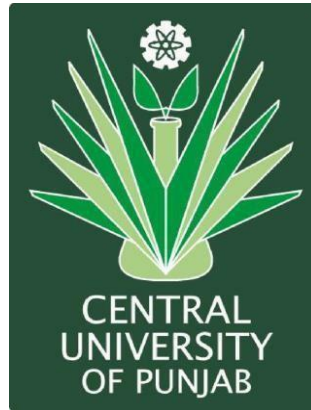


Central University of Punjab



M.Sc. Zoology

Batch: 2023 – 2025

Department of Zoology

Through 10th BoS – dt: 08-06.2023

Programme Learning Outcome:

Zoology is a gateway to modern day allied and applied branches of life sciences that deals with animal/cell model systems to understand life processes with potential application in the field of health and agriculture. The program focuses on developing conceptual clarity, research aptitude and employable skills required in the area to meet the challenges in capacity building and to develop compassion for other species and concern for the environment. The program is also aims to inculcate innovation in the field of Zoology, allied life sciences and interdisciplinary sciences.

Graduate Attributes:

Through participation in theory and practical courses offered by the M.Sc. Programme of the department as well as through the research and hands on training i.e. dissertation, graduates will be able to acquire in-depth-understanding of relevant concepts and develop research aptitude and critical thinking. They will also able to design scientific experiments and carry out research independently as well as in a team. Further, students will able to formulate scientific questions, exchange scientific ideas with fellow colleagues, analyze, troubleshoot and summarize the research data. Students will apply domain-specific knowledge to explore feasible solutions for relevant problems of national and global relevance

**Course Structure of the Programme
M.Sc. Zoology**

Semester – I

Course Code	Course Title	Type of course	L	T	P	Cr
	Core Courses					
ZOL.508	Biochemistry	Core	3	0	0	3
ZOL.511	Cell Biology	Core	3	0	0	3
ZOL.516	Animal Evolution and Classification	Core	3	0	0	3
ZOL.517	Ecological Principles	Core	3	0	0	3
ZOL.520	Lab Course (Practical) – I	SBC	0	0	10	5
	Discipline Elective (Opt any one)					
ZOL.514	Animal Cell Culture and Applications	DE	3	0	0	3
ZOL.525	Nanobiology	DE	3	0	0	
ZOL.579	Cytogenetics	DE	3	0	0	
BCH.511	Genetics	DE	3	0	0	
	Remedial Teaching					
ZOL.XXX	Individualized Education Plan (Non-credited course)	--	0	2	0	0
	Total Credits					20

L: Lectures; T: Tutorials; P: Practical; Cr: Credits; DE: Discipline Elective Course; IDC: Interdisciplinary Course; SBC: Skill based Course

Semester – II

Course Code	Course Title	Type of course	L	T	P	Cr
	Core Courses					
ZOL.521	Animal Physiology	Core	3	0	0	3
ZOL.522	Immunology	Core	3	0	0	3
ZOL.523	Molecular Biology	Core	3	0	0	3
ZOL.574	Animal Behavior	Core	3	0	0	3
ZOL.540	Lab Course (Practical) – II	SBC	0	0	10	5
	Discipline Elective (Opt any one)					
ZOL.529	Genetic Engineering	DE	3	0	0	3
ZOL.553	Vascular Biology	DE	3	0	0	
ZOL.554	Neurobiology and Degenerative Pathophysiology	DE	3	0	0	
ZOL.572	Endocrinology	DE	3	0	0	
ZOL.580	Stem Cell Technology and Translation Research	DE	3	0	0	
	Interdisciplinary (ID) Courses (for students of other departments)					
ZOL.515	Fundamentals of Cell Biology	IDC	2	0	0	2
ZOL.528	Basics in Neuroscience	IDC	2	0	0	
ZOL.560	Basics in Nanobiology	IDC	2	0	0	
	Remedial Teaching					
ZOL.XX	Individualized Education Plan (Non-credited course)	--	0	2	0	0
	Total Credits					22

L: Lectures; T: Tutorials; P: Practical; Cr: Credits; DE: Discipline Elective Course; IDC: Interdisciplinary Course; SBC: Skill based Course

Semester – III

Course Code	Course Title	Type of course	L	T	P	Cr
	Core Courses					
ZOL.513	Techniques in Life Sciences	Core	3	0	0	3
ZOL.551	Developmental Biology	Core	3	0	0	3
	Discipline Elective (Opt any one)					
ZOL.552	Cancer Biology	DE	3	0	0	3
ZOL.577	Reproductive Physiology	DE	3	0	0	
ZOL.578	Insect Biology	DE	3	0	0	
BCH.557	Clinical Diagnostics	DE	3	0	0	
HGE.555	Biosafety, Bioethics and Intellectual Property Rights	DE	3	0	0	
	Compulsory Foundation Courses					
ZOL.556	Research Methodology	CF	3	0	0	3
ZOL.557	Basic Statistics for Sciences	CF	3	0	0	3
ZOL.558	Entrepreneurship	CF	2	0	0	2
	Value Added Course					
ZOL.559	Scientific writing	VAC	2	0	0	2
ZOL.600	Dissertation – Part I	SBC	-	-	8	4
	Remedial Teaching					
ZOL.XX	Individualized Education Plan (Non-credited course)	--	0	2	0	0
	Total Credits					23

L: Lectures; T: Tutorials; P: Practical; Cr: Credits; DE: Discipline Elective Course; IDC: Interdisciplinary Course; SBC: Skill based Course

Semester – IV

Course Code	Course Title	Type of course	L	T	P	Cr
ZOL.601	Dissertation- Part II	SBC	0	0	40	20
	Total Credits					20

L: Lectures; T: Tutorials; P: Practical; Cr: Credits; SBC: Skill-based Course

Students will have an option to carry out dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking.

Total Credits Distribution:

S.N.	Types of Courses	Total Credits
1	Core	30
2.	Skill based including Dissertation/Internship	34
3.	Discipline Elective	09
4.	Interdisciplinary (ID)	02
5.	Compulsory Foundation	08
6.	Value based	02
	Total	85

MOOCs may be taken upto 40% of the total credits (excluding dissertation credits). MOOC may be taken in lieu of any course but content of that course should match a minimum 70%.

Evaluation Criteria for Theory Courses: 100 marks

Two or more of the given methods (Surprise Tests, in-depth interview, unstructured interview, Jigsaw method, Think-Pair Share, Students Teams Achievement Division (STAD), Rubrics, portfolios, case based evaluation, video based evaluation, Kahoot, Padlet, Directed paraphrasing, Approximate analogies, one sentence summary, Pro and con grid, student generated questions, case analysis, simulated problem solving, media assisted evaluation, Application cards, Minute paper, open book techniques, classroom assignments, homework assignments, term paper).

A. Continuous Assessment (Course-wise): [25 Marks]

B. Mid Semester Test: Based on Subjective Type Test [25 Marks]

C. End-Term Exam: Based on Objective Type Tests [50 Marks]: 70% subjective type and 30% objective type.

The objective type will include one word answers, fill-in the blank, sentence completion, true/false, MCQs', and matching, analogies. The subjective type will include a very short answer (1-2 lines), short answer (one paragraph), essay type with restricted response, and essay type with extended response.

Examination pattern from 2022-23 session onwards

Core, Discipline Elective, and Compulsory Foundation Courses			IDC, VAC, and Entrepreneurship, Innovation and Skill Development Courses	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	--	--
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester exam (ESE)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

Dissertation Proposal (Third Semester)			Dissertation (Fourth Semester)		
	Marks	Evaluation		Marks	Evaluation
Supervisor	50	Dissertation proposal and presentation	Supervisor	50	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	50	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	50	Dissertation report (30), presentation (10), final viva-voce (10)

Marks for internship shall be given by the supervisor, HoD and senior-most faculty of the department.

Evaluation Criteria for Practical Courses: 100 Marks

Internal Assessment	50 Marks
Attendance:	10 Marks
Continuous assessment:	30 Marks
Lab records:	10 Marks

End-semester exam	50 Marks
Identification of Spotters	10 Marks
Minor Question	10 Marks
Major Question	20 Marks
Viva-voce:	10 Marks

SEMESTER – I

L	T	P	Cr
3	0	0	3

Course Code: ZOL.508

Course Title: Biochemistry

Teaching hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Define fundamentals and basics of biochemistry

CLO2: Illustrate a thorough knowledge of the intersection between the disciplines of biology and chemistry

CLO3: Explain advanced aspects of biochemistry such as nutrition and metabolism associated with human physiology and diseases

CLO4: Develop a comprehensive knowledge of the theory and practice of modern biochemistry and its application to solve chemical problems

Unit/ Hours	Contents	Mapping with course Learning Outcome
I/ 12 Hours	Bioenergetics and Biomolecules: Thermodynamics, Internal Energy, Enthalpy, Entropy, Concept of free energy, standard free energy. Relationship between equilibrium constant and standard free energy change. Biological oxidation-reduction reactions. Classification, structure, general properties and functions of polysaccharides, Lipids, Proteins and Nucleic acids.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	
II/ 11 Hours	Enzymology: Historical perspective, general characteristics, nomenclature, IUB enzyme classification, measurement and expression of enzyme activity, enzyme assay, factors influencing enzyme activity, active site, Michaelis-Menten equation and its importance. Definitions of IU, Katal, enzyme turnover and specific activity. Industrially and clinically important enzymes.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	
III/ 11 Hours	Carbohydrate and Lipid Metabolism: Glycolysis, gluconeogenesis, TCA cycle, hexose monophosphate (HMP) shunt, disorders of carbohydrate metabolism. Biosynthesis and oxidation of saturated and unsaturated fatty acids, and disorders of lipid metabolism.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	

IV / 11 Hours	Amino Acid and Nucleic Acid Metabolism: Biosynthesis of protein, general catabolism of amino acids, deamination, transamination, urea cycle, disorders of amino acid metabolism. Biosynthesis of purine and pyrimidine nucleotides, disorders of purine and pyrimidine metabolism.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	

Mode of Transaction

The classroom learning would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brainstorming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2010). Biochemistry. W.H. Freeman &Company. USA.
2. Mathews, C. K., Van Holde, K. E. and Ahern, K. G. (2000). Biochemistry. Oxford University Press Inc. New York.
3. Nelson, D. and Cox, M. M. (2008). Lehninger Principles of Biochemistry. BI publications Pvt. Ltd. Chennai, India.
4. Shukla, A. N. (2009). Elements of Enzymology. Discovery Publishing. New Delhi, India.
5. Voet, D. and Voet, J. G. (2008). Principles of Biochemistry. CBS Publishers & Distributors. New Delhi, India.
6. Nelson, D. and Cox, M.M. (2021) Lehninger Principles of Biochemistry. WH Freeman & Co Publisher
7. Singh and Goyal (2020) Lippincott's Illustrated Reviews - Biochemistry South Asian Edition. Wolters Kluwer (India) Pvt. Ltd.
8. Botham, K. ; McGuinness, O. and Weil, P. A. (2022) Harper's Illustrated Biochemistry, Thirty-Second Edition. McGraw-Hill Education
9. Voet, D., Voet J.G. and Pratt C.W.(2018) Voet's Principles of Biochemistry 5th Edition. Wiley Publisher
10. Berg, J. M., Tymoczko, J.L. and Stryer, L. (2019) Biochemistry 9th Edition WH Freeman Publisher

Web sources:

<https://epgp.inflibnet.ac.in/Home>

<https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Code: ZOL.511

Course Title: Cell Biology

Total Hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Define the structure and basic components of a cell

CLO2: Distinguish the structure of prokaryotic and eukaryotic cell

CLO3: Explain macromolecules, membranes, organelles and their related functions in cell and molecular biology

CLO4: Develop a basis for understanding the basic cell physiology and disease processes in which signaling is compromise

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 12 Hours	Cell evolution and Membrane Structure and Function: Evolution of the cell, molecules to cell, prokaryotes and eukaryotes, Models of membrane structure, membrane proteins, membrane carbohydrates, membrane transport types, passive, active transport, transport of small molecules and membrane transport of macromolecules.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	
II / 11 Hours	Structural Organization and Function of Intracellular Organelles: Lysosomes, ribosomes, peroxisomes, golgi apparatus, endoplasmic reticulum and its types, Structure and function of mitochondria and nucleus.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions	
III / 11 Hours	Cytoskeleton and Cell Communication: The nature of cytoskeleton, intermediate filaments, microtubules, actin filaments, cilia and centrioles, organization of the cytoskeleton. Cell adhesions, cell junctions, cell-cell adhesion and communication and cell-extracellular matrix interaction.	CLO3
	Learning activity: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Cell Cycle and signaling pathways: Mitosis and meiosis, cell cycle and their regulation, Introduction to cell signalling: signalling networks, protein phosphorylation/dephosphorylation, Intracellular signalling pathways: covering the major pathways in cells (MAPK, PI3K-AKT, JAK-STAT, and NF-kB) and recent research work	CLO4

	Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	
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Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brainstorming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J. D. (2015). Molecular Biology of the Cell. Garland publishers, Oxford.
2. Celis, J. E. (2006). Cell Biology: A Laboratory Handbook, Vol 1, 2, 3. Academic Press, UK.
3. Gupta, P. K. (2012). Cytology, Genetics and Evolution. Rastogi publications, Meerut, India.
4. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India.
5. Gupta, P. K. (2005). Cell and Molecular Biology. Rastogi publications, Meerut, India.
- James, D. W., Baker, T.A., Bell, S.P., Gann, A. (2009). Molecular Biology of the Gene. Benjamin Cummings, USA.
6. Johnson, A., Lewis, J., Raff, M. (2007). Molecular Biology of the Cell. Garland Science, USA.
7. Lodish, H., Berk, A., Chris, A. K. and Krieger, M. (2008). Molecular Cell Biology. W.H. Freeman, USA.
8. Alberts, B. , Heald. R. and and Johnson A. (2022) Molecular Biology of the Cell Seventh edition. WW Norton & Co. Publisher
9. <https://epgp.inflibnet.ac.in/Home>
10. <https://www.vlab.co.in/>
11. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Code: ZOL.516

Course Title: Animal Evolution and Classification

Total hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to obtain

CLO1: Detailed understanding of how galaxies, stars, solar system and planets came into existence and conditions of earth before life, origin of life, micro evolutionary forces driven diversity of life forms, evolutionary trends and applications of evolution in agriculture, disease and research

CLO2: Updated knowledge on Animal Systematics and methods used& updated information of Animal biodiversity and conservation strategies

CLO3: Knowledge on updated Animal Classification and detailed description of Non-chordates and latest research

CLO4: Knowledge on updated Animal Classification and detailed description of Chordates and latest research

Unit/ Hours	Contents	Mapping with Course Learning Outcome
I / 12 h	Evolution: Macroevolutionary concepts and processes, Geological time scale, Microevolutionary forces: Darwinism& the origin of species, Natural selection, Sexual Selection, Genetic Drift & Mutation, Gene flow, Hardy Weinberg equilibrium, Concept of Speciation, Hybrid zone, latest evolutionary trends and research, Applications of the study of evolution	CLO1
	Learning activities: Flipped classroom approach, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
II / 12 h	Systematics: Binomial nomenclature; three domain classifications; phylogenetic tree construction; applications of phylogeny; cladistics: monophyletic, paraphyletic and polyphyletic groups; shared and derived characters; homoplasy; parsimony analysis; molecular clocks, Biodiversity and Conservation	CLO2
	Learning activities: Problem solving, oral presentations, online resources including e-books, videos and research publications	
III / 11 h	Non-chordates: Phylum sporifera, cnidarian, Platyhelminthes, Rotifera, Lopophorates, Mollusca, Annelida, nematode, Arthropoda, Echinodermata	CLO3

	Learning activities: Oral presentations, online resources including e-books, videos and research publications	
IV / 10 h	Chordates: Overview of chordates: cephalochordate, urochordata, Myxini, Petromyzontida, Chondrichthyes, Actinopterygii, Actinistia, Dipnoi, Amphibia, Reptilia and Mammalia	CLO4
	Learning activities: Oral presentations, online resources including e-books, videos and research publications	

Mode of Transaction

The classroom learning/practical's/project work would be based on:

Lecture, Demonstration, Flipped Classroom approach, Digital learning, Project Method, Activity-based, Field-based, Seminars, Group discussions, Focused group discussions, brainstorming sessions, E-tutoring, Dialogue Mode, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, textbook reading assignments and case studies.

The following tools shall be used in teaching and practicals:

Textbooks, GoI e-learning platforms, PowerPoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Evolution: Making sense of life by Carl Zimmer and Douglas Emlen, 2020, 3rd Edition
2. Evolution by Carl T. Bergstrom, Lee Alan Dugatkin, 2016. 2nd Edition
3. Modern textbook of Zoology: Vertebrates by R.L. Kothpal, 2019-20, 4th Edition
4. Modern textbook of Zoology: Invertebrates by R.L. Kothpal, 2019-20, 12th Edition
5. Mayr, E. & Ashlock, P.D., Principles of Systematic Zoology. 1991. 2nd edition. McGraw Hill International Edition
6. Relevant research articles and digital resource

L	T	P	Cr
3	0	0	3

Course Name: Ecological Principles

Course Code: ZOL.517

Course type: Core Course

Total Hours: 45

Course Learning Outcomes (CLO): On completion of this course, students will be able to:

CLO1: Describe the process of interaction among the living organisms with their environment

CLO2: Develop a broad understanding of the processes that shape the distribution and abundance of organisms

CLO3: Explain energy flow and the movement and recycling of matter in communities and ecosystems

CLO4: Describe changes in population growth in an ecosystem and types of population factors

Units/Hours	Contents	Mapping with Course Learning Outcome
I / 10 Hours	<p>Introduction to Ecology: Habitat and niche, niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Adaptation, ecosystem, biotic and abiotic factors, food chain, food webs, trophic levels. Biomes: types (terrestrial and aquatic), distribution and unique features, Major habitat types of the subcontinent, geographic origins and migrations of species. Common Indian mammals, birds. Seasonality and phenology of the subcontinent.</p>	CLO1
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit</p>	
II / 12 Hours	<p>Community ecology and biogeography: Nature of communities; community structure and attributes; richness and evenness; keystone species, flagship species and umbrella species; dominant species, ecotone, edge effect, ecotypes, plant indicators; ecological succession – types and mechanism; MacArthur and Wilson’s island biogeography equilibrium theory-limitations and modifications; colonization vs. extinction; species area relationship.</p>	CLO2
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit</p>	
III / 11 Hours	<p>Ecosystem Dynamics: Concept and components of ecosystem, ecological pyramids, energy flows in different ecosystems, energy models, ecosystem productivity. Types and characteristics of ecosystem- terrestrial (forest, desert, grassland) and aquatic (pond, marine), wetlands, estuaries, natural and manmade ecosystems, forest types in India. Biogeochemical cycles – cycling of water, nutrients.</p>	CLO3
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit</p>	
IV / 12 Hours	<p>Population Ecology: Population characteristics, population interaction; prey-predator relationships; Theories of population growth, population dynamics, regulation. Population growth curves; population regulation; life history strategies (<i>r</i> and <i>K</i> selection); Concept of metapopulation, demes and dispersal, niche- concept and types, interdemec extinctions, age structured populations</p>	CLO4
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit</p>	

Transaction Mode:**The classroom learning/practicals/project work would be based on:**

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Urry, L. A. et al. (2016). Campbell Biology. Pearson publishers, 11th edition.
2. Smith, T. M. and Smith, R. L. (2015). Elements of Ecology. Benjamin Cummings Publishing Company, 9th edition.
3. Begon, M., and Townsend, C. R. (2021). Essentials of Ecology. Wiley Publishers, 5th edition.
4. Odum, E. and Barrett, G. W. (2005). Fundamentals of Ecology. Cengage Learning, 5th edition.
5. Relevant research articles and digital resources

L	T	P	Cr
0	0	10	5

Course Code: ZOL.520**Course Title: Lab Course (Practical) – I****Total Hours: 150**

Course learning outcomes: After going through the course the learners will be able to

CLO1: Acquaint students with a fundamental knowledge of the lab instrumentation and reagents preparation

CLO2: Illustrate biochemical estimation of biomolecules

CLO3: Demonstrate different techniques involved in biomolecule separation

CLO4: Illustrate techniques and procedures routinely used in the core courses offered in the semester

1. Laboratory instrumentation
2. Preparation of Buffers and Solutions
3. Biochemical estimation and analysis of Proteins, Lipids and Carbohydrates
4. SDS-and native polyacrylamide gel electrophoresis
5. Cell structure: Compound, Fluorescence, and Electron microscopy
6. Histochemistry: Fixation, Sectioning, Embedding, Processing and Staining
7. Immunocytochemistry
8. Identification of cell mitosis and meiosis stages
9. Life cycles of Silkworm

10. Life cycle of the honeybee
11. Cell trypsinization and Cell count (Hemocytometer)
12. MTT Assay
13. *In vitro* free radicals-based assays
14. Peripheral blood leukocyte culture for chromosomal studies
15. Isolation of Lymphocytes from whole blood
16. Karyogram/Karyotype
17. Buccal micronucleus
18. Medical Case study
19. FISH (Video demonstration)

Mode of Transaction

The classroom learning/practical's/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brainstorming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching and practical:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Sambrook, J. (2006). The Condensed Protocols from Molecular Cloning: A Laboratory Manual. Cshl Press. New York.
2. Sambrook, J. and Russell, D. W. (2000). Molecular Cloning: A Laboratory Manual (3 Vol-set). 3rd Edition, CSHL Press, New York.
3. <https://epgp.inflibnet.ac.in/Home>
4. <https://www.vlab.co.in/>
5. <https://lms.cup.edu.in/course/index.php?categoryid=76>

Discipline Elective Courses:

L	T	P	Cr
3	0	0	3

Course Code: ZOL.514

Course Title: Animal Cell Culture and Applications

Total hours: 45 hours

Course learning outcomes (CLO): After going through the course the learners will be able to

- CLO1: Describe the foundational knowledge of cell culture techniques and competence in laboratory techniques
- CLO2: Explain problems common to routine cell culture
- CLO3: Develop a thorough knowledge on application of molecular techniques to *in vitro* conditions

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Introduction to Animal Cell Culture: Historical background. Good Laboratory Practices (GLP), sterilization methods and techniques. Biology of animal cell and cell-cell interactions, growth environment and culture requirement. Culture, subculture, cell line, cell strain, cell clone. Importance of serum and serum-free media.	CLO 1
	Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	
II / 12 Hours	Cell Culture Types and Characterization: Primary cell culture, tissue culture, organ culture, cell line immortalization, cell line preservation & characterization, karyotype analysis, cellular markers, commercial cell lines, and insect cell culture.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions	
III / 12 Hours	Applications of Animal Cell Culture: <i>In vitro</i> transfection of animal cells, cell-based assays, and cell differentiation and movement. Cancer Research, vaccine manufacture, gene and stem cell therapy, production of recombinant proteins, and toxicology studies.	CLO2& CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 10 Hours	Translational Research Applications: Animal cells as the applicable products (recombinants, hybridomas, stem cells and transplants). Focus on Rodent and murine models in scientific research associated with cancer and neurodegenerative diseases.	CLO2& CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Freshney, R. I. (2010). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell, 2010. 6th Edition.
2. Davis, J. M. (2008). Basic Cell Culture. Oxford University Press. New Delhi.
3. Davis, J. M. (2011). Animal Cell Culture. John Willy and Sons Ltd. USA.
4. Freshney R. I. (2005). Culture of Animal Cells. John Willy and Sons Ltd. USA.
5. Butler, M. (2004). Animal Cell Culture and Technology. Taylor and Francis. New York
6. Ian Freshney, R. (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications
7. <https://epgp.inflibnet.ac.in/Home>
8. <https://www.vlab.co.in/>
9. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Code: ZOL.525

Course Title: Nanobiology

Total hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Define the interdisciplinary knowledge of basic concepts of nanoscience and biomaterials

CLO2: Explain characterization of techniques and biomedical aspects of nanomaterials

CLO3: Apply learned knowledge to develop nanomaterials

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Nanoscience: Definition and concepts, nanomaterials classification, properties, applications, Criteria for suitability of nanostructures for biological applications.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	Nanomaterials: Synthesis, biofunctionalization and characterization techniques like electron microscopy (scanning and transmission), atomic force microscopy; nanoparticle analyzer, zeta potential measurement, flow cytometry, spectroscopic techniques including spectrophotometer, spectrofluorimeter & FTIR.	CLO1 & CLO2

	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 11 Hours	Materials in Medicine: Biomaterials, Theranostics, Nanostructures for drug delivery and therapeutics, biosensor, electrochemical biosensor, bioimaging and point-of-care diagnostics tools including lateral flow immunoassay and microfluidic devices.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Nanotoxicity: Effect of nanomaterials on human health, nanomaterial-cell interaction, <i>in vitro</i> nanotoxicity assays, and challenges in the risk assessment of nanomaterials.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Bagchi, D., Bagchi, M., Mariyama, H. and Shahidi, F. (2013). BioNanotechnology: A Revolution in Food, Biomedical and Health Sciences. Wiley–Blackwell publication.
2. Rai, M., Duran, N. and Southam, G. (2011). Metal Nanoparticles in Microbiology. Springer publication.
3. Udupa, N., Gupta, P. D. (2009). Nanotechnology in Health Care. ShyamPrakashan publication.
4. Xie, Y. (2012). The Nanobiotechnology Handbook. CRC Press.
5. Murty, B. S., Shankar, P., Raj, B., Rath, B. B. and Murday, J. (2013). A Textbook of Nanoscience and Nanotechnology. Tata McGraw Hill Publication.
6. Sougata Ghosh, Thomas J Webster (2021), Nanobiotechnology

L	T	P	Cr
3	0	0	3

Course Code: **ZOL. 579**
 Course Title: **Cytogenetics**
 Total hours: **45**

Course Learning outcomes: After going through the course the learners will be able to

CLO1: Provide the knowledge about the genetic influence and history of human genetics, Chromosome, and Mendelian laws to the students for their curriculum development and knowledge enrichment.

