Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Structure and Curriculum of FourYear Multidisciplinary Degree (Honors/Research) Programme with Multiple Entry and Exit option

Undergraduate Programme of Science and Technology

B.Sc. (Honors/Research) in Zoology

Board of Studies

in

Zoology

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

[UG IV Year]

w.e.f. June, 2026

(In Accordance with NEP-2020)

Review Statement

The NEP Cell reviewed the Curriculum of **B.Sc. (Honors/Research) in Zoology** to be effective from the **Academic Year 2026-27.** It was found that, the structure is as per the NEP-2020 guidelines of Govt. of Maharashtra.

Date: 11/04/2026

Place: Latur

NEP CELL

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

CERTIFICATE

I hereby certify that the documents attached are the Bonafide copies of the Curriculum of **B.Sc. (Honors/Research) in Zoology**to be effective from the **Academic Year 2026-27.**

Date: 11/04/2026

Place: Latur

(Dr. D.S. Rathod)
Chairperson
Board of Studies in Zoology
Rajarshi Shahu Mahavidyalaya, Latur
Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya,Latur

Empowered Autonomous Institution

Members of Board of Studies in Zoology

Under the Faculty of Science and Technology

Sr. No.	Name	Designation	In position
1	Dr. Dnyaneshwar Rathod, Associate Professor, Rajarshi Shahu Mahavidyalaya, Latur	Chairperson	HoD
2	Prof. Dr. M.Y. Kulkarni, Head, Department of Zoology N.S. B College, Nanded	Member	V.C. Nominee
3	Prof. Dr. Mamidala Estari, Kakatiya University, Warangal	Member	Academic Council Nominee
4	Dr. RavikumarBaburao Shinde, Shri. PundlikMaharaj Mahavidyalaya, Nandura, Dist. Buldana - 443404	Member	Academic Council Nominee
5	Mr. Ishrar Deshmukh, QMS Head, Sai Life Science , Hyderabad	Member	Expert from Industry
6	Dr. Ravi Solunke, Head, Department of Zoology Dayanand Science College, Nanded	Member	Expert from outside for Special Course
7	Mr. Balasaheb Venktrao Sager, Fishery Development Officer, Latur	Member	Expert from outside for Special Course
8	Dr. Kakasaheb Raut, Associate Professor, Rajarshi Shahu Mahavidyalaya, Latur	Member	Faculty Member
9	Mr. Datta Nalle, Assistant Professor, Rajarshi Shahu Mahavidyalaya, Latur	Member	Faculty Member
10	Ms. Pratiksha Patil, Assistant Professor, Rajarshi Shahu Mahavidyalaya, Latur	Member	Faculty Member
11	Ms. Sakshi Rajput, Assistant Professor, Rajarshi Shahu Mahavidyalaya, Latur	Member	Faculty Member

From the Desk of the Chairperson…

The Department of Zoology was established in the year 1971. The department has been recognized by our parent University as Research center since 8th May 2003 and now it has been developed into center of teaching and research in Zoology.

To reach the mission of "Pursuit of Excellence" in higher education to make our students globally competent. The departmental staff is committed towards our work with dedication, determination and devotion.

National Education Policy NEP-2020 focuses more on practical rather than theoretical learning. It also focus on developing overall personality of students by incorporating Humanitarian and Constitutional values, creativity and critical thinking, harnessing innovation, use of modern technology and interaction with various stakeholders. It uses the practical based pedagogy to evolve and make education more experiential, holistic, integrated, learner-centric, flexible and developing skill etc. To skilled and trained students can accept the challenge of the future, as we know that the new policy also envisages the refinement and improvement in the Learning Outcome based Curriculum Framework.

The syllabus of B.Sc. I has been designed as per the National Education Policy (NEP), 2020, the present structure comprises Discipline specific courses (DSC), Discipline Specific Electives (DSE), Discipline Specific Minor Course (DSM), Generic/Open Electives (GE/OE), Vocational Specific Course (VSC), Skill Enhancement Course (SEC), Ability Enhancement Course (AEC) etc. The discipline specific courses (DSC) are compulsory and the elective courses can be chosen from the given Basket. Except Ability Enhancement courses, all other courses, comprise theory and practicals.

The project work is specially underlined in this structure. The project will mainly involve experimental work. The students will be asked their choice for project. The Generic Electives will be offered to the students of other departments of the college. The students will have the option to choose one generic elective from the given Basket. The generic elective comprises theory as well as practical. The students will also undertake one Vocational Specific Course (VSC) and one Skill Enhancement Course (SEC) of two credits each. The VSC and SEC also comprise theory and practicals. These courses will be chosen by the students from the concerned basket. One of the DSC is specified for Indian Knowledge Systems (IKS). Indian Knowledge Systems have a strong foundation in Indian Culture, Philosophy and Spirituality and have evolved through thousands of years.

B.Sc. Zoology course will help to understand the behaviour, structure and evolution of animals. Zoologists use a wide range of approaches to do this, from genetics to molecular and cellular biology, as well as physiological processes and anatomy, whole animals, populations, and their ecology. The scope of Zoology as a subject is very broad. The intention is to understand the subject of Zoology in

the evolving biological paradigm in modern times; where, living beings need to be understood at the level of atomic interactions; and comparative systems of organisms need to be studied through the prism of integrated chemical, physical, mathematical and molecular entities to appreciate the inner working of different organisms at morphological, cellular, molecular, interactive and evolutionary levels. The key areas of study within the disciplinary/subject area of Zoology comprise: animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied zoology, behaviour, immunology, reproductive biology, and insect, vectors and diseases. B.Sc. degree programme in Zoology also deals with skill enhancement courses such as apiculture, aquarium fish keeping, medical diagnostics, sericulture etc. The depth and breadth of study of individual topics dealt with would vary with the nature of specific Zoology programmes.

Our institution gives importance in mission to provide value and need based education, which can be useful to students to get the skill for entrepreneurship and jobs or self-help for earnings. This institution is connected long back with anti-superstition activity to develop the scientific attitude among students.

As a part of the efforts to enhance the interest and employability of graduates of Zoology programmes, the curricula for these programmes are expected to include learning experiences that offer opportunities for higher studies and research at reputed laboratories.

Dr. D. S. Rathod
Chairperson
Board of Studies in Zoology
Rajarshi Shahu Mahavidyalaya, Latur
Empowered Autonomous Institution

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Structure for Four Year Multidisciplinary Undergraduate Degree Programme in Zoology Multiple Entry and Exit (In accordance with NEP-2020)

Year & Level	Sem	Major		Minor	OE	VSC/ SEC (VSEC)	AEC/ VEC	OJT,FP,CEP, RP	Credit per Sem.	Cum./Cr. per exit
		DSC	DSE							
1	**2**	**3**		**4**	**5**	**6**	**7**	**8**	**9**	**10**
I 4.5	VII	DSC XIII: 04 Cr. DSC XIV: 04 Cr. DSC XV: 04 Cr. DSC XVI: 02 Cr.	DSE III: 04 Cr.	RMC : 04 Cr				OJT: 04 CR/FP-II 04Cr	22	44 Cr. UG Certificate
	VIII	DSC XVII: 04 Cr. DSC XVIII: 04 Cr. DSC XIX: 04 Cr. DSC XX: 02 Cr.	DSE IV: 04 Cr.						22	
	Cum. Cr.	16	-	-	08	04+04=08	04+02+02=08	04	44	

Exit Option: Award of UG Certificate in Major with 44 Credits and Additional 04 Credits Core NSQF Course/Internship or continue with Major and Minor

Abbreviations:

1. DSC : Discipline Specific Core (Major)
2. DSE : Discipline Specific Elective (Major)
3. DSM : Discipline Specific Minor
4. OE : Open Elective
5. VSEC : Vocational Skill and Skill Enhancement Course
6. VSC : Vocational Skill Course
7. SEC : Skill Enhancement Course
8. AEC : Ability Enhancement Course
9. MIL : Modern Indian Languages
10. IKS : Indian Knowledge System
11. FSRCE : Fostering Social Responsibility & Community Engagement
12. VEC : Value Education Course
13. OJT : On Job Training
14. FP : Field Project
15. CEP : Community Engagement Programme
16. CC : Co-Curricular Course
17. RP : Research Project/Dissertation
18. SES : Shahu Extension Services
19. RMC : Research Methodology Course

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

B.Sc. IV Year In Zoology

Year & Level	Semester	Course Code	Course Title	Credits	No. of Hrs.
IV 4.5	VII	DSC XIII	Structure and Function OF Invertebrates	03	45
		DSC XIII	Lab Course- XIII	01	30
		DSC XIV	Molecular Cell Biology	03	45
		DSC XIV	Lab Course-XIV	01	30
		DSC XV	Endocrinology	03	45
		DSC XV	Lab Course-XV	01	30
		DSC XVI	NET/SET Paper-I	02	30
		DSE-III	Molecular Genetics	03	45
		DSE-III	Lab Course-III	01	30
		RMC	Research Methodology	04	60
	Total Credits			**22**	
	VIII	DSC XVII	Comparative Anatomy OF Vertebrates	03	45
		DSC XVII	Lab Course- XVII	01	30
		DSC XVIII	Molecular Biology	03	45
		DSC XVIII	Lab Course-XVIII	01	30
		DSC XIX	Biochemistry	03	45
		DSC XIX	Lab Course-XIX	01	30
		DSC XX	NET/SET Paper-I	02	30
		DSE-IV	Developmental Biology-IV	03	45
		DSE-IV	Lab Course-IV	01	30
		OJT / FP:	Field Project	04	60
	Total Credits			**22**	
Total Credits (Semester VII & VIII)				**44**	

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Name of the Programme:B.Sc. In Zoology

Programme Outcomes (POs) for B.Sc. Zoology Programme	
PO 1	**Fundamental Knowledge and Specialization** Students will demonstrate a deep understanding of the fundamental concepts, principles, and processes of animal biology. This includes mastery over animal diversity, morphology, anatomy, physiology, genetics, and evolutionary biology.
PO 2	**Practical Skills and Laboratory Techniques** Graduates will be proficient in standard laboratory and field techniques, including microscopy, dissection, specimen preservation, and biochemical analysis, ensuring high technical competence in biological investigations.
PO 3	**Analytical Competence and Data Interpretation** Students will possess the ability to accurately collect, analyze, and interpret biological data. They will be adept at using statistical tools and bioinformatics to derive meaningful conclusions from complex biological datasets.
PO 4	**Ecological Consciousness and Sustainable Management** Students will develop a strong awareness of environmental issues and biodiversity. They will evaluate the impact of human activities on animal populations and suggest sustainable solutions for managing natural resources, wildlife, and ecosystems.
PO 5	**Scientific Temper and Critical Thinking** Graduates will exhibit a scientific mindset characterized by inquisitiveness and objective reasoning. They will be capable of identifying research gaps, designing controlled experiments, and formulating evidence-based solutions to biological problems.
PO 6	**Ethics, Professionalism, and Animal Welfare** Students will apply ethical principles in all professional activities, focusing on animal welfare, biosafety, and intellectual property rights. They will adhere to legal frameworks and understand the moral implications of biological research.
PO 7	**Communication and Digital Literacy** Graduates will communicate complex biological information effectively through technical reports, presentations, and digital platforms, using modern software to visualize biological systems and patterns for scientific and public audiences.
PO 8	**Career Readiness, Lifelong Learning, and Social Responsibility** Students will explore commercial applications of Zoology (e.g., aquaculture, sericulture) while committing to continuous professional development. They will apply biological knowledge to address social issues like public health and community welfare.

