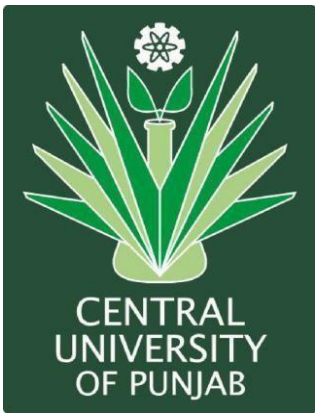
Central University of Punjab



M.Sc. Zoology

Batch: 2022

Department of Zoology

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	
BCH.511	Genetics		**DE**	3	0	0	
MME.527	Stem Cell and Regenerative Medicine		**DE**	3	0	0	
HGE.527	Human Embryology and Developmental Genetics		**DE**	3	0	0	
XXX.XXX	**Interdisciplinary (ID) Course**		**IDC**	2	0	0	2
	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	
	Total Credits						**22**

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	
LBI.526	Biomolecular Structure Modelling and Drug Designing	**DE**	3	0	0	
	Value Added Course					
ZOL.559	Scientific writing	**VAC**	2	0	0	2
	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.526	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**	1	0	0	1
	Discipline Enrichment course					
ZOL.575	Career Prospects in Life Sciences	**DEC**	2	0	0	2
ZOL.600	Dissertation – Part I	**SBC**	-	-	8	4
	Total Credits					**22**

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.	Value based	02
4.	Discipline Elective	09
5.	Discipliner Enrichment	02
6.	Interdisciplinary (ID)	02
7.	Compulsory Foundation	07
	Total	**86**

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%. Mapping will be done by the department and students will be informed accordingly.

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.

Core, Discipline Elective, Compulsory Foundation, Value Added and Interdisciplinary Courses			Discipline Enrichment Course		Entrepreneurship Course	
	Marks	Evaluation	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various		-		-
Mid-semester test (MST)	25	Subjective	50	Objective	25	Objective
End-semester test (EST)	50	Subjective (70%) Objective (30%)	50	Objective	25	Subjective

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**
Major Question:	20 Marks
Minor Question:	10 Marks
Viva-voce:	20 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.

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 key roles of protein kinases and phosphatases.	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, 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. **https://epgp.inflibnet.ac.in/Home**
9. **https://www.vlab.co.in/**
10. **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:**Phylumsporifera, 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 resources

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	**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.	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
II / 12 Hours	**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.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
III / 11 Hours	**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.	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV / 12 Hours	**Population Ecology:** Population characteristics, population interaction; prey-predator relationships; Theories of population growth, population dynamics, regulation. Population growth curves; population regulation; life history strategies (*r* and *K* selection); Concept of metapopulation, demes and dispersal, niche- concept and types, interdemic extinctions, age structured populations	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, 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
3	0	0	3

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. Measurement Frequency and abundance of plant communities
12. Mark recaptures method
13. Isolation of Lymphocytes from whole blood
14. Cell trypsinization and Cell count (Hemocytometer)
15. MTT Assay
16. *In vitro* free radicals-based assays

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 practicals:

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:** *In vitro* 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, USA.
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
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	**Nanotoxicity**: Effect of nanomaterials on human health, nanomaterial-cell interaction, *in vitro* nanotoxicity assays, and challenges in the risk assessment of nanomaterials.	CLO3

Hours	**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.andMurday, J. (2013). A Textbook of Nanoscience and Nanotechnology. Tata McGraw Hill Publication.

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	apping with CLO
Unit I/ 13 Hours	**Mendelian Principles:** Dominance, segregation, independent assortment, Allele, multiple alleles, pseudoallele, complementation tests. **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. **Extra-Chromosomal Inheritance:** Chloroplast and Mitochondrial inheritance; Cytoplasmic inheritance (Coiling in Snails).	**LO1 & CLO3**
	Learning activities: *Apply Punnett squares to solve problems in Genetics.*	
Unit II/ 12 Hours	**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. **Human Genetics:** Pedigree analysis, LOD score for linkage testing, karyotypes, genetic disorders. **Quantitative Genetics:** Polygenic inheritance, heritability and its measurements, QTL mapping.	**LO1 & CLO2**
	Learning activities: Flipped classroom for understanding concepts in genetic mapping.	
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.	**LO2 & 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	**LO3**

	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.	
	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
-Flipped learning

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

L	T	P	Cr
3	0	0	3

Course Code: MME.527
Course Title: Stem Cell and Regenerative Medicine
Total Hours: 45

Course learning Outcomes (CLO): On successful completion of the course the student will be able to:

