sperm count.
14. Examine the electrical activity of skeletal muscles by using EMG.
16. Histological and microscopic analysis.

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	L	M	S	S	M	M	S
CO2	M	S	M	M	S	M	S	M	M	M
CO3	M	S	S	M	S	S	S	S	S	S
CO4	S	S	M	L	M	M	S	S	S	S
CO5	S	S	M	M	S	S	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Mali RP and Afsar SK. 2015. A Practical Manual on Innovative Animal Physiology. Oxford book company.
2. Verma PS and Srivastava PC. 2020. Advanced Practical Zoology. Chand Publ.
3. Kumar S, Padubidri VG and Daftary SN. 2018. Howkins & Bourne, Shaw's Textbook of Gynecology (XVII Ed.). Elsevier Health Sciences.
4. Chawla R. 2014. Practical Clinical Biochemistry: Methods and Interpretations (IV Ed.). JP Medical Ltd.
5. Preston DC and Shapiro BE. 2012. Electromyography and Neuromuscular Disorders. (e-book: Clinical-electrophysiologic Correlations (III Ed). Elsevier Health Sciences).

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SEMESTER - III

GENOMICS AND PROTEOMICS (Major Elective - II)

Course Code	22ZOOME31	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic fundamentals of genomics and proteomics								

Course Objectives:

- Explain the basic concepts of genomics and proteomics.
- Interpret the advantage and limitation of DNA sequencing
- Discuss about the tools which are used for genome annotation and its application
- Analyze deep, shallower scoring matrices and compare the homology
- Demonstrate the tools for protein structural prediction and protein engineering
- Inculcate the major online database
- Summarize the application of proteomics in Clinical diagnosis

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the structure of the genome and their importance in health.	K2
CO2	Explain the process involving in genome sequencing and editing	K4
CO3	Interpret amino acid scoring matrices of the conservative and non-conservative changes for evolutionary information	K7
CO4	Predict the protein folding while aligning the sequence	K2, K4
CO5	Design the structure of the protein for invitro modification for novel protein	K6

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Genomics, proteomics and their importance** **6 Lectures**	Introduction to genomics - sequence complexity and genome size in prokaryotes and eukaryotes - introduction to proteomics - structural proteomics - Serine/arginine-rich (SR) protein and their role - Exonic Splicing Enhancers (ESE) - Exonic Splicing Suppressors (ESS) - Intronic Splicing Enhancers (ISE) and Intronic Splicing Suppressors (ISS) - functional proteomics - proteome mining - Protein-Protein Interaction (PPI) networks - Post translational modification. Introduction to proteogenomics - bridging genomics and proteomics.

Unit II **Genome sequencing** **8 Lectures**	Genome sequencing techniques - understanding a genome sequence - locating the genes in a genome sequence - determining the functions of individual genes - studying the activity of a protein coded of an unknown gene. Whole shotgun genome sequencing - sequencing technology - types of sequencing - advantage and limitation of sequencing.
Unit III **Genome annotation and Analysis** **8 Lectures**	Structural genomics - genome annotation - nucleotide protein and process level annotation. Gene identification - detecting open-reading frames - CpG methylation - intron and exon prediction. Functional genomics - identifying the function of a gene - gene silencing - gene ontology - expression profiling - tools for analyzing expression profile. Comparative genomics - overview of comparative genomics - determining gene function by sequence comparison and protein structure.
Unit IV **Proteomics** **4 Lectures**	Protein engineering - protein chips and functional proteomics - clinical and biomedical application of proteomics - proteome database - proteomics industry. Protein analysis (includes measurement of concentration, amino-acid composition, N-terminal sequencing) - 2-D electrophoresis of proteins - peptide fingerprinting - Liquid chromatography-tandem mass spectrometry (LC/MS-MS) for identification of proteins and modified proteins. STRING Analysis - Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway.
Unit V **Bioinformatics** **4 Lectures**	1. Bioinformatics and its application - major online databases - practical use of databases. 2. DNA - RNA - proteins in bioinformatics. Similarity, - homology - alignment. Scoring matrices [Point Accepted Mutation (PAM), BLOcks SUbstitution Matrix (BLOSUM)] - local and global sequence - short- and long-range order - prediction of protein folding. 3. Pairwise alignment. 4. DOCKING and molecular dynamic simulation.
Current Contour	Get practice on methods of sequencing and analyze the results using advanced software in genomics and proteomics.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	S	S	S	M	S	S
CO2	M	M	M	M	S	M	M	M	M	M
CO3	S	L	L	M	S	S	M	S	S	S
CO4	S	S	S	S	M	M	S	M	M	S
CO5	S	L	M	M	L	M	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Thangadurai D and Sangeetha J. 2015. Genomics and Proteomics: Principles, Technologies, and Applications. (I Ed.). CRC Press.
2. Saraswathy N and Ramalingam P. 2011. Concepts and Techniques in Genomics and Proteomics. Woodhead Publ. Ltd, UK.
3. Campbell AM and Heyer L. 2007. Discovering Genomics, Proteomics and Bioinformatics. (II Ed.). Benjamin - Cummings Publ.
4. Primrose SB and Twyman RM. 2006. Principles of Gene Manipulation and Genomics. (VII Ed.). Blackwell Publ. UK.
5. Pennington S and Dunn M. 2001. Proteomics from Protein Sequence to Function. (I Ed.). Oxford, BIOS,
6. Suhai. S. 1999. Genomics and Proteomics, Functional and Computational Aspects, Springer Publ.
7. Singh R. 2015. Bioinformatics Genomics and Proteomics. (I Ed.). VIKAS Publ.
8. Tisdall J. 2001. Beginning Perl for Bioinformatics: An Introduction to Perl for Biologists. Penguin Books Ltd.
9. Pevsner J. 2015. Bioinformatics and Functional Genomics. Wiley–Blackwell Publ.
10. Malkoff C. 2016. Functional Genomics and Proteomics. Syrawood Publishing House.