Programme Specific Outcomes (PSOs) for M.Sc. Zoology	
PSO No.	**After completion of this programme the students will be able to -**
PSO 1	**Advanced Biological, Evolutionary, and Molecular Expertise** Demonstrate a profound understanding of complex functional mechanisms, genetic inheritance, systemic physiology, and evolutionary relationships. Students will master the intricate workings of the cell—including signaling pathways and gene expression—while applying modern taxonomic tools to classify organisms using both morphological and molecular data.
PSO 2:	**Ecological Stewardship and Sustainable Environmental Management** Evaluate ecosystem dynamics, conservation biology, and wildlife management strategies. Graduates will be equipped to address global environmental challenges, such as habitat loss and climate change, by implementing scientific interventions and sustainable ecological practices to preserve biodiversity.
PSO 3	**Research Methodology, Technical Proficiency, and Data Analytics** Design and execute independent research projects using advanced laboratory techniques (such as PCR, chromatography, and microscopy) and rigorous field-based data collection. Students will apply sophisticated biostatistical methods and bioinformatics tools to analyze large-scale genomic, proteomic, or ecological datasets with high accuracy.
PSO 4	**Professional Ethics, Applied Zoology, and Scientific Communication** Practice high ethical standards in animal handling and biosafety while translating academic knowledge into socio-economic benefits through applied fields like aquaculture, pest management, and clinical diagnostics. Graduates will effectively communicate complex biological concepts through publication-quality reports and professional presentations.

Semester- VII

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XIII

Course Title : Structure and Function of Invertebrates

Course Code :

Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To analyze the structural organization and symmetry across various invertebrate phyla.

LO2. To understand the functional mechanisms of vital systems like locomotion, respiration, and excretion.

LO3. To evaluate the evolutionary transitions from simple to complex body plans.

LO4. To examine the significance of larval forms in invertebrate development and phyla

Course Outcomes:

After the completion of this course students will be able to:

CO1. Describe the diverse morphological features used for invertebrate classification.

CO2. Explain the physiological adaptations that allow invertebrates to thrive in different environments.

CO3. Identify and distinguish between various types of coeloms and skeletal systems.

CO4. Appreciate the ecological and evolutionary roles of invertebrates within the animal kingdom.

Unit No.	Title of Unit & Contents	Hrs.
I	**Organization and Protozoa to Cnidaria**	**12**
	• **Body Organization:** Symmetry (Radial vs. Bilateral), levels of organization, and germ layers. • **Protozoa:** Locomotory organelles (cilia, flagella, pseudopodia); nutrition and osmoregulation. • **Porifera:** Types of canal systems; skeletal elements (spicules and Spongin fibers). • **Cnidaria:** Polymorphism in Siphonophores; formation and types of coral reefs.	
	Unit Outcomes: UO 1. Describe the body organization and key diagnostic features of Protozoa, Porifera, and Cnidaria for classification.	
II	**Body Cavity and The Helminths to Annelids**	**11**
	• **Evolution of Coelom:** Acoelomates, Pseudocoelomates, and Coelomates (Schizocoely and Enterocoely). • **Platyhelminthes & Nemathelminthes:** Structural adaptations for a parasitic lifestyle; excretion via Flame cells. • **Annelida:** Metameric segmentation; Coelomoducts and Nephridia. • **Locomotion:** Role of setae, parapodia, and the hydrostatic skeleton.	

Unit No.	Title of Unit & Contents	Hrs.
	Unit Outcome: UO 1. Explain the evolution of coelom and structural adaptations in helminths and annelids.	
III	**Arthropoda and Mollusca**	**11**
	• **Arthropoda:** Success of the exoskeleton; the process of ecdysis (molting). • **Respiration:** Diversity in respiratory organs—Gills, Book-lungs, and Tracheal systems. • **Vision:** The structure and physiology of the compound eye. • **Mollusca:** Torsion and detorsion in Gastropoda; respiratory organs (Ctenidia); Pearl formation in Bivalves.	
	Unit Outcomes: **UO 1.** Understand the major adaptations and physiological specializations of Arthropoda and Mollusca.	
IV	**Echinodermata and Phylogenetic Significance**	**11**
	• **Echinodermata:** The Water Vascular System (Ambulacral system) and its role in locomotion and feeding. • **Skeletal System:** Structure of the calcareous endoskeleton. • **Larval Forms:** Types and evolutionary significance of Trochophore, Veliger, Bipinnaria, and Auricularia larvae. • **Affinities:** The phylogenetic position of Hemichordata as a link between invertebrates and chordates.	
	Unit Outcomes: **UO 1.** Explain the unique features of echinoderms and larval forms, and discuss their phylogenetic significance..	

Learning Resources:

1. A Manual of Zoology (Invertebrates) – A.S. Ekambaranatha Ayyar – S. Chand Publishing
2. Biology of Invertebrates – E.L. Nigam – New Age International Publishers
3. Invertebrate Zoology – A. Jordan & E.L. Verma – S. Chand Publishing
4. Invertebrate Zoology – R.C. Sinha & B.B. Chatterjee – Kalyani Publishers
5. Invertebrate Zoology – R.D. Barnes – Saunders College Publishing
6. Invertebrate Zoology: A Functional Evolutionary Approach – Ruppert, Fox & Barnes – Cengage Learning
7. Modern Textbook of Zoology: Invertebrates – R.L. Kotpal – Rastogi Publications
8. Textbook of Invertebrate Zoology – S.N. Prasad – Vishal Publishing Co.
9. The Invertebrates (Vol. I–VI) – L.H. Hyman – McGraw-Hill Book Company
10. Zoology: Invertebrates – P.S. Verma & V.K. Agarwal – S. Chand Publishing

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Video

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	-	1	-	1	-	3	1	2	-
CO2	3	-	-	3	2	-	-	1	3	2	1	-
CO3	3	3	-	-	1	-	-	-	3	-	2	-
CO4	3	-	1	3	3	1	2	2	3	3	2	2

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XIII

Lab Course :DSC-XIII- Structure and Function of Invertebrates

Course Code :

Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To develop skills in the microscopic examination of protozoans and lower invertebrates.

LO2. To master the technique of dissection to study the internal organ systems of major invertebrate phyla.

LO3. To observe and document the diversity of invertebrate larval forms and their developmental significance.

LO4. To understand the functional relationship between skeletal structures and locomotion through specimen study.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Identify common invertebrates and their specific larval stages using morphological keys.

CO2. Demonstrate proficiency in performing dissections of Earthworms, Cockroaches, or Pila.

CO3. Prepare temporary mounts of specialized structures like setae, radula, or salivary glands.

CO4. Maintain a scientific laboratory record (Practical Manual) with accurate biological illustrations.

Unit No.	Title of Unit & Contents	Hrs.
I	**Practicals**	**30**
1	Protozoa: Observation of live cultures of *Amoeba*, *Euglena*, and *Paramecium*; Permanent slides of binary fission and conjugation.	
2	Porifera: Study of different canal system models; Preparation of temporary mounts of spicules and gemmules.	
3	Cnidaria: Identification of *Hydra*, *Obelia* (polyp and medusa), *Physalia*, and various coral skeletons (Fungia, Meandrina).	
4	Annelida (Earthworm/Nereis): External morphology; Dissection to study digestive, nervous, and reproductive systems.	
5	Arthropoda (Cockroach/Prawn): Study of mouthparts; Dissection of the digestive system and nervous system; Mounting of salivary glands.	
6	Mounting Techniques: Preparation of temporary/permanent slides of:	
7	Trachea and Malpighian tubules of Cockroach.	
8	Statocyst of Prawn.	
9	Study of Adaptations: Observation of specialized appendages (legs and wings) in insects.	
10	Echinodermata: External features of Starfish (*Asterias*), Sea Urchin, and Brittle Star.	

Unit No.	Title of Unit & Contents	Hrs.
11	Museum Specimen Study: Representative types from Platyhelminthes to Hemichordata.	

Learning Resources:

1. A Manual of Practical Zoology: Invertebrates – P.S. Verma – S. Chand Publishing
2. A Manual of Practical Zoology: Invertebrates – R.C. Kotpal – Rastogi Publications
3. A Textbook of Practical Zoology: Invertebrates – S.C. Verma – S. Chand Publishing
4. Invertebrate Practical Manual – P.N. Pandey & B.K. Tiwari – S. Chand Publishing
5. Laboratory Manual of Invertebrate Zoology – R.L. Kotpal – Rastogi Publications
6. Manual of Zoology Practical: Invertebrates – V.K. Agarwal – S. Chand Publishing
7. Practical Zoology (Non-Chordates) – Dr. A. K. Dutta – New Central Book Agency
8. Practical Zoology: Invertebrates – B.D. Chaurasia – CBS Publishers & Distributors
9. Practical Zoology: Invertebrates – K.N. Tandon – S. Chand Publishing
10. Practical Zoology: Invertebrates – S.S. Lal – Rastogi Publications

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Video

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1	1	-	-	-	3	1	2	-
CO2	2	3	-	-	1	2	-	1	2	-	3	2
CO3	2	3	-	-	1	1	-	-	1	-	3	-
CO4	1	2	2	-	2	1	3	1	-	-	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XIV
Course Title : Molecular Cell Biology
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

CO1. To explain the molecular organization of the cell membrane and the mechanisms of membrane transport.

CO2. To understand the processes of DNA replication, transcription, and translation in prokaryotic and eukaryotic systems.

CO3. To analyze the mechanisms of protein sorting, intracellular signaling, and protein trafficking.

CO4. To investigate the regulation of the cell cycle and the molecular basis of programmed cell death (apoptosis).

Course Outcomes:

After the completion of this course students will be able to:

CO1. Diagram the molecular structure of the plasma membrane and its associated transport proteins.

CO2. Compare and contrast the molecular machinery of gene expression across different domains of life.

CO3. Describe the pathways of signal transduction and their role in cellular communication.

CO4. Evaluate the molecular checkpoints that ensure genomic stability during the cell cycle.

