SIDO KANHU MURMU UNIVERSITY, DUMKA

(A State University recognized under Section 2(f) & 12(B) of the UGC Act, 1956)

SYLLABUS

FOUR-YEAR UNDER GRADUATE PROGRAMME (FYUGP)
FOR
ZOOLOGY HONOURS/RESEARCH

(Zoology Major/Advance Major/Research)

Accordance with
The Implementation of FYUGP in State Universities of Jharkhand Regulations, 2024

Implemented from
Academic Session 2025-2029 Onwards

Board of Studies Meeting Proceedings

A meeting of the Board of Studies for the revision and finalization of the **ZOOLOGY HONS/RESEARCH/PG DIPLOMA** syllabus for the Four-Year Undergraduate Programme (FYUGP), in accordance with the Implementation of FYUGP in State Universities of Jharkhand Regulations, 2024, was convened on 09.10.2025
The following members of the Board of Studies were present in this meeting. The committee unanimously accepted and recommended the syllabi, incorporating major modifications.
Members of the Board of Studies:

S. N.	MEMBERS	SIGNATURE
1.	**Dr. Nilesh Kumar** HOD, Associate Professor, Univ. Dept. of Zoology, S.K.M.U., Dumka	09/10/25
2.	**Dr. Md. Equbal Ahmad** Univ. Professor, Univ. Dept. of Zoology, T.M.B. University Bhagalpur	09.10.25
3.	**Dr. Nirmala Tripathi** Assistant Professor, Univ. Dept. Of Zoology, SKMU, Dumka	Nirmala Tripathi 09.10.2025
4.	**Dr. Punam Hembrom** Assistant Professor, Univ. Dept. Of Zoology, SKMU, Dumka	9.10.25
5.	**Dr. Amita Hembrom** Assistant Professor, S. P. College Dumka, Dept. of Zoology, SKMU, Dumka	09 Oct 2025
6.	**Sunil Besra** Assistant Professor, S. P. College Dumka, Dept. of Zoology, SKMU, Dumka	———
7.	**Dr. Khushboo Tigga** Assistant Professor, Dept. of Zoology, S. P. Mahila College Dumka, SKMU, Dumka	Khushboo Tigga 09.10.2025
8.	**Pooja Soni** Assistant Professor, Dept. of Zoology, Deoghar College Deoghar, SKMU, Dumka	09/10/2025
9.	**Meenu Bala** Assistant Professor, Dept. of Zoology, Deoghar College Deoghar, SKMU, Dumka	Meenu Bala 09/10/2025
10	**Dr. Wasim Raza** Assistant Professor, Dept. of Zoology, Sahibganj College Sahibganj, SKMU, Dumka	9/10/25

09/10/25
Dr. Nilesh Kumar
Chairman

Semester wise Subject Combination for B.Sc. (ZOOLOGY)

Semester	Course Category	Code	Papers	Credits
First Semester	Major	MJ-1	Animal Kingdom, Non-chordates	4
	Associated Core/Associated Vocational	AC-1A	Select any one subject from the Associated Core Table with the guidance of the Class Teacher.	4
	Multidisciplinary Course	MDC-1	**Choose any one of the following:** • Mathematical and Computational Thinking Analysis • Gender Studies • Goods and Services Tax (GST) • Pollution Control and Waste Management	3
	Ability Enhancement Course	AEC-1	Hindi (Compulsory)	2
	Skills Enhancement Course	SEC-1	Introduction to Computer and IT (Compulsory)	2
	Value Added Course	VAC-1	Understanding India (Compulsory)	3
	Indian Knowledge System	IKS-I	Indian Knowledge System (Compulsory)	2
Second Semester	Major	MJ-2	Chordates	4
	Associated Core/Associated Vocational	AC-2B	Select any one subject either from the Associated Core subjects not studied in Semester-I or from the Associated Vocational subjects, with the guidance of the Class Teacher.	4
	Multidisciplinary	MDC-2	**Choose any one of the following:** • Nutrition and Health education • Digital Marketing • Introduction to Indian Values and Ethics • Santhal Tribes and Culture	3
	Ability Enhancement	AEC-2	English (Compulsory)	2
	Skills Enhancement	SEC-2	Digital Communication and Data Management (Compulsory)	3
	Value Added Course	VAC-2	Environmental Studies (Compulsory)	2
	Indian Knowledge System	IKS-2	Social Awareness (Compulsory)	2
Third Semester	Major	MJ-3	Cell Biology, Cell Signalling and Communication, Cell Division	4
		MJ-4	Evolution and Paleontology	4
	Elective Course	ELC-1A	Elective Paper-1 from the Chosen Associated Core Subject in Semester I	4
	Multidisciplinary	MDC-3	**Choose any one of the following:** • Indian Philosophy • Indian Cultural Studies • Kautilya's Arthashastra • Vedic Mathematics	3
	Ability Enhancement	AEC-3	**Select One Language Course:** Students must choose **one** of the following languages: **Hindi, English, Bangla, Sanskrit, Urdu, Santali, Persian, or Maithili.** **Note:** Students are required to study **Paper-I** of the language they choose.	2
	Skills Enhancement	SEC-3	Computer Software, Programming and AI(Compulsory)	3