Related Online Contents:

1. https://string-db.org/
2. https://www.nature.com/articles/nprot.2016.051
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6209097/pdf/nihms-1506121.pdf

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SEMESTER - III

CANCER BIOLOGY (Major Elective – II)

Course Code	22ZOOME32	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				3	1	-	4		
Pre-requisite	Fundamental knowledge in cell cycle, regulation and factors influence the regulation								

Course Objectives:

- Summarize the knowledge in and about cancer biology
- Understand the characters of cancer and carcinogenic agents
- Discuss on the molecules play in oncogenic pathways
- Elucidate the knowledge on tumor suppressor genes at metastasis stage
- Illustrate molecular mechanisms and its pathways with reference to metastasis gene regulations
- Interpret therapeutic methods and their regulative mechanisms
- Describe the diagnostic methods and therapies for cancer

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Explain the fundamentals of patho-physiology in cancer and its mechanism	K4
CO2	Interpreting molecular regulation in signaling pathways	K5
CO3	Demonstrate the oncogenic regulatory pathways	K3
CO4	Discuss the various techniques used in the diagnosis and treatment of cancer	K2
CO5	Understand the therapeutic strategies for betterment of life of cancer patients	K2

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Fundamentals of cancer biology** **6 Lectures**	Introduction - types of cancer - epidemiology. Risk factors of cancer - genetic defects - inherited susceptibility to cancer and microbial factors in cancer - loss of heterogeneity and barriers to cancer. Theories of carcinogenesis - Somatic Mutation Theory (SMT) and Tissue Organization Field Theory (TOFT).

Unit II **Carcinogenic agents and Carcinogenesis** **6 Lectures**	Historical perspective of carcinogenesis - mechanism of action - direct acting - pro-carcinogens and co-carcinogens. Carcinogenic agents - physical (rays) chemical (heavy metal ions and tobacco) and biological (virus). Carcinogenesis - tumor initiation - defects in growth control - activation of protooncogene - promotion - resistance to cytotoxicity - inactivation of tumor suppressor gene - progression - inactivation.
Unit III **Tumor suppressor genes** **6 Lectures**	Two hit hypothesis - Rb protein family - role and signaling pathways - relationship between P^{53} and P^{21}. Apoptosis pathways - (intrinsic and extrinsic) - apoptosome caspases and key players in regulating cytochrome - Mitochondrial Outer Membrane Permeabilization (MOMP) - ER stress - telomere - senescence and apoptosis vz necrosis.
Unit IV **Signaling molecules and Oncogenes in cancer** **6 Lectures**	Modulation of cell - coordination of cell proliferation - differentiation and terminal differentiation. Signal transduction pathways - growth factor receptor - tyrosine kinases - RAS-RAF-MAP kinase - Wnt-β-catenin and Notch signaling pathway. Oncogenes - characters of proto-oncogene - conversion of proto-oncogenes to oncogenes - oncogene family - activation and inactivation of oncogenes.
Unit V **Cancer diagnosis and Therapy** **6 Lectures**	Diagnostic methods - biochemical - histological and radiological methods. Strategies for cancer treatment - radiotherapy - chemotherapy - cytotoxic drug and radiotherapy treatment. Immunotherapy of cancer - rationale of immunotherapy - cytokines - vaccines - monoclonal antibodies - gene and hormone therapy.
Current Contour	Recent development in biology of cancer cells - applications of CRISPR - pathological examinations of tumors with 3D light.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	M	M	M	S	S	S	S
CO2	S	L	S	S	M	S	S	S	S	S
CO3	S	M	M	L	S	S	S	S	M	M
CO4	M	S	S	M	S	M	S	M	S	S
CO5	M	M	S	M	S	S	M	L	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Stella P and Michael K. 2013. The Molecular Biology of Cancer: A bridge from bench to bedside. (II Ed.). Blackwell Publ.
2. Molcolm RA. 2001. The Cancer Hand Book. (Vol I.). Palgrave MacMillan Publ.
3. Berk A, Kaiser CA, Lodish H, Amon A, Ploegh H, Bretscher A, Krieger M and Martin KC. 2016. Molecular Cell Biology. (VIII Ed.). W.H. Freeman & Co.
4. Robert AW. 2013. The Biology of Cancer. (II Ed.). Garland Science Publ.
5. Lewis JK. 2006. Principles of Cancer Biology. (I Ed.). Pearson Benjamin - Cummings Publ.
6. Kleinsmith JK. 2016. Principles of Cancer Biology. (I Ed.). Pearson Publ.
7. Pecorino L. 2021. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. (V Ed.). OUP Oxford.
8. Chandar N and Viselli S. 2018. LIR: Cell and Molecular Biology. Wolters Kluwer India Pvt. Ltd.
9. Pezella F, Tavassoli M and Kerr D. 2019. Oxford textbook of Cancer Biology. Oxford University Press.
10. McKinnell RG. Parchment RE, Perantoni AO, Pierce GB and Damjanov I. 2006. The Biological Basis of Cancer. Cambridge University Press.
11. King RJB and Robins MW. 2006. Cancer Biology. (III Ed.). Prentice Hall.

