

**Syllabus for four year Undergraduate Course
In Universities of Bihar**

**Bachelor of Science
Zoology**



**Submitted by
Subject Expert Committee**

21.09.2023

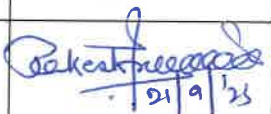
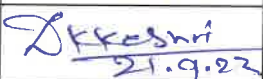
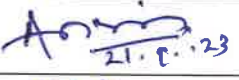
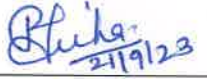



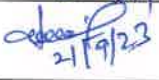
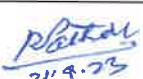



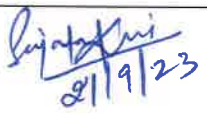
To,
The Principal Secretary to Governor
Raj Bhawan, Patna.

Subject: Submission of Uniform Syllabus for 4 year Undergraduate Courses of Bachelor of Science under CBCS in the Subject- Zoology.

Sir,

With reference to letter No. BSU (UGC) -02/2023-1457/GS (I) dated 14.09.2023, a meeting of the panel of experts in Zoology was held on 20-09-2023 & 21-09-2023 to finalize the syllabus of Zoology. We are submitting the syllabus of the same.

Your Sincerely,

Sl. No.	Name and Designation	Signature
1	Prof. (Dr) Rakesh Prasad (Retd.) Department of Zoology, Jai Prakash university, Chapra.	 21/9/23
2	Prof. (Dr) Dilip Kumar Keshri Department of Zoology, Magadh University, Bodhgaya	 21.9.23
3	Prof. (Dr) Ajit Kumar Sinha Department of Zoology, Veer Kunwar Singh University, Ara	 21.9.23
4	Prof. (Dr) Preety Sinha Department of Zoology, Patliputra University, Patna	 21/9/23
5	Prof. (Dr) Parimal Kumar Khan Department of Zoology, Patna University, Patna.	 21.9.2023
6	Prof. (Dr) Narendra Srivastava Department of Zoology, B N Mandal University, Madhepura	 21/9/23
7	Prof. (Dr) Rana Vikram Singh Department of Zoology, Jai Prakash university, Chapra	 21/9/23
8	Dr. Gyanendra Bahadur Chand Department of Zoology, Patna University, Patna	 21/9/23
9	Sri Ravindra Nath Pathak Department of Zoology, D A V College, J P university, Chapra.	 21.9.23
10	Dr. Dhiraj Kumar Department of Zoology, R S College, BRA Bihar University, Muzaffarpur	 21/09/2023
11	Dr. Shushovan Banik Department of Zoology, L N M U, Darbhanga	 21/9/23
12	Dr. Mayank Madhukar Department of Zoology, R D & D J College, Munger University, Munger	 21.09.23
13	Dr. Sujata Kumari Department of Zoology, M M College, Patna University, Patna.	 21/9/23

**Syllabus for 4 Year Undergraduate Course in Universities of Bihar.
Bachelor of Science, Zoology.**

Programme Outcomes: At the completion of the programme, students will attain:

- PO1. Disciplinary knowledge:** Acquire comprehensive knowledge of major concepts, theoretical principles and experimental findings in Zoology, and some of the applied areas of study such as wildlife conservation and management; environmental science; various techniques, instruments, used for analysis of animal forms and functions.
- PO2. Effective communication and Critical thinking:** Convey the intricate zoological information effectively and efficiently, analyze and solve the problems related to animal sciences without reckoning on assumptions and guesses.
- PO3. Research & Leadership quality:** Recognize and mobilize relevant resources essential for a research project, and manage the project in a responsible way by following ethical scientific conduct and bio-safety protocols.
- PO4. Digitally literate and Ethical awareness:** Use computers for computation and data analysis with appropriate software for biostatistics, and employ search tools to locate and retrieve relevant information, recognize and avoid unethical behaviour such as fabrication, or misrepresentation of data or commit plagiarism.
- PO5. Environment and Sustainability:** Understand the environmental and sustainability issues, acquire self-paced and self-directed learning aimed at personal and social development.

Programme Specific Outcomes: At the completion of the programme, students will attain:

- PSO1.** Students should be able to identify, classify and differentiate diverse chordates and non chordates based on their morphological, anatomical and systemic organization.
- PSO2.** They will also be able to describe economic, ecological and medical significance of various animals in human life. This will create a curiosity and awareness among them to explore the animal diversity and explore related career options. The procedural knowledge about identifying and classifying animals will provide students professional advantages in teaching, research and taxonomist jobs in various government organizations.
- PSO3.** Acquired practical skills in molecular biology; biotechnology; microscopy; enzymology and analytical biochemistry and genetics will provide an extra edge to our students, who wish to undertake higher studies.
- PSO4.** In-depth knowledge and understanding about comparative anatomy and developmental biology of various biological systems; and learning about the organisation, functions, strength

and weaknesses of various systems will let students critically analyse the way evolution has shaped these traits in the human body.

PSO5. Acquired skills in diagnostic testings, haematology, histopathology, staining procedures etc. used in clinical and research laboratories will provide students opportunity to work in diagnostic or research laboratory. Deep understanding of different physiological systems and methods available to measure vital physiological parameters and to comprehend the mechanism behind occurrence of different lifethreatening disease *via* laboratory examination, assessment of basic physiological functions by interpreting physiological charts will help to find their career options.

(A) Major Core Courses

Sl. No.	Semester	Type of Course	Name of Course	Credits	Marks
1.	I	MJC-1 (T)	Diversity of Non-Chordates (T)	4	100
		MJC-1 (P)	Diversity of Non-Chordates (P)	2	100
2.	II	MJC-2 (T)	Diversity of Chordates (T)	4	100
		MJC-2 (P)	Diversity of Chordates (P)	2	100
3.	III	MJC-3 (T)	Comparative Anatomy (T)	3	100
		MJC-3 (P)	Comparative Anatomy (P)	2	100
		MJC-4 (T)	Physiology (T)	3	100
		MJC-4 (P)	Physiology (P)	1	100
4.	IV	MJC-5 (T)	Cell Biology (T)	3	100
		MJC-5 (P)	Cell Biology (P)	2	100
		MJC-6 (T)	Endocrinology (T)	3	100
		MJC-6 (P)	Endocrinology (P)	2	100
		MJC-7 (T)	Ecology (T)	3	100
		MJC-7 (P)	Ecology (P)	2	100
5.	V	MJC-8 (T)	Biochemistry (T)	3	100
		MJC-8 (P)	Biochemistry (P)	2	100
		MJC-9 (T)	Genetics (T)	3	100
		MJC-9 (P)	Genetics (P)	2	100
6.	VI	MJC-10 (T)	Developmental Biology (T)	3	100
		MJC-10 (P)	Developmental Biology (P)	1	100
		MJC-11 (T)	Evolution (T)	3	100
		MJC-11 (P)	Evolution (P)	2	100
		MJC-12 (T)	Animal Behaviour (T)	3	100
		MJC-12 (P)	Animal Behaviour (P)	2	100