CLO2: Basically cytogenetic studies are widely used for genetic testing of various diseases; hence the students will get trained in identifying different hereditary diseases and could analyze any chromosomal anomalies which will be helpful in medical practice.

CLO3: Define the type of various chromosomal alterations and recent diagnostic techniques

CLO4: Describe the various prenatal and postnatal techniques, genetic counselling and recent studies

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	History and development of human genetics Mendelian Laws (law of dominance, law of segregation, law of independent assortment); Human genome database; Genetic principles and their application in medical practice; case studies (Interacting with patients, learning family history, and drawing pedigree chart), Interaction with patients to create the case report; Case report preparation, NCBI database; OMIM	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	International System of Chromosomal Nomenclature (ISCN) Karyotyping, Karyotyping terminology, International system of Human Chromosome Nomenclature, Nomenclature of aberrant karyotypes, common syndromes due to numerical chromosomal changes, Structural alterations (translocations, duplications, deletions, microdeletions, fragile sites), Chromosomal basis and non-chromosomal basis of sex-determination, consanguinity and its effects	CLO2

	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 12 Hours	Structural, Autosomal, Sex-Chromosomal alterations and recent detection techniques Structural chromosomal alternations, deletion, addition, translocation, inversion, dicentric chromosome, mosaics, and others; FISH, Comparative genomic hybridization (CGH), aCGH.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Prenatal diagnosis (Invasive and Non-invasive techniques) Chorionic villi sampling, fetoscopy, Ultrascopy, amniocentesis. Postnatal diagnosis: Peripheral blood leucocyte culture, sister chromatid exchange, fragile site, Mitotic index, Genetic Counselling. Mosaicism, PGD, Neonatal diagnostics	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Mode of Transaction

The classroom learning/practical's/Video lecture/ project work would be based on: Lecture, Demonstration, Project Method, Seminars, Group discussions, Brainstorming, E- tutoring, Experimentation, Panel discussion and Case studies.

The following tools shall be used in teaching:

Textbooks, GOI e-learning platforms, PowerPoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. DP Snustad and MJ Simmons (2012) Principles of Genetics, John Willey & Sons Publication, 6th Edition.
2. Gelehrter, T.D., Collins, F.S. and Ginsburg, D., 1998. Principles of medical genetics. Lippincott Williams & Wilkins.
3. Principle and Practice of Medical Genetics, Rimoinet et al., 2002
4. ISCN 2020: An International System for Human Cytogenomic Nomenclature 2020. Jean McGowan-Jordan, Ros J. Hastings, Sarah Moore. S.Karger AG.
5. Cytogenetics and Molecular Cytogenetics. 1st Edition, 2023. Thomas Liehr, Taylor & Francis.

Web Sources:

1. https://link.springer.com/protocol/10.1007/978-1-4939-6703-2_25
2. <https://www.mayo.edu/research/core-resources/cytogenetics-core/overview>
3. <https://www.gfmer.ch/SRH-Course-2011/community-genetics/pdf/Cytogenetics-Dahoun-2011.pdf>

L	T	P	Cr
3	0	0	3

Course Code: BCH.511

Course Title: Genetics

Total Hours: 45

Course learning outcomes (CLO): Students will be able to

CLO1: Demonstrate the principles of inheritance at the molecular, cellular and organismal levels.

CLO2: Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums related to concepts of genetics.

CLO3: Describe and correlate hereditary information and their application to real life situations.

Units/ Hours	Contents	Mapping with course Learning Outcome
Unit I/ 13 Hours	<p>Mendelian Principles: Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests.</p> <p>Extensions of Mendelian Principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.</p> <p>Extra-Chromosomal Inheritance: Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance (Coiling in Snails).</p>	CLO1 & CLO3
	<p>Learning activities: <i>Apply Punnett squares to solve problems in Genetics.</i></p>	
Unit II/ 12 Hours	<p>Gene Mapping Methods: Molecular markers: RAPD, RFLP, SSR, SNP, ISSR, and SCAR; Linkage maps, tetrad analysis in Neurospora, mapping with molecular markers, development of mapping population in plants.</p> <p>Human Genetics: Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders.</p> <p>Quantitative Genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.</p>	CLO1 & CLO2
	<p>Learning activities: Flipped classroom for understanding concepts in genetic mapping.</p>	

Unit III/ 10 Hours	Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal vs somatic mutants, insertional mutagenesis, applications in reverse and forward Genetics; Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications; Hardy Weinberg equilibrium. Molecular basis of spontaneous and induced mutations.	CLO2 & CLO3
	Learning activities: Problem solving using Hardy Weinberg law.	
Unit IV/ 10 Hours	Microbial Genetics: Microbes as tools for genetic studies. Organization of genetic material in bacteria; and viruses, Gene transfer mechanisms, F plasmid; Lambda phage: structure, genetic makeup and life cycle (lytic and lysogeny); Natural transformation and competence; Molecular basis of natural transformation – DNA uptake competence systems in gram positive and gram negative bacteria. Bacterial Conjugation- Properties of the F plasmid, F ⁺ x F ⁻ mating, F' x F ⁻ conjugation. Transduction- Generalized and specialized transduction, virus life cycle and replication.	CLO3
	Learning activities: Visualization of animations assembled by student teams.	

Suggested Readings:

1. Snusted, D.P., Simmons, M. J. (2015). *Principles of Genetics*. 7th Edition, John Wiley & Sons, New York.
2. Raven P, Johnson GB, Mason KA, Losos JB, Duncan T (2020). *Biology*, 12th Edition, McGraw-Hill, USA.
3. Griffiths AJF, Doebley J, Peichel C, Wassarman, DA. (2020). *An introduction to Genetic Analysis*. 12th Edition W.H. Freeman publication, USA.
4. Snyder L, Peters JE, Henkin TM, Champness W. (2013) *Molecular Genetics of Bacteria*, 4th edition; ASM Press.
5. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2017). *Molecular Biology of the Gene*. 7th Edition, Benjamin Cummings, USA.

Web Resources:

- <https://www.genome.gov/about-genomics/teaching-tools/Genomics-Education-Websites>
- <https://projects.ncsu.edu/cals/course/gn411/net-resources.html>

Modes of transaction

Lecture cum Demonstration; Problem solving approach, Self-Learning, Inquiry training, Co-operative learning, and Flipped learning

Tools used: PPT, Animations, YouTube, Google Drive, Google Classroom

SEMESTER – II

L	T	P	Cr
3	0	0	3

Course Code: ZOL.521

Course Title: Animal Physiology

Total hours: 45

Course learning outcomes: After going through the course the learners will be able to

CLO1: Describe physiology of human and other animals.

CLO2: Differentiate digestive, respiratory, excretory and musculoskeletal systems

CLO3: Relate chemical and biological processes occurring at the different organizational level in animal and human species.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 12 Hours	Introduction to human physiology and organ systems. Digestive System: Digestive System: Hunger and thirst mechanisms, Feeding strategies, Foregut, midgut, and hindgut fermentation in animals, ruminant and monogastric digestive system, absorption, metabolic energy balance, and BMR.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
II / 11 Hours	Excretory System: Comparative physiology of excretion, kidney, urine formation, urine concentration, waste elimination, micturition, regulation of water balance, blood volume, blood pressure, electrolyte balance, acid-base balance.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
III / 12 Hours	Respiratory System:- Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
IV / 10 Hours	Musculoskeletal System: Bones of the skeleton, muscles, cartilage, tendons, ligaments, joints and other connective tissues, The basic mechanism of muscle contraction and muscle fatigue.	CLO2 & CLO3

	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
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Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Brain storming, E-tutoring, Experimentation, Panel discussion, Tutorials, Problem solving, Debates and Case studies.

The following tools shall be used in teaching:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Guyton. (2007). Textbook of Medical Physiology. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
2. Hill, R. W, Wyse, G. A. and Anderson, M. (2016). Animal Physiology. 4th Edition. Sinauer Associates Inc. USA.
3. Murray, R. K. (2009). Harper’s Illustrated Biochemistry. Jaypee Publishers, New Delhi.
4. Tyagi, P. (2016). A Textbook of Animal Physiology. Dominant Publishers and distributors, New Delhi, India.
5. Relevant research articles and digital resources
6. Vaz (2020) Guyton & Hall Textbook of Medical Physiology: Third South Asia Edition. Elsevier Health Science
7. Tortora, G. J. and Derrickson, B.H. (2017) Tortora's Principles of Anatomy and Physiology 15th Edition. Wiley Publisher
8. Netter H. F. (2022) Netter Atlas of Human Anatomy: Classic Regional Approach, International Edition -8th Ed: A Regional Approach (Netter Basic Science) . Elsevier - Health Sciences Division Publisher
9. <https://epgp.inflibnet.ac.in/Home>
10. <https://www.vlab.co.in/>
11. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Code: ZOL.522

Course Title: Immunology

Total hours: 45

Course learning outcomes: After going through the course the learners will be able to
CLO1: Define the basics of immune system

CLO2: Illustrate the components and molecules of immunity

CLO3: Explain various immune responses at the cellular level that work together to protect the host.

CLO4: Develop a thorough knowledge on Immune-Based Diagnosis and Therapy for inflammatory Diseases

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 12 Hours	Introduction to Immune System: Recognition of self and non-self, primary and secondary lymphoid organs, innate and adaptive immunity, Cells involved in immune responses, Professional phagocytes, Non-professional phagocytes, Natural Killer cells, Antigen Presenting cells, T lymphocyte and B lymphocytes, Cytokines, Interferons and interleukins.	CLO1
	Learning activity: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
II / 12 Hours	Complement System, Major Histocompatibility Complex and Immunoglobulins: Complement system structure, function, activation pathways and its biological consequences, Structure and functions of Major Histocompatibility Complex (MHC) and Human Leukocyte Antigen (HLA) system. Antigen processing and role of MHC molecules in antigen presentation, Immunoglobulins: basic structure, classes and subclasses, structural and functional relationship, Molecular mechanisms of antibody diversity and class switching.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
III / 11 Hours	Hypersensitivity: Types, features and mechanisms of immediate and delayed hypersensitivity reactions, immunity to microbes, immunity to tumors, AIDS and immune-deficiencies, hybridoma technology, Auto-immune disorders.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
IV / 10 Hours	Monoclonal Antibodies and Diagnostic Immunology: Production, characterization and applications in diagnosis, therapy, quantitative and qualitative methods for immunoglobulin determination, antigen and antibody reactions, agglutination-precipitation, immunofluorescence and immunoblotting, assessment of human allergic and hormonal diseases.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Seminars, Workshop, Group discussions, Team teaching, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Quiz, Experimentation, Scientific discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Kindt, T. J., Osborne, B. A. and Goldsby, R. A. (2007). Kuby Immunology. 7th Edition. W.H. Freeman, USA.
2. Abbas. (2008). Cellular and Molecular Immunology. CBS Publishers & Distributors, India.
3. Charles, A. and Janeway, J. R. (1994). Immunobiology: The Immune System in Health and Disease. Blackwell Publishing, USA.
4. Delves, P. J., Roitt, I. M. and Seamus, J. M. (2006). Roitt's Essential Immunology (Series–Essentials). Blackwell Publishers, USA.
5. Elgert K. D. (2009). Immunology: Understanding the Immune System. Wiley-Blackwell, USA.
6. Paul, W. E. (1993). Fundamental Immunology. Raven Press, SD, USA.
7. Punt, J. ; Stranford. S. and Jones, P. Kuby Immunology (2018) 8th Edition. WH Freeman & Co Publisher
8. Abbas (2021) Cellular and Molecular Immunology, 10th Ed, South Asia Edition

L	T	P	Cr
3	0	0	3

Course Code: ZOL.523

Course Title: Molecular Biology

Total hours: 45

Course Learning outcomes: After going through the course the learners will be able to

CLO1: Define the basic knowledge on chromosome, chromatin and chromatid and its regulation as well as the recent cytogenetic techniques and research work

CLO2: Detailed understanding on the DNA biology, replication and mechanism.