Related Online Contents:

1. https://www.sciencedirect.com/science/article/abs/pii/S2405803318300608
2. CRISPR Identifies Genes Allowing Cancer to Evade Immune Detection | Inside Precision Medicine
3. https://www.cell.com/trends/cancer/issue?pii=S2405-8033(21)X0005-2
4. https://www.sciencedirect.com/science/article/pii/S2405803318300645

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SEMESTER - III

RESEARCH METHODS (Major Elective - II)

Course Code	22ZOOME33	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic idea on data collection and types								

Course Objectives:

- Define about the research theme, limitation and its advantage
- Distinguish in detail about the indexed /non-indexed journal and journal matrix.
- Grade the data based on normal distribution and other evaluation methods
- Demonstrate the suitable statistical methods to analyze the obtained data
- Differentiate between parametric and non-parametric statistical analysis
- Illustrate the different strategies to design the experiment based on objective of the research
- Understand the principles of biophysical equipments

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the importance of following uniformity in data collection	K2
CO2	Describe the different stages in designing the experiment	K2
CO3	Implement the statistical analysis and interpret the data	K3
CO4	Explain the importance about level of significance	K4
CO5	Connect the importance of data collection and expression analysis	K5, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to research** **6 Lectures**	Selection of problem - stages in execution of research - preparation of manuscript - thesis format. Standard of research journals - peer reviewed - impact factor - citation index - choice of journals for publication. Information retrieval - archives - databases and search engines - Google - PubMed - online data base library - GenBank. Research paper - oral and poster presentation. Synopsis - facing viva voce using LCD. Latex and Science direct.

Unit II **Statistical methods** **6 Lectures**	Measures of central tendency and dispersal. Probability distributions – binomial - Poisson - normal. Sampling distribution. Difference between parametric and non-parametric statistics. Confidence interval. Errors - levels of significance. Regression and correlation. t-test. Analysis of variance. $\chi 2$ test. Basic introduction to multivariate statistics.
Unit III **Biophysical methods** **6 Lectures**	Molecular analysis using UV/visible - fluorescence - circular dichroism - Nuclear Magnetic Resonance (NMR) and Electron spin Resonance (ESR) spectroscopy. Molecular structure determination using X-ray diffraction and NMR. Molecular analysis using light scattering, different types of mass spectrometry and surface plasma resonance methods.
Unit IV **Expression analysis** **6 Lectures**	Antibody generation - detection of molecules using Enzyme Linked Immuno-Sorbent Assay (ELISA) - Radio Immuno Assay (RIA) - Western blot - immunoprecipitation - flow cytometry and immunofluorescence microscopy. Detection of molecules in living cells - *In situ* localization techniques – Fluorescence *In situ* Hybridization (FISH) and Genomic *In situ* Hybridization (GISH). Separation of biomolecules based on size and electric potential.
Unit V **Microscopic, histochemical and immuno-techniques** **6 Lectures**	Visualization of cells and subcellular components by light microscopy. Resolving powers of different microscopes. Microscopy of living cells - scanning and transmission microscopes - different fixation and staining techniques for EM - freeze-etching and freeze - fracture methods for EM - image processing methods in microscopy.
Current Contour	Recent applications of tools for research methods and data collection - manipulation in different fields of biology.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	M	S	S	M	S	M	M
CO2	S	S	M	L	S	M	S	S	S	S
CO3	S	M	M	M	S	S	S	S	M	M
CO4	S	S	M	L	M	S	M	M	S	M
CO5	M	M	M	M	S	S	S	S	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Davis GB and Parker CA. 2012. Writing the Doctoral Dissertation: A Systematic Approach. (III Ed.). Barron's Educational Series.
2. Dunleavy P. 2003. Authoring a Ph.D. thesis: How to Plan, Draft, Write and Finish a Doctoral Thesis or Dissertation? Palgrave MacMillan, London.
3. Sokal RR and Rohlf FJ. 1994. Biometry. (III Ed.). W.H. Freeman & Co, New York.
4. Zar JH. 2014. Biostatistical analysis. (V Ed.). Pearson Education, India.
5. Suvarna KS, Layton C, Bancroft JD. 2012. Bancroft's Theory and Practice of Histological Techniques. Elsevier Health Sciences.
6. Kothari CR. Garg G. 2019. Research Methodology: Methods and Techniques. New Age International Publ.
7. Mishra SB and Alok S. 2017. Hand Book of Research Methodology. Educreation Publ.
8. Creswell JW. 2002. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. (II Ed.). SAGE Publications, Inc.
9. Merriam SB. 2009. Qualitative Research: A Guide to Design and Implementation. Jossey Bass.
10. Machi LA and McEvoy BT. 2008. The Literature Review: Six Steps to Success. Corwin Publ.
11. Murray N and Beglar D. 2009. Inside Track to Writing Dissertations and Theses. Longman.