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7.	VII	MJC-13 (T)	Molecular Biology (T)	3	100
		MJC-13 (P)	Molecular Biology (P)	2	100
		MJC-14	Research Methodology	5	100
		MJC-15 (T)	Immunology and Microbiology (T)	4	100
		MJC-15 (P)	Immunology and Microbiology (P)	2	100
8.	VIII	MJC-16 (T)	Instrumentation and Biometry	4	100

Sub Total = 80

(B) Minor Courses to be offered by the Department for students of other Departments of Science

Sl. No.	Semester	Type of Course	Name of Course	Credits	Marks
1.	I	MIC-1 (T)	Diversity of Non-Chordates(T)	2	100
		MIC-1 (P)	Diversity of Non-Chordates(P)	1	100
2.	II	MIC-2 (T)	Diversity of Chordates (T)	2	100
		MIC-2 (P)	Diversity of Chordates (P)	1	100
3.	III	MIC-3(T)	Physiology(T)	2	100
		MIC-3(P)	Physiology(P)	1	100
4.	IV	MIC-4(T)	Ecology(T)	2	100
		MIC 4(P)	Ecology(P)	1	100
5.	V	MIC-5(T)	Cell Biology (T)	2	100
		MIC-5(P)	Cell Biology (P)	1	100
6.	V	MIC-6(T)	Genetics (T)	2	100
		MIC-6(P)	Genetics (P)	1	100
7.	VI	MIC-7(T)	Evolution (T)	2	100
		MIC-7(P)	Evolution (P)	1	100
8.	VI	MIC-8(T)	Developmental Biology(T)	2	100
		MIC-8(P)	Developmental Biology (P)	1	100

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Sl. No.	Semester	Type of Course	Name of Course	Credits	Marks
1.	I	VAC-1	To be selected from the basket	3	100
2.	II	VAC-2	To be selected from the basket	3	100

Sub Total = 06

Sl. No.	Semester	Type of Course	Name of Course	Credits	Marks
1.	V	INT-1	Summer Internship	4	100

Sl. No.	Semester	Type of Course	Name of Course	Credits	Marks
1.	VIII	RP-1	Research/Dissertation	12	100

Grand Total Credits = 160

(G) Basket for Multidisciplinary Courses (MDC)
To be decided by Respective Department

(H) Basket for Skill Enhancement Courses (SEC)
See at the end of structure (this booklet)

(I) Basket for Value Added Courses (VAC)
See at the end of structure (this booklet)

Question Paper Pattern

The question paper shall consist of three parts: -

Part A -Compulsory- Consisting of ten objective/Multiple choice type - each carrying two marks. 10x2= 20 marks

Part B -Short answers type - Four questions are to be answered out of six questions - each carrying five marks. 04x5 = 20 marks

Part C- Long answers type questions. Three questions to be answered out of five questions - each carrying ten marks. 03x10 = 30 marks

Examinations shall not be held on OMR Sheets strictly.

Syllabus for Four-Year B.Sc. Course in Zoology

Semester -I

Major Course 1 (MJC-1)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Diversity of Non-Chordates	6	4	2

Course outcomes: After completion of the course, students should be able to:

- CO-1:** Learn about the importance of systematics, taxonomy, and structural organization of non-chordates.
- CO-2:** Understand & appreciate the diversity of non-chordates living in varied habits and habitats.
- CO-3:** Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- CO-4:** Critically analyze the organization, complexity and characteristic features of non-chordates.
- CO-5:** Recognize the life functions and the ecological roles of the animals belonging to different phyla.

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Handwritten signatures: Pheka, Anil

Handwritten signatures: Sanik, 203, Sujata

1	Study of whole mount of <i>Euglena</i> , <i>Amoeba</i> , <i>Paramecium</i> , <i>Monocystis</i> ; Binary fission and Conjugation in <i>Paramecium</i> .
2	Study of <i>Sycon</i> ; T.S. of <i>Sycon</i> , L.S. of <i>Sycon</i> ; Gemmule, Hyalonema.
3	Permanent stained preparation of spicules of sponges
4	Study of <i>Obelia</i> , <i>Aurelia</i> , <i>Metridium</i> , <i>Physalia</i> .
5	Specimen/slide of any one Ctenophore.
6	Study of adult <i>Fasciola hepatica</i> , <i>Taenia solium</i> and <i>Ascaris</i> (male & female).
7	Study of Aphrodite, Septal nephridia and Ovary of Earthworm; Jaws of leech; Trochophore larva.
8	Study of T.S. through pharynx, gizzard, and typhlosolar region of earthworm.
9	Study of <i>Limulus</i> , <i>Scolopendra</i> , Grasshopper, <i>Phyllium</i> , Praying mantis, Palaemon, Sacculina, Cancer, <i>Eupagurus</i> , <i>Apis</i> , <i>Musca</i> . Salivary gland of Cockroach, Mouth parts of Mosquito.
10	Study of <i>Chiton</i> , <i>Dentalium</i> , Octopus, Glochidim larva.
11	Study of <i>Asterias</i> , <i>Echinus</i> , <i>Antedon</i> .
	Practical Records/Charts/Models.
	Viva-voce.

Suggested Books:

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science.
- Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.
- Verma P S, Jordan E L. (2009). *Invertebrate Zoology*. S. Chand publishers.
- Brusca R C (2016). *Invertebrates*. Published by Sinauer Associates, an imprint of Oxford University Press.
- S. S. Lal, *Practical Zoology Invertebrate*.

Semester -I

Minor Course 1 (MIC-1)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Diversity of Non-Chordates	3	2	1

Course outcomes: After completion of the course, students should be able to:

CO-1: Learn about the importance of systematics, taxonomy, and structural organization of non-chordates.

CO-2: Critically analyse the organization, complexity and characteristic features of non-chordates.

CO-3: Recognize the life functions and the ecological roles of the animals belonging to different phyla.