CLO1: Understand basics of cell culture
CLO2: Understand basic stem cell biology.
CLO3: Gain conceptual knowledge about requirements for tissue engineering.
CLO4: Know regenerative medicine and its potential applications.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 11 Hours	Basics of cell culture and media, Culturing primary cells and cell lines, suspension and adherent cultures, cell growth, growth inhibition and apoptotic studies, Embryo culture, transplantation and teratogens, teratomas, stem cell culture, organ culture.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	**Stem Cells:** Stem cells and their properties, classification of stem cells, *in-vitro* culture techniques, isolation, identification and characterization of stem cells, stem cells in various organs and in disease conditions.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 12 Hours	**Tissue Engineering:** Principles of tissue culture, tissue and organ culture, extracellular matrices, bioreactors, ethical issues related to stem cell therapies, stem cell banks, bone marrow transplantation.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	**Regenerative Medicine:** Modes of tissue and organ delivery, tissue Engineering and transplantation techniques, immuno isolation techniques, regeneration of bone and cartilage, Islet cell transplantation and bio-artificial pancreas, lung regeneration	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Lecture cum demonstration; Problem solving; Self-learning.

Internal assessment shall be through any of the following: Group discussions, Surprise Tests, case analysis, simulated problem solving, classroom assignments, term paper, presentations and discussions.

Suggested Reading:

1. Lanza, R., Gearhart,J. (2016). Essential of Stem Cell Biology. Elsevier Academic Press.
2. Lanza, R., Klimanskaya, I. (2018). Essential Stem Cells Methods.Academic Press.
3. Mao, J. J. & (2017). Translational approaches in tissue engineering and regenerative medicine. Artech House.
4. Lanza, R. (2017). Principles of Tissue Engineering, 3rd Edition. Academic Press

5. Stein, G. S., Borowski, M., Luong, M. X., Shi, M. J., Smith, K. P., & Vazquez, P. (Eds.). (2011). Human stem cell technology and biology: A research guide and laboratory manual. John Wiley & Sons.
6. Lanza, R., Blau, H., Gearhart, J., Hogan, B., Melton, D., Moore, M., ...&Weissman, I. (Eds.). (2014). Handbook of Stem Cells, Two-Volume Set: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells. Elsevier.

L	T	P	Cr
3	0	0	3

Course Code: HGE.527
Course Title: Human Embryology and Developmental Genetics
Total Hours: 45

Course learning outcomes (CLO): On successful completion of the course the student will be able to

CLO1: Conceptualize basics of reproductive physiology.
CLO2: Correlate genetic regulation in different embryonic developmental stages
CLO3: Evaluate the role of biomolecules in embryonic development.
CLO4: Know different genetic and environmental triggers for post-natal development, ageing and senescence.

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 12 Hours	Basic concepts of development: Gametogenesis; fertilization; embryogenesis: gastrulation and implantation of embryo; fetal membrane and placenta; potency, commitment, specification, induction, competence, determination, and differentiation. Role of *Sry, Sox9 and WNT4 and DAX1* in early gonad differentiation.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 11 Hours	Gene expression regulation in development: Basics of gene expression regulation during early embryogenesis; homeotic genes, P granules, role of key developmental genes: polycomb gene, *SOX*, *HOX*.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 11 Hours	Stem Cell and Organogenesis: Stem cell: embryonic and adult; cell-cell communication; neural crest cells and axonal specificity; vertebrate eye and central nervous system development; hematopoiesis.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

IV / 11 Hours	Post-natal Development, Aging and senescence: Environmental and genetic factors during maturations, Sex linked changes, Deciduous and primary teeth, Clinical death. Teratology: Teratogens, introduction to toxicogenomic.	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Transactional Modes: Lecture**;** Demonstration**;** Tutorial**;** Virtual classrooms; Lecture cum demonstration; Problem solving; 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. Gilbert, S.F. (2013). Developmental Biology.Tenth Edition.
2. Slack, J.M.W. (2012). Essentiel Developmental Biology.Third Edition.
3. Moody, A.A. (2014). Principles of Developmental Genetics.Second Edition.
4. Slack, J.M.W. (2018). The Science of Stem Cells.First Edition.
5. Milunsky, J. &Milunsky, A. (2010). Genetic Disorders and the Fetus: Diagnosis, Prevention & Treatment. Willey Blackwell India, New Delhi.
6. Prakash, G. (2007). Reproductive Biology.Narosa Publication House Pvt. Ltd., New Delhi.
7. Sadler, T.W., Tosney, K., Chescheir, N.,C., Imseis, H., Leland, J. and Sadler-Redmond, S.,L.(2011) .Langman's Medical Embryology (Longmans Medical Embryolgy). Lippincott Williams and Wilkins.
8. Keith L. Moore BA, T. V. N. Persaud MD., Mark G. Torchia (2019 The Developing Huma Clinically Oriented Embryology, Elsevier, Netherlands