CLO3: Provide the knowledge about the RNA biology and its mechanism towards various diseases.

CLO4: Define the basic information about Prokaryotic and Eukaryotic Transcription and post-translational modifications

Unit/ Hours	Contents	Mapping with Course
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		Learning Outcome
I / 12 h	Introduction of Chromosome, Chromatin, and recent diagnostics methods Historical event of Chromosomes; Definition, Types of Chromosomes, Chromatin and its regulation, Chromatid, peripheral blood lymphocyte cultures; Arrangement of 23 pairs of human chromosomes by banding position, Molecular Cytogenetics, Fluorescence in-situ hybridization (FISH).	CLO1
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
II / 12 h	Basics of DNA Structure of DNA (Watson and Crick's model), Types of DNA, Prokaryotic and Eukaryotic DNA replication, Mechanism of DNA replication, Mismatch, Epigenetics and its regulation, DNA repair pathways, DNA methylation	CLO2
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
III / 11 h	RNA Biology Structure of RNA; Types of RNA; Coding – role of mRNA nuclear export and human diseases, Non-Coding Housekeeping - structure and role of tRNA, rRNA, Non-Coding Regulatory – role and functions of lncRNA; X-inactivation (Xist) and ncRNA in imprinting, role and functions of smallncRNA and its types. Recent research work.	CLO1, CLO3 & CLO4
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
IV / 10 h	Transcription and Translation Prokaryotic and Eukaryotic Transcription: initiation, elongation & termination, Post transcriptional modifications, capping, polyadenylation, splicing, regulation of gene expression, Prokaryotic and Eukaryotic Translation, post-translational modifications (Phosphorylation, Acetylation, Methylation)	CLO3 & CLO4
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	

Mode of Transaction

The classroom learning/practical's/project work would be based on: Lecture, Demonstration, Project Method, Seminars, Group discussions, Brainstorming, E- tutoring, Experimentation, Panel discussion and Self-learning.

The following tools shall be used in teaching:

Textbooks, Power point, Educational Videos and Animations, Research and Review articles

Suggested Readings:

1. Hardin, J. and Lodolce J. (2020) Becker's World of the Cell. 10th Edition. Pearson Publication
2. The Principles of Clinical Cytogenetics, Steven L. Gersen, Martha B. Keagle, Springer; 3rd Edition. 2013
3. CHROMOSOME STRUCTURE AND ABERRATIONS, Bhat, Tariq Ahmad, Wani, Aijaz Ahmad, 2017
4. Cell and Molecular Biology, De Robertis E.D.P, 8th Edition, 2017.
5. Principles of Genetics, D. Peter Snustad, Michael J. Simmons, 7th Edition, 2015
6. Molecular Biology of the Gene by James D. Watson, Seventh Edition, 2013.
7. Ozkan E, Lacerda MP. Genetics, Cytogenetic Testing and Conventional Karyotype. [Updated 2022 Aug 8]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK563293/>
8. Molecular Biology of the Gene by James D. Watson, 2013, Seventh Edition
9. Molecular Biology: Principles and Practice by M.M. Cox, 2016, 2nd Edition
10. Molecular Biology by Robert Weaver, 2012, 5th edition
11. Hardin, J. and Lodolce J. (2020) Becker's World of the Cell. 10th Edition. Pearson Publication

L	T	P	Cr
3	0	0	3

Course Name: Animal Behavior

Course Code: ZOL.574

Course type: Core Course

Total Hours: 45

Course learning outcomes (CLO):

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

CLO1: Define Animal Behavior

CLO2: Explore variety of different behaviors found in a broad range of animal groups, using a scientific and evolutionary approach

CLO3: Describe the communication process in animals

CLO4: Analyze behavior in animals including humans

Units/Hours	Contents	Mapping with Course Learning Outcome

I / 11 Hours	Approaches and methods in study of behavior: Conceptual, theoretical and empirical; proximate and ultimate causation; altruism and evolution group selection, kin selection, reciprocal altruism, co-operation.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
II / 11 Hours	Cognition: Neural basis of learning, memory, cognition, sleep and arousal; biological clocks; development of behavior	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
III / 12 Hours	Sociality: Social communication; social dominance; use of space and territoriality; mating systems, courtship behavior, parental investment and reproductive success; parental care; aggressive behavior.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV / 11 Hours	Foraging: Habitat selection and optimality in foraging; migration, orientation and navigation; domestication and behavioral changes, ageing and disease, animal personalities	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	

Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brainstorming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Alcock, J. (2013). Animal Behavior: An Evolutionary Approach. Sinauer Associates, 10th Edition
2. Dugatkin, L.A. (2020). Principles of Animal Behavior. The University of Chicago Press, 4th edition.
3. Breed, M and Moore, J. (2012). Animal Behaviour. Academic Press, 2nd edition.
4. Nichollas et al. (2012). From Brain to Behavior. Sinauer Associates, 5th edition.
5. Griffith et al. (2004). Introduction to Genetic Analysis. W H Freeman & Co Ltd, 8th Revised edition.
6. Relevant research articles and digital resources

L	T	P	Cr
0	0	10	5

Course Code: ZOL.540

Course Title: Lab Course (Practical) – II

Total hours: 150

Course learning outcomes: After going through the course the learners will be able to

CLO1: Describe parameters toward understanding the pathophysiology of various human disease

CLO2: Apply techniques involved in identification and quantification of protein expression

CLO3: Demonstrate various molecular biology techniques.

CLO4: Illustrate techniques and procedures routinely used in the core courses offered in the semester

1. Measurement of vital parameters: Blood pressure, Blood glucose, Heartbeat (ECG), Pulse Rate, and Glucose tolerance test.
2. DigiFrog: Online animal dissection modules.
3. Spirometry
4. ELISA
5. Western blotting
6. Dot blot technique
7. Double immunodiffusion
8. RNA isolation
9. DNA isolation
10. Polymerase Chain Reaction
11. cDNA synthesis and RT-PCR analysis
12. Gene cloning: Primer designing, Restriction digestion, ligation, transformation and screening.
13. Animal handling: mice/rat/rabbit (tutorials only)
14. Animal Perfusion
15. Immunohistochemistry
16. Cell cycle monitoring by flow cytometry
17. Microscopic examination of human parasite life cycles (amoeba, cestodes, nematodes, and plasmodium)
18. Blood Micronucleus test
19. Mitochondrial DNA isolation
20. mtDNA copy number variations
21. Stem Cell maintenance (Video demonstration)
22. Establishment of hiPSCs (Video demonstration)

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile

teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Hofmann, A. (2018) Wilson And Walkers Principles And Techniques Of Biochemistry And Molecular Biology 8th Edition. Cambridge University Press
2. Sambrook, J. (2006). The Condensed Protocols from Molecular Cloning: A Laboratory Manual. Cshl Press. New York.
3. Sambrook, J. and Russell, D. W. (2000). Molecular Cloning: A Laboratory Manual (3 Vol-set). 3rd Edition, CSHL Press, New York.
4. Hofmann, A. (2018) Wilson And Walkers Principles And Techniques Of Biochemistry And Molecular Biology 8th Edition. Cambridge University Press
5. <https://epgp.inflibnet.ac.in/Home>
6. <https://www.vlab.co.in/>
7. <https://lms.cup.edu.in/course/index.php?categoryid=76>

Discipline Elective Courses:

L	T	P	Cr
3	0	0	3

Course Code: ZOL.529

Course Title: Genetic Engineering

Total hours: 45

Course learning outcomes: After going through the course the learners will be able to
 CLO:1 Describe versatile tools and techniques employed in recombinant DNA technology
 CLO:2 Formulate knowledge required to design, execute, and analyze the results of genetic experimentation in animal model systems
 CLO:3 Develop a thorough knowledge on methodological repertoire that allows students to innovatively apply in basic and applied fields of biological research

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Tools of Genetic Engineering: Restriction enzymes, Enzymes in genetic engineering, recombinant cloning vectors & their biology (Plasmid-, Phage-, and yeast-based), transformation and selection, genomic and cDNA library construction & DNA-sequencing techniques.	CLO1

	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	Recombinant Expression Systems & Mutagenesis: prokaryotic (Fusion proteins, surface display, removal of selectable marker genes, secretion into periplasm & medium) & eukaryotic (<i>Sachharomyce scerevisiae</i> & Mammalian cell expression system), oligonucleotide-directed and site directed mutagenesis.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 11 Hours	Molecular Biotechnology of Microbial Systems: Vaccines (subunit-, peptide-, attenuated-, DNA- and vector-based), Enzymes, Antibiotics, Bioremediation, and Gene therapy.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Molecular Biotechnology of Eukaryotic Systems: Engineering of plants (Ti-based system), Transgenic animals (Transgenic rodents), Regulation of recombinant DNA technology, Concerns about safety of consuming genetically modified foods, concerns about the impact of genetically modified organisms on the environment.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Suggested Readings:

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA by Bernard J. Glick, Jack J. Pasternak, Cheryl L. Patten, 4th edition. 2010 Hours
2. Principles of Gene Manipulation by Sandy B. Primrose, Richard Twyman, Bob Old Seventh edition. 2008
3. An introduction to genetic engineering, Third edition by Dr. Desmond S.T. Nicholl. 2011
4. Molecular cloning by R. Green and Joseph Sambrook, 4th Edition, CSHL Press. 2013

L	T	P	Cr
3	0	0	3

Course Code: ZOL.554

Course Title: Neurobiology and Degeneration

Total hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Describe Human Nervous system and Neurobiology

CLO2: Illustrate major degenerative diseases affecting the nervous system

CLO3: Distinguish physiological and molecular features of human neurobiology and degeneration

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Nervous System: Gross neuroanatomy of the human brain and spinal cord, blood brain barrier, central and peripheral nervous system, Neurons, Neuroglial cells, action potential, neurotransmitters, neural control of muscle tone and posture. Sense Organs: Vision, hearing and tactile response.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions	
II / 12 Hours	Metabolic functions of the Brain: Energy Requirements; Oxidative stress; Factors contributing to the neurodegeneration. Alzheimer's disease (AD): Mechanism(s) of AD pathogenesis and pathophysiology, e.g. amyloid cascade hypothesis, tau, and the therapeutic approaches. Review of recently completed clinical trials and treatment prospects.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 11 Hours	Parkinson's Disease (PD): genetics - alpha synuclein, parkin, DJ1, PINK1, and LRRK2. Gene therapy for PD. Huntington's Disease, multiple sclerosis, clinical overview of frontotemporal degeneration (FTD) and amyotrophic lateral sclerosis (ALS).	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	
IV / 11 Hours	Therapeutic intervention: Current treatment strategies including Pharmaceutical and Natural products-based therapies for various human neurodegenerative diseases.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Guyton. (2007). *Textbook of Medical Physiology*. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
2. Hill, R. W, Wyse, G. A. and Anderson, M. (2008). *Animal Physiology*. Sinauer Associates Inc. USA.
3. Tyagi, P. (2009). *A Textbook of Animal Physiology*. Dominant Publishers and distributors, New Delhi, India.
4. Mason, P. (2011) *Medical Neurobiology*. OUP USA publishers; 1st edition.
5. Charney, Dennis, S., (2013) *Study guide for Neurobiology of Mental Illness*. Cram 101 Publishers.
6. Dennis S. Charney, Nestler, E. J., Sklar, P., and Buxbaum, J. D. (2013). *Neurobiology of Mental Illness*. OUP USA publishers; 4th edition.
7. Zigmond, M. J, Coyle, J. T., and Rowland, L. P. (2014). *Neurobiology of Brain Disorders: Biological Basis of Neurological and Psychiatric Disorders*. Academic Press; 1st edition.
8. Purves, D. , Augustine, G. and Fitzpatrick, D. (2018) *Neuroscience* 6th Edition OUP USA Publisher
9. Kandel, E. R. (2021) *Principles Of Neural Science*. 6th edition. McGraw Hill Medical Publisher
10. Peplow, P. Martinez, B. and Gennarell T. A. (2022) *Neurodegenerative Diseases Biomarkers: Towards Translating Research to Clinical Practice: 173 (Neuromethods)* Springer-Verlag New York Inc.; Publisher
11. <https://epgp.inflibnet.ac.in/Home>
12. <https://www.vlab.co.in/>
13. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Code: ZOL.553