MIC-1: Diversity of Non-Chordates (Theory: 2 Credits) 20 hrs		
Unit	Topics to be covered	No. of Lectures
1	I. Introduction to Non-chordates General characteristics and classification (up to order) of the following Phyla: Protozoa, Porifera, Cnidaria, Ctenophora, Platyhelminthes, Nematelminths, Annelida, Arthropoda, Mollusca, Echinodermata.	5
2	2. Structure and life history of:- Protozoa - <i>Paramecium</i> Porifera - <i>Sycon</i>	4
3	3. Structure and life history of:- Cnidaria - <i>Obelia</i> Platyhelminthes - <i>Fasciola</i> Aschelminthes - <i>Ascaris</i>	5
4	4. Study of coelomates:- Annelida - <i>Pheretima</i> Arthropoda - <i>Palaemon</i> Mollusca - <i>Pila</i> Echinodermata - <i>Asteries</i> Hemichordata - <i>Balanoglossus</i>	6
	TOTAL	20

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MIC-1: Diversity of Non-Chordates (Practical: 1 Credit) 10 hrs	
End Semester Examination	
Time – 3 hours 70	Full Marks-
Permanent slides	15
Museum specimen	15
Larval forms	10
Comments on display charts provided	10
Practical record/Chart/Model	10
Viva-voce	10
Sl. No.	Name of Practicals/Experiments
1	Study of whole mount of <i>Euglena</i> , <i>Paramecium</i> , <i>Leshmania</i>
2	Study of <i>Sycon</i> , <i>Spongilla</i> , T.S. of <i>Sycon</i> , L.S. of <i>Sycon</i> .
3	Study of <i>Obelia</i> , <i>Aurelia</i> , <i>Gorgonia</i>
4	Study of adult <i>Fasciola hepatica</i> , <i>Taenia solium</i> and their life stages
5	Study of <i>Pheretima</i> , <i>Hirudinaria</i>
6	Study of T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.
7	Study of <i>Limulus</i> , <i>Palaemon</i> , <i>Apis</i> .
8	Mouth parts of Mosquito and Cockroach.
9	Study of <i>Pila</i> , <i>Unio</i> .
10	Study of <i>Asterias</i> .

Suggested Books :

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J. I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson
- Verma P S, Jordan E L. (2009). *Invertebrate Zoology*. S. Chand publishers
- Brusca R C (2016). *Invertebrates*. Published by Sinauer Associates, an imprint of Oxford University Press.
- S. S. Lal, *Practical Zoology, Invertebrate*.

Semester -I

Multidisciplinary Course 1 (MDC-1)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Diversity of Non-Chordates	3	2	1

Course outcomes: After completion of the course, students should be able to:

CO-1: Learn about the importance of systematics, taxonomy, and structural organization of non-chordates.

CO-2: Critically analyse the organization, complexity and characteristic features of non chordates.

CO-3: Recognize the life functions and the ecological roles of the animals belonging to different phyla.

MDC-1: Diversity of Non-Chordata (Theory: 2credits)20 hrs		
Unit	Topics to be covered	No. of Lectures
1	I. Introduction to Non-chordates General characteristics and classification (up to order) of the following Phyla: Protozoa, Porifera, Cnidaria, Ctenophora, Platyhelminthes and Nematelminths, Annelida, Arthropoda, Mollusca, Echinodermata.	5
2	2 Structure and life history of:- Protozoa - <i>Paramecium</i> Porifera - <i>Sycon</i>	4
3	3. Structure and life history of:- Cnidaria - <i>Obelia</i> Platyhelminthes - <i>Fasciola</i> Aschelminthes - <i>Ascaris</i>	5
4	4. Study of coelomates: Annelida - <i>Pheretima</i> Arthropoda - <i>Palaemon</i> Mollusca - <i>Pila</i> Echinodermata - <i>Asteries</i> Hemichordata - <i>Balanoglossus</i>	6
	TOTAL	20

MDC-1: Diversity of Non-Chordates (Practical: 1 Credit) 10 hrs	
End Semester Examination	
Time – 3 hours	Full Marks-70
Permanent slides	15
Museum specimen	15
Larval forms	10
Comments on display charts provided	10
Practical record/Chart/Model	10
Viva-voce	10
Sl. No.	Name of Practicals/Experiments
1	Study of whole mount of <i>Euglena</i> , <i>Paramecium</i> , <i>Leshmania</i>
2	Study of <i>Sycon</i> , <i>Spongilla</i> , T.S. of <i>Sycon</i> , L.S. of <i>Sycon</i> .
3	Study of <i>Obelia</i> , <i>Aurelia</i> , <i>Gorgonia</i>
4	Study of adult <i>Fasciola hepatica</i> , <i>Taenia solium</i> and their life stages
5	Study of <i>Pheretima</i> , <i>Hirudinaria</i>
6	Study of T.S. through pharynx, gizzard, and typhlosolar intestine of earthworm.
7	Study of <i>Limulus</i> , <i>Palaemon</i> , <i>Apis</i> .
8	Mouth parts of Mosquito and Cockroach.
9	Study of <i>Pila</i> , <i>Unio</i> .
10	Study of <i>Asterias</i> .

Suggested Books:

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J. I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- Bannington, E.J.W. (1919). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson
- Verma P. S, Jordan E. L. (2009). *Invertebrate Zoology*. S. Chand publishers
- Brusca R C (2016). *Invertebrates*. Published by Sinauer Associates, an imprint of Oxford University Press.
- S. S. Lal, *Practical Zoology, Invertebrate*.

Semester II

Major Course 2 (MJC-2)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Diversity of Chordates	6	4	2

Course Outcomes: After completion of the course, the students will be able to:

CO-1: Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.

CO-2: Study about diversity in animals making students understand about their distinguishing features.

CO-3: Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.

CO-4: Comprehend the circulatory, nervous and skeletal system of chordates.

CO-5: Know about the habit and habitat of chordates in marine, freshwater and terrestrial ecosystems.

MJC-2: Diversity of Chordates (Theory: 4 Credits) 40 hrs		
Unit	Topics to be covered	No. of Lectures
1	1.1 Introduction to Chordates: 1.2 General characteristics and classification (upto Order): Cephalochordata, Urochordata, Cyclostomata, Pisces, Amphibia, Reptilia, Aves and Mammalia.	8
2	2.1 Origin and Evolution of Chordata. 2.2 Cephalochordata: <i>Amphioxus</i> . 2.3 Urochordata: <i>Herdmania</i> (including retrogressive metamorphosis). 2.4 Cyclostomata: <i>Petromyzon</i> .	10
3	3.1 Pisces: Migration, Osmoregulation, and Accessory respiration. 3.2 Amphibia: Origin and Evolution; Parental care and Neoteny. 3.3 Reptilia: Poison and Non-poisonous snakes; Poison apparatus; biting and feeding mechanism in snakes.	12
4	4.1 Aves: Origin of birds, Flight adaptations and Migration in birds. 4.2 Mammalia: Characters, distribution and affinities of Prototheria Metatheria and Eutheria.	10
TOTAL		40

MJC-2: Diversity of Chordates (Practical: 2 Credits) 20 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-
70		
Permanent slides	15	
Museum specimen	15	
Larval forms	10	

CO-2: To acquire knowledge about the General Characters and Classification of Agnatha, Pisces and Amphibia.

CO-3: To understand the General Characteristics and Classification of Reptilia, Aves and Mammals, Biting Mechanism in Snakes, Flight Adaptations in Birds and Migration in Birds.