Unit No.	Title of Unit & Contents	Hrs.
I	**Biomembranes and Cell Architecture**	
	• Membrane Structure: Fluid Mosaic Model; lipid composition (phospholipids, sphingolipids, cholesterol); integral and peripheral proteins. • Membrane Transport: Passive and active transport; Na^+/K^+ pump; symporters and antiporters; ion channels and aquaporins. • Cytoskeleton: Structure and dynamic assembly of Microtubules, Microfilaments, and Intermediate filaments; molecular motors (Kinesin, Dynein, Myosin). • Cell Junctions: Molecular basis of Tight junctions, Desmosomes, and Gap junctions	
	Unit Outcomes: UO 1. Diagram the molecular structure of the plasma membrane and its associated transport proteins.	
II	**The Flow of Genetic Information**	**11**
	• DNA Replication: Molecular machinery in E. coli vs. Eukaryotes; enzymes involved (DNA polymerases, helicase, primase, ligase). • Transcription: RNA polymerase and promoter recognition; post-transcriptional	

Unit No.	Title of Unit & Contents	Hrs.
	modifications (capping, polyadenylation, and splicing). • Translation: Genetic code; tRNA charging; stages of initiation, elongation, and termination; role of ribosomes and translation factors. • Regulation of Gene Expression: The Lac Operon and Tryptophan Operon models; transcription factors in eukaryotes.	
	Unit Outcomes: UO 1. Compare and contrast the molecular machinery of gene expression across different domains of life.	
III	**Protein Sorting and Cell Signaling**	**11**
	• Protein Trafficking: Targeting proteins to the Endoplasmic Reticulum (Signal Hypothesis), Mitochondria, and Nucleus (Nuclear Pore Complex). • Vesicular Transport: Secretory and endocytic pathways; role of COPI, COPII, and Clathrin-coated vesicles. • Cell Signaling: Principles of cell communication; G-Protein Coupled Receptors (GPCRs); Receptor Tyrosine Kinases (RTKs). • Second Messengers: Role of cAMP, IP3, DAG, and Ca2+ in amplifying cellular signals.	
	Unit Outcomes: UO 1. Describe the pathways of signal transduction and their role in cellular communication	
IV	**Cell Cycle, Apoptosis, and Cancer**	**11**
	• **The Cell Cycle:** Phases of the cell cycle (G_1, S, G_2, M); molecular regulation by Cyclins and Cyclin-Dependent Kinases (CDKs). • **Cell Cycle Checkpoints:** Role of p53 and Rb proteins in DNA damage repair and cell cycle arrest. • **Apoptosis:** Extrinsic (death receptor) and intrinsic (mitochondrial) pathways; the role of Caspases and Pro-apoptotic/Anti-apoptotic proteins. • **Cancer Biology:** Molecular basis of cancer; transformation of proto-oncogenes to oncogenes; tumor suppressor genes.	
	Unit Outcomes: UO 1. Evaluate the molecular checkpoints that ensure genomic stability during the cell cycle	

Learning Resources:

1. Cell and Molecular Biology: Concepts and Experiments – Gerald Karp – John Wiley & Sons
2. Cell Biology – Thomas D. Pollard, William C. Earnshaw& Jennifer Lippincott-Schwartz – Elsevier (Saunders)
3. Essential Cell Biology – Alberts, Hopkin, Johnson, Morgan, Raff, Roberts & Walter – Garland Science
4. Genes XII – Benjamin Lewin – Jones & Bartlett Learning
5. Molecular Biology – David P. Clark & Nanette J. Pazdernik – Academic Press (Elsevier)
6. Molecular Biology of the Cell – Alberts, Johnson, Lewis, Morgan, Raff, Roberts & Walter – Garland Science (Taylor & Francis Group)

7. Molecular Biology of the Gene – James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine & Richard Losick – Pearson
8. Molecular Cell Biology – Darnell, Lodish & Baltimore – W.H. Freeman
9. Molecular Cell Biology – Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon& Martin – W.H. Freeman (Macmillan Learning)
10. The Cell: A Molecular Approach – Geoffrey M. Cooper & Robert E. Hausman – Sinauer Associates (Oxford University Press)

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Video

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-	1	-	2	-	3	-	1	1
CO2	3	-	2	-	3	-	1	1	3	-	2	2
CO3	3	-	1	-	2	-	-	-	3	-	2	-
CO4	3	-	2	-	3	2	-	1	3	-	3	1

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

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Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XIV
Lab Course : DSC-XIV-Molecular Cell Biology
Course Code :
Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To develop proficiency in advanced light microscopy and cytochemical staining techniques.
LO2. To master the techniques of cell fractionation and organelle isolation.
LO3. To execute fundamental molecular protocols for the extraction and quantification of nucleic acids.
LO4. To demonstrate the principles of membrane transport and cellular osmosis through experimental models.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Prepare and observe various stages of mitosis and meiosis from biological samples.
CO2. Isolate genomic DNA from prokaryotic or eukaryotic sources using standardized protocols.
CO3. Perform thin-layer chromatography or electrophoresis to separate biological molecules.
CO4. Analyze cell viability and membrane permeability using vital staining methods.

Unit No.	Title of Unit & Contents	Hrs.
I	**Practicals**	**30**
1	Microscopy: Calibration of the ocular micrometer and measurement of cell size.	
2	Cell Division: Preparation of temporary onion root tip squashes to study stages of Mitosis.	
3	Meiosis: Study of different stages of meiosis using permanent slides or grasshopper testis.	
4	Special Chromosomes: Observation of Polytene and Lampbrush chromosomes from permanent slides.	
5	Cell Fractionation: Principles of homogenization and differential centrifugation.	
6	Organelle Isolation: Isolation of Chloroplasts from spinach leaves or Mitochondria from mammalian liver (demonstration).	
7	Vital Staining: Use of Janus Green B to stain mitochondria and Neutral Red for vacuoles.	
8	Permeability: Study of plasmolysis and de-plasmolysis in *Rhoeo discolor* epidermal peels.	
9	Quantification: Colorimetric estimation of DNA using the Diphenylamine (DPA) method.	
10	Quantification: Colorimetric estimation of RNA using the Orcinol method.	

Unit No.	Title of Unit & Contents	Hrs.
11	Chromatography: Separation of amino acids or cell pigments using Paper Chromatography or Thin Layer Chromatography (TLC).	

Learning Resources:

1. Basic Methods in Molecular Biology – Leonard G. Davis, Mark D. Dibner & James F. Battey – Elsevier
2. Cell Biology: A Laboratory Handbook – Julio E. Celis – Academic Press (Elsevier)
3. Current Protocols in Molecular Biology – Frederick M. Ausubel et al. – John Wiley & Sons
4. DNA and RNA: A Laboratory Manual – S. P. Ralph – Academic Press (Elsevier)
5. Gene Cloning and DNA Analysis: An Introduction – T.A. Brown – Wiley-Blackwell
6. Methods in Molecular Biology (Series) – John M. Walker (Editor) – Humana Press (Springer)
7. Molecular Biology Laboratory Manual – Michael R. Green & Joseph Sambrook – Cold Spring Harbor Laboratory Press
8. Molecular Cloning: A Laboratory Manual – Sambrook & Russell – Cold Spring Harbor Laboratory Press
9. Principles and Techniques of Biochemistry and Molecular Biology – Keith Wilson & John Walker – Cambridge University Press
10. Short Protocols in Molecular Biology – Ausubel, Brent, Kingston, Moore, Seidman, Smith & Struhl – John Wiley & Sons

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	-	2	-	-	-	3	-	2	-
CO2	2	3	1	-	2	1	-	1	3	-	3	1
CO3	1	3	3	-	2	1	-	-	2	-	3	1
CO4	2	3	2	-	2	1	-	-	2	-	2	1

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XV
Course Title : Endocrinology
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To understand the anatomical organization of the major endocrine glands in mammals.
LO2. To analyze the chemical nature of hormones and their synthesis, storage, and release.
LO3. To examine the molecular pathways of signal transduction triggered by different hormone classes.
LO4. Investigate the feedback mechanisms and hormonal interactions that maintain internal homeostasis.

Course Outcomes:

After the completion of this course students will be able to:

CO1. Differentiate between endocrine, paracrine, and autocrinesignaling mechanisms.
CO2. Explain the molecular basis of hormone-receptor interactions for both lipid-soluble and water-soluble hormones.
CO3. Describe the physiological consequences of hormonal hyper-secretion and hypo-secretion.
CO4. Relate endocrine dysfunction to common metabolic disorders like Diabetes Mellitus and Thyroiditis.

Unit No.	Title of Unit & Contents	Hrs.
I	**Introduction and the Hypothalamic-Pituitary Axis**	**12**
	• Principles of Endocrinology: Definition of hormones; classification (Amines, Peptides, Steroids); neurohormones and neurotransmitters. • Hypothalamus:Neurosecretory cells; hypothalamic releasing and inhibiting hormones. • Pituitary Gland (Hypothesis):Adenohypophysis and Neurohypophysis; hormones of the pars distalis and pars intermedia. • The Portal System: The hypothalamic-hypophyseal portal system and its role in coordinating endocrine responses.	
	Unit Outcomes: UO 1: Differentiate between endocrine, paracrine, and autocrine signaling mechanisms.	
II	**Peripheral Endocrine Glands**	**11**
	• Thyroid Gland: Biosynthesis of T_3 and T_4; Role of Iodine; Physiological actions of thyroid hormones. • Parathyroid & Calcium Homeostasis: Role of Parathyroid Hormone (PTH), Calcitonin, and Vitamin D in calcium and phosphate regulation. • Adrenal Gland: Adrenal Cortex (Glucocorticoids, Mineralocorticoids) and	

Unit No.	Title of Unit & Contents	Hrs.
	Adrenal Medulla (Epinephrine, Norepinephrine); the "Stress Response." • Pancreas: Endocrine islets of Langerhans; reciprocal regulation of Insulin and Glucagon.	
	Unit Outcomes: UO 1: Explain the molecular basis of hormone-receptor interactions for both lipid-soluble and water-soluble hormones.	
III	**Molecular Mechanisms of Hormone Action**	**11**
	• Hormone Receptors: Cell surface receptors (GPCRs, Enzyme-linked receptors) and Intracellular/Nuclear receptors. • Second Messenger Systems: Role of cAMP, IP_3/DAG and Ca2+in mediating hormone effects. • Steroid Hormone Action: Transcription factor activation and regulation of gene expression. • Termination of Signal: Mechanisms of receptor desensitization, internalization, and hormone degradation.	
	Unit Outcomes: UO 1: Describe the physiological consequences of hormonal hyper-secretion and hypo-secretion.	
IV	**Reproductive Endocrinology and Dysfunctions**	**11**
	• Gonadal Hormones: Regulation of the Male (Testis) and Female (Ovary) reproductive systems; the Menstrual Cycle. • Hormones of Pregnancy: Role of hCG, Progesterone, Estrogen, and Oxytocin in gestation and parturition. **Endocrine Pathologies:** • Thyroid: Graves' disease, Myxedema, Goiter. • Adrenal:Cushing's Syndrome, Addison's Disease. • Metabolic: Type 1 and Type 2 Diabetes Mellitus. • Growth Disorders: Gigantism, Acromegaly, and Dwarfism.	
	Unit Outcomes: UO 1: Relate endocrine dysfunction to common metabolic disorders like Diabetes Mellitus and Thyroiditis.	

Learning Resources

1. Textbook of Endocrinology – Williams (Melmed, Auchus, Goldfine, Koenig & Rosen) – Elsevier
2. Endocrinology – S. S. Hadley & J. E. Levine – Pearson
3. Greenspan's Basic & Clinical Endocrinology – David G. Gardner & Dolores Shoback – McGraw-Hill Education
4. Endocrinology: An Integrated Approach – Stephen Nussey & Saffron Whitehead – CRC Press (Taylor & Francis)
5. General and Comparative Endocrinology – P.J. Bentley – Cambridge University Press
6. Comparative Endocrinology – Chester A. Bisbee – Oxford University Press

7. Handbook of Physiology: Endocrinology – American Physiological Society (APS) – Wiley-Blackwell
8. Textbook of Medical Physiology (Endocrine section) – Guyton & Hall – Elsevier
9. Endocrine Physiology – Patricia E. Molina – McGraw-Hill Education (Lange Series)
10. Principles of Endocrinology and Hormone Action – J.C. Marshall & R.P. Millar – **Springer**

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	-	2	-	-	-	3	-	2	-
CO2	2	3	1	-	2	1	-	1	3	-	3	1
CO3	1	3	3	-	2	1	-	-	2	-	3	1
CO4	2	3	2	-	2	1	-	-	2	-	2	1

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XV
Lab Course : DSC-XV-Endocrinology
Course Code :
Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To identify the location and gross anatomy of endocrine glands in vertebrate models.
LO2. To examine the micro-anatomy (histology) of endocrine tissues to relate structure to secretory function.
LO3. To perform surgical demonstrations (where permissible) or witness simulations of endocrine gland removal.
LO4. To develop skills in biochemical assays for the detection and quantification of hormones or their metabolites.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Differentiate between the various endocrine glands based on their unique histological staining patterns.
CO2. Demonstrate the physiological effects of hormones through bioassays or case-study simulations.
CO3. Execute basic diagnostic tests used in clinical endocrinology, such as glucose tolerance tests.
CO4. Interpret experimental data related to hormonal feedback loops and target organ responses.