Related Online Contents:

1. https://www.euacademic.org/BookUpload/9.pdf
2. https://www.researchgate.net/publication/299229154_Research_Methods_Concepts_Methodologies_Tools_and_Applications
3. https://www.researchgate.net/publication/325846997_METHODS_OF_DATA_COLLECTION
4. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3659807/
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3626472/pdf/blt-11-217.pdf
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3474301/pdf/ijspt-07-512.pdf

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SEMESTER - III

TECHNIQUES AND TOOLS FOR BIOLOGY (Non - Major Elective - II)

Course Code	22ZOONME31	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basics knowledge on biological equipments								

Course Objectives:

- Categorize the different equipments and its applications
- Summarize the principle of microscopy and its types
- Demonstrate the types and limitations in chromatography
- Signify the advanced applications of chromatography
- Explain the principle and types of centrifuges
- Demonstrate the types of spectroscopy and its principle mechanism
- Emphasize the calibration of instruments in bio-medical sciences

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the basic lab protocols and techniques	K2
CO2	Understand the handling of microscopes based on principle	K2
CO3	Differentiate the chromatography techniques for separation of biomolecules	K3
CO4	Relate the application and limitations in usage of centrifuge	K2
CO5	Understand the basic knowledge on spectrophotometry	K3

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Basic concepts and Sterilization technique** **5 Lectures**	Introduction - general lab techniques and limitations. Sample collection and animal handling. Buffers - Sorenson's pH scale - principle and applications. Volumetric conversion. Filtration and distillation. Sterilization - autoclaving - principle - types and applications.
Unit II **Microscopic techniques** **7 Lectures**	Principle - resolving power - working - applications and limitations of bright field microscopy - dark field microscopy - fluorescent microscopy - immuno fluorescence - Electron microscopy - (TEM and SEM) - confocal microscopy - spinning disc. Scanned Probe Microscopy (SPM) – Atomic Force Microscopy (AFM). Interference microscopy – differential contrast and fluorescent contrast microscopy. X-ray microscopy.

Unit III **Chromatographic techniques** **6 Lectures**	Introduction - principle - application and limitations – paper - thin layer - column - partition - adsorption - ion-exchange - molecular Size Exclusion Chromatography (SEC) - affinity - super-critical chromatography - Gas Chromatography (GC) - High-Performance Liquid chromatography (HPLC) - Fast Performance Liquid chromatography (FPLC).
Unit IV **Centrifugation** **6 Lectures**	Introduction - principle - Svedberg co-efficient - centripetal and centrifugal action - types - uses and limitations - differential - density gradient and sub-cellular fractionation.
Unit V **Spectrophotometry** **6 Lectures**	Light and electromagnetic radiation - Beer-Lambert's law - molar extinction coefficient - transmittance. Principles and uses of photoelectric colorimeter - UV - atomic and NMR spectroscopy. Radio-isotopic technique - Radioimmunoassay (RIA). X-ray diffraction - principle and applications.
Current Contour	Techniques for detection and applications in biosensors and drug delivery - cellular imaging and its comparative research advancement in biological sciences.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	L	M	M	M	M	S	S	S	S	S
CO2	S	M	S	S	S	M	S	S	M	M
CO3	M	M	S	M	S	S	M	S	M	M
CO4	M	M	S	S	S	M	M	S	S	S
CO5	M	M	S	M	M	S	S	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bull HB and Davis FH. 1971. An Introduction to Physical Biochemistry. (II Rev. Ed.). Davis FA Company, Philadelphia.
2. Cotterill RMJ. 2014. Biophysics- An Introduction. John Wiley and Sons Ltd, England.
3. David S. 2009. Physical Biochemistry: Principles and Applications. (II Ed.). John Wiley and Sons Ltd, England.
4. David F. 1985. Principles of Physical Chemistry: Applications to the Biological Sciences. (II Ed.). Jones and Bartlett Learning, Inc.
5. Keith W and John W. 2010. Principles and Techniques of Practical Biochemistry, (VII Ed.). Cambridge University Press.
6. Unbriet WW. 2016. Manometric and Biochemical Techniques: A Manual Describing Methods Applicable to the Study of Tissue Metabolism. Burgess Publication Co., Minneapolis.
7. Rana SVS. 2018. Biotechniques. (III Ed.). Rastogi Publ.
8. Fulekar MH and Pandey B. 2019. Bioinstrumentation. Dreamtech Press.