MIC-2: Diversity of Chordates (Theory: 2credits)20 hrs		
Unit	Topics to be covered	No. of Lectures
1	General characteristics and classification (upto Order): Cephalochordata, Urochordata, Cyclostomata, Pisces, Amphibia, Reptilia, Aves and Mammals.	5
2	Cephalochordata: <i>Amphioxus</i> . Urochordata: <i>Herdmania</i> (including retrogressive metamorphosis).	4
3	Pisces: <i>Scoliodon</i> . Reptilia: Biting and feeding mechanism in snakes.	5
4	Aves: Flight adaptations, Elementary idea of migration. Mammals: Characters, distribution and affinities of Prototheria and Metatheria.	6
TOTAL		20

MIC-2: Diversity of Chordates (Practical: 1 Credits) 10 hrs		
End Semester Examination		
Time – 3 hours	Full Marks-70	
Permanent slides	15	
Museum specimen	15	
Larval forms	10	
Comments on display charts provided Practical record/Chart/Model	10	
Viva-voce	10	
Sl. No.	Name of Practicals/Experiments	
1	Amphioxus: Section through pharyngeal, intestinal, and caudal regions.	
2	Herdmania: Whole mount, Spicules.	
3	Cyclostomata: <i>Petromyzon</i> , <i>Myxine</i>	
4	Fish: <i>Scoliodon</i> , <i>Torpedo</i> , <i>Chimaera</i> , <i>Labeo</i> , <i>Exocoetus</i> , <i>Echeneis</i> , <i>Hippocampus</i> ; Scales of fishes.	
5	Amphibia: <i>Ichthyophis</i> , <i>Bufo</i> , <i>Hyla</i> , <i>Alytes</i> , <i>Salamandra</i> , Axolotle larva.	
6	Reptilia: <i>Chelone</i> , <i>Hemidactylus</i> , <i>Varanus</i> , <i>Vipera</i> , <i>Naja</i> , <i>Bungarus</i> , <i>Uromastix</i> , <i>Chamaeleon</i> , <i>Draco</i> , <i>Calotes</i> , <i>Heloderma</i> ; Key for Identification of poisonous and non-poisonous snakes.	

1	General characteristics and classification (upto Order): Cephalochordata, Urochordata, Cyclostomata , Pisces, Amphibia, Reptilia, Aves and Mammals.	5
2	Cephalochordata: <i>Amphioxus</i> . Urochordata: <i>Herdmania</i> (including retrogressive metamorphosis).	4
3	Pisces: <i>Scoliodon</i> . Reptilia: Biting and feeding mechanism in snakes.	5
4	Aves: Flight adaptations, Elementary idea of migration. Mammals: Characters, distribution and affinities of Prototheria & Metatheria.	6
	TOTAL	20

MDC-2: Diversity of Chordates (Practical: 1 Credits) 10 hrs	
End Semester Examination	
Time – 3 hours	Full Marks-70
Permanent slides	15
Museum specimen	15
Larval forms	10
Comments on display charts provided Practical record/Chart/Model	10
Viva-voce	10
Sl. No.	Name of Practicals/Experiments
1	Amphioxus: Section through pharyngeal, intestinal, and caudal regions.
2	Herdmania: Whole mount, Spicules.
3	Cyclostomata: <i>Petromyzon</i> , <i>Myxine</i>
4	Fish: <i>Scoliodon</i> , <i>Torpedo</i> , <i>Chimaera</i> , <i>Labeo</i> , <i>Exocoetus</i> , <i>Echeneis</i> , <i>Hippocampus</i> ; Scales of fishes.
5	Amphibia: <i>Ichthyophis</i> , <i>Bufo</i> , <i>Hyla</i> , <i>Alytes</i> , <i>Salamandra</i> , Axolotle larva.
6	Reptilia: <i>Chelone</i> , <i>Hemidactylus</i> , <i>Varanus</i> , <i>Vipera</i> , <i>Naja</i> , <i>Bungarus</i> , <i>Uromastix</i> , <i>Chamaeleon</i> , <i>Draco</i> , <i>Calotes</i> , <i>Heloderma</i> ; Key for Identification of poisonous and non-poisonous snakes.
7	Aves: Types of beaks and claws, Study of pecten from fowl head and brain of fowl.
8	Mammalia: <i>Sorex</i> , Bat (Insectivorous and Frugivorous), <i>Funambulus</i> , <i>Loris</i> , <i>Herpestes</i> , <i>Erinaceous</i> , <i>Macropus</i> , <i>Echidna</i> .

Suggested Books:

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- Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford university press.
- Pough H. *Vertebrate life*, VIII Edition, Pearson International.
- Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger Pub Co.
- Hall B. K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett Publishers Inc.
- Classification from Young, J. Z. (2004) to be followed.
- S. S. Lal, Practical Zoology Vertebrates.

Semester III

Major Course 3 (MJC-3)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Comparative Anatomy	5	3	2

Course Outcomes: Upon completion of the course, students should be able to:

- CO-1: Explain comparative account of the different vertebrate systems
- CO-2: Understand the pattern of vertebrate evolution, organization and functions of various systems.
- CO-3: Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- CO-4: Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.
- CO-5: Learn the evolution of brain, sense organs and excretory organs to a complex, highly evolved form in mammals;
- CO-6: Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.

MJC-3: Comparative Anatomy of Vertebrates (Theory: 3 credits) 30 hrs		
Unit	Topics to be covered	No. of lectures

1	1. Integumentary System: Structure and derivatives of integument, functions of skin.	4
2	2. Skeletal System: Basic plan of axial and appendicular skeleton.	4
3	3. Digestive System: Alimentary canal and associated glands.	4
4	4. Respiratory System: Respiratory organs and accessory respiratory organs.	5
5	5. Circulatory System: 5.1 General plan of circulation. 5.2 Evolution of heart and aortic arches.	4
6	6. Urinogenital System: Evolution of kidney and urinogenital ducts.	4
7	7. Nervous System: Comparative account of Central nervous system and Peripheral nervous system.	5
Total		30

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MJC-3: Comparative Anatomy (Practical: 2 Credits) 20 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Study of placoid, cycloid and ctenoid scales of fish through permanent slides.	15
2	Study of afferent and efferent branchial vessels of Scoliodon through videos/models.	15
3	Study of digestive tract of frog/ rat through videos/models.	10
4	Disarticulated skeleton of Frog, Varanus, Fowl and Rabbit (Skull, Limb bones, Vertebral Column, Sternum, Girdles, Ribs)	10
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Kardong, K.V. (2005). Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
- Kotpal, R. L. (2010). Modern text book of zoology: vertebrates. Rastogi Publications.

Online Tools and Web Resources:

- SWAYAM (Structure of heart), Link <https://www.swayamprabha.gov.in/index.php/program/archive/9>.
- COURSERA (PALEONTOLOGY: Early vertebrate evolution, Link – <https://www.coursera.org/learn/early-vertebrate-evolution>).