Unit No.	Title of Unit & Contents	Hrs.
I	**Practicals**	**30**
1	Dissection/Demonstration: Location and anatomical relationships of endocrine glands (Pituitary, Thyroid, Adrenal, Pancreas, and Gonads) in a vertebrate model (e.g., Rat or Fish).	
2	Vascularization Study: Observation of the blood supply to the hypothalamic-hypophyseal region in charts/models.	
3	Surgical Technique (Simulation/Video): Principles of Thyroidectomy and Adrenalectomy and their physiological consequences.	
4	Microscopic Study: Examination of permanent slides of the following:	
5	Pituitary: Distinction between Acidophils, Basophils, and Chromophobes.	
6	Thyroid & Parathyroid: Follicular cells, Colloid, and Chief cells.	
7	Adrenal: Layers of the Cortex (Glomerulosa, Fasciculata, Reticularis) and Medulla.	

Unit No.	Title of Unit & Contents	Hrs.
8	Pancreas: Islets of Langerhans vs. Acinar tissue.	
9	Gonads: Testis (Leydig cells, seminiferous tubules) and Ovary (Graafian follicles, Corpus luteum).	
10	Blood Glucose Regulation: Effect of Insulin and Adrenaline on blood glucose levels in a model organism.	
11	Metamorphosis Assay: Effect of Iodine or Thyroxine on the metamorphosis of tadpoles (demonstration).	
12	Pregnancy Testing: Principles of the Immunological Pregnancy Test (hCG detection).	
13	Feedback Simulation: Computer-based simulations of the HPA (Hypothalamic-Pituitary-Adrenal) axis response to stress.	
14	Urine Analysis: Detection of glucose and ketone bodies as indicators of endocrine dysfunction (Diabetes Mellitus).	
15	Case Study Analysis: Interpretation of clinical reports (TSH, T3, T4 levels) to diagnose thyroid disorders.	

Learning Resources:

1. An Introduction to Practical Biochemistry – David T. Plummer – McGraw-Hill Education
2. Basic and Clinical Endocrinology Laboratory Manual – Gardner & Shoback – McGraw-Hill Education
3. Biochemical Methods – S. Sadasivam & A. Manickam – New Age International Publishers
4. Endocrine Laboratory Methods – R. Edwards – Academic Press (Elsevier)
5. Laboratory Manual in Biochemistry – J. Jayaraman – New Age International Publishers
6. Medical Laboratory Technology (Vol. I & II) – Kanai L. Mukherjee – Tata McGraw-Hill
7. Practical Biochemistry – Keith Wilson & John Walker – Cambridge University Press
8. Practical Clinical Biochemistry: Methods and Interpretations – Harold Varley – CBS Publishers & Distributors
9. Practical Physiology – A.K. Jain – Avichal Publishing Company
10. Textbook of Practical Physiology – C.L. Ghai – Jaypee Brothers Medical Publishers

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	3	-	-	1	-	-	-	2	-	2	-
CO2	2	3	2	-	3	2	1	1	3	-	3	2
CO3	1	3	3	-	2	1	-	3	1	-	2	3
CO4	3	-	3	-	3	-	2	1	3	-	2	1

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

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Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSC-XVI
Course Title : NET/SET Paper –I
Course Code :
Credits : 02 **Max. Marks: 50** **Lecture: 30 Hrs.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSE-III
Course Title : Molecular Genetics
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To analyze the molecular structure of nucleic acids and the topology of the bacterial and eukaryotic genomes.

LO2. To understand the high-fidelity mechanisms of DNA replication, repair, and recombination.

LO3. To examine the regulatory networks that control gene expression at transcriptional and post-transcriptional levels.

LO4. To explore the principles of genetic engineering and the molecular tools used in genome analysis.

Course Outcomes:

After the completion of this course students will be able to:

CO1. Describe the biochemical properties of DNA and RNA and their interactions with proteins.

CO2. Identify the molecular basis of mutations and the cellular pathways dedicated to maintaining genomic integrity.

CO3. Explain how operons and eukaryotic enhancers coordinate complex biological responses.

CO4. Apply knowledge of molecular markers and recombinant DNA technology to solve genetic problems.

Unit No.	Title of Unit & Contents	Hrs.
I	**Genetic Material and Genome Organization**	**12**
	• Nucleic Acid Structure: DNA as the genetic material (Griffith, Avery-MacLeod-McCarty, Hershey-Chase experiments); Watson-Crick model; A, B and Z DNA forms. • Genome Organization: Supercoiling and Topoisomerases; Chromatin structure—Nucleosomes, Solenoid model, Euchromatin, and Heterochromatin. • Repetitive DNA: Transposons (jumping genes), SINEs, LINEs, and Satellite DNA. • Organelle Genetics: Structure and inheritance of Mitochondrial and Chloroplast DNA.	
	Unit Outcomes: UO 1. Describe the biochemical properties of DNA and RNA and their interactions with proteins.	
II	**DNA Dynamics—Replication and Repair**	**11**
	• Replication Mechanism: Semi-conservative replication; Replisome assembly;	

Unit No.	Title of Unit & Contents	Hrs.
	Leading and lagging strand synthesis; The "End-replication" problem and Telomerase. • Mutations: Molecular types (point mutations, frameshifts); Chemical and physical mutagens. • Repair Pathways:Photoreactivation, Nucleotide Excision Repair (NER), Base Excision Repair (BER), and Mismatch Repair (MMR). • Recombination: Holliday model of homologous recombination; Site-specific recombination	
	Unit Outcomes: UO 1. Identify the molecular basis of mutations and the cellular pathways dedicated to maintaining genomic integrity.	
III	**Regulation of Gene Expression**	**11**
	• Prokaryotic Regulation: Concept of the Operon; Positive and negative regulation in the *Lac* operon; Attenuation in the *Trp* operon. • Eukaryotic Transcription: Role of RNA Polymerases I, II, and III; Promoters, Enhancers, and Silencers. • Epigenetics: DNA methylation; Histone acetylation and deacetylation; Genomic imprinting. • Post-Transcriptional Control: Alternative splicing; RNA interference (miRNA and siRNA) and gene silencing.	
	Unit Outcomes: UO 1. Explain how operons and eukaryotic enhancers coordinate complex biological response	
IV	**Molecular Techniques and Genomics**	**11**
	• Recombinant DNA Technology: Restriction endonucleases; Cloning vectors (Plasmids, Cosmids, BACs/YACs). • Amplification and Sequencing: Principles of PCR (Polymerase Chain Reaction); Sanger sequencing vs. Next-Generation Sequencing (NGS). • Blotting Techniques: Southern, Northern, and Western blotting for DNA, RNA, and protein analysis. • Applications: Molecular markers (RFLP, RAPD, SNP); Brief introduction to CRISPR-Cas9 genome editing	
	Unit Outcomes: UO1. Apply knowledge of molecular markers and recombinant DNA technology to solve genetic problems.	

Learning Resources

1. Genes – Benjamin Lewin – Jones & Bartlett Learning
2. Genetics: A Conceptual Approach – Benjamin A. Pierce – W.H. Freeman (Macmillan Learning)
3. Molecular Biology – David P. Clark & Nanette J. Pazdernik – Academic Press (Elsevier)
4. Molecular Biology of the Gene – James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine & Richard Losick – Pearson

5. Molecular Genetics – David Freifelder – Jones & Bartlett Publishers
6. Molecular Genetics – Gunther S. Stent & Richard Calendar – W.H. Freeman
7. Molecular Genetics and Biotechnology – K. G. Ramawat – S. Chand Publishing
8. Molecular Genetics of Bacteria – Larry Snyder & Wendy Champness – ASM Press
9. Molecular Genetics: An Introductory Narrative – Geoffrey H. Darnell – Academic Press (Elsevier)
10. Principles of Gene Manipulation and Genomics – Sandy B. Primrose & Richard Twyman – Wiley-Blackwell

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-	1	-	-	-	3	-	1	-
CO2	3	-	2	-	3	1	-	1	3	-	2	1
CO3	3	-	1	-	2	-	1	-	3	-	2	-
CO4	2	3	3	1	3	2	2	3	2	1	3	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : DSE-III
Lab Course : DSE-III Molecular Genetics
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To master the techniques of genomic and plasmid DNA extraction from diverse biological sources.
LO2. To understand the principles and applications of the Polymerase Chain Reaction (PCR) in gene amplification.
LO3. To utilize restriction enzymes and gel electrophoresis for DNA mapping and analysis.
LO4. To apply statistical tools like Chi-square tests to analyze genetic inheritance and linkage data.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Isolate high-quality DNA and quantify its concentration and purity using spectrophotometry.
CO2. Perform Agarose Gel Electrophoresis to visualize and determine the size of DNA fragments.
CO3. Execute restriction digestion and interpret the resulting DNA banding patterns.
CO4. Solve complex genetic problems involving gene mapping and Mendelian inheritance using experimental data.

Unit No.	Title of Unit & Contents	Hrs.
I	**Practicals**	**30**
1	Genomic DNA Extraction: Isolation of DNA from plant tissue animal tissue (Liver).	
2	Bacterial DNA Isolation: Small-scale preparation (Miniprep) of Plasmid DNA from *E. coli*.	
3	Quantification: Estimation of DNA concentration using the Diphenylamine (DPA) colorimetric assay.	
4	Agarose Gel Electrophoresis (AGE): Preparation of agarose gel, loading of samples, and running the electrophoresis unit.	
5	Visualization: Use of Ethidium Bromide or safe stains and UV-Transillumination to visualize DNA bands.	
6	Restriction Digestion: Digestion of DNA with restriction endonucleases (e.g., *EcoRI*, *HindIII*) and analysis of fragments.	
7	DNA Laddering: Using DNA markers to estimate the base-pair size of unknown fragments.	
8	PCR Components: Understanding the role of Taq polymerase, dNTPs, primers, and Mg+ ions.	

Unit No.	Title of Unit & Contents	Hrs.
9	Thermal Cycling: Setting up a PCR reaction and understanding the steps of Denaturation, Annealing, and Extension.	
10	Primer Design (Theory/Dry Lab): Basic principles of designing primers for specific gene sequences.	
11	Validation: Checking PCR products on an agarose gel.	
12	Mendelian Genetics: Problems on Mono-hybrid and Di-hybrid crosses using *Drosophila* or Maize models.	
13	Statistical Analysis: Applying the Chi-square Test to verify the goodness of fit for observed genetic ratios.	
14	Gene Mapping: Three-point test cross problems to determine gene order and map distances.	
15	Pedigree Analysis: Interpreting human pedigree charts to determine modes of inheritance (Autosomal/Sex-linked).	