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., Lews, 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 Hours	**Introduction to Nervous System:** Basic anatomy, parts of central nervous system & peripheral nervous system.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes	
II / 8 Hours	**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.	CLO1 & CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Asking Questions, Paper discussions	
III / 8 Hours	**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.	CLO2 & CLO3

	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 7 Hours	**Action Potential & Neurotransmitters:** Action potentials & channels responsible for action potential, all or none law, Nernst equation; neurotransmitters: excitatory neurotransmitters & inhibitory neuro transmitters.	CLO3
	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. 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, *in vitro* 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, 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.andMurday, J. (2013). A Textbook of Nanoscience and Nanotechnology. Tata McGraw Hill Publication.

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	

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, GoI 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

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, immunoflourescence 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.

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 obtain

CLO1: The bird's eye view of the molecular processes of a cell and in-depth understanding of structure and properties of nucleic acids

CLO2: Detailed understanding and updated knowledge on prokaryotic and eukaryotic replication and epigenetic mechanisms

CLO3: Detailed understanding and updated research on prokaryotic and eukaryotic transcription of various cellular RNAs and the regulation of gene expression

CLO4: Detailed understanding and updated research on prokaryotic and eukaryotic translation and post translational modifications

Unit/ Hours	Contents	Mapping with Course Learning Outcome
I / 2 h	**Genome Organization, Structure and Conformation of Nucleic Acids:** Chromosome structure, chromatin and its regulation, nucleosome and its assembly, nucleolus, repetitive DNA, Structure of DNA, denaturation and renaturation, Various conformations of nucleic acids including non-B DNA structures.	CLO1
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
II / 12 h	**DNA Replication:** Prokaryotic and eukaryotic DNA replication, mechanism of DNA replication, enzymes and accessory proteins involved in DNA replication, replication errors, DNA repair and genome editing, epigenetics	CLO2
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	

III / 1 h	**Transcription and mRNA Processing:** Types of RNA, prokaryotic & eukaryotic transcription, general and specific transcription factors, regulatory elements and mechanisms of transcription regulation, transcriptional and posttranscriptional gene silencing: initiation, elongation & termination of transcription, capping, polyadenylation, splicing, editing, mRNA stability, Control of gene expression at transcription level, operon concepts	CLO3
	Learning activities: Brain storming, problem solving, oral presentations, online resources including e-books, videos and research publications, Quizzes	
IV / 0 h	**Translation:** Genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanisms of chain initiation, elongation and termination, regulation of translation, co- and post-translational modifications, control of gene expression at translation level.	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/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. Molecular Biology of the Gene by James D. Watson, 2013, Seventh Edition
2. Molecular Biology: Principles and Practice by M.M. Cox, 2016, 2nd Edition
3. Molecular Biology by Robert Weaver, 2012, 5th edition
4. Latest review and research articles along with digital resources

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, GoI 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. Determination of BOD/COD
9. RNA isolation
10. DNA isolation

11. Polymerase Chain Reaction
12. cDNA synthesis and RT-PCR analysis
13. Gene cloning: Primer designing, Restriction digestion, ligation, transformation and screening.
14. Animal handling: mice/rat/rabbit (tutorials only)
15. Animal Perfusion
16. Polyclonal antibody raising
17. Immunohistochemistry
18. Cell cycle monitoring by flow cytometry
19. Microscopic examination of human parasite life cycles (amoeba, cestodes, nematodes, and plasmodium)
20. Animal cell transfection (lipid based and electroporation)

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. 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.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 (*Sachharomyce scerevisiae* & 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. https://epgp.inflibnet.ac.in/Home
9. https://www.vlab.co.in/
10. 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
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	**General Introduction to Hormone:** History, endocrine glands, hormones as chemical messengers, stimulus for hormone release: change in homeostasis, Neurosecretion and neuroendocrine system. **Hormones:** Structure, receptor type, regulation of biosynthesis and release (including feedback mechanism like short, long and ultra-feedback system).	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Latest research paper discussion	
II / 10 Hours	**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/condional knockout/wild type animals	CLO2

	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
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: LBI.526
Course Title: Biomolecular Structure Modelling and Drug Designing
Total Hours: 45