MIC-3: Physiology (Practical: 1 Credit)		10 hrs
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Enumeration of red blood cells and white blood cells using haemocytometer,	10
2	Determination of erythrocyte sedimentation rate.	10
3	Estimation of haemoglobin.	10
4	Examination of histological sections of mammalian oesophagus, stomach, duodenum, ileum, rectum, trachea, lung, Testis and Ovary.	20
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Tortora, G.J.& Grabowski, S (2006) Principles of Anatomy & Physiology, XI edition. John Wiley & Sons
- Vander A, Sherman J, and Luciano D (2014). Vander's Human Physiology: The mechanism of Body Function. XIII Edition, Mc Graw Hills.
- Guyton, A.C & Hall, J.E. (2006). Textbook of Medical Physiology, XI Edition. Hercourt Asia PTE Ltd/W.B. Saunders Company

Online Tools and Web Resources:

- e portals like SWAYAM
<http://nsdl.niscair.res.in>

Multidisciplinary Course 3 (MDC-3)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Physiology	3	2	1

Course Outcomes:

Upon completion of the course, students will be able to:

- Know the principles of normal biological function in human body.
- Outline basic human physiology and correlate with histological structures.
- Comprehend and analyse problem-based questions on physiological aspects.

- Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body; and use of feedback loops to control the same.
- Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body.

MDC-3: Physiology (Theory: 2 credits) 20 hrs		
Unit	Topics to be covered	No. of lectures
1	1.1. Structure and function of digestive system, 1.2. Digestion and absorption of food.	3
2	2.1. Structure of neuron and propagation of nerve impulse. 2.2. Structure of skeletal muscle and mechanism of muscle contraction.	4
3	3.1. Structure of respiratory organs, pulmonary ventilation. 3.2. Transport of gases in blood.	4
4	4.1. Structure of excretory organs. 4.2. Mechanism of urine formation.	2
5	5.1. Structure and function of heart. 5.2. Cardiac cycle.	2
6	6.1. Structure and function of endocrine glands. 6.2. Spermatogenesis and oogenesis.	5
Total		20

MDC-3: Physiology (Practical: 1 Credit)		10 hrs
End Semester Examination		
Time – 3 hours		Full Marks-
70		
Sl. No.	Name of Practicals/Experiments	Marks
1	Enumeration of red blood cells and white blood cells using haemocytometer,	10
2	Determination of erythrocyte sedimentation rate.	10
3	Estimation of haemoglobin.	10
4	Examination of histological sections of mammalian oesophagus, stomach, duodenum, ileum, rectum, trachea, lung, Testis and Ovary.	20
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Tortora, G.J. & Grabowski, S (2006) Principles of Anatomy & Physiology, XI edition.

- John Wiley & Sons
- Vander A, Sherman J, and Luciano D (2014). Vander's Human Physiology: The mechanism of Body Function. XIII Edition, Mc Graw Hills.
 - Guyton, A.C & Hall, J.E. (2006). Textbook of Medical Physiology, XI Edition. Hercourt Asia PTE Ltd/W.B. Saunders Company

Online Tools and Web Resources:

- e portals like SWAYAM
<http://nsdl.niscair.res.in>

**Semester IV
Major Course 5 (MJC-5)**

Course Title	Credit	Credit Distribution	
		Theory	Practical
Cell Biology	5	3	2

Course Outcome: Upon completion of the course, students should to be able to:

- CO-1:** Understand fundamental principles of cell biology.
- CO-2:** Explain structure and functions of cell organelles involved in diverse cellular processes.
- CO-3:** Appreciate how cells grow, divide, survive, die and regulate these important processes.
- CO-4:** Comprehend the process of cell signaling and its role in cellular functions.
- CO-5:** Have an insight of how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases.
- CO-6:** Learn the advances made in the field of cell biology and their applications.

MJC-5: Cell Biology (Theory: 3 Credits) 30 hrs		
Unit	Topics to be covered	No. of lectures
1	1. Overview of Virus, Prokaryotic and Eukaryotic cells.	2
2	2. Plasma Membrane: 2.1 Various models of plasma membrane. 2.2 Transport across membranes (passive and active transport).	6
3	3. Cytoplasmic organelles: 3.1 Endoplasmic Reticulum – Structure, Signal hypothesis. 3.2 Golgi apparatus – Structure, Protein sorting. 3.3 Lysosomes and Peroxisomes. 3.4 Mitochondria – Structure, Respiratory chain and oxidative phosphorylation.	10

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4	4. Nucleus: 4.1 Structure of Nucleus. 4.2 Euchromatin and Heterochromatin.	6
5	5. Cell Division: 5.1 Cell cycle and Molecular basis of its regulation. 5.2 Mitosis and Meiosis.	6
	Total	30

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MJC-5: Cell Biology (Practical: 2 Credits) 20hrs		
End Semester Examination		
Time – 3 hours		Full Marks-
70		
Sl. No.	Name of Practicals/Experiments	Marks
1	Vital staining of mitochondria in buccal epithelium	10
2	Preparation of temporary stained squash of onion root tip to study various stages of mitosis.	15
3	Study of various stages of meiosis through permanent slides.	10
4	Preparation of temporary stained mount to show the presence of Barr body in human female blood cells/ cheek cells. or Preparation of polytene chromosome from salivary gland of Chironomus larva.	15
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments, VI Edition, John Wiley & Sons Inc.
- Powar, C. B. (1991) Cell Biology, Himalaya Publishing House

Online Tools and Web Resources:

- <https://swayam.gov.in/course/150-cell-biology>
- <https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology>
- <https://www.jove.com/science-education-library/9/cell-biology>
- <https://www.khanacademy.org/science/biology>

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MJC-6: Endocrinology (Practical: 2 Credits) 20 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of practicals/experiments	Marks
1	Display of gonads, thyroid, adrenal, pancreas in mammal through videos/models	15
2	Study of the permanent slides of Pituitary, Adrenal, Ovary, Testes, Islets of Langerhan's, Thymus, Thyroid and Parathyroid, Study of the permanent slide of vaginal smears	4x5=20
3	Estimation of plasma level of any hormone using ELISA Or Chromatographic separation of steroid hormones using paper chromatography.	15
4	Practical Records/Charts/Models	10
5	Viva- voce.	10

Suggested Books:

- J. Larry Jameson Leslie De Groot (2010). Endocrinology. VI Edition.
- David O. Norris. Vertebrate Endocrinology. V Edition, Elsevier Academic press.
- Franklin F. Bolander. Molecular Endocrinology. III Edition, Academic Press, USA.

Online Tools and Web Resources:

- <https://www.endocrine.org/topics>

Major Course 7 (MJC- 7)

Course Outcome: Upon completion of the course, students should be able to:

CO-1: Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.

Course Title	Credit	Credit Distribution	
		Theory	Practical
Ecology	5	3	2

CO-2: Comprehend the population characteristics, dynamics, growth models and interactions.

CO-3: Understand the community characteristics, ecosystem development and climax theories.

CO-4: Know about the types of ecosystems, food chains, food webs, energy models and ecological efficiencies.

CO-5: Apply the basic principles of ecology in wildlife conservation and management.

CO-6: Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyse and use information available in scientific literature.