Learning Resources

1. Molecular Cloning: A Laboratory Manual – Sambrook, Fritsch & Maniatis – Cold Spring Harbor Laboratory Press
2. Basic Methods in Molecular Biology – Leonard G. Davis, Mark D. Dibner & James F. Battey – Elsevier
3. Current Protocols in Molecular Biology – Frederick M. Ausubel et al. – John Wiley & Sons
4. DNA and RNA: A Laboratory Manual – A. J. Carmichael – Academic Press (Elsevier)
5. Gene Cloning and DNA Analysis: An Introduction – T.A. Brown – Wiley-Blackwell
6. Laboratory Manual of Genetic Engineering – P.K. Gupta – Rastogi Publications
7. Methods in Molecular Biology (Series) – John M. Walker (Editor) – Humana Press (Springer Nature)
8. Molecular Biology Laboratory Manual – Michael R. Green & Joseph Sambrook – Cold Spring Harbor Laboratory Press
9. Principles and Techniques of Biochemistry and Molecular Biology – Keith Wilson & John Walker – Cambridge University Press
10. Short Protocols in Molecular Biology – Ausubel, Brent, Kingston, Moore, Seidman, Smith & Struhl – John Wiley & Sons

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Video

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	2	-	2	1	-	1	3	-	3	1
CO2	2	3	3	-	2	1	-	-	2	-	3	-
CO3	3	3	3	-	3	-	-	-	3	-	3	1
CO4	3	-	3	-	3	-	1	1	3	-	3	1

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VII

Course Type : RMC
Course Title : Research Methodology
Course Code :
Credits : 04 **Max. Marks: 100** **Lecture: 60 Hrs.**

Learning Objectives:

LO1. To understand the philosophy of scientific inquiry and the steps involved in identifying a research problem in animal sciences.
LO2. To develop proficiency in searching, citing, and critically analyzing scientific literature.
LO3. To learn the principles of experimental design and the application of biostatistics to animal research.
LO4. To examine the ethical considerations, biosafety protocols, and legal frameworks governing animal experimentation.

Course Outcomes:

After the completion of this course students will be able to:

CO1. Formulate a clear, testable research hypothesis and design a structured research proposal.
CO2. Select and apply appropriate statistical tests for different types of biological data.
CO3. Execute animal-based experiments in compliance with institutional and international ethical guidelines (IAEC/CPCSEA).
CO4. Communicate research findings effectively through technical reports, posters, and peer-reviewed journal formats.

Unit No.	Title of Unit & Contents	Hrs.
I	**Foundations of Research and Literature**	**12**
	• Introduction to Research: Objectives, types (Basic vs. Applied), and the "Scientific Method" in biology. • Research Problem Identification: Literature gap analysis; formulating the research question and hypothesis. • Literature Retrieval: Efficient use of databases (PubMed, Scopus, Google Scholar); role of Reference Management Systems (Zotero, Mendeley). • Technical Writing: Structure of a research paper (IMRaD); abstract writing; the importance of avoiding plagiarism..	
	Unit Outcomes: UO1. Formulate a clear, testable research hypothesis and design a structured research proposal.	
II	**Experimental Design in Animal Science**	**11**
	• Principles of Design: Replication, Randomization, and Local Control; the concept of "Power Analysis." • Standard Designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), and Factorial Designs in	

Unit No.	Title of Unit & Contents	Hrs.
	animal trials. • Variables and Sampling: Types of biological data; sampling techniques (Random, Stratified, Systematic); sample size determination (The "Power of 3" and Resource Equation). • Bias and Error: Minimizing experimental error and avoiding confounding variables in kennel/field trials	
	Unit Outcomes: UO 1. Select and apply appropriate statistical tests for different types of biological data.	
III	**Biostatistics and Data Analysis**	**11**
	• Descriptive Statistics: Measures of central tendency (Mean, Median, Mode) and dispersion (SD, SEM, Variance). • Inferential Statistics: Concept of P-values, Level of Significance, and Confidence Intervals. • Hypothesis Testing: Parametric tests (Student's t-test, ANOVA) and Non-parametric tests (Mann-Whitney, Kruskal-Wallis). • Correlation and Regression: Linear relationship between variables (e.g., feed intake vs. weight gain); introduction to statistical software (SPSS, R, or GraphPad Prism).	
	Unit Outcomes: UO1. Execute animal-based experiments in compliance with institutional and international ethical guidelines (IAEC/CPCSEA).	
IV	**Ethics, Biosafety, and Intellectual Property**	**11**
	• Animal Ethics: The 3 Rs (Replacement, Reduction, Refinement); role of the Institutional Animal Ethics Committee (IAEC). • Regulations: Guidelines for the care and use of laboratory animals (CPCSEA/CCSEA in India); anesthesia and euthanasia protocols. • Biosafety & Waste Management: Handling of hazardous biological materials and disposal of animal carcasses/sharps. • Intellectual Property Rights (IPR): Patents, Copyrights, and Trade Secrets; ethics in data reporting and the peer-review process.	
	Unit Outcomes: UO1. Communicate research findings effectively through technical reports, posters, and peer-reviewed journal formats.	

Learning Resources

1. Biostatistical Analysis – Jerrold H. Zar – Pearson Education
2. Biostatistics: A Foundation for Analysis in the Health Sciences – Wayne W. Daniel & Chad L. Cross – Wiley India / John Wiley & Sons
3. Design and Analysis of Experiments – Douglas C. Montgomery – Wiley
4. Experimental Designs – Douglas C. Montgomery – Wiley
5. Fundamentals of Biostatistics – Bernard Rosner – Cengage Learning
6. Handbook of Biological Statistics – John H. McDonald – Sparky House Publishing
7. Practical Statistics for Medical Research – Douglas G. Altman – Chapman & Hall / CRC Press

8. Research Methodology: A Step-by-Step Guide for Beginners – Ranjit Kumar – SAGE Publications
9. Research Methodology: Methods and Techniques – C.R. Kothari – New Age International Publishers
10. Research Methods in Biological Sciences – S.C. Rastogi – New Age International Publishers

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	1	2	1	3	1	2	1	1	1	3	2
CO2	1	-	3	-	3	-	2	1	-	-	3	1
CO3	-	2	-	2	1	3	1	2	-	2	2	3
CO4	1	-	1	1	1	1	3	2	-	1	2	3

Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.

Semester- VIII

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC-XVII
Course Title : Comparative Anatomy of Vertebrates
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To trace the evolutionary transition from Protochordates to specialized vertebrate groups.
LO2. To compare the anatomical structures of different vertebrate classes to understand adaptive radiation.
LO3. To analyze the physiological mechanisms of the integumentary, skeletal, and circulatory systems.
LO4. To evaluate the transition from aquatic to terrestrial life through respiratory and reproductive adaptations.

Course Outcomes:

After the completion of this course students will be able to:

CO1. Identify and classify vertebrates based on comparative anatomical features
CO2. Explain the functional evolution of the vertebrate heart, kidney, and brain
CO3. Describe the structural modifications of the skeletal system for different modes of locomotion.
CO4. Relate vertebrate physiological adaptations to their specific environmental challenges.

Unit No.	Title of Unit & Contents	Hrs.
I	**Origin of Chordates and Lower Vertebrates**	**12**
	• Chordate Characteristics: Fundamental characters and classification of Phylum Chordata. • Protochordates: Structure and affinities of Hemichordata, Urochordata (Retrogressive metamorphosis), and Cephalochordata. • Agnatha: General characters and classification of Cyclostomes (Lampreys and Hagfishes). • Pisces: Origin of jaws; Cartilaginous vs. Bony fishes; Accessory respiratory organs and swim bladders in fishes.	
	Unit Outcomes: UO 1. Identify and classify vertebrates based on comparative anatomical featur	
II	**Comparative Integumentary and Skeletal Systems**	**11**
	• The Integument: Structure of the skin; Comparative account of derivatives (scales, feathers, hair, and glands). • Skeletal System: Evolution of the axial skeleton (vertebral column) and appendicular skeleton (limbs and girdles). • Skull Evolution: Types of jaw suspension; Comparative account of the vertebrate skull (Anapsid, Diapsid, and Synapsid). • Digestive System: Comparative anatomy of the alimentary canal and	

Unit No.	Title of Unit & Contents	Hrs.
	associated glands in vertebrates.	
	Unit Outcomes: UO 1. Explain the functional evolution of the vertebrate heart, kidney, and brain.	
III	**Circulatory and Respiratory Systems**	**11**
	• Evolution of Heart: Transition from two-chambered to four-chambered hearts; Aortic arches and their transformations. • Blood Components: Comparative study of vertebrate blood cells and hemoglobin. • Respiratory System: Mechanisms of aquatic respiration (Gills) vs. terrestrial respiration (Lungs and Air sacs in birds). • Vocalizations: Structure and function of the syrinx in birds and larynx in mammals.	
	Unit Outcomes: UO 1. Describe the structural modifications of the skeletal system for different modes of locomotion.	
IV	**Excretion, Nervous Control, and Reproduction**	**11**
	• Excretory System: Evolution of the kidney (Pronephros, Mesonephros, and Metanephros) and mechanisms of osmoregulation. • Nervous System: Comparative anatomy of the vertebrate brain (Cerebrum, Cerebellum, and Medulla oblongata). • Sense Organs: Evolution of the vertebrate eye and ear (from lateral line systems to the mammalian ear). • Reproduction: Types of ovaries and testes; Modes of reproduction (Oviparity, Viviparity); Extra-embryonic membranes.	
	Unit Outcomes: UO 1. Relate vertebrate physiological adaptations to their specific environmental challenges	

Learning Resources

1. A Textbook of Vertebrate Zoology – R.L. Kotpal – Rastogi Publications
2. Chordate Zoology (Vertebrates) – P.S. Verma & V.K. Agarwal – S. Chand Publishing
3. Comparative Anatomy and Physiology of Vertebrates – E.L. Willey – McGraw-Hill Book Company
4. Comparative Anatomy of Vertebrates – G.C. Kent & R.K. Carr – McGraw-Hill Education
5. Comparative Anatomy of Vertebrates – Hyman, L.H. – McGraw-Hill Book Company
6. Comparative Anatomy of Vertebrates – S.S. Rao – Oxford & IBH Publishing
7. Integrated Principles of Zoology (Chordates Section) – Hickman, Roberts, Keen, Larson & Eisenhour – McGraw-Hill Education
8. Textbook of Vertebrate Zoology – Jordan & Verma – S. Chand Publishing
9. The Anatomy of the Chordates – H.E. Walter & W.J. Peterson – McGraw-Hill Book Company
10. Vertebrate Comparative Anatomy, Function and Evolution – Kenneth V. Kardong – McGraw-Hill Education

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	1	1	-	1	-	3	1	2	-
CO2	3	-	1	-	3	-	-	-	3	-	1	-
CO3	3	2	-	-	2	-	-	-	3	-	1	-
CO4	3	-	1	3	2	1	1	1	3	2	1	1

1.

2. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC-XVII
Lab. Course : Comparative Anatomy of Vertebrates
Course Code :
Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To identify and compare the skeletal frameworks of different vertebrate classes.
LO2. To examine the modifications of the integument and its derivatives across taxa.
LO3. To understand the evolutionary transition of the circulatory and respiratory systems through dissection or models.
LO4. To develop skills in anatomical drawing and the identification of homologous and analogous structures

Course Outcomes:

After completion of the course the students will be able to-

CO1. Distinguish between various types of vertebrate skulls and jaw suspensions.
CO2. Identify specific integumentary structures such as scales, feathers, and hairs under microscopy.
CO3. Compare the internal anatomy of fish, amphibians, reptiles, birds, and mammals using specimens or virtual tools.
CO4. Relate skeletal and organ modifications to the specific locomotory and environmental needs of the animal

Unit No.	Title of Unit & Contents	Hrs.
	Practicals	**30**
1	Protochordates: Balanoglossus, salpa, Doliolum, Herdmania, Amphioxus	
2	Pisces: Zygaena, pristis, ophiocephalus, Mastacembalus, Catla-catla,	
3	Exocoetus, Hippocampus, Syngnathus, Diodon, Notopterus	
4	Amphibia: Icthyophis, Rhacophorus, Rana, Necturus, Ambystoma.	
5	Reptilia Chameleon, phrynosoma, varanus, crocodilus, cobra	
6	Aves: Bubo, Duck, Vulture, Psittacula, Pigeon.	
7	Mammalia: Loris, Bat, Pangolin, Funambulus, Shrew	
8	Study of whole mount of Cycloid, Ctenoid and Placoid Cells	
9	Estimation of age of fishes through Scales	
10	Dissection and/ or its demonstration through models/video/CD etc Digestive system, Brain , Afferent and Efferent artery of fish	

Unit No.	Title of Unit & Contents	Hrs.
11	**Osteology:** Skull of fowl, Dog, /Rabbit.	
12	Vertebral column: Atlas vertebra, Axis vertebra, Trunk, lumbar, caudal. Pelvic Girdle, Pectoral girdle	
13	Visit to Zoo park	

Learning Resources

1. A Manual of Practical Zoology: Chordates – P.S. Verma – S. Chand Publishing
2. Practical Zoology: Vertebrates (Chordates) – K.N. Tandon – S. Chand Publishing
3. A Textbook of Practical Zoology: Chordates – S.C. Verma – S. Chand Publishing
4. Practical Zoology: Chordates – R.L. Kotpal – Rastogi Publications
5. Practical Zoology: Vertebrates – R.C. Kotpal – Rastogi Publications
6. Practical Zoology (Chordates) – B.D. Chaurasia – CBS Publishers & Distributors
7. Laboratory Manual of Vertebrate Zoology – P.D. Sharma – Rastogi Publications
8. Practical Manual of Zoology (Chordates) – V.K. Agarwal – S. Chand Publishing
9. Practical Zoology: Chordates – S.S. Lal – Rastogi Publications
10. Manual of Practical Zoology: Vertebrates – A. Jordan & E.L. Verma – S. Chand Publishing

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-	2	-	-	-	3	-	2	-
CO2	2	3	-	-	1	-	-	-	2	-	3	-
CO3	3	3	1	-	2	2	-	-	3	-	2	2
CO4	3	2	1	3	3	-	1	1	3	2	1	1

1.

2. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC-XVIII
Course Title : Molecular Biology
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To analyze the chemical and physical properties of nucleic acids and their organizational hierarchy.

LO2. To understand the molecular mechanisms of DNA replication and the maintenance of genomic integrity.

LO3. To examine the processes of transcription and translation and the regulation of the genetic code.

LO4. To explore the molecular techniques used to manipulate and analyze DNA and RNA

Course Outcomes:

After the completion of this course students will be able to:

CO1. Describe the structural differences between DNA and RNA and their functional implications.

CO2. Identify the enzymatic machinery involved in the central dogma of molecular biology.

CO3. Explain the mechanisms of gene regulation in both prokaryotic and eukaryotic organisms.

CO4. Relate molecular defects in DNA repair and expression to the development of genetic diseases.

Unit No.	Title of Unit & Contents	Hrs.
I	**Nucleic Acid Structure and Genome Organization**	12
	• DNA Structure: Watson and Crick Model; A, B, and Z DNA; DNA denaturation and renaturation (T_mand Cot curve). • RNA Structure: Types of RNA (mRNA, tRNA, rRNA) and their secondary structures (Cloverleaf model of tRNA). • Genome Organization: DNA packaging in prokaryotes; Eukaryotic nucleosome and chromatin higher-order structure. • Special Sequences: Introduction to Introns, Exons, Transposons, and repetitive DNA sequences.	
	Unit Outcomes: UO 1.Distinguish between various types of vertebrate skulls and jaw suspensions.	
II	**DNA Replication and Repair**	11
	• DNA Replication: Semi-conservative replication (Meselson-Stahl experiment); Bidirectional replication; Replication fork mechanics. • Enzymology: Role of DNA Polymerases, Helicase, Primase, Ligase, and Topoisomerases in *E. coli* and Eukaryotes. • Fidelity and Repair: Proofreading activity; Mechanisms of Mismatch Repair,	

Unit No.	Title of Unit & Contents	Hrs.
	Nucleotide Excision Repair, and Base Excision Repair. • End Replication: Structure of Telomeres and the role of Telomerase.	
	Unit Outcomes: UO 1. Identify the enzymatic machinery involved in the central dogma of molecular biology.	
III	**Transcription and RNA Processing**	**11**
	• Prokaryotic Transcription: RNA Polymerase; Promoter structure; Initiation, Elongation, and Termination (Rho-dependent and independent). • Eukaryotic Transcription: RNA Polymerases I, II, and III; General transcription factors; Enhancers and Silencers. • RNA Processing: 5' Capping; 3' Polyadenylation; Splicing mechanisms (Spliceosome machinery and Self-splicing). • RNA Interference: Overview of miRNA and siRNA mediated gene silencing	
	Unit Outcomes: UO 1. Identify specific integumentary structures such as scales, feathers, and hairs under microscopy.	
IV	**Translation and Regulation of Gene Expression**	**11**
	• Genetic Code: Properties of the genetic code; Wobble hypothesis; Suppressor mutations. • Translation Mechanism: Ribosome structure; Charging of tRNA; Phases of initiation, elongation, and termination in prokaryotes. • Prokaryotic Regulation: Operon concept; Induction and Repression in the *Lac* and *Trp* operons. • Eukaryotic Regulation: Overview of transcriptional control; DNA methylation and Histone acetylation	
	Unit Outcomes: UO 1. Compare the internal anatomy of fish, amphibians, reptiles, birds, and mammals using specimens or virtual tools.	

Learning Resources

1. Essential Cell Biology – Bruce Alberts, Karen Hopkin, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter – Garland Science
2. Genes XII – Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick – Jones & Bartlett Learning
3. Lewin's Genes – Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick – Jones & Bartlett Learning
4. Molecular Biology – David P. Clark, Nanette J. Pazdernik – Academic Press (Elsevier)
5. Molecular Biology – R. C. Dubey – S. Chand Publishing
6. Molecular Biology of the Cell – Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter – Garland Science (Taylor & Francis)
7. Molecular Biology of the Gene – James D. Watson, Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick – Pearson
8. Molecular Biology: Principles and Practice – P. K. Gupta – Rastogi Publications

9. Molecular Cell Biology – Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Kelsey Martin – W.H. Freeman (Macmillan Learning)
10. Principles of Gene Manipulation and Genomics – Sandy B. Primrose, Richard Twyman – Wiley-Blackwell

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-	1	-	-	-	3	-	1	-
CO2	3	-	1	-	2	-	1	-	3	-	2	-
CO3	3	-	2	-	3	-	1	-	3	-	2	1
CO4	3	-	2	-	3	1	2	2	3	-	1	3

1. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC-XVIII

Lab. Course Title: Molecular Biology

Course Code :

Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To master the extraction of genomic and plasmid DNA from various biological sources.

LO2. To understand the principles of spectrophotometry for the quantification and purity analysis of nucleic acids.

LO3. To develop technical proficiency in gel electrophoresis for the separation of DNA and proteins.

LO4. To execute fundamental molecular techniques like restriction digestion and bacterial transformation.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Isolate genomic DNA and analyze its quality using the A_{260}/A_{280} ratio.

CO2. Prepare and run Agarose Gel Electrophoresis to visualize DNA fragments and estimate their size.

CO3. Perform SDS-PAGE to separate proteins based on their molecular weight.

CO4. Interpret the results of restriction enzyme activity and DNA ligation experiments.

Unit No.	Title of Unit & Contents	Hrs.
	Practicals	**30**
1	Genomic DNA Isolation: Extraction of DNA from bacterial culture (*E. coli*) or plant tissue (Onion/Spinach).	
2	Plasmid DNA Isolation: Preparation of plasmid DNA using the Alkaline Lysis method (Miniprep).	
3	Quantification: Spectrophotometric estimation of DNA concentration and determination of purity.	
4	Storage: Principles of DNA preservation and the role of EDTA and low temperatures.	
5	Agarose Gel Electrophoresis (AGE): Preparation of agarose gel; role of Ethidium Bromide and Loading Dye.	
6	DNA Visualization: Visualization of DNA bands using a UV-Transilluminator.	
7	SDS-PAGE: Principles of Polyacrylamide Gel Electrophoresis; preparation of resolving and stacking gels for protein separation.	
8	Molecular Weight Estimation: Using DNA ladders and Protein markers to analyze sample migration.	
9	Restriction Digestion: Digestion of DNA with Type II restriction endonucleases (e.g., *EcoRI*, *BamHI*).	
10	Ligation: Principles of joining DNA fragments using T4 DNA Ligase.	

Unit No.	Title of Unit & Contents	Hrs.
11	PCR Demonstration: Understanding the thermal cycling profile—Denaturation, Annealing, and Extension.	
12	Elution: Techniques for recovering DNA fragments from agarose gels.	
13	Competent Cell Preparation: Preparation of chemically competent *E. coli* using the Calcium Chloride ($CaCl_2$) method.	
14	Transformation: Transformation of competent cells with plasmid DNA (Heat Shock method).	
16	Selection: Screening for transformants using antibiotic selection (e.g., Ampicillin resistance).	
17	Reporter Gene Expression: Observation of Blue-White screening or GFP (Green Fluorescent Protein) expression.	

Learning Resources

1. Basic Methods in Molecular Biology – Leonard G. Davis, Mark D. Dibner, James F. Battey – Elsevier (Academic Press)
2. Current Protocols in Molecular Biology – Frederick M. Ausubel et al. – John Wiley & Sons
3. DNA and RNA Profiling in Human Blood: Methods and Protocols – Peter Bugert (Editor) – Springer (Methods in Molecular Biology Series)
4. Gene Cloning and DNA Analysis: An Introduction – T. A. Brown – Wiley-Blackwell
5. Human Molecular Genetics: Laboratory Manual – Tom Strachan & Andrew Read – Garland Science
6. Laboratory Manual in Biochemistry, Immunology and Biotechnology – S. S. Jain & Sunita Jain – Vishal Publishing / Pragati Prakashan (Indian Edition)
7. Molecular Biology Techniques: A Classroom Laboratory Manual – D. V. S. S. Rama Rao – University Press / Scientific Publishers (India editions vary)
8. Molecular Cloning: A Laboratory Manual – Sambrook, Russell & David W. Russell – Cold Spring Harbor Laboratory Press
9. PCR Protocols: A Guide to Methods and Applications – Michael A. Innis, David H. Gelfand, John J. Sninsky, Thomas J. White – Academic Press (Elsevier)
10. PCR: The Basics (From Background to Bench) – McPherson & Møller – Springer

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	-	2	1	-	1	3	-	3	1
CO2	2	3	3	-	2	1	-	-	2	-	3	-
CO3	2	3	3	-	2	1	-	-	3	-	3	-
CO4	3	3	2	-	3	-	-	1	3	-	3	1

1. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC- XIX
Course Title : Biochemistry
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To describe the chemical structures and biological roles of carbohydrates, lipids, proteins, and nucleic acids.
LO2. To understand the kinetics and mechanisms of enzyme action and inhibition.
LO3. To analyze the bioenergetics and regulatory steps of major metabolic pathways.
LO4. To examine the integration of metabolic processes in maintaining cellular homeostasis.