9. Ghosal S and Avasthi AS. 2018. Fundamentals of Bioanalytical Techniques and Instrumentation. (II Ed.). PHI Publ.
10. Talluri S. 2012. Bioanalytical Techniques. IK International Publ. House.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4862100/
2. https://www.pnas.org/doi/10.1073/pnas.1508524112
3. https://www.nibib.nih.gov/science-education/science-topics/drug-delivery-systems-getting-drugs-their-targets-controlled-manner

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SEMESTER - III

INTEGRATED FARMING MANAGEMENT (Non - Major Elective - II)

Course Code	22ZOONME32	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basics knowledge on farming methods								

Course Objectives:

- Acquire the knowledge about the farming systems and its management
- Evaluate different enterprises suitable for different agro-climatic conditions for sustainable agriculture
- Sensitize students about importance, scope, components, and interaction within components of Integrated farming system
- Practicing on various sustainable farming practices and their significance
- Promote the learning on socio economic conceptual based integrated management system
- Create awareness among the students regarding the mission of our government for the sustainable farming practices
- Add values on green revolution and food security

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Know about the fundamental practices of farming systems and their management	K1
CO2	Understand various methods and their advantages in integrated farming system	K2
CO3	Examine the terms in production and economics of integrated farming management and GDP	K1
CO4	Know about the role of Government and Non-Government organizations related to integrated farming practices	K3
CO5	Learn the responsibility and imply for sustainable farming approach	K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Farming system and Classification** **6 Lectures**	Farming systems - definition and importance - classification of farming systems - type of rotation - intensity of rotation - degree of commercialization - water supply - enterprises. Concept of sustainability in farming systems - efficient farming systems. Natural resources - identification and management.
Unit II **Scope and importance of Integrated Farming System (IFS)** **6 Lectures**	Integrated Farming System (IFS) - importance and scope - components of IFS. Production potential of different components of farming systems - interaction and mechanism of different production factors. Stability in different systems through research - eco-physiological approaches to intercropping - IFS for different agro-climatic conditions.
Unit III **Sustainable agriculture** **6 Lectures**	Various agriculture related concepts and their relevance in IFS - crop rotations - cropping systems - cropping pattern. Sustainable agriculture - farming systems – monoculture - multiple cropping - intercropping - mixed cropping - sequential cropping - multi-storey cropping - terra farming. Agro-forestry systems - permaculture - allelopathy - organic farming - mushroom cultivation - bee keeping - sericulture - pisciculture in pond - aqua forestry - boundary plantations - shelter belts - wind breaks - duckery - poultry farming - vermin-composting.
Unit IV **Production and economics of Integrated Farming System (IFS)** **6 Lectures**	Simulation models for intercropping - soil nutrient in intercropping - study of different IFS models - evaluation of different farming systems. Production and economics of IFS - small and marginal farmers - eco-physiological approaches to intercropping.
Unit V **Role of government in sustainable agriculture** **6 Lectures**	Introduction - objectives and role of the government organization in integrated farming management. Department of Agriculture Research and Education (DARE) - National Mission for Sustainable Agriculture (NMSA) - National Bank for Agriculture and Rural Development (NABARD) - evergreen revolution and food security - Sustainable Development Goals (SDG 1, 2, 7, 8, 15).
Current Contour	Recent strategies for sustainable management by Department of Agriculture and Cooperation, Ministry of Agriculture Government of India.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	S	M	S	S	M
CO2	S	M	S	S	S	M	M	S	S	M
CO3	S	S	M	S	L	S	S	S	S	S
CO4	S	S	M	S	S	S	S	M	S	S
CO5	S	S	M	S	S	M	S	S	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Balasubramanian P and Palaniappan SP. 2006. Principles and Practices of Agronomy. Agrobios.
2. Behera UK and France J. 2016. Integrated Farming Systems and the Livelihood Security of Small and Marginal Farmers in India and Other Developing Countries. Advances in Agronomy.
3. Manna MC, Rahman MM, Naidu R, Bari AF, Singh AB, Thakur JK and Subbarao A. 2021. Organic farming: A Prospect for Food, Environment and Livelihood Security in Indian Agriculture.
4. Ferron P and Deguine JP. 2009. Crop Protection, Biological Control, Habitat Management and Integrated Farming in Sustainable Agriculture. Springer, Dordrecht.
5. Venkatramanan V, Shah S and Prasad R (Eds.). 2021. Sustainable Bioeconomy: Pathways to Sustainable Development Goals. Springer, Nature.
6. Reddy SR. 2016. Farming System and Sustainable Agriculture. Kalyani Publ.
7. Jayadeva HM and Ramachandrappa BK. 2021. Integrated Farming Systems. Brillion Publ.
8. Bansal M. 2017. Basics of Organic Farming. CBS Publ.
9. NPCS Board of Consultants & Engineers. 2021. The Complete Book on Organic Farming and Production of Organic Compost. (II Rev. Ed.). Asia Pacific Business Press.
10. Reddy GH, Reddy S and Yallamanda T. 2016. Principles of Agronomy. Kalyani Publ.