MJC-7: Ecology (Theory: 3 Credits) 30 hrs		
Unit	Topics to be covered	No. of lectures
1	1. Components of Ecology: 1.1 Biotic factors. 1.2 Abiotic factors. 1.3 Laws of limiting factors.	2
2	2. Ecosystem: 2.1 Definition, structure, and function of different types of ecosystems including wetland ecosystem. 2.2 Food chain and Food web. 2.3 Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies. 2.4 Biogeochemical cycles.	10
3	3. Population ecology: 3.1 Study of population attributes (Natality, Mortality, Density). 3.2 Life tables; Exponential and logistic growth, equation and patterns, r and k strategies. 3.3 Population interactions; Lotka-Volterra model.	6
4	4. Community Ecology: 4.1 Community characteristics: species richness, dominance, diversity, abundance, Ecotone and Edge effect. 4.2 Ecological succession with examples and types.	4
5	5. Applied Ecology: 5.1 Biodiversity - Importance and threats. 5.2 Wildlife conservation and management; National Parks, Bioreserves and Sanctuaries. 5.3 Pollution and its hazards.	8
	Total	30

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MJC-7: Ecology (Practical: 2 Credits)		20 hrs
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Analysis of Soil/Pond Biota Or Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.	10
2	Determination of dissolved oxygen and pH measurements of different water samples.	15
3	Determination of population density in a natural/ hypothetical community by quadrat method.	15
4	Report on a visit to National Park/Biodiversity Park/ Wild life sanctuary/Zoo.	10
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Odum, E.P. (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Smith, R. L. (2000). Ecology and field biology. Harper and Row published

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Semester IV
Minor Course 4 (MIC-4)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Ecology	3	2	1

Course Outcome: Upon completion of the course, students should be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.
- Apply the basic principles of ecology in wildlife conservation and management.
- Inculcate scientific quantitative skills, evaluate experimental design, read graphs, and analyse and use information available in scientific literature.

MIC-4: Ecology (Theory: 2 Credits) 20 hrs		
Unit	Topics to be covered	No. of lectures
1	Introduction to Ecology, Scope of ecology, Laws of limiting factors.	2
2	Population dynamics, Demographic indices, Population interactions.	4
3	Community: Biodiversity and study of diversity index.	2
4	Ecosystem: Types of ecosystems, Detailed study of Aquatic ecosystem, Food chain, Food web, Ecological pyramids and Biogeochemical cycle.	7
5	Applied Ecology: Wildlife conservation; Importance, threats and management, Protected areas; National Parks, Bioreserves and Sanctuaries.	5
	Total	20

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MJC-8: Biochemistry (Theory: 3 credits) 30 hrs		
Unit	Topics to be covered	No. of Lectures
1	1. Elementary idea of biomolecule: 1.1 Structure and classification of Carbohydrates, Lipid and Protein. 1.2 Structure, classification and physiological importance of Amino Acids. 1.3 Structure, classification and physiological importance of Vitamins.	10
2	2. Enzymes: 2.1 Nomenclature and classification, Isozymes. 2.2 Kinetics of enzyme-substrate reactions. 2.3 Regulation of enzyme action.	6
3	3. Carbohydrate Metabolism: 3.1 Glycolysis and Citric acid cycle. 3.2 Pentose Phosphate Pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.	8
4	4. Lipid and Protein Metabolism: 4.1 Beta oxidation and omega-oxidation of fatty acids, Ketogenesis. 4.2 Transamination, Deamination, Urea cycle.	6
TOTAL		30

MJC 8 : Biochemistry (Practical: 2 credits) 20 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-
70		
Sl. No.	Name of Practicals/Experiments	Marks
1	Qualitative tests of carbohydrates, proteins and lipids.	20
2	Paper chromatography of amino acids.	15
3	Demonstration of impact of pH, temperature and inhibitors on the action of salivary amylase.	15
4	Practical Records/Charts/Models.	10
5	Viva- voce.	10

Suggested Books:

- Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.

Semester V
Minor Course 5 (MIC-5)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Cell Biology	3	2	1

MIC-5: Cell Biology (Theory: 2 Credits) 20 hrs		
Unit	Topics to be covered	No. of lectures
1	Overview of Prokaryotic and Eukaryotic cells	2
2	Plasma Membrane: Fluid Mosaic Model, Active and passive transport.	3
3	Endomembrane System: Structure and Functions of Endoplasmic Reticulum, Golgi apparatus, Lysosomes and Peroxisomes.	4
4	Mitochondria: Structure, Respiratory chain and ATP production.	4
5	Nucleus: Structure of Nucleus and organization of Chromatin.	3
6	Cell cycle: Mitosis, Meiosis and their regulation in brief.	4
	Total	20

MIC-5: Cell Biology (Practical:1 Credit) 10 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Vital staining of mitochondria in buccal epithelium	15
2	Study of various stages of mitosis through permanent slides. (any two)	5x2=10
3	Study of various stages of meiosis through permanent slides (any two)	5x2=10
4	Preparation of temporary stained mount to show the presence of Barr body in human cheek cells.	15
5	Practical Records/Charts/Models.	10
6	Viva- voce.	10

Suggested Books:

- Cooper, G.M., Hausman, R.E. (2009) The Cell: A Molecular Approach. V Edition, ASM Press and Sinauer Associates.
- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments, VI Edition, John Wiley & Sons Inc.
- Powar, C. B. (1991) Cell Biology, Himalaya Publishing House.
- Alberts et al: Molecular Biology of the Cell (2008, Garland)

MIC-06 : Genetics (Practical: 1 Credit) 10 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Preparation of Polytene chromosomes from Chironomous/Drosophila.	20
2	Identification of various mutants of Drosophila in the given photograph.	15
3	Study of pedigree analysis of human inherited traits.	15
4	Practical Records/Charts/Models.	10
5	Viva- voce.	10

Suggested Books:

- Gardner, E. J., Simmons, M. J., Snustad, D. P. (2008). *Principles of Genetics*. VIII Edition. Wiley, India
- Snustad, D. P., Simmons, M. J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc
- Klug, W. S., Cummings, M. R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition. Benjamin Cummings
- Russell, P. J. (2009). *Genetics- A Molecular Approach*. III Edition. Benjamin Cummings
- Fletcher H. and Hickey I. (2015). *Genetics*. IV Edition. G S, Taylor and Francis Group, New York and London.

**Semester VI
Major Course 10 (MJC-10)**

Course Title	Credit	Credit Distribution	
		Theory	Practical
Developmental Biology	4	3	1

Course Outcome: After the completion of the course, the student will be able:

CO 1- To describe the mechanism of gametogenesis, fertilization and blocks to polyspermy.

CO 2- To explain early embryonic development in frog and chick.

CO 3- To understand the concepts of late embryonic development in model organisms.

CO4 - To describe post embryonic development such as metamorphosis and regeneration with suitable examples and apply important experiments and project work.