Course Title: Vascular Biology

Total hours: 45

Course learning outcomes (CLO): After going through the course, the learners will be able to

CLO1: Describe vascular system and cardiovascular biology

CLO2: Illustrate platelet physiology and signaling mechanism

CLO3: Classify vascular dysfunction and disorders

CLO4: Categorize antiplatelet drugs and diagnostics methods

Unit/ Hours	Contents	Mapping with course Learning Outcome
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I / 12 Hours	Vascular Biology: Introduction, structure and function of the vascular system. Vascular dysfunction in various pathophysiological states including endothelial dysfunction, inflammation, atherosclerosis and diabetes.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	Cardiovascular Biology: Basic cardiovascular physiology, cardiovascular system including blood coagulation system, platelet biology, haemostasis & thrombosis and signalling pathways involved in thrombus biology.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 10 Hours	Vascular Disorders: Peripheral vascular disease, stroke, platelet in cardiovascular diseases, diseases of the circulatory system including lymphatic diseases.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Vascular Medicine: Novel drugs including antiplatelet drugs, diagnostic methods including vascular angiography, imaging modalities, and other therapeutic approaches to better diagnose, prevent, or treat cardiovascular diseases.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brainstorming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-Learning, and Case studies.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Michael, R. J. and Christopher, J. W. (2011). Vascular Disease: Diagnostic and Therapeutic Approaches. Cardiotext Publishing. 1st Edition.
2. Minar, E. and Schillinger, M. (2013). Peripheral Vascular Disease: Basic & Clinical Perspectives. Future Medicine Ltd.
3. Rasmussen, T. E., Clouse, W. D., and Tonnessen, B. H. (2008). Handbook of Patient Care in Vascular Diseases. Lippincott Williams & Wilkins. 5th Edition.

4. Bhatt, D. L. (2008). Platelets in Cardiovascular Disease. Imperial College Press.
5. Kirali, K. (2015). Coronary Artery Disease – Assessment, Surgery, Prevention. InTech Publication.
6. Bozic-Mijovski, M. (2015). Thrombosis, Atherosclerosis and Atherothrombosis – New Insights and Experimental Protocols. InTech Publication.

L	T	P	Cr
3	0	0	3

Course Name: Endocrinology

Course Code: ZOL.572

Course type: Discipline Elective

Total Hours: 45

Course learning outcomes: On completion of this course, students will be able to:

CLO1: Define the role of the endocrine system in maintaining homeostasis and different feedback mechanism

CLO2: Describe different types of reproductive hormones and disorders associated with these hormones

CLO3: Explain the knowledge of the major endocrine disorders and future challenges

CLO4: Develop an advanced knowledge on future clinical problems of the endocrine system

Units/Hours	Contents	Mapping with Course Learning Outcome
I / 12 Hours	<p>General Introduction to Hormone: History, endocrine glands, hormones as chemical messengers, stimulus for hormone release: change in homeostasis, Neurosecretion and neuroendocrine system.</p> <p>Hormones: Structure, receptor type, regulation of biosynthesis and release (including feedback mechanism like short, long and ultra-feedback system).</p>	CLO1
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion</p>	
II / 10 Hours	<p>Reproductive Hormones: Male and female sex hormones. Hypothalamic hormones: CRH, TRH, GnRH, PRL/PRIH, GHRH/GHRIH. Pituitary hormones - Anterior and posterior pituitary hormones. Molecular mechanism of origin of GnRH cells, migration and site of release, reproductive cycles in females. Role of different guidance molecules involved during early GnRH development and adult GnRH System. Interplay of hormones during reproductive cycle, pregnancy, parturition and lactation: Different pathologies and genes involved. Breeding in animals, including knockout/conditional knockout/wild type animals</p>	CLO2
	<p>Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit</p>	

III / 11 Hours	Hormone Biosynthesis and Mode of Action: The hypothalamo- hypophyseal axis. Hypothalamo-vascular system. Hormones from hypothalamus: chemistry and physiology of releasing and release inhibiting hormones; Regulation of hypothalamic hormone secretion. Thyroid hormones, growth hormones, adrenal hormones and catecholamines, glucocorticoid hormones Neurohypophysis: synthesis and storage of oxytocin and vasopressin	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV / 12 Hours	Other endocrine organs: Regulation of the release of neurohypophyseal hormones; Other organs with endocrine function: heart (ANP), kidney (erythropoietin), liver (angiotensinogen, IGF-1), adipose tissue (leptin, adiponectin).	CLO4
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	

Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brain storming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Norris, D. O., and Carr, J. A. (2012). Vertebrate Endocrinology, 5th Edition. Academic Press.
2. Nelson, D. L., and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition. WH Freeman & Company, New York
3. Widmaier, E. P., Raff, H., and Strang, K. T. (2013).Vander’s Human Physiology, 13 Hours Hoursth Edition. McGraw-Hill Higher Education
4. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., and Scott, M. P. (2012). Molecular Cell Biology, 7th Edition. W.H. Freeman.
5. Goswami, M. P. (2013). Endocrinology and Molecular Cell Biology.
6. Relevant research articles and digital resources

L	T	P	Cr
3	0	0	3

Course Code: **ZOL. 580**

Course Title: **Stem Cell Technology and Translational Research**

Total hours: **45**

Course Learning outcomes: After going through the course the learners will be able to

CLO1: Define the basic knowledge about stem cell, types, and culturing techniques, recent technology, and application part.

CLO2: Explain the overall idea about regenerative medicine and its potential applications, translational research, and recent research study.

CLO3: Define the Human Induced Pluripotent stem cells (hiPSCs), Therapeutic approaches and recent research study.

CLO4: Describe the importance of ethical issues and it is associated with stem cell research.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / Hours	Introduction to stem cells Basics of stem cell biology, Definition, properties, proliferation, Classification, Sources, Stem cells- Culture Techniques, medical applications of stem cells, maintenance aspects in ethical and legal issues in use of stem cells.	CLO1 & CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	Types of stem cells Stem Cell biology and therapy, types of stem cell, Adult stem cell, Embryonic stem cells, hematopoietic stem cells, mesenchymal stem cells, cancer stem cells, induced pluripotent stem cells, the potential benefits of stem cell technology, translational research - recent research study	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 12 Hours	Therapeutics and recent advances of stem cells Introduction to induced pluripotent stem cells technology iPSCs; Reprogramming of iPSCs; transcriptional factors; difference between iPSCs and Human Induced Pluripotent stem cells (hiPSCs); Advantages and disadvantages of iPSCs; Application of iPSCs and HiPSCs, translational research; recent research work	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Ethical Issues associated with stem cell-based regenerative medicine field Regulatory and Ethical Considerations of stem cell, Assessing Human Stem Cell Safety, recent medical approaches with hiPSCs in neurodegenerative diseases; Ethical and regulatory issues in the use of stem cells.	CLO4

	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
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Mode of Transaction

The classroom learning/practical's/Video lecture/ project work would be based on: Lecture, Demonstration, Project Method, Seminars, Group discussions, Brainstorming, E- tutoring, Experimentation, Panel discussion and Case studies.

The following tools shall be used in teaching:

Textbooks, Gol e-learning platforms, PowerPoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Human Neural Stem Cells: From Generation to Differentiation and Application. 1st Edition, 2018. Leonora Buzanska. Springer.
2. Stem Cell and Gene-Based Therapy: Frontiers in Regenerative Medicine, Alexander Battler, Jonathan Leo, Springer, 2005
3. Advances in stem cell therapy: bench to bedside. El-Badri, Nagwa. Humana Press. 1st edition. 2016
4. Stem cells: an insider's guide. Knoepfler, P. World Scientific Publishing Company; 1st edition, 2013.
5. Essential of Stem Cell Biology, 3rd edition, Lanza R, et al, Elsevier Academic Press, 3rd Edition, 2013
6. Stem Cell Repair and Regeneration, Vol. 2, Habib NA, Levièar NY, Gordon M, Jiao L & FiskN, Imperial College Press; 1st edition, 2007.
7. Rodrigues, G. and Eileen, B. A. J. (2020) Concepts and Applications of Stem Cell Biology: A Guide for Students (Learning Materials in Biosciences) . Springer Publisher
8. Birbrair, A. (2021) Recent Advances in iPSC Technology (Advances in Stem Cell Biology Book 5) Academic Press Publisher
9. Slack, J. M.W. (2018) The Science of Stem Cells. Wiley-Blackwell Publisher

Web Sources:

1. <https://www.mayoclinic.org/tests-procedures/bone-marrow-transplant/in-depth/stem-cells/art-20048117>.
2. Borowski M, Giovino-Doherty M, Ji Let al., authors; Laning J, editor. Basic pluripotent stem cell culture protocols. 2012 Jun 10. In: StemBook [Internet]. Cambridge (MA): Harvard Stem Cell Institute; 2008-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK133258/>
3. CiRA-<https://www.cira.kyoto-u.ac.jp/e/>

Inter-Disciplinary Course

L	T	P	Cr
2	0	0	2

Course Code: ZOL.515

Course Title: Fundamentals of Cell Biology

Total hours: 30

Course learning outcomes: After going through the course, the learners will be able to

CLO1: Origin of Life, Life at the cellular and molecular level

CLO2: Define the basic unit of cell structure and function: Origin of Prokaryotes and Eukaryotes

CLO3: Membrane models and transport of micro-molecules and macro-molecules across the cell membrane

CLO4: Cell organelles and their role in different physiological processes

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 8 Hours	Basic unit of Life: Life at the cellular and molecular level. Introduction to the topics include cellular energetics, membrane phenomena, genetics, and molecular biology.	CLO1
	Learning activities: Brainstorming, Paper discussion, Asking Questions	
II / 7 Hours	Introduction to the Cell: The evolution of the cell, from molecules to first cell, from prokaryotes to eukaryotes, prokaryotic and eukaryotic genomes, from single cell to multicellular organism.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 8 Hours	Membrane Structure and Function: Biomembrane at a glance, membrane models: structure and composition, and membrane transport.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 7 Hours	Structural Organization of Intracellular Organelles: Introduction of subcellular organelles: lysosomes, ribosomes, peroxisomes, golgi apparatus, endoplasmic reticulum, nucleus, mitochondria, and chloroplast.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self Learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Gupta, P. K. (2015). Cell and Molecular Biology. Rastogi publications, Meerut, India.
2. James, D. W., Baker, T.A., Bell, S.P., Gann, A. (2009). Molecular Biology of the Gene. Benjamin Cummings, USA.
3. Johnson, A., Lewis, J., Raff, M. (2007). Molecular Biology of the Cell. Garland Science, USA.
4. Lodish, H., Berk, A., Chris, A. K. and Krieger, M. (2008). Molecular Cell Biology.
5. W.H. Freeman, USA. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. (2010). Molecular Biology of the Cell. Garland publishers, Oxford.
6. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons. Inc. New Delhi, India.
7. <https://epgp.inflibnet.ac.in/Home>
8. <https://www.vlab.co.in/>
9. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
2	0	0	2

Course Code: ZOL.528

Course Title: Basics in Neuroscience

Total hours: 30

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Describe the role of human nervous system and its control over the entire body

CLO2: Explain the properties of individual cells to their function in organized neural circuits and systems

CLO3: Develop testable scientific hypotheses and generate research plans to test these hypotheses

Unit/ Hours	Contents	Mapping with course Learning Outcome
I/ 7 Hour	Introduction to Nervous System: Basic anatomy, parts of central nervous system & peripheral nervous system.	CLO1

	Learning activities: Brainstorming, Presentation, Quizzes	
II / 8 Hour	Introduction to Neurons: The neuron doctrine, Nissl and Golgi stains, components of neurons, classification and types of neurons, cytology of neurons, dendrite's structure and function, axons structure and functional aspects, ultrastructure, myelination and synapses. Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions, Paper discussions	CLO1 & CLO2
III / 8 Hour	Structure and Function of Glial Cells: Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells, types of astrocytes, importance of astrocytes in glutamate metabolism and blood brain barrier, functions of other glial cells: oligodendrocyte and microglial cells, microglial phenotypes, overview of glial and neuronal relationship in the CNS, glial neuronal interplay in the CNS. Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	CLO2 & CLO3
IV / 7 Hour	Action Potential & Neurotransmitters: Action potentials & channels responsible for action potential, all or none law, Nernst equation; neurotransmitters: excitatory neurotransmitters & inhibitory neurotransmitters. Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	CLO3

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Guyton. (2007). Textbook of Medical Physiology. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
2. Hill, R. W, Wyse, G. A. and Anderson, M. (2008). Animal Physiology. Sinauer Associates Inc. USA.
3. Tyagi, P. (2009). A Text Book of Animal Physiology. Dominant Publishers and distributors, New Delhi, India.
4. Levitan, I. B., Kaczmarek, L. K. (2015). The Neuron: Cell and Molecular Biology. Oxford University Press, USA; 4th edition.