Course Outcomes:

After the completion of this course students will be able to:

CO1. Identify and draw the structural configurations of essential biomolecules.
CO2. Calculate enzyme kinetic parameters (Vmax}andK_M) using Michaelis-Menten equations.
CO3. Trace the flow of carbon and energy through glycolysis, the TCA cycle, and oxidative phosphorylation.
CO4. Correlate biochemical deficiencies with specific metabolic disorders and clinical manifestations.

Unit No.	Title of Unit & Contents	Hrs.
I	**Structure and Function of Biomolecules**	**12**
	• Carbohydrates: Classification, structure, and biological importance of monosaccharides, disaccharides, and polysaccharides (Starch, Glycogen, Cellulose). • Lipids: Classification and properties of fatty acids, triglycerides, phospholipids, and cholesterol; structure of biological membranes. • Proteins: Amino acids as building blocks; four levels of protein structure (Primary, Secondary, Tertiary, and Quaternary); Ramachandran plot. • Nucleic Acids: Nucleotides; structural hierarchy of DNA (Double helix) and RNA types (mRNA, tRNA, rRNA).	
	Unit Outcomes: UO1. Identify and draw the structural configurations of essential biomolecules	
II	**Enzymology and Bioenergetics**	**11**
	• Enzymes: Nomenclature and classification; Mechanism of action (Lock and Key, Induced Fit); Activation energy. • Enzyme Kinetics:Michaelis-Menten equation; Lineweaver-Burk plot; Factors affecting enzyme activity (pH, Temperature, Concentration). • Enzyme Inhibition: Competitive, Non-competitive, and Uncompetitive inhibition.	

Unit No.	Title of Unit & Contents	Hrs.
	• Bioenergetics: Laws of thermodynamics; High-energy compounds (ATP Phosphocreatine); Redox potentials and free energy changes (Delta G).	
	Unit Outcomes: UO1. Calculate enzyme kinetic parameters (Vmax}andK_M) using Michaelis-Menten equations.	
III	**Carbohydrate and Lipid Metabolism**	**11**
	• Glycolysis & TCA Cycle: Detailed steps, energetic yield, and regulatory enzymes of the Embden-Meyerhof pathway and Citric Acid Cycle. • Gluconeogenesis & Glycogen Metabolism: Pathways for glucose synthesis and glycogen storage/breakdown. • Pentose Phosphate Pathway (PPP): Significance in generating NADPH and ribose-5-phosphate. • Lipid Metabolism:β -oxidation of saturated fatty acids; Biosynthesis of fatty acids; Ketone body formation and utilization.	
	Unit Outcomes: UO1. Trace the flow of carbon and energy through glycolysis, the TCA cycle, and oxidative phosphorylation.	
IV	**Nitrogen Metabolism and Oxidative Phosphorylation**	**11**
	• Amino Acid Metabolism: Transamination, Deamination, and the Urea Cycle. • Nucleotide Metabolism: Overview of De novo and Salvage pathways for purines and pyrimidines. • Electron Transport Chain (ETC): Organization of respiratory complexes (I–IV) in the inner mitochondrial membrane. • Oxidative Phosphorylation:Chemiosmotic hypothesis; Structure and function of ATP synthase (Fo F1 complex).	
	Unit Outcomes: UO1. Correlate biochemical deficiencies with specific metabolic disorders and clinical manifestations.	

Learning Resources

1. Biochemistry – A. L. Lehninger – CBS Publishers (Indian Edition)
2. Biochemistry – Donald Voet & Judith G. Voet – John Wiley & Sons
3. Biochemistry – Garrett & Grisham – Cengage Learning
4. Biochemistry – J. L. Jain, Sunjay Jain, Nitin Jain – S. Chand Publishing
5. Biochemistry – Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., Lubert Stryer – W.H. Freeman
6. Biochemistry – U. Satyanarayana & U. Chakrapani – Elsevier
7. Harper's Illustrated Biochemistry – Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil – McGraw-Hill Education
8. Lehninger Principles of Biochemistry – David L. Nelson & Michael M. Cox – W.H. Freeman (Macmillan Learning)
9. Outlines of Biochemistry – Erich E. Stumpf & Bernard L. Horecker – John Wiley & Sons

10. Textbook of Biochemistry – A. V. S. S. Rama Rao – UBS Publishers / New Age International

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-	1	-	1	-	3	-	1	-
CO2	3	2	3	-	3	-	-	1	3	-	3	1
CO3	3	-	2	-	2	-	1	-	3	-	1	-
CO4	3	-	2	-	3	1	2	3	3	-	2	3

1. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC-XIX

Lab. Course Title: Biochemistry

Course Code :

Credits : 01 **Max. Marks: 50** **Lecture: 30 Hrs.**

Learning Objectives:

LO1. To master the preparation of standard solutions, buffers, and the use of pH metry in biological systems.

LO2. To develop skills in the qualitative identification of carbohydrates, lipids, and proteins.

LO3. To understand the principles of colorimetry and spectrophotometry for the quantitative estimation of biomolecules.

LO4. To execute experiments to study enzyme activity and the factors affecting biological catalysis.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Calculate molarity and normality to prepare precise reagents for biochemical assays.

CO2. Identify unknown biological samples through a systematic series of chemical tests.

CO3. Determine the concentration of glucose, cholesterol, or proteins using standard calibration curves.

CO4. Interpret the kinetic behavior of enzymes through graphical analysis.

Unit No.	Title of Unit & Contents	Hrs.
	Practicals	**30**
1	Safety & Measurements: Laboratory safety protocols and the use of analytical balances and micropipettes.	
2	Buffer Preparation: Preparation of Phosphate and Citrate buffers; verification of pH using a pH meter.	
3	Titration: Neutralization titration of a strong acid vs. a strong base.	
4	Amino Acid Titration: Determination of the pK_a and isoelectric point (pI) of Glycine.	
5	Glucose Estimation: Quantification of blood or sample glucose using the Anthrone or DNS method.	
6	Protein Estimation: Determination of total protein concentration using the Lowry's or Biuret method.	
7	Cholesterol Estimation: Estimation of total lipids/cholesterol using the Zak's or Liebermann-Burchard method.	
8	Enzyme Assay: Study of the activity of Salivary Amylase on starch.	
9	Factors Affecting Enzymes: Effect of varying Temperature and pH on the rate of enzymatic reactions.	
10	Chromatography: Separation of amino acids or sugars using Ascending Paper Chromatography.	

Unit No.	Title of Unit & Contents	Hrs.
11	Vitamins: Qualitative detection of Vitamin C (Ascorbic Acid) through titration.	

Learning Resources

1. An Introduction to Practical Biochemistry – David T. Plummer – McGraw-Hill / Tata McGraw-Hill
2. Biochemical Methods: A Manual for Students – S. Sadasivam & A. Manickam – New Age International Publishers
3. Biochemistry Laboratory Manual – R. K. Sharma & D. S. Rajput – Pragati Prakashan
4. Biochemistry Practical Manual – S. K. Sawhney & Randhir Singh – Narosa Publishing House
5. Clinical Biochemistry: Methods and Interpretation – Dinesh Puri – CBS Publishers & Distributors
6. Laboratory Manual in Biochemistry – Jayaraman – New Age International Publishers
7. Practical Biochemistry – Harold Varley – CBS Publishers & Distributors
8. Practical Biochemistry for Medical Students – Ranjna Chawla – Jaypee Brothers Medical Publishers
9. Practical Clinical Biochemistry: Methods and Interpretations – Harold Varley, Alan H. Gowenlock, Maurice Bell – Heinemann Medical / CBS Publishers
10. Textbook of Practical Biochemistry – C. J. Chatterjee – Jaypee Brothers Medical Publishers

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	3	3	-	2	1	-	-	2	-	3	-
CO2	3	3	1	-	3	1	-	-	3	-	2	1
CO3	2	3	3	-	2	-	1	-	2	-	3	1
CO4	3	2	3	-	3	-	1	1	3	-	3	1

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Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSC
Course Title : SET/NET Paper i
Course Code :
Credits : 02 **Max. Marks: 50** **Lecture: 45 Hrs.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSE-IV
Course Title : Advance Developmental Biology
Course Code :
Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To analyze the molecular signaling pathways that govern cell fate determination and pattern formation.
LO2. To understand the genetic basis of morphogenesis and organogenesis in major model organisms.
LO3. To examine the role of differential gene expression and epigenetic regulation in embryonic development.
LO4. To explore the modern applications of stem cell biology, cloning, and regenerative medicine

Course Outcomes:

After the completion of this course students will be able to:

CO1. Explain how morphogen gradients establish body axes and segment polarity during early development.
CO2. Compare and contrast developmental strategies across taxa (Drosophila, Xenopus, and Mammals).
CO3. Critically evaluate the molecular mechanisms underlying limb development and neural induction.
CO4. Discuss the ethical and scientific implications of organoid technology and stem cell therapy.

Unit No.	Title of Unit & Contents	Hrs.
I	**Principles of Commitment & Early Patterning**	**12**
	• (Cellular Potency: Concepts of Totipotency, Pluripotency, and Unipotency; Specification (Autonomous vs. Conditional) and Determination. • Maternal Determinants: Role of localized mRNAs and proteins in early cleavage; Cytoplasmic determinants. • Axis Specification in Drosophila: Maternal effect genes (*Bicoid*, *Nanos*); the cascade of Zygotic genes (Gap, Pair-rule, and Segment polarity). • The Hox Code: Homeotic genes and the molecular conservation of positional identity across species	
	Unit Outcomes: UO1. Explain how morphogen gradients establish body axes and segment polarity during early development.	
II	**Morphogenesis and Molecular Signaling**	**11**

Unit No.	Title of Unit & Contents	Hrs.
	• Cell Adhesion & Sorting: Molecular basis of cell-cell interaction;Cadherins and the Epithelial-Mesenchymal Transition (EMT). • Core Signaling Pathways: Paracrine factors and their receptors (Hedgehog, Wnt, TGF-β, and FGF signaling). • The Organizer Concept: Molecular nature of the Spemann-Mangold Organizer in *Xenopus*; Neural induction and BMP inhibitors (Noggin, Chordin). • Gastrulation Mechanics: Comparative molecular mechanics of cell movements: Invagination, Involution, Epiboly, and Delamination	
	Unit Outcomes: UO1. Compare and contrast developmental strategies across taxa (Drosophila, Xenopus, and Mammals).	
III	**Organogenesis and Functional Patterning**	**11**
	• Neurogenesis: Primary and secondary neurulation; Molecular markers of dorso-ventral patterning in the Central Nervous System. • Vertebrate Limb Development: The Apical Ectodermal Ridge (AER) and Zone of Polarizing Activity (ZPA); Role of Shh and FGF in limb patterning. • Heart and Kidney Development: Induction and specification of mesodermal derivatives; molecular regulation of cardiogenesis. • Eye Development: Lens induction, the concept of "competence," and reciprocal induction.	
	Unit Outcomes: UO1. Critically evaluate the molecular mechanisms underlying limb development and neural induction.	
IV	**Stem Cells, Regeneration, and Evo-Devo**	**11**
	• Stem Cell Niches: Molecular regulation of hematopoietic and embryonic stem cells; induced Pluripotent Stem Cells (iPSCs). • Regenerative Biology:Epimorphic (salamander limb), Morphallactic (Hydra), and Compensatory (liver) regeneration. • Evolution and Development (Evo-Devo): Genetic tinkering; how changes in gene regulation lead to the evolution of novel body plans. • Medical Embryology:Teratogenesis; environmental impacts on development; advances in In-vitro fertilization (IVF) and prenatal screening.	
	Unit Outcomes: UO1. Discuss the ethical and scientific implications of organoid technology and stem cell therapy.	