MJC-10: Developmental Biology (Theory: 3 credits) 30 hours		
Unit	Topics to be covered	No. of Lectures
1	1. Introduction: 1.1 Principles and Basic concepts of development biology - Phases of development, Cell-Cell interaction, Differentiation and growth 1.2 Gametogenesis: Spermatogenesis and Oogenesis.	10

	1.3 Mechanism of fertilization, Types of eggs and cleavage, Blastulation, Fate maps (including Techniques).	
2	2. Early and Late Embryonic Development: 2.1 Early development of frog and chick up to gastrulation. 2.2 Late Embryonic Development: Fate of Germ Layers, Extra-embryonic membranes in birds, Placentation.	8
3	3. Post Embryonic Development: 3.1 Metamorphosis: Changes, hormonal regulations in amphibians. 3.2 Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).	6
4	4. Implications of Developmental Biology: 4.1 Teratogenesis: Teratogenic agents and their effects on embryonic development. 4.2 In vitro fertilization, Stem cell, Amniocentesis. 4.3 Basic concept of Aging and senescence.	6
	TOTAL	30

MJC-10: Developmental Biology (Practical: 1 Credit) 10 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-70
Sl. No.	Name of Practicals/Experiments	Marks
1	Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).	2x5=10
2	Study of whole mounts of developmental stages of chick through permanent slides (Different hours of incubation).	5x3=15
3	Study of the developmental stages and life cycle of Drosophila from stock culture.	15
4	Study of different sections of placenta (Photomicrograph/ slides).	10
5	Practical Records/Charts/Models.	10
6	Viva-voce.	10

Suggested Books:

- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
- Carlson, R. F. Patten's Foundations of Embryology
- Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
- Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press

Major Course 11 (MJC-11)

Course Title	Credit	Credit Distribution
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- Ridley, M. (2004). Evolution III Edition Blackwell publishing
- Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
- Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition Wiley-Blackwell

Minor Course 08 (MIC-08)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Developmental Biology	3	2	1

Course Outcome: After the completion of the course, the student will be able:

CO 1- To describe the mechanism of gametogenesis, fertilization.

CO 2- To explain early embryonic development in frog and chick.

CO 3- To understand the concepts of late embryonic development in model organisms.

CO4 - To describe post embryonic development such as metamorphosis and regeneration with suitable examples and apply important experiments and project work.

MIC-08 : Developmental Biology (Theory: 2 credits) 20 hours		
Unit	Topics to be covered	No. of Lectures
1	Introduction: 1. Basic concepts of reproduction and development.	4
2	Early and Late Embryonic Development: 2.1 Gametogenesis - Spermatogenesis, Oogenesis. 2.2 Types of eggs, Patterns of cleavage and Blastulation. 2.3 Early development of frog up to gastrulation, 2.4 Extra-embryonic membranes in birds.	6
3	Post Embryonic Development: 3.1 Metamorphosis: Changes, hormonal regulations in amphibians; 3.3 Ageing: Concepts and Theories	5
4	Implications of Developmental Biology: 4.1 Teratogenesis: Teratogenic agents and their effects on embryonic development. 4.2 In vitro fertilization.	5
TOTAL		20

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MIC-08: Developmental Biology (Practical: 1 Credit) 10 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-
70		
Sl. No.	Name of Practicals/Experiments	Marks
1	Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula.	20
2	Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak 18, 24, 36, 48, 72, and 96 hours of incubation.	20
3	Study of different sections of placenta (Photomicrograph/ slides)	10
4	Practical/Project report on chick embryo development.	10
5	Viva- voce.	10

Suggested Books:

- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press.
- Carlson, R. F. Patten's Foundations of Embryology.
- Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw Hill Publishers.
- Lewis Wolpert (2002). Principles of Development. II Edition, Oxford University Press.

Semester VII Major Course 13 (MJC-13)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Molecular Biology	5	3	2

Course Outcome: After the completion of the course, the student will be able:

CO 1- To understand Central dogma of molecular biology. Explain and distinguish mechanism of replication, transcription and translation in prokaryotes and eukaryotes.

CO 2- To understand and explain the post transcriptional modifications in eukaryotes.

CO 3- To explain and differentiate the mechanism of gene expression and regulation in prokaryotes and eukaryotes

CO 4- To describe the concept of regulatory RNAs, Ribo-switches and RNA interference and to enhance skill in molecular biology through relevant experiments.

MJC-13: Molecular Biology (Theory: 3 credits) 30 hours		
Unit	Topics to be covered	No. of Lectures
1	1. Basics of Nucleic Acid: 1.1 Central Dogma of Molecular Biology. 1.2 Structure of DNA, DNA forms, Repetitive DNA. 1.3 Structure and functions of mRNA, tRNA, and rRNA.	8
2	2. DNA replication and repair: 2.1 DNA replication in prokaryotes. 2.2 DNA repair, mismatch repair, Base excision repair (BER), Nucleotide excision repair (NER). 2.3 Difference between prokaryotic and eukaryotic replication (A brief account)	8
3	3. Transcription: 3.1 Mechanism of transcription in prokaryotes. 3.2 Difference between prokaryotic and eukaryotic transcription (A brief account).	6
4	4. Translation: 4.1 Genetic code, degeneracy of genetic code and Wobble hypothesis. 4.2 Structure of ribosomes. 4.3 Mechanism of translation in prokaryotes. 4.4 Difference between prokaryotes and eukaryotes translation (A brief account).	8
TOTAL		30

MJC-13: Molecular Biology (Practical: 2 Credits) 20 hrs		
End Semester Examination		
Time – 3 hours 70		Full Marks-
Sl. No.	Name of Practicals/Experiments	Marks
1	Demonstration of DNA by Feulgen reaction or RNA by Methyl Green Pyronin (MGP) method.	20
2	Isolation of plasmid/genomic DNA or Restriction digestion of DNA.	15
3	DNA gel electrophoresis or Preparation of nucleotide model by beads and sticks.	15
4	Practical/Project report on chick embryo development.	10
5	Viva- voce.	10

Suggested Books :

- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
- Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: *Molecular Biology of the Cell*, IV Edition.
- Cooper G. M. and Robert E. Hausman R. E. *The Cell: A Molecular Approach*, V Edition, ASM Press and Sinauer Associates.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- Karp, G. (2010) *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.

Major Course 14 (MJC-14)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Research Methodology	5	5	0

Common Syllabus of MJC -14 for all the subjects of the Faculty of Sciences has been separately prepared.

Major Course 15 (MJC-15)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Immunology and Microbiology	6	4	2

Course Outcomes: After the completion of the course, the student will be able:

- CO 1- To explain cells and organs of the immune system, innate and adaptive immunity.
- CO 2- To describe autoimmunity with reference to rheumatoid arthritis and tolerance and AIDS.
- CO 3- To understand antigens and its type, structure and functions of immunoglobulins, antigen-antibody interactions and immunoassays (such as ELISA and RIA).
- CO 4- To explain structure and functions major histocompatibility complex, know the concept of hypersensitivity and vaccines.
- CO 5- To understand the microbial basis of diseases.