Course learning outcomes (CLO): On completion of the course the student should be able to:

CLO1: Describe different types of protein–ligand interactions and characterize binding pockets
CLO2: Use different search methods to find compounds with specific properties in large compound databases
CLO3: Set up, perform and evaluate different virtual screening methods using large datasets
CLO4: Account for and set up molecular dynamics simulations and free energy calculations

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 10 Hours	Basics of Biomolecules: Principles of protein and nucleic acid structure: Primary, Secondary, Tertiary structure and Quaternary structure. Protein secondary structure: Introduction, Hydrogen bond, Defining a secondary structure element, Methods for predicting secondary structure.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 12 Hours	Protein tertiary structure modeling: Basic concepts, Protein folding and Energetics, Comparative modeling, Threading, Ab initio modeling, Modeling protein sidechains, CASP: A blind protein structure prediction competition, CAPRI, Protein Structure Initiative (PSI).	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 12 Hours	Introduction to drug designing, ADMET, drug metabolism, toxicity and pharmacokinetics. lipinski rule of 5, Identification and validation strategies. Drug Target classification, Concept of Pharmacophore, Functional group considered as pharmacophore, Structure-based drug design, docking, QSAR	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 11 Hours	Modelling macromolecular structure: Homology modelling, *ab-initio* structure modeling; Molecular Recognition: Prediction of Protein-ligand interaction sites, Prediction of Protein-protein interaction sites, Prediction of Protein-membrane interaction sites, Prediction of Protein-nucleic acid interaction sites	CLO4
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Transactional Modes: Lecture, Laboratory based Practical, Seminar, Group discussion, Team teaching, Self-learning, Online tools.

Suggested Readings

1. Hybrid Biomolecular Modeling. (2019): Frontiers Media SA. ISBN:9782889456994
2. Biomolecular Modelling and Simulations. (2014). United Kingdom: Elsevier Science.ISBN:9780128007891
3. Molecular Modeling of Proteins. (2017). United States: Springer New York. ISBN:9781493954919
4. Biomolecular Simulations in Structure-Based Drug Discovery. (2019). Germany: Wiley. ISBN:9783527342655
5. Schneider, Gisbert; Baringhaus, Karl-Heinz; Kubinyi, Hugo Molecular design : concepts and applications Weinheim: Wiley-VCH, c2008
6. Andrew R.Leach Molecular Modelling Principles and applications. (2001) II ed.
7. Prentice Hall

Web Resources

https://www.uniprot.org/
bioinformatics.org/molvis/phipsi/

Value Based Course:

Course Name: Scientific Writing

L	T	P	Cr
2	0	0	2

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 of Literature and review articles, Methods of literature review, Process of summarizing, synthesizing and presentation of reviewed literature, Presentation of primary research from Peer-reviewed journal articles.	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, Steps in designing a research problem, Formulation of research questions, research objectives and construction of a hypothesis, Designing an experiment.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
III / 8 Hours	Goal of data analysis, Collection, processing and interpretation of data, Presentation, visualization of results, Analysis and reporting of results, Basics of citation and bibliography/reference preparation styles	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, group discussion, Field visit	
IV / 6 Hours	Writing a grant proposal, Technology requirements in scientific writing, Ethics in writing and scientific misconduct, Patents and copyrights.	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

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 / 10	**Regeneration:** Tertrapod limb development, metamorphosis, regeneration and ageing, teratogenesis.	CLO3

Hours	**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. 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, *In situ* 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, varicocoele, 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; Seroli 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, GoI e-learning platforms, Powerpoint, Educational Videos and Animations, TED Talks, Research and Review articles

Suggested Readings:

1. Norris and Carr: Vertebrate Endocrinology (8th ed, Vol 5, 2016, Academic Press)
2. Brooks and Marshall: Essentials of Endocrinology (1995, Blackwell Science)
3. Larson: Williams Textbook of Endocrinology (10th ed, 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 (6th ed, 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:** *Drosophila melanogaster*, *Manducasexta*, *Bombyxmori*, female *Anopheles* sp., *Aedesaegypti, Apismellifera, Muscadomestica* and other non-model organisms.	CLO3
	Learning activities: Brain storming, oral presentations, online resources including e-books, videos and research publications, Quizzes	
IV / 0 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.527
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
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II / 12 Hours	**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, Radioimmunossay; 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.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

III / 11 Hours	**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, *In situ* PCR, Long-PCR, PCR-ELISA, iPCR, applications and limitations) DNA fingerprinting and polymorphism studies (SNP, RAPD, RFLP, VNTR, Mutation detection etc). Emphasis on interpretation of results and quality control. **High-throughput Technologies and Pathological 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	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
IV / 11 Hours	**Case Studies:** Diagnosis of Infectious Diseases – some specific examples. Diagnosis of bacterial infection caused by *Coliforms, Salmonella, Shigella, Vibrio, and Mycobacterium tuberculosis.* 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.	CLO4
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

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.