Learning Resources

1. Developmental Biology – Scott F. Gilbert – Sinauer Associates (Oxford University Press)
2. Principles of Development – Lewis Wolpert, Cheryll Tickle, Alfonso Martinez Arias – Oxford University Press
3. Developmental Biology – Michael J. F. Barresi & Scott F. Gilbert – Sinauer Associates / Oxford University Press
4. Molecular Biology of the Cell (Development & Differentiation chapters) – Bruce Alberts et al. – Garland Science (Taylor & Francis)
5. From Egg to Embryo: Regional Specification in Early Development – Claudio D. Stern – Cambridge University Press
6. Pattern Formation in Development – L. Wolpert – Oxford University Press
7. Mechanisms of Development – Jonathan M. W. Slack – Oxford University Press
8. Essential Developmental Biology – Jonathan M. W. Slack – Wiley-Blackwell
9. The Developing Genome: An Introduction to Behavioral Epigenetics – David S. Moore – Oxford University Press
10. Human Embryology and Developmental Biology – Bruce M. Carlson – Elsevier (Churchill Livingstone)

Internal Examination Pattern :

CAT – I : Surprise Test

CAT – II Seminar with Vide

Mapping of POs, PSOs and COs:

COs/POs & PSOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	-	1	-	2	-	1	-	3	-	1	-
CO2	3	1	-	-	2	-	-	-	3	-	2	-
CO3	3	-	2	-	3	-	1	-	3	-	2	1
CO4	2	-	1	-	3	3	2	3	2	-	1	3

1. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

Shiv Chhatrapati Shikshan Sanstha's

Rajarshi Shahu Mahavidyalaya, Latur

Empowered Autonomous Institution

Faculty of Science and Technology

Department of Zoology

UG IV Sem VIII

Course Type : DSE-IV

Course Title : Lab. Course Advance Developmental Biology

Course Code :

Credits : 03 **Max. Marks: 75** **Lecture: 45 Hrs.**

Learning Objectives:

LO1. To identify the developmental stages of representative vertebrate and invertebrate model organisms.

LO2. To understand the structural changes during gametogenesis and fertilization through microscopic study.

LO3. To perform practical techniques for the recovery and observation of live embryos.

LO4. To examine the physiological processes of regeneration and metamorphosis in the laboratory.

Course Outcomes:

After completion of the course the students will be able to-

CO1. Distinguish between different cleavage patterns and gastrulation stages in amphibians and birds.

CO2. Prepare and observe live chick embryos to identify key milestones like heart formation and neurulation.

CO3. Analyze the role of specific hormones and environmental factors in animal metamorphosis.

CO4. Document and illustrate the regenerative capacity of simple multicellular organisms.

Unit No.	Title of Unit & Contents	Hrs.
	Practicals	**30**
1	Microscopic Study: Observation of permanent slides of sections through the Testis and Ovary (Rat/Rabbit) to identify stages of gametogenesis.	
2	Sperm Morphology: Preparation of a temporary mount of mammalian sperm (from a rat or bull) and observation of motility.	
3	Egg Types: Study of various egg types based on yolk distribution (Isolecithal, Mesolecithal, Telolecithal, Centrolecithal).	
4	Frog Development: Observation of cleavage stages (2-cell, 4-cell, 8-cell), Blastula, Gastrula, and Neurula using permanent slides or preserved specimens.	
5	Chick Embryo Study: Recovery of live embryos from incubated eggs and identification of the 24h, 48h, and 72h stages.	
6	Somite Counting: Determination of the developmental stage of a chick embryo by counting somite pairs.	
7	Chick Whole Mounts: Identification of the Primitive Streak, Heart, Brain vesicles (Prosencephalon, Mesencephalon, Rhombencephalon), and Limb Buds.	
8	Extra-embryonic Membranes: Study of the Amnion, Chorion, Allantois, and Yolk Sac in chick embryos using models or charts.	

Unit No.	Title of Unit & Contents	Hrs.
9	Placental Diversity: Study of different types of placenta (Epitheliochorial, Syndesmochorial, Endotheliochorial, Hemochorial) using slides or charts.	
10	Regeneration in Planaria/Hydra: Study of regenerative capacity by observing fragments under a microscope.	
11	Amphibian Metamorphosis: Observation of the transition from tadpole to adult frog; study of the effects of Iodine/Thyroxine (via simulation or demonstration).	
12	Teratogenesis: Study of the effect of common chemicals (e.g., Ethanol) on the development of zebrafish or chick embryos (Simulation).	

Unit No.	Title of Unit & Contents	Hrs.
I	**Practical**	**12**
	Microscopic Study: Observation of permanent slides of sections through the Testis and Ovary (Rat/Rabbit) to identify stages of gametogenesis. Sperm Morphology: Preparation of a temporary mount of mammalian sperm (from a rat or bull) and observation of motility. Egg Types: Study of various egg types based on yolk distribution (Isolecithal, Mesolecithal, Telolecithal, Centrolecithal). Frog Development: Observation of cleavage stages (2-cell, 4-cell, 8-cell), Blastula, Gastrula, and Neurula using permanent slides or preserved specimens. Chick Embryo Study: Recovery of live embryos from incubated eggs and identification of the 24h, 48h, and 72h stages. Somite Counting: Determination of the developmental stage of a chick embryo by counting somite pairs. Chick Whole Mounts: Identification of the Primitive Streak, Heart, Brain vesicles (Prosencephalon, Mesencephalon, Rhombencephalon), and Limb Buds. Extra-embryonic Membranes: Study of the Amnion, Chorion, Allantois, and Yolk Sac in chick embryos using models or charts. Placental Diversity: Study of different types of placenta (Epitheliochorial, Syndesmochorial, Endotheliochorial, Hemochorial) using slides or charts. Regeneration in Planaria/Hydra: Study of regenerative capacity by observing fragments under a microscope. Amphibian Metamorphosis: Observation of the transition from tadpole to adult frog; study of the effects of Iodine/Thyroxine (via simulation or demonstration). Teratogenesis: Study of the effect of common chemicals (e.g., Ethanol) on the development of zebrafish or chick embryos (Simulation).	

Learning Resources

1. Manipulating the Mouse Embryo: A Laboratory Manual – Richard Behringer, Marina Gertsenstein, Kristina Vintersten Nagy, Andras Nagy – Cold Spring Harbor Laboratory Press
2. Zebrafish: A Practical Approach – Nüsslein-Volhard & Dahm (Editors) – Oxford University Press
3. Drosophila: A Laboratory Handbook – Michael Ashburner – Cold Spring Harbor Laboratory Press
4. Drosophila: Methods and Protocols – Christian Dahmann (Editor) – Humana Press (Springer), Methods in Molecular Biology Series
5. Mouse Development: Patterning, Morphogenesis and Organogenesis (Lab reference) – Kathy J. Niakan – Academic Press / Elsevier
6. Developmental Biology Protocols, Volume I & II – Richard S. Tuan & Cecilia W. Lo (Editors) – Humana Press (Springer)
7. In Situ Hybridization Protocols – Ian A. Darby (Editor) – Humana Press (Springer)
8. Immunocytochemical Methods and Protocols – Lorette C. Javois (Editor) – Humana Press (Springer)
9. Cell Biology: A Laboratory Handbook (3 Volumes) – Julio E. Celis (Editor) – Academic Press (Elsevier)
10. Essential Developmental Biology: A Practical Approach – Jonathan M. W. Slack – Wiley-Blackwell

Internal Examination Pattern :

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CO2	2	3	1	-	2	2	-	-	3	-	3	1
CO3	3	1	2	2	3	-	1	1	3	1	2	-
CO4	3	2	1	-	2	-	3	1	3	-	2	2

1. **Scale : 3 = High, 2 = Moderate, 1 = Low, 0 = No correlation.**

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Extra Credit Activities

Sr. No.	Course Title	Credits	Hours T/P
1	MOOCs	Min. of 02 credits	Min. of 30 Hrs.
2	Certificate Courses	Min. of 02 credits	Min. of 30 Hrs.
3	IIT Spoken English Courses	Min. of 02 credits	Min. of 30 Hrs.

Guidelines:

Extra -academic activities

1. All extra credits claimed under this heading will require sufficient academic input/ contribution from the students concerned.
2. Maximum 04 extra credits in each academic year will be allotted.
3. These extra academic activity credits will not be considered for calculation of SGPA/CGPA but will be indicated on the grade card.

Additional Credits for Online Courses:

1. Courses only from SWAYAM and NPTEL platform are eligible for claiming credits.
2. Students should get the consent from the concerned subject Teacher/Mentor/Vice Principal and Principal prior to starting of the course.
3. Students who complete such online courses for additional credits will be examined/verified by the concerned mentor/internal faculty member before awarding credits.
4. Credit allotted to the course by SWAYAM and NPTEL platform will be considered as it is.

Additional Credits for Other Academic Activities:

1. One credit for presentation and publication of paper in International/National/State level seminars/workshops.
2. One credit for measurable research work undertaken and field trips amounting to 30 hours of recorded work.
3. One credit for creating models in sponsored exhibitions/other exhibits, which are approved by the concerned department.
4. One credit for any voluntary social service/Nation building exercise which is in collaboration with the outreach center, equivalent to 30 hours
5. All these credits must be approved by the College Committee.

Additional Credits for Certificate Courses:

1. Students can get additional credits (number of credits will depend on the course duration) from certificate courses offered by the college.
2. The student must successfully complete the course. These credits must be approved by the Course Coordinators.
3. Students who undertake summer projects/ internships/ training in institutions of repute through a national selection process, will get 2 credits for each such activity. This must be done under the supervision of the concerned faculty/mentor.

Note:

1. The respective documents should be submitted within 10 days after completion of Semester End Examination.
2. No credits can be granted for organizing or for serving as office bearers/ volunteers for Inter-Class / Associations / Sports / Social Service activities.
3. The office bearers and volunteers may be given a letter of appreciation by the respective staff coordinators. Besides, no credits can be claimed for any services/activities conducted or attended within the college.
4. All claims for the credits by the students should be made and approved by the mentor in the same academic year of completing the activity.
5. Any grievances of denial/rejection of credits should be addressed to Additional Credits Coordinator in the same academic year.
6. Students having a shortage of additional credits at the end of the third year can meet the Additional Credits Coordinator, who will provide the right advice on the activities that can help them earn credits required for graduation.

Theory:
40% Continuous Assessment Tests (CATs) and 60% Semester End Examination (SEE)
Practical:
50% Continuous Assessment Tests (CATs) and 50% Semester End Examination (SEE)

Course	Marks	CAT & Mid Term Theory				CAT Practical		Best Scored CAT & Mid Term	SEE	Total
1	2	3				4		5	6	5 + 6
		Att.	CAT I	Mid Term	CAT II	Att.	CAT			
DSC/DSE/ GE/OE/Minor	100	10	10	20	10	-	-	40	60	100
DSC	75	05	10	15	10	-	-	30	45	75
Lab Course/AIPC/ OJT/FP/SEC(Science & Technology)	50	-	-	-	-	05	20	-	25	50
VSC/SEC/ AEC/VEC/CC	50	05	05	10	05	-	-	20	30	50

Note:

1. All Internal Exams are compulsory
2. Out of 02 CATs best score will be considered
3. Mid Term Exam will be conducted by the Exam Section
4. Mid Term Exam is of Objective nature (MCQ)
5. Semester End Exam is of descriptive in nature (Long & Short Answer)
6. CAT Practical (20 Marks): Lab Journal (Record Book) 10 Marks, Overall Performance 10 Marks