MJC-15 : Immunology and Microbiology (Theory: 4 credits) 40 hours		
Unit	Topics to be covered	No. of Lectures
1	1. Basic Concept of immunity: 1.1 Overview of Immune System, Cells and organs of Immune system.	10

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	1.2 Innate and Adaptive Immunity - Anatomical barriers, Inflammation and Phagocytosis, Mechanism of cell and humoral mediated immunity, Active and Passive immunity.	
2	2. Antigen and Immunoglobulin: 2.1 Antigens; Antigenicity vs immunogenicity, Factors influencing immunogenicity, Adjuvants and haptens. 2.2 Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen-antibody interactions	8
3	3. MHC and Cytokines: 3.1 Major Histocompatibility Complex: Structure and functions of MHC I and II, Antigen processing and presentation. 3.2 Cytokines – Types and function.	6
4	4. Complement system and Vaccines: 4.1 Complement System: Components and pathways of complement activation. 4.2 Vaccines: Various types of vaccines.	6
5	5. Microbiology: 5.1 Bacteria; Structure, Classification, Growth, Culture and Pathogenicity. 5.2 Virus; Morphology and Pathogenicity. 5.3 A brief outline of endoparasitic diseases.	10
	TOTAL	40

MJC-15 : Immunology and Microbiology (Practical: 2 Credits) 20 hrs		
End Semester Examination		
Time – 3 hours		Full Marks-
		70
Sl. No.	Name of Practicals/Experiments	Marks
1	Determination of ABO blood group using ABD antisera method.	15
2	Study of lymphoid organs: (i) Kidney (ii) Spleen (iii) Bone marrow (iv) Lymph node	15
3	Comment upon working principle of RIA, Flow Cytometry, ELISA.	10
4	Culture and Gram staining of Bacteria	10
5	Practical/Project report on chick embryo development.	10
6	Viva- voce.	10

Suggested Books:

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition. W.H. Publication.

- David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology*, VII Edition, Mosby, Elsevier Edition. Saunders Publication.
- Abbas, K. Abul and Lichtman H. Andrew (2003.) *Cellular and Molecular Immunology*. V
- Owen J A, Punt J, Stanford S A (2013). *Kuby Immunology* W H Freeman & Co;
- Wood P. (2007). *Basic Immunology*. Pearson publication
- Principles of Microbiology, Ronald M. Atlas, Wm. C. Brown Publishers.
- Microbiology by Pelczar, M. J. Pelczar.

Minor Course 09

(MIC-09)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Animal Behaviour	3	2	1

Course Outcomes: After the completion of the course, the student will be able:

CO 1- To understand various pattern of animal behaviours such as stereotyped, instinct, learnt, associative behaviour along with operant conditioning and habituation imprinting and to explain the concept of social and sexual behaviour.

CO 2- To provide the concept of biological rhythm, photoperiod and regulation of seasonal reproduction of vertebrates and role of melatonin.

CO 3- To understand the relevance of biological clock in terms of chronopharmacology, chronomedicine and chronotherapy.

CO 4- To develop the skill in this course by performing practical works such as studying nest and nesting habitat of birds and social insects and other significant experiments.

MIC-09 : Animal Behaviour (Theory: 2 credits) 20 hours		
Unit	Topics to be covered	No. of Lectures
1	Introduction to Animal Behaviour: 1.1 Definition and types of behaviour 1.2 Origin and history of ethology.	5
2	Patterns of Behaviour: 2.1 Instinct behaviours. 2.2 Learned behaviours.	5
3	Biological Rhythm: 3.1 Biological clocks in animals and its adaptive significance. 3.2 Types of biological rhythms- Tidal, Lunar, Circadian and Circannual.	5
4	Social Behaviour: 4.1 Social behaviour in insects (Honey bee). 4.2 Parental care in fishes.	5
TOTAL		20

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Dr. Shri Sakshi
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Dr. Sakshi

- David O. Norris. Vertebrate Endocrinology. V Edition, Elsevier Academic press.
- Franklin F. Bolander. Molecular Endocrinology. III Edition, Academic Press, USA.

Online Tools and Web Resources:

- <https://www.endocrine.org/topics>

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Semester VIII
Major Course 16 (MJC-16)

Course Title	Credit	Credit Distribution	
		Theory	Practical
Instrumentation and Biometry	4	4	0

Course Outcomes: After the completion of the course, the student will be able:

- CO1:** To understand the principles and working of various instruments used in biological experimentation.
- CO2:** Gain insight of relationship between mathematics and biology
- CO3:** To present their data in statistically reliable form
- CO4:** To test their hypothesis using different models
- CO5:** To correlate their data with different factors

MJC-16: Instrumentation and Biometry (Theory: 4 credits) 40 hours		
Unit	Topics to be covered	No. of Lectures
1	1. Instrumentation: 1.1 Principle and uses of: pH meter, Colorimeter, Spectrophotometer, Centrifuge. 1.2 Microscopy: Light microscope, Compound microscope, Phase contrast, Fluorescent and Electron Microscope.	10
2.	2. Biological Techniques: 2.1 Electrophoresis - Agarose gel, SDS-PAGE electrophoresis. 2.2 Chromatography - Column, GLC. 2.3 Cell separation by density gradient centrifugation. 2.4 Introduction to different culture medium and tools used. 2.5 PCR 2.6 Recombinant DNA Technology	10
3	3. Introduction to Biometry: 3.1 Concept of data and graphical presentation of data. 3.2 Measures of central tendency: mean, mode and median. 3.3 Measures of dispersion, standard deviation, standard error. 3.4 Types of variables; Poisson, Binomial and Normal distribution. 3.5 Experimental design and hypothesis testing.	10
4	Tests of Significance: 4.1 Test of significance: t-test, F-test, chi square test 4.2 Multiple linear regression – ANOVA (One way and two-way ANOVA). 4.3 Correlation and simple linear regression 4.4 Karl-Pearson correlation coefficient and Ranks correlation coefficient	10
TOTAL		40

Suggested Books :

- AB Khanal (2016). Mahajan's Methods in Biostatistics for Medical Students and Research Workers. Jaypee Brothers Medical Publishers.

- Jerrold H. Zar (2009). Biostatistical analysis. Pearson publication.
- RC Elston and WD Johnson (2008). Basic Biostatistics for Geneticists and Epidemiologists. Wiley publication.
- Norman TJ Bailey (2000). Statistical Methods in Biology. Published by: Cambridge University Press
- Biological instrumentation and Methodology, P. K. Bajpai.
- Instrumentation: Theory and Application, S. Sheel.

Virtual Labs:

1. <http://www.vlab.co.in>
2. <http://zoologygysan.blogpost.com>
3. www.onlinelabs.in
4. www.labinapp.com
5. www.uwlax.edu
6. info@premiereducationaltechnologyies.com

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