Related Online Contents:

1. http://www.icarzcu3.gov.in
2. http://www.hillagric.ac.in/edu/coa/agronomy/lect/agron-4711/Lecture%201%20Farming%20system%20scope%20importance%20and%20concept.pdf
3. https://www.nature.com/scitable/knowledge/library/sustainable-agriculture-23562787/
4. https://agritech.tnau.ac.in/sustainable_agri/susagri%20_%20india_policies.html

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SEMESTER – IV

PROJECT WORK

Course Code	22ZOOPW41	Course Type	Core - Research	L	T	P	C	Syllabus version	2022-2023
				-	2	28	8		

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SEMESTER - I

BIOINSTRUMENTATION (Value added - I)

Course Code	22ZOOVC19	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic knowledge about different equipments								

Course Objectives:

- Classify the different equipments
- Summarize the safety procedure to be followed during equipment handling
- Demonstrate the application of equipments
- Explain the physical principle implemented in equipments
- Illustrate the problems and trouble-shooting in operation of equipments
- Emphasize the calibration of instruments in bio-medical sciences
- Discuss the advancement in equipments and their fine applications

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Describe the calibration methods in different types of equipment (Microscope, spectrophotometer, and pH meter)	K2
CO2	Understand the importance of safety procedures in the laboratory (BSL 1- 4)	K2
CO3	Demonstrate the separation of biomolecules using chromatography techniques	K3
CO4	Describe the application of different types of equipment	K1
CO5	Troubleshoot and optimize the protocol for flowcytometry analysis	K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Basic concepts of bioinstrumentation** **6 Lectures**	Introduction - scope and role of instrumentation in biomedical sciences. Units of measurements - metric system - conversion of units. Cytometry and flow cytometry. pH - Sorenson's pH scale - principle and applications. Manometry - Warburg manometer - principle and working.

Unit II **Sterilization and Centrifugation techniques** **6 Lectures**	Autoclave - principle - types and applications. Centrifuge - clinical and ultra-centrifuge - principles and its applications.
Unit III **Microscopic techniques** **6 Lectures**	Microscopy - principle - working and applications of phase contrast and interference - differential interference contrast microscope - fluorescence and immuno-fluorescence - confocal microscopy - bright field and dark field microscope.
Unit IV **Spectroscopic techniques** **6 Lectures**	Principles and uses of UV - atomic and NMR spectroscopy. Radio-isotopic technique - Radioimmunoassay (RIA). Biochemical applications of radio-isotopes. X-ray diffraction - principle and applications.
Unit V **Chromatographic techniques** **6 Lectures**	Introduction - scope - principles - instrumentation and applications of adsorption - partition - ion exchange - reverse phase - gel filtration. Super-critical chromatography - Gas chromatography (GC) - High Performance Liquid chromatography (HPLC) and Fast protein Liquid chromatography (FPLC).
Current Contour	Techniques for detection and applications in biosensors and drug delivery. Cellular imaging and its comparative research advancement in biomedical sciences.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	S	S	S	M	L	S
CO2	S	L	L	S	M	S	M	S	M	M
CO3	M	S	M	S	S	S	S	S	M	S
CO4	S	S	S	M	M	M	L	S	M	S
CO5	S	S	M	M	S	S	L	S	M	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Bull HB and Davis FH. 1971. An Introduction to Physical Biochemistry. (II Ed.). Philadelphia.
2. Cottenill RMJ. 2001. Biophysics: An Introduction. John Wiley and Sons Ltd. England.
3. David S. 2009. Physical Biochemistry: Principles and Applications. (II Ed.). John Wiley and Sons Ltd, England.
4. David F. 1984. Principles of Physical Chemistry: Applications to the Biological Sciences. (II Ed.). Jones and Bartlett Publishers, Inc.
5. Keith W and John W. 2000. Principles and Techniques of Practical Biochemistry. (V Ed.). Cambridge University Press.