5. Kandel, E. R., Schwartz, J. H., Jessell, T. M. (2012). Principles of Neural Science. McGraw-Hill Companies; 5th edition.
6. <https://epgp.inflibnet.ac.in/Home>
7. <https://www.vlab.co.in/>
8. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
2	0	0	2

Course Code: ZOL.560

Course Title: Basics in Nanobiology

Total hours: 30

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Define the interdisciplinary knowledge of basic concepts of nanoscience and biomaterials

CLO2: Explain characterization of techniques and biomedical aspects of nanomaterials

CLO3: Apply learned knowledge to develop bioinspired biocompatible nanomaterials

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 7 Hours	Nanoscience: Definition and concepts, nanomaterials classification, types, properties and applications	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 9 Hours	Nanomaterials synthesis and Characterization: Nanomaterial synthesis methods, biofunctionalization and characterization techniques like electron microscopy (scanning and transmission), atomic force microscopy; nanoparticle analyzer, Flow cytometry, spectroscopic techniques including spectrophotometer, spectrofluorimeter & FTIR.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 7 Hours	Materials in Medicine: Biomaterials, Theranostics, Nanostructures for drug delivery, biosensor, electrochemical biosensor, bioimaging and point-of-care diagnostics tools including lateral flow immunoassay and microfluidic devices.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 7 Hours	Nanotoxicity: Effect of nanomaterials on human health, nanomaterial-cell interaction, <i>in vitro</i> nanotoxicity assays, and challenges in the risk assessment of nanomaterials.	CLO3

Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
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Mode of Transaction:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Workshop, Group discussions, Team teaching, Brainstorming, E- tutoring, Scientific discussion, Mobile teaching, Collaborative learning, Quiz, Experimentation, Tutorials, Problem solving, Debates, sample analysis and identification.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

- 1) Bagchi, D., Bagchi, M., Mariyama, H. and Shahidi, F. (2013). BioNanotechnology: A Revolution in Food, Biomedical and Health Sciences. Wiley–Blackwell publication.
- 2) Rai, M., Duran, N. and Southam, G. (2011). Metal Nanoparticles in Microbiology. Springer publication.
- 3) Udupa, N., Gupta, P. D. (2009). Nanotechnology in Health Care. ShyamPrakashan publication.
- 4) Xie, Y. (2012). The Nanobiotechnology Handbook. CRC Press.
- 5) Murty, B. S., Shankar, P., Raj, B., Rath, B. B. and Murday, J. (2013). A Textbook of Nanoscience and Nanotechnology. Tata McGraw Hill Publication.

SEMESTER – III

L	T	P	Cr
3	0	0	3

Course Name: Developmental Biology

Course Code: ZOL.551

Course type: Core

Total Hours: 45

Course learning outcomes: On completion of this course, students will be able to:

CLO1: Describe mammalian development

CLO2: Illustrate developmental processes of vertebrates i.e. Blastulation, Gastrulation and different morphological movements

CLO3: Differentiate extra-embryonic developments and regenerative mechanism

Units/ Hours	Contents	Mapping with Course Learning Outcome
I / 12 Hours	Beginning of a new organism: Principles of development, Oogenesis, Spermatogenesis, Fertilization, Polyspermy and prevention of polyspermy, Morula, Cleavage and its types, Blastulation and Gastrulation, Different movements occur during Gastrulation	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
II / 12 Hours	Early embryonic development: Anatomical and morphological changes that occur during development, Early development of amphibians, Drosophila and mammals; axis formation in Drosophila and Amphibians	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
III / 11 Hours	Later embryonic development: Central nervous system and the epidermis; Neural crest cells and axonal specificity; Endoderm, Mesoderm and Ectoderm.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV /	Regeneration: Tetrapod limb development, metamorphosis, regeneration and ageing, teratogenesis.	CLO3

10 Hours	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
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Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brain storming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Lewis, W. (2011). Developmental biology: a very short introduction. Oxford University Press, 1st edition.
2. Hake, S. and Wilt, F. (2003). Principles of Developmental Biology. W.W. Norton & Company, New York, USA.
3. Lewin, R. (2004). Human Evolution - An Illustrated Introduction. WileyBlackwell, USA.
4. Baressi, M.J.F., Scott, F. and Gilbert, S. F. (2018). Developmental Biology. Sinauer Associates, Inc. USA. 11th edition.
5. Relevant research articles and digital resources

L	T	P	Cr
3	0	0	3

Course Code: ZOL.513

Course Title: Techniques in Life Sciences

Total hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Describe analytical tools in Life Sciences.

CLO2: Distinguish spectroscopy, microscopy, molecular and immunological techniques.

CLO3: Apply analytical instruments in life science research

CLO4: Qualitative and quantitative techniques to analyze different physiological/immunological/metabolic experimental results.

Unit/ Hours	Contents	Mapping with course Learning Outcome

I / 12 Hours	Spectroscopy and Chromatography Techniques: UV-Vis, fluorimeter, circular dichroism, FTIR, mass spectroscopy, and NMR. Thin layer chromatography (TLC), gel filtration and ion exchange, affinity chromatography, GC, GLC and HPLC.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
II / 10 Hours	Microscopy: Light microscopy, phase contrast microscopy, fluorescent microscopy, confocal microscope, scanning electron microscopy (SEM), transmission electron microscopy (TEM) and live cell microscopy.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
III / 12 Hours	Basic Molecular Biology Techniques: Isolation, purification and analysis of protein and nucleic acids. Electrophoresis: Principle of gel electrophoresis, polyacrylamide gel electrophoresis (PAGE and SDS-PAGE), agarose gel electrophoresis. Polymerase chain reaction (PCR): Principle, types and applications. Blotting techniques: Southern, Northern, Western analysis, <i>In situ</i> hybridization etc.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
IV / 11 Hours	Immunological and Cell Culture Techniques: Perfusion, Fixation, different techniques of sectioning, MTT assay, Electrophysiological techniques like Patch clamp immunochemical techniques, immunocytochemistry, immunofluorescence, radioimmunoassay (RIA), Different enzyme linked immunosorbent assay (ELISA), immunoprecipitation, Cell and tissue culture techniques: Primary and secondary cultures.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Workshop, Group discussions, Team teaching, Brainstorming, E- tutoring, Scientific discussion, Mobile teaching, Collaborative learning, Quiz, Experimentation, Tutorials, Problem solving, Debates, sample analysis and identification.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Goldsby, R. A., Kindt, T. J. and Osborne, B. A. (2018). Kuby Immunology. 6th Edition, W. H. Freeman & Company, San Francisco.
2. Gupta, P. K. (2015). Elements of Biotechnology. Rastogi Publications, Meerut.
3. Kothari, C. R. (2008) Research Methodology. New Age International (P) Ltd., New Delhi
4. Lewin, B. (2014). Genes X, CBS Publishers & Distributors. New Delhi.
5. Nelson, D. and Cox, M. M. (2016). Lehninger Principles of Biochemistry. W.H. Freeman and Company, New York.
6. Primrose. S. B. and Twyman, R. (2006). Principles of Gene Manipulation and Genomics. Blackwell Publishing Professional, U.K.
7. Sawhney, S. K. and Singh, R. (2005). Introductory Practical Biochemistry. Narosa Publishing House, New Delhi.
8. Wilson, K. and Walker, J. (2006). Principles and Techniques of Biochemistry and Molecular biology. 6th Edition, Cambridge University Press India Pvt. Ltd., New Delhi.

L	T	P	Cr
3	0	0	3

Course Code: ZOL.552

Course Title: Cancer Biology

Total hours: 45

Course learning outcomes (CLO): After going through the course the learners will be able to

CLO1: Describe Cancer biology

CLO2: Explain cause and progression of Cancer

CLO3: Classify Cancer

CLO4: Distinguish different forms of Cancer treatment and therapies

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 12 Hours	Biology and Classification of Cancer: Classification, phenotype of a cancer cell, causes of cancer, DNA tumor viruses, RNA tumor viruses, Different forms of cancers, screening and early detection, tumor markers and molecular tools for early diagnosis of cancer.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Paper discussion	
II / 11 Hours	Basis of Cancer: Oncogenes, tumor suppressor genes, aberrations in signaling pathways, oncogenic mutations in growth promoting proteins, mutations causing loss of growth-inhibition DNA repair in cancer.	CLO2

	Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions	
III / 12 Hours	Oncogenesis and Apoptosis: Intracellular proteolytic cascade, cascade of caspase proteins, adapter proteins, Bcl-2, IAP family proteins, Extracellular control of cell division, tumor necrosis factor and related death signals.	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Metastasis and Cancer therapy: Heterogeneity of metastatic phenotype, metastatic cascade, basement membrane disruption, three step theory of invasion, proteinase and tumor cell division, prediction of aggressiveness of cancer, different forms of cancer therapy (chemotherapy, radiotherapy, surgery, etc.), use of signal targets towards therapy of cancer and gene therapy.	CLO3 & CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Content Focus	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Selflearning, and Case studies.

The following tools shall be used in teaching:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks, e-content, and google drive.

Suggested Readings:

1. Dimmock, N. J. and Primrose, S. B. (2005). Introduction to Modern Virology. Bookbarn International, UK.
2. Ford, C. H. J., Casson, A. G. and Macdonald, F. (2004). Molecular Biology of Cancer. Bios Scientific Publishers, USA.
3. King, R. J. B. and Robins M. W. (2006). Cancer Biology. Prentice Hall, USA.
4. Margaret, A. K. and Peter, J. S. (2005). Introduction to the Cellular and Molecular Biology of Cancer. Oxford University Press, USA.
5. Neoptolemos, L. J. (1994). Cancer: A Molecular Approach. Blackwell Publishing, USA.
6. Phillis, R., Goodwin, S. and Palladino, M. A. (2002). Biology of Cancer. Benjamin-cummings Publishing Company, USA.
7. <https://epgp.inflibnet.ac.in/Home>
8. <https://www.vlab.co.in/>
9. <https://lms.cup.edu.in/course/index.php?categoryid=76>

L	T	P	Cr
3	0	0	3

Course Name: Reproductive Physiology

Course Code: ZOL.577

Course type: Discipline Elective

Total Hours: 45

Course Learning Outcomes: On completion of this course, students will be able to

CLO1: Illustrate various reproductive disorders which are cause of major concern in modern times i.e. obesity, PCOS and IHH

CLO2: Provide in-depth knowledge of male and female reproductive systems along with the mechanistic aspects

Units/ Hours	Contents	Mapping with Course Learning Outcome
I/ 11 Hours	Introduction: Regulation of Anterior and Posterior Pituitary hormones, Puberty and mechanism of puberty, Neuroendocrine system and neurosecretion; Concept of neurogenesis, pruning and brain plasticity, Neuron glial endothelial tripartite interactions, Blood brain barrier, Homeostasis, Sexual behavior: Pheromones, Copulatory patterns; Hormones in sexual behavior; Control by different brain centers.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II/ 12 Hours	Endocrine disorders: Reproductive disorders: IHH and Kallmann syndrome, precocious and delayed puberty, Origin and causes of male sterility (azoospermia, oligozoospermia, varicocele, cryptorchidism). Female sterility: Tubal factors; Premature ovarian failure; Luteal insufficiency; Endometriosis, PCOS.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
III/ 11 Hours	Male reproductive system: Spermatogenesis and hormonal regulation; Oxidative stress and spermatogenesis; Sertoli cells; Leydig cells; Cell-cell interaction Epididymis: Structure, function and regulation Male accessory sex glands: Structure, function and regulation Male sterility: Parameters of male sterility.	CLO2

	Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	
IV / 11 Hours	Female reproductive system: Oogenesis and hormonal regulation; Mechanism of ovulation; Reproductive cycles in female: Menstrual cycle; Control of seasonal reproductive cycle Follicular atresia Female accessory sex glands: Structure, function and regulation Assisted Reproductive Techniques (ART): Principle of ART and protocols; Types of ART; Cryopreservation of gametes.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion	

Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brain storming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Norris and Carr: Vertebrate Endocrinology (8thed, Vol 5, 2016, Academic Press)
2. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
3. Larson: Williams Textbook of Endocrinology (10thed, 2012, Saunders)
4. Knobil and Neill: Encyclopedia of Reproduction (Vol 1-4, 2018, Academic Press)
5. Leuang and Adashi: The Ovary (2004, Raven Press)
6. Strauss and Barbieri: Yen and Jaffe's Reproductive Endocrinology (6thed, 2009, Saunders)
7. Knobil and Neill: Encyclopedia of Reproduction (Vol 1-2, 2015, Academic Press)

L	T	P	Cr
3	0	0	3

Course Code: ZOL.578

Course Title: Insect Biology

Total hours: 45

Course learning outcomes: After completion of the course the learners will be able to obtain

- CLO1: Updated knowledge on Insect evolution, classification, physiology, immunity and behavior
- CLO2: Updated knowledge of various fields of insect biology
- CLO3: Detailed information of Research models and trends in insect biology

CLO4: Detailed knowledge of applications of Insect Biology in Agriculture, Biodiversity, Health and Entrepreneurship opportunities

Unit/ Hours	Contents	Mapping with Course Learning Outcome
I / 12 h	Basics of Insect Biology: Insect classification, taxonomy, biodiversity, physiology, metamorphosis, evolution, reproduction, immunity, pheromones and other semiochemicals	CLO1
	Learning activities: Brain storming, oral presentations, online resources including e-books, videos and research publications, Quizzes	
II / 12 h	Avenues in Insect Biology: Agricultural Entomology: Insects pests and beneficial insects Medical Entomology: Insect vectors of human and veterinary disease; Medically beneficial insects Forensic entomology: Medicolegal, urban, and stored product pests	CLO2
	Learning activities: Brain storming, oral presentations, online resources including e-books, videos and research publications, Quizzes	
III / 11 h	Insect models in research: <i>Drosophila melanogaster</i> , <i>Manducasexta</i> , <i>Bombyxmori</i> , female <i>Anopheles</i> sp., <i>Aedesaegypti</i> , <i>Apismellifera</i> , <i>Muscadomestica</i> and other non-model organisms.	CLO3
	Learning activities: Brain storming, oral presentations, online resources including e-books, videos and research publications, Quizzes	
IV / 10 h	Opportunities in Insect Biology: Apiculture, Sericulture, Lac culture, Mass rearing of biocontrol agents, Vermiculture, Taxonomy, Ecology, Biology, Behaviour, and latest thrust research areas	CLO4
	Learning activities: Brain storming, oral presentations, online resources including e-books, videos and research publications, Quizzes	

Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Flipped Classroom approach, Digital learning, Project Method, Activity-based, Field-based, Seminars, Group discussions, Focused group discussions, brainstorming sessions, E-tutoring, Dialogue Mode, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, textbook reading assignments and case studies.

The following tools shall be used in teaching and practicals.

Textbooks, GoI e-learning platforms, PowerPoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. For Love of Insects. by Thomas Eisner.
2. Life on a Little Known Planet. by Howard Ensign Evans.
3. Introduction to the Study of Insects. by Charles Triplehorn and Norman F Johnson.
4. Encyclopedia of Insects. by Vincent H Resh and Ring T Cardé
5. The Insect Societies. by Edward O Wilson
6. Review and Research articles

L	T	P	Cr
3	0	0	3

Course Code: BCH.557

Course Title: Clinical Diagnostics

Total Hours: 45

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

CLO1: Demonstrate the general approach to clinical samples

CLO2: Illustrate the protein based diagnostics methods

CLO3: Discuss the DNA based diagnostics methods

CLO4: Analyze the diverse clinical methods in diagnosing human diseases which will further help them to use these techniques in various applied fields of biological research.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Introduction to Clinical Diagnostics: Philosophy and general approach to clinical specimens, Sample collection (Blood, urine, spinal fluid, synovial fluid, amniotic fluid) - method of collection, preservation, transport and processing of samples. Diagnosis – disease altered state, prognosis, direct and indirect, concept of antigen and antibody. Principles of validation of diagnostic assays for infectious diseases, Validation and quality control of polymerase chain reaction methods used for the diagnosis of infectious diseases.	CLO1 & CLO2
	Learning Activities: <i>Classroom discussion on sample type and applicable diagnostic assays with appropriate controls</i>	

<p>II / 12 Hours</p>	<p>Protein based Clinical Diagnostics: Antigen – Antibody Interaction, Lattice Theory, Precipitin Curve, Simple Immunodiffusion (Radial Immunodiffusion – Qualitative, Quantitative); Double Diffusion (Mechanism of Reaction of Identity, Partial Identity, and Non-Identity); Rocket Electrophoresis, Immunoelectrophoresis; Western Blot, Immunofluorescence, Radioimmunoassay; ELISA – types and assay development; Agglutination – Antibody titer, Prozone Phenomenon, Direct and Indirect Agglutination, ABO Blood typing, Agglutination Inhibition; Advantages and limitation with respect to clinical diagnosis and research usage. Microparticle based antigen - Antibody interaction techniques. Monoclonal antibody – production, applications, novel approaches in detection, Humanized monoclonal antibodies.</p> <p>Learning Activities: <i>Drawing out the similarities and dissimilarities along with advantages and disadvantages with reference to different diagnostic assays as part of group learning</i></p>	<p>CLO1 & CLO2</p>
<p>III / 11 Hours</p>	<p>DNA based Clinical Diagnostics: Nucleic acid extraction from clinical samples, quantization, digestion, hybridization, Amplification by PCR (Inverse PCR, Multiplex PCR, Nested PCR, Alu-PCR, Hot-start, <i>In situ</i> PCR, Long-PCR, PCR-ELISA, iPCR, applications and limitations) DNA fingerprinting and polymorphism studies (SNP, RAPD, RFLP, VNTR, Mutation detection).</p> <p>High-throughput Technologies and Diagnostics: Microarray (protein, DNA), Real-Time PCR, Reporter assays. Biosensors – types, applications, examples (glucose etc), telemedicine. Fluorescence based techniques (FISH analysis, Flow cytometry, Fluorescent Microscopy) Mass spectrometry, Histopathology, Immunohistochemistry and Real-Time PCR. Microbiological Diagnosis and Hematology. Enzyme and hormone based diagnostic techniques.</p> <p>Learning Activities: <i>Emphasis on interpretation of results and quality control. Drawing out the similarities and dissimilarities along with advantages and disadvantages with reference to different diagnostic assays as part of group learning.</i></p>	<p>CLO1 & CLO3</p>
<p>IV / 11 Hours</p>	<p>Case Studies: Diagnosis of Infectious and Emerging Diseases. Bacterial infection caused by <i>Coliforms, Salmonella, Shigella, Vibrio, and Mycobacterium tuberculosis</i>. Diagnosis of fungal infections. Dermatophytosis, Candidiasis and Aspergillosis. Diagnosis of DNA and RNA viruses. Pox viruses, Adenoviruses, Rhabdoviruses, Hepatitis Viruses and Retroviruses. Diagnosis of Protozoan diseases: Amoebiasis, Malaria, Trypanosomiasis, Leishmaniasis, Filariasis and Schistosomiasis. Medical Genetics: Organization of human genome, Human Genome Project, Identifying human disease genes. Genetic Counselling. Genetic disorders: Sickle cell anaemia, Duchenne muscular Dystrophy, Retinoblastoma, Cystic Fibrosis and Sex –linked inherited disorders. Neonatal and Prenatal disease diagnostics.</p>	<p>CLO4</p>

	Learning activities: <i>Case studies to be taken up by students covering different diseases as assignments</i>	
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Mode of Transaction

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Flipped Classroom approach, Digital learning, Project Method, Activity-based, Field-based, Seminars, Group discussions, Focused group discussions, brainstorming sessions, E-tutoring, Dialogue Mode, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Self-learning, textbook reading assignments and case studies.

The following tools shall be used in teaching and practicals.

Textbooks, GoI e-learning platforms, PowerPoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Burtis, Carl A, Ashwood, Edward R, Bruns, David E., “*Tietz textbook of Clinical Chemistry & Molecular Diagnostics*” USA: Saunders, 2006.
2. World Organization for Animal Health: “*Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*” Volumes I & II, 6th Edition, 2010.
3. Rao, Juluri R, Fleming, Colin C., Moore, John E., “*Molecular Diagnostics: current technology and Applications*”, Horizon Bioscience, U. K., 2006.
4. Goldsby, Richard A., Kuby, Janis, “*Immunology*”, New York: WH Freeman and Company, 2003.
5. Mahon, Connie R.; Lehman, Donald C.; Manuselis, George “*Textbook of Diagnostic Microbiology*”. USA: Saunders, 2007.

L	T	P	Cr
3	0	0	3

Course Code: HGE.555

Course Title: Biosafety, Bioethics, and Intellectual Property Rights

Total Hours: 45

- Course learning outcomes:** On successful completion of the course, the student will be able to
- CLO1: Interpret the bioethical issues concerning biotechnological advancements like recombinant DNA
 - CLO2: Understanding the technology related to cloning and gene manipulation.
 - CLO3: Implement biosafety while carrying out research.
 - CLO4: Distinguish different types of Intellectual Property Rights.
 - CLO5: Describe the ways of protecting traditional knowledge from Biopiracy.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Biosafety: Good laboratory practices; Risk and safety assessment from genetically engineered organisms; special procedures for r-DNA based products; biological containment (BC) and physical containment (PC); CDC biosafety levels; biohazard management.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II / 11 Hours	Bioethics: Ethical considerations during research, Use of Animals for clinical research, Embryonic and adult stem cell research, assisted reproductive technologies, cloning, MTP and Euthanasia; the element of informed consent; ethical issues of the human genome project.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
III / 11 Hours	Intellectual Property Rights (IPRs): Various forms of IP – patents, industrial designs, trademark, geographical indications, and plant breeder's right; copyright: fair use, plagiarism; protection of indigenous intellectual property.	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
IV / 12 Hours	Patent system: Patent filing procedure in India and ways of patent protection in other countries: Determination of patentability of inventions, filing a patent application in India: timeline, procedure involved in the granting of a patent, patent cooperation Treaty (PCT).	CLO4 & CLO5
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

Transactional Modes: Lecture; Demonstration; Virtual classrooms; Tutorial; Lecture cum demonstration; Problem solving; Case study; Self-learning.

Internal assessment shall be through any of the following:

Surprise Tests, one sentence summary, case analysis, simulated problem solving, open book techniques, classroom assignments, homework assignments, term paper, Seminars, term papers, discussions, and presentations.

Suggested Readings:

1. Clarke, A (2012). *Genetic Counseling: Practice and Principles*. Taylor & Francis

2. Fleming, D.O. and Hunt, D.L. (2006). *Biological Safety: Principles and Practices*. American Society for Microbiology, USA.
3. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*. Routledge.
4. Shannon, T.A. (2009). *An Introduction to Bioethics*. Paulist Press, USA.
5. Thompson J and Schaefer, B.D (2013). *Medical Genetics: An Integrated Approach*. McGraw Hill.
6. Vaughn, L. (2009). *Bioethics: Principles, Issues, and Cases*. Oxford University Press, UK.
7. WHO. (2005). *Laboratory Biosafety Manual*. World Health Organization.
8. Ahuja, V.K. (2017). *Law relating to Intellectual Property Rights*. LexisNexis, India. 3rd Edition.
9. Mahop, M.T. (2010). *Intellectual Property, Community Rights and Human Rights: The Biological and Genetic Resources of Developing Countries*. Routledge, USA.
10. Neeraj, P. and Khusdeep, D. (2014). *Intellectual Property Rights*. India, IN: PHI learning Private Limited.
11. Nithyananda, K V. (2019). *Intellectual Property Rights: Protection and Management*. India, IN: Cengage Learning India Private Limited.

Course type: Compulsory Foundation

L	T	P	Cr
3	0	0	3

Course Code: ZOL.556

Course Name: Research Methodology

Total Hours: 45

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

CLO1 Write review of literature

CLO2: Classify various aspects of research methodology

CLO3: Design research experiment and Analyzing experimental data results

CLO4: Implement biosafety while carrying out research.