Fourth Semester	Major	MJ-5	Indian Knowledge System in Zoology	4
		MJ-6	Endocrinology and Reproductive Biology	4
		MJ-7	Biochemistry and Mammalian Physiology	4
	Elective Course	ELC-1B	Elective Paper-1 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4
	Ability Enhancement	AEC-4	Paper-2 of Selected Language course in Semester-III	2
	Value Added Course	VAC-3	Health& Wellness, Yoga Education, Sports & Fitness (Compulsory)	2
Fifth Semester	Major	MJ-8	Developmental Biology	4
		MJ-9	Molecular Biology	4
		MJ-10	Ecology and Toxicology	4
		MJ-11	Genetics	4
	Elective Course	ELC-2A	Elective Paper-2 from the Chosen Associated Core Subject in Semester I	4
Sixth Semester	Major	MJ-12	Immunology	4
		MJ-13	Animal Behavior, Biotechnology	4
		MJ-14	Biostatistics and Economic Zoology	4
		MJ-15	Wildlife Conservation	4
	Elective Course	ELC-2B	Elective Paper-2 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

- In the fourth year, students have two pathways: they can either complete their graduation with **Honours**, or with **Honours with Research**.
- Those who wish to graduate with **Honours only** must follow **Table-A**, while those opting for **Honours with Research** must follow **Table-B**.

TABLE-A FOR HONOURS ONLY
FOURTH YEAR

Seventh Semester	Major	MJ-16	Comparative Anatomy of Vertebrates	4
		MJ-17	Tools and Techniques	4
		MJ-18	Histology and Histochemistry	4
	Advance Major	AMJ-1	Hematology and Instrumentation	
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4
Eighth Semester	Major	MJ-19	Microbiology	4
		MJ-20	GROUP DISCUSSION AND DISSERTATION	
	Advance Major	AMJ-2	Hematology and Instrumentation	4
		AMJ-3	Entomology OR FISH and Fisheries	4
	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

TABLE-B FOR HONS WITH RESEARCH
FOURTH YEAR

Seventh Semester	Major	MJ-16	Comparative Anatomy of Vertebrates	4
		MJ-17	Tools and Techniques	4
		MJ-18	Histology and Histochemistry	4
	Research Methodology	RM-1	Research Methodology	4
	Elective Course	ELC-3A	Elective Paper-3 from the Chosen Associated Core Subject in Semester I	4

Eighth Semester	Major	MJ-19	Microbiology	4
		MJ-20	GROUP DISCUSSION AND DISSERTATION	4
	Research Project/ Dissertation	RC-2	Research Project or Dissertation	8
	Elective Course	ELC-3B	Elective Paper-3 from the Chosen Associated Core/Associated Vocational Subject in Semester-II	4

Compulsory Summer Internship:

1. ***If a student exits after Semester II, IV, or VI:***

To receive a Certificate/Diploma/Bachelor's Degree, students must complete a summer internship/project/dissertation worth 4 credits. This should be done during the summer break of any semester within the first three years.
Note: The Certificate/Diploma/Bachelor's Degree will not be awarded without completing this internship.

2. ***If a student exits after Semester VIII:***

Under the National Education Policy (NEP), all students must complete a 4-credit summer internship to get a Bachelor's Hons/Hons with Research/P.G. Diploma Degree.
There are two ways to complete this requirement:

a. Two internships of 4 weeks each (2 credits each), or
b. One internship of 8 weeks (4 credits total)

The college will help arrange the internship, and students can complete it any time between Semester 1 and Semester 6 Summer Vacation.
Note: The Bachelor (Hons)/Hons with Research, or P.G. Diploma will not be awarded without completing the internship.

INSTRUCTIONS FOR QUESTION SETTER

1. **Semester Internal Examination Question Pattern** (15 Marks)

The **Semester Internal Examination (SIE)** will carry a total of **15 marks**, which includes **10 marks for the internal test** and **5 marks for class attendance**.

The remaining **5 marks** will be based on **class attendance**, as per the following:

- **Up to 45% attendance: 1 mark**
- **46% to 54%: 2 marks**
- **55% to 64%: 3 marks**
- **65% to 74%: 4 marks**
- **75% and above: 5 marks**

2. **End Semester University External Examination Question Pattern** (60 Marks)

The **End Semester Examination (ESE)** will be of **60 marks** and will also have **two groups**.

Group A (Compulsory):

Question 1: Five very short answer questions (1×5=05 marks)
Questions 2: Two short answer questions (5×2=10 marks)

Group B:

Questions 3: Five descriptive-type questions of **15 marks each**, out of which students must answer **any three** ((3 ×15=45 marks)

Note: Questions may have sub-parts if needed in the theory examination.

3. **End Semester University Practical Examination Question Pattern** (25 Marks)

The **End Semester Practical Examination (ESE)** will be of **6 hours duration**.