6. Unbriet WW, Burri ZH and Stamffier JF. 1972. Manometric and Biochemical Techniques. (V Ed.). Burges Publication Co., Minneapolis.
7. Rana SVS. 2018. Biotechniques. (III Ed.). Rastogi Publ.
8. Fulekar MH and Pandey B. 2019. Bioinstrumentation. Dreamtech Press.
9. Ghosal S and Avasthi AS. 2018. Fundamentals of Bioanalytical Techniques and Instrumentation. (II Ed.). PHI Publ.
10. Talluri S. 2012. Bioanalytical Techniques. IK International Publ. House.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4862100/
2. https://www.pnas.org/doi/10.1073/pnas.1508524112
3. https://www.nibib.nih.gov/science-education/science-topics/drug-delivery-systems-getting-drugs-their-targets-controlled-manner

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SEMESTER - II

MEDICAL PARASITOLOGY (Value added - II)

Course Code	22ZOOVC23	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	2		
Pre-requisite	Basic knowledge about different human parasites								

Course Objectives:

- Discuss the general characteristics of parasites and host - vector interaction
- Define the role and impact of parasitism in ecological imbalance
- Elucidate the unique adaptation of ecto- and endo-parasites
- Differentiate the evolution of parasitism, hosting and vector system
- Understand the basic knowledge on protozoan and helminth parasites
- Discuss on the transmission and management of ecto-parasites
- Analyze and practice the basic laboratory diagnosis of parasitic disease and its treatments

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Interpret the general characteristics and habituation of different parasites	K2
CO2	Acquire knowledge about the host parasitic relationship and parasitic diseases	K1, K2
CO3	Create and integrate data related to localized parasite of a specific region	K5, K6
CO4	Understand the pathogenic mechanism of ectoparasites and the significance of parasitology in the modern era	K2, K5
CO5	Predict and recommend the efficient laboratory diagnosis for different parasitic diseases	K2, K7

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to parasitology** **6 Lectures**	Brief introduction to parasites - host and vector - mechanical and biological vector. Taxonomical distribution and evolution of parasitism in animal kingdom. Basic concepts - host parasite relationship and parasitic adaptations. Life cycle of parasites - common features of parasitic diseases.

Unit II **Protozoan parasites** **6 Lectures**	Introduction to protozoan parasites - mode of transmission - pathogenesis and treatment of Entamoeba – Giardia - Trichomonas - Leishmania - Trypanosoma - Plasmodium - Toxoplasma - Sarcocystis - Cryptosporidium - Babesia - Balantidium.
Unit III **Helminth parasites** **8 Lectures**	Introduction to helminth parasites - mode of transmission - pathogenesis and management of parasitic disease in respect to Cestodes - Trematode and Nematode. Cestode - Diphyllobothrium - Taenia - Echinococcus - Hymenolepis - Dipyllidium and Multiceps. Trematode – Schistosoma - Fasciola - Gastrodiscoides - Paragonimus - Clonarchis and Opisthorchis. Nematodes - Trichuris - Trichinella - Strongyloides - Ancylostoma - Ascaris - Enterobius - Filarial worms and Dracunculus.
Unit IV **Ectoparasites** **5 Lectures**	Introduction to Arthropods - mode of transmission - pathogenesis - disease management and treatment - *Sarcoptes scabiei* - *Cimex lectularius* - *Pediculus humanus* and *Phthirius pubis*.
Unit V **Laboratory diagnosis of parasitic disease** **5 Lectures**	Introduction - morphological identification - culture - immunodiagnostic methods - molecular methods - intra-dermal skin tests - xeno-diagnostic techniques - animal inoculation methods and imaging techniques.
Current Contour	Modern approach in parasitic disease diagnosis - multi-pathogen diagnostic assays - relation to nucleic acids and proteomics. Screening the early diagnosis with suitable molecular markers - challenges and significance.
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	M	L	S	S	S	M	M
CO2	S	S	M	M	M	S	S	M	S	M
CO3	M	S	M	S	S	M	M	S	M	S
CO4	M	S	S	S	S	S	M	M	S	S
CO5	S	M	S	M	S	M	M	S	M	M
S-Strong; M-Medium; L-Low										

Recommended References:

1. Sougata G. 2021. Paniker's Textbook of Medical Parasitology. (IX Ed.). Jaypee brothers Medical Publishers.
2. Chatterjee KD. 2012. Parasitology (Protozoology and Helminthology) (XIII Ed.). CBS Publishers.
3. Rajesh K and Ajit DA. 2003. Medical Parasitology. Books and Allied Pvt Ltd.
4. Apurba SS and Sandhya B. 2020. Essentials of Medical parasitology. (Rev. Ed.) Jaypee Brothers Medical Publ. (P) Ltd.
5. Cox FEG. 2009. Modern Parasitology: A Text Book of Parasitology, (II Ed.). Wiley Blackwell Publ.
6. Willis L. 2020. Professional Guide to Pathophysiology. (IV Ed.). LWW 45.
7. Lone BA, Ahamad F and Chishti. 2016. Handbook of Veterinary Parasitology. IP Innovative Publication Pvt. Ltd.
8. Baveja V and Bavaja CP. 2021. Parasitology. (V Ed.) Arya Publ. Company.
9. Strayer DS, Saffitz JE and Rubin E. 2019. Rubin's Pathology: Mechanisms of Human Disease. (VIII Ed.). Wolters Kluwer Health.
10. Manna S and Manna B. 2019. Advanced Laboratory Manual of Parasitology and Immunoparasitology. NCBA Publ.