Modes of transaction

-Lecture
-Problem Solving
-Self-Learning
- Case study
-Group discussions

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 / 7 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 / 7 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 / 8 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 / 8 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, Kolmogrov-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, GoI 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
1	0	0	1

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 / 3 Hours	Characteristics of an entrepreneur; Characteristics of entrepreneurship; entrepreneurial traits and skills; innovation and entrepreneurship; Types of entrepreneurial ventures; enterprise and society in Indian context; Importance of women entrepreneurship	CLO1
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
II / 4 Hours	Why to start a small business; How to start a small business; opportunity analysis, external environmental analysis, legal requirements for establishing a new unit, raising of funds financial management for procurement of capital Collaborations & partnership, Establishing the venture - Project report preparation – format for a preliminary project report, format for a detailed/final project report.	CLO2
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	
III / 4 Hours	Road map from Familiarization with Entrepreneurial development programs of public and private agencies (MSME, DBT, BIRAC, Make In India); Technology assessment, development &upgradation, Managing Quality control and technology transfer, Knowledge centers and Technology transfer agencies. Understanding regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).	CLO2 & CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

IV / 4 Hours	Innovation and science-based ideas to business development within segments such as health & disease, agricultural, environmental and/or industrial value addition. Case studies and discussion sessions with successful science-based entrepreneurs	CLO3
	Learning Activities: Brainstorming, Presentation, Quizzes, Group discussion, Latest research paper discussion and Self-learning, and Case studies	

Suggested Readings:

1. Arora, Renu (2008). Entrepreneurship and Small Business, DhanpatRai& Sons Publications.
2. Chandra, Prasaaan (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

Discipline Enrichment Course:

L	T	P	Cr
2	0	0	2

Course Code: ZOL.575
Course Title: Career Prospects in Life Sciences
Total hours: 30

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

CLO1: Describe basic biological processes

CLO2: Revisit and revise the courses offered

CLO3: Solve exercises, mock tests and practice tests for competitive examinations

Unit/ Hours	Contents	Mapping with course Learning Outcome
I / 7 Hours	**Life Sciences:** Scope, importance & career opportunities; classical zoology and basic animal biology; timeline of animal research.	CLO1
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
II / 8 / Hours	**A revision of concepts in core courses**: Animal Evolution & Classification, Developmental Biology; Animal Physiology, Ecological Principles, Applied Zoology Molecular Biology and Animal behavior.	CLO2
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
III / 7 Hours	**A revision of concepts in elective courses:** Genetic Engineering, Stem cell technology Hybridoma technology and Endocrinology, Animal Cell culture & Applications	CLO2 & CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	
IV / 8 Hours	Exercises, Mock Tests, Practice Tests from the previous year's related to UGC-CSIR – NET and ICMR - NET examinations and other competitive examinations.	CLO3
	Learning activities: Brainstorming, Presentation, Quizzes, Discussions and Group Learning	

Mode of Transaction

The classroom learning 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 practicals:

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

Suggested Readings:

1. Damron, W. S. (2012). Introduction to Animal Science. Prentice Hall. 5th Edition
2. Lisa AU. et al. (2016). Campbell Biology. Pearson publishers, 11th edition.
3. Voet, D. and Voet, J. G. (2008). Principles of Biochemistry. CBS Publishers & Distributors. New Delhi, India.
4. Urry, L. A. et al. (2016). Campbell Biology. Pearson publishers, 11th edition.
5. Smith, T. M. and Smith, R. L. (2012). Elements of Ecology. Benjamin Cummings Publishing Company, 8th edition.

6. Alberts, B., Bray, D., Lews, J., Raff, M., Roberts, K. and Watson, J. D. (2010). Molecular Biology of the Cell. Garland publishers, Oxford.
7. Guyton. (2007). Textbook of Medical Physiology. 11th Edition. Elsevier India Pvt. Ltd. New Delhi.
8. Alcock J. Animal Behavior: An Evolutionary Approach, 10th Edition
9. Lee Alan D. Principles of Animal Behavior (Third Edition)
10. Competitive examination papers.

Web resources:
www.csirhrdg.res.in

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.