CLO5: Distinguish different types of Intellectual Property Rights and Describe the ways of protecting traditional knowledge from Biopiracy.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I/ 11 Hours	Literature survey and review, sources of literature, methods of literature review and techniques of writing the reviewed literature. Understanding a research problem, selecting the research problem, steps in formulation of a research problem, formulation of research objectives, and construction of a hypothesis.	CLO1 & CLO2

	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II / 11 Hours	Basic principles of experimental designs, data collection, processing, and interpretation. Basics of citation and bibliography/reference preparation styles, report presentation.	CLO2 & CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
III / 11 Hours	Good laboratory practices (GLP), biosafety issues for using cloned genes in medicine, agriculture, industry. Genetic pollution, risk and safety assessment from genetically engineered organisms.	CLO4
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
IV / 12 Hours	Ethical theories, ethical considerations during research, ethical issues related to animal testing and human project. Intellectual property rights (IPRs), patents and copyrights, fair use, plagiarism and open access publishing.	CLO4 & CLO5
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

Mode of Transaction:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Focused group discussions, Team teaching, Field visits, Brain storming, E- tutoring, Dialogue Mode, Mobile teaching, Collaborative learning, Experimentation, Panel discussion, Tutorials, Problem solving, Debates, Selflearning, and Case studies.

The following tools shall be used in teaching and practical:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, e-content, and google drive.

Suggested Readings:

1. Gupta, S. (2005). Research Methodology and Statistical Techniques. Deep & Deep Publications (p) Ltd. New Delhi.
2. Kothari, C. R. (2008). Research Methodology (s). New Age International (p) Limited. New Delhi.
3. Fleming, D. O. and Hunt, D. L. (2006). Biological Safety: Principles and Practices. American Society for Microbiology, USA.
4. Rockman, H. B. (2004). Intellectual Property Law for Engineers and Scientists. Wiley-IEEE Press, USA.
5. Shannon, T. A. (2009). An Introduction to Bioethics. Paulist Press, USA.
6. Kothari, C. R. and G. Garg (2014): Research Methodology: Methods and Techniques, 3rd ed., New Age International Pvt. Ltd. Publisher
7. Kumar, R. (2014): Research Methodology – A Step-By-Step Guide for Beginners, 4th ed., Sage Publications.

8. Jerrold, H. Z. (2010): Biostatistical Analysis, Fifth ed., Pearson.
9. Sokal, R. F and Rohlf, F. J. (2011): Biometry, Fourth Ed., W.H. Freeman Publishers.

L	T	P	Cr
3	0	0	3

Course Code: ZOL.557

Course Name: Basic Statistics for Sciences

Total Hours: 45

Course learning outcomes: On completion of this course, students will be able to:

CLO1: Describe Statistical tools used in Life Sciences

CLO2: Interpret statistical variables and distributions

CLO3: Apply statistical parameters to available data

CLO4: Distinguish between parametric and non-parametric statistics

Units/ Hours	Contents	Mapping with Course Learning Outcome
I / 10 Hours	Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II / 11 Hours	Measures: Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Linear regression and correlation (Karl Pearson's and Spearman's) and residual plots	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
III / 12 Hours	Random variables and Distributions: Discrete and continuous random variables. Discrete Probability distributions like Binomial, Poisson and continuous distributions like Normal, F and student-t distribution	CLO3

	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
IV / 12 Hours	Differences between parametric and non-parametric statistics. Confidence interval, Errors, Levels of significance, Hypothesis testing. Parametric tests: Test for parameters of Normal population (one sample and two sample problems) z-test, student's t-test, F and chi-square test and Analysis of Variance (ANOVA). Non-Parametric tests: One sample: Sign test, signed rank test, Kolmogorov-Smirnov test, run test. Critical difference (CD), Least Significant Difference (LSD), Kruskal-Wallis one-way ANOVA by ranks, Friedman two-way ANOVA by ranks.	CLO4
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brain storming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

Textbooks, Gol e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Pagano, M. and Gauvreau, K. (2018). Principles of Biostatistics. Chapman and Hall/CRC, 2nd edition.
2. Rosner, B. (2015). Fundamentals of Biostatistics. Brooks Cole. 8th edition.
3. Das. D and Das. A. (2003). Statistics in Biology and Psychology. Academic Press, 3rd edition.
4. P. G. Hoel, Introduction to Mathematical Statistics, 1997.
5. Relevant research articles and digital resources

L	T	P	Cr
2	0	0	2

Course Title: Entrepreneurship

Course Code: ZOL.516

Total Hours: 15 Hours

Course learning outcomes: Students will be able to:

CLO1: Understand the basic concepts of entrepreneur, entrepreneurship and its importance.

CLO2: Comprehend the opportunities, challenges and strategies required in entrepreneurship.

CLO3: Develop capabilities of preparing proposals for starting small businesses. Bring new ideas, patents, technologies and innovative services to the market.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 7 Hours	<p>Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; Innovation in diagnostics and therapeutics; Importance of women entrepreneurship and successful personalities; Types of entrepreneurial ventures in biological aspects; Case studies, discussion sessions and case report submission with successful science-based entrepreneurs</p> <p>Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies</p>	CLO1
II / 7 Hours	<p>Why to start a small business in biological aspects; How to start a small business; opportunity analysis, government funding sources, Establishing the venture - Project report preparation and submission– format for a preliminary project report, format for a detailed/final project report.</p> <p>Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies</p>	CLO2
III / 8 Hours	<p>Indian Government agencies, MSME, DBT, BIRAC, Make in India Road map from Familiarization with Entrepreneurial development programs of public and private agencies; International opportunities for fund mobilization, Technology assessment and technology transfer, Understanding regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).</p> <p>Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies</p>	CLO2 & CLO3
IV / 8 Hours	<p>Innovation and science-based ideas to business development within segments such as health & disease, agricultural and environmental. Science based innovative project related proposal submission</p> <p>Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies</p>	CLO3

Suggested Readings:

1. Arora, Renu (2008). Entrepreneurship and Small Business, Dhanpat Rai & Sons Publications.
2. Chandra, Prasanna (2018). Project Preparation, Appraisal, Implementation, Tata Mc-Graw Hills.
3. Desai, Vasant (2019). Management of a Small Scale Industry, Himalaya Publishing House.
4. Jain, P. C. (2015). Handbook of New Entrepreneurs, Oxford University Press.
5. Srivastava, S. B. (2009). A Practical Guide to Industrial Entrepreneurs, Sultan Chand & Sons.
6. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge, Routledge Studies in Innovation, Organizations and Technology (2018) 1st ed. Onetti, A, & Zucchella, A, CRC press, Taylor and Francis group. ISBN: 9781138616905.
7. Innovation, Commercialization, and Start-Ups in Life Sciences. (2014) 1st ed. Jordan, JF, CRC Press. Taylor and Francis group, ISBN: 9781482210125.
8. Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences (2008) Adams, DJ, Sparrow JC, Bloxham, Scion, ISBN:1904842364.

Modes of transaction:

- Lectures and tutorials.
- Group-work
- Ideathons and design sprints
- Brain-storming sessions
- Group activities-learning by doing

Tools to be used: PPT, Video, Google drive, etc.

Value Based Course:

L	T	P	Cr
2	0	0	2

Course Name: Scientific Writing

Course Code: ZOL.559

Course type: Value Based

Total Hours: 30

Course learning outcomes: On completion of this course, students will be able to

- CLO1: Explain how scientific research is published (including the peer review process, open-access journals, and the embargo system)
- CLO2: Describe when it is appropriate to use the different types of scientific literature such as primary literature, reviews, and textbooks
- CLO3: Explain how scientific research is published (including the peer review process, open-access journals, and the embargo system)

CLO4: Analyze different online research tools (e.g. databases, e-journals, Google Scholar, Web of Science) to collect relevant information on a particular topic

Units/ Hours	Contents	Mapping with Course Learning Outcome
I / 8 Hours	Survey, Methods and collection of Literature and review articles, literature review process, types of articles, how to prepare the review article, content and importance of review article, how to prepare the case report and research articles, Peer-reviewed journal search and find the suitable Journal - online session	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
II / 8 Hours	Identifying and formulating a research problem, writing a research problem, Formulation of research questions, research gap, key question, Construction of a hypothesis, Steps in designing a research problem, research objectives and practical session to prepare the research problem; Preparation of research proposal for Internship and PhD program and independent funding	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
III / 8 Hours	NCBI, Google Scholar, Research gate, PubMed, various publishers, Basics of citation and bibliography/reference preparation styles, recent advancement in the form of Zotero and End Note analysis	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV / 6 Hours	Scientific ethics in writing the research/review and proposal, Scientific misconduct, plagiarism, various software's to detect the plagiarism, Patents and copyrights and practical session to detect the plagiarism.	CLO4
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	

Transaction Mode:

The classroom learning/practicals/project work would be based on:

Lecture, Demonstration, Project Method, Seminars, Group discussions, Field visits, Brain storming, E- tutoring, Experimentation, Panel discussion, Tutorials, Debates and Case studies.

The following tools shall be used in teaching and practicals:

PPT, WhatsApp, Videos, Blogs, Multimedia packages, TED Talks and e-content

Suggested Readings:

1. Kumar, R. (2014): Research Methodology – A Step-By-Step Guide for Beginners, 4th ed., Sage Publications.
2. Pagano, M. and Gauvreau, K. (2018). Principles of Biostatistics. Chapman and Hall/CRC, 2nd edition.
3. Gupta, S. (2005). Research Methodology and Statistical Techniques. Deep & Deep Publications (p) Ltd. New Delhi.
4. Rockman, H. B. (2004). Intellectual Property Law for Engineers and Scientists. Wiley-IEEE Press, USA.
5. Shannon, T. A. (2009). An Introduction to Bioethics. Paulist Press, USA.
6. Kothari, C. R. and G. Garg (2014): Research Methodology: Methods and Techniques, 3rd ed., New Age International Pvt. Ltd. Publisher
7. Relevant research articles and digital resources

L	T	P	Cr
0	0	8	4

Course Code: ZOL.600

Course Title: Dissertation-Part I

Total hours: 120

Course learning outcomes:

CLO1: Critically analyze, interpret, synthesize existing scientific knowledge based on literature review

CLO2: Demonstrate an understanding of the selected scientific problem and identify the knowledge gap

CLO3: Formulate a hypothesis and design an experimental/theoretical work

Students will prepare a research proposal based on literature review and extensive student-mentor interactions involving discussions, meetings and presentations. Each student will submit a research/dissertation proposal of the research work planned for the M.Sc. dissertation with origin of the research problem, literature review, hypothesis, objectives and methodology to carry out the planned research work, expected outcomes and bibliography.

Students will have an option to carry out dissertation work in industry, national institutes or Universities in the top 100 NIRF ranking. Group dissertation may be opted, with a group consisting of a maximum of four students. These students may work using a single approach or multidisciplinary approach. Research projects can be taken up in collaboration with industry or in a group from within the discipline or across the discipline.

Evaluation Criteria:

The evaluation of the dissertation proposal will carry 50% weightage by supervisor and 50% by HoD and senior-most faculty of the department.

Dissertation Proposal (Third Semester)		
	Marks	Evaluation
Supervisor, HoD and Senior-most faculty of the department	50	Dissertation proposal and presentation

Modes of transaction

Group discussions and presentations; Self-Learning; Experimentation

SEMESTER – IV

L	T	P	Cr
0	0	40	20

Course Code: ZOL.601

Course Title: Dissertation-Part II

Total hours: 600

Course learning outcomes:

CLO1: Demonstrate an in-depth knowledge of scientific research pertaining to the area of study

CLO2: Demonstrate experimental/theoretical research capabilities based on rigorous hands-on training

CLO3: Critically analyze, interpret and present the data in light of existing scientific knowledge to arrive at specific conclusions

CLO4: Develop higher order thinking skills required for pursuing higher studies (Ph.D.)/research-oriented career options

Students will carry out their research work under the supervision of a faculty member. Students will interact with the supervisors through meetings and presentations on a regular basis. After completion of the research work, students will complete the dissertation under the guidance of the supervisor. The dissertation will include literature review, hypothesis, objectives, methodology, results, discussion, and bibliography.

Evaluation Criteria:

The evaluation of dissertation in the fourth semester will be as follows: 50% weightage for continuous evaluation by the supervisor which includes regularity in work, mid-term evaluation, report of dissertation, presentation, and final viva-voce; 50% weightage based on average assessment scores by an external expert, HoD and senior-most faculty of the department. Distribution of marks will be based on report of dissertation (30%), presentation (10%), and final viva-voce (10%). The final viva-voce will be through offline or online mode.