Related Online Contents:

1. https://www.hindawi.com/journals/ipid/2009/278246/
2. https://link.springer.com/article/10.1007/s42690-020-00213-9

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SEMESTER - III

BIOSTATISTICS (Value Added Course)

Course Code	22ZOOVC33	Course Type	Core	L	T	P	C	Syllabus version	2022-2023
				2	1	-	3		
Pre-requisite	Knowledge on statistical data collection								

Course Objectives:

- Describe the concepts of data representation
- Integrate and analyze the data collected
- Formulate different concepts of variation
- Analyze the hypothesis and interpret the probability
- Measure the correlation coefficient using different applications
- Test the different types of parametric equations
- Interpret the non-parametric test using various methods

Expected Course Outcomes:

On the completion of the course the student will be able to

COs	COURSE OUTCOMES	KNOWLEDGE LEVEL
CO1	Understand the different methods of data representations	K2
CO2	Measure the mean, standard deviation, error and apply the concepts of variation in biological aspects	K7
CO3	Demonstrate the binomial and probability distribution and elucidate the importance of linear correlation coefficient	K3
CO4	Describe the paired and unpaired test to interpret the data	K2
CO5	Explain the importance of chi square test and Simpsons paradox	K4

K1 - Knowledge; K2 - Understanding; K3 - Practice; K4 – Analysis; K5 - Synthesis; K6 – Creation; K7- Evaluation

Unit I **Introduction to biostatistics and Representation of data** **6 Lectures**	Definition - importance of primary data - secondary data - functions and limitations. Data presentation - numerical data - discrete and continuous. Frequency distribution - relative frequency and graphical presentation.
Unit II **Descriptive statistics** **6 Lectures**	Measures of central tendency - mean - median - mode. Range - variability - standard deviation - standard error - standardization of rates - dispersion. Concept of variation - measures of skewness and kurtosis.
Unit III **Probability** **6 Lectures**	Binomial distribution – Poisson distribution - normal distribution - central limit theorem. Confidence intervals - levels of significance - hypothesis testing and interpretation.
Unit IV **Correlation and Regression** **6 Lectures**	Correlation - correlation coefficient (r) - Karl Pearson's coefficient of correlation and Spearman rank correlation. Regression - definition - types - linear regression - logistic regression analyses - univariate - bivariate and ordinal - Poisson regression - algebraic method - probable error - lag and lead correlation - regression difference and significance.
Unit V **Parametric and Non-parametric test** **6 Lectures**	Parametric tests - t-test - paired or unpaired. Analysis of Variance (ANOVA) - one-way - non-repeated and repeated - two-way ANOVA. Non-parametric tests - Sign test - Wilcoxon test - Kruskal-Wallis H test. Chi square test (χ^2) – characteristics - test of independence - Yates correction - Simpson's paradox.
Current Contour	Biostatistics in public health - importance in research - statistics using software - open source - Jeffrey's Amazing Statistics Program (JASP). Proprietary - statistical package for social sciences (SPSS) - Graphpad - PRISM and Matrix Laboratory (MATLAB).
Total Lectures – 30	

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	L	L	S	M	S	S	M	M
CO2	M	M	M	M	S	M	S	S	M	M
CO3	S	S	M	M	S	M	S	M	S	S
CO4	S	M	M	S	S	M	S	S	S	S
CO5	S	M	L	S	S	M	S	M	S	S
S-Strong; M-Medium; L-Low										

Recommended References:

1. Pagano M, Gaureau K and Mattie H. 2022. Principles of Biostatistics. (III Ed.). CRC Press, USA.
2. Rosner B. 2010. Fundamentals of Biostatistics. (VII Ed.). Duxbury Press.
3. Quinn GP and Keough MJ. 2012. Experimental design and data analysis for biologists. (I Ed.). Cambridge University Press, UK.
4. Kulkarni AP. 2019. Basics of Biostatistics. (II Ed.). CBS Publ, India.
5. Hanumanth RP and Janardhan K. 2010. Fundamentals of Biostatistics. IK International Publ. House.
6. Negi KS. 2013. Methods in Biostatistics. (with latest MCQs). Aitbs Publ. India.
7. Mahajan BK. 2010. Methods in Biostatistics: For Medical Students and Research Workers. Jayapee Publ.
8. Balaji K, Raghavaiah AVS and Jayaveera KN. 2020. Biostatistics. Dreamtech Press.
9. Rao S. 2012. Introduction to Biostatistics and Research Methods. (V Ed.). PHI Learning Pvt. Ltd.
10. Chow SC, Shao J, Wang H and Lokhnygina Y. 2020. Sample Size Calculations in Clinical Research. (III Ed.). Chapman & Hall/CRC.

Related Online Contents:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5037948/
2. http://biostatcourse.fiu.edu/
3. https://link.springer.com/referenceworkentry/10.1007/978-1-4020-5614-7_255

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