Students must score **at least 10 marks** to pass the practical examination.

Question format for **60 Marks**:

Subject/ Code

F.M. =60 **Time**=3Hrs. Exam Year

General Instructions:

i. **Group A** carries very short answer type **compulsory** questions.
ii. **Answer 3 out of 5** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]
3. ..... [5]

Group B

4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

PROMOTION CRITERIA

- All students will be promoted in odd Semesters (I, III, V & VII).
- To get a promotion from Semester II to Semester III, from Semester IV to Semester V, and from Semester VI to Semester VII a student has to procure a minimum of 4 CGPA.
- However, it will be necessary to obtain a minimum credit (4) to pass in each of the subjects individually before completion of the course.

CALCULATION OF MARKS FOR THE PURPOSE OF RESULT

The passing in a subject will be based on the combined marks obtained in both the internal and external examinations of the semester. However, the student must pass the theory and practical examinations separately.

FOUR YEAR UNDERGRADUATE PROGRAMME
SUBJECT: ZOOLGY
PAPER: MAJOR

U.G. SEM-I

MJ-ZOO-01, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objectives: The primary objective of the course in semester-I is to make acquaintance with different life forms (Non chordates) on earth and drive home the relationship between different living forms both at the genetic and the ecological level. It will provide an opportunity to have a novel branch of science dealing with identification and assigning exact position in animal kingdom.

ANIMAL KINGDOM AND NON-CHORDATES

UNIT-I

DIVERSITY OF LIFE FORMS:

1.1 An overview of animal kingdom
1.2 Concepts of species and hierarchical taxa
1.3 Basis of classification (Symmetry, protostomes & deuterostome, celom)
1.4 Zoological Nomenclature (binomial and trinomial)

NON-CHORDATES

1.5 General characters and classification up to class

Phylum Protozoa:

1.6 Type study: *Amoeba*
1.7 General Locomotion, Nutrition & Reproduction

Phylum Porifera:

1.8 Type study: *Sycon* (Morphology, Histology, Reproduction)
1.9 General Canal System
1.10 Types of spicules

Phylum Cnidaria/ Coelenterata:

1.11Type study: *Obelia* (Morphology, Reproduction)
1.12 Coral and Coral reefs

UNIT-II

Phylum Ctenophora:

2.1 Affinities

Phylum Platyhelminthes:
2.2 Type Study: *Fasciola hepatica* (life cycle)
2.3 General parasitic adaptation

Phylum Nemathelminthes:
2.4 Type Study: *Ascaris* (life cycle)
2.5 General parasitic adaptation

Phylum Annelida:
2.6 Type study: Earthworm (Digestive, Excretory, Circulatory, Nervous system)
2.7 Metamerism

UNIT-III
Phylum Arthropoda:
3.1 Type study: Prawn (Excretory, Nervous system)
3.2 Larval forms of Crustacea
3.3 Mouth parts in insects
3.4 Mosaic Vision (Prawn and Cockroach)

Phylum Mollusca:
3.5 Type study: *Pila* (Respiration)
3.6 Torsion and detorsion in Gastropod

Phylum Echinodermata:
3.7 Type study: *Asterias* (Water vascular system)
3.8 Larval forms of Echinoderms

Phylum Hemichordata:
3.9 Type study: *Balanoglossus* (General characters and affinities)

PRACTICAL of MJ-ZOO-01

Zoological names of some common animals.

DISSECTION:
1. General anatomy and Nervous system of Earthworm
2. Nervous system of Prawn
3. Nervous system of *Pila* / *Unio*

MOUNTING:
1. Earthworm: Spermathecae, Septal nephridia
2. Arthropoda: Statocyst of Prawn
3. Mollusca: Osphradium, Radula- *Pila*

STUDY OF SLIDES:
1. Protozoa: *Amoeba, E. histolytica*

STUDY OF MUSEUM SPECIMENS:

1. Porifera: *Sycon*
2. Coelenterata: *Hydra, Obelia*
3. Ctenophora: *Hormiphora*
4. Helminthes: *Taenia, Ascaris*
5. Annelida: *Pheretima*
6. Arthropoda: *Palaemon*, *Periplaneta*
7. Mollusca: *Unio, Pila*
8. Echinodermata: *Asterias*
9. Hemichordate: *Balanoglossus*

Examination pattern for ZOO-MJ-01 Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Dissection	06
02	Mounting	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Recommended books:

1. Invertebrate Zoology: Barnes, R.D. - (W.B. Saunders Co.)
2. Invertebrate structure and function: Barrington (Nelson)
3. Modern Textbook of Zoology: Invertebrate (Kotpal, Agarwal & Khetrapal, Rastogi Publication)
4. Invertebrate series – Protozoa to Minor phyla: R.L. Kotpal, Rastogi publication
5. Practical Zoology INVERTEBRATE- S.S. LAL
6. Biology of Non-Chordates: Nigam (1997, S Chand)
7. A textbook of Zoology, Parker & Haswell – VOL-I

Course Learning Outcomes: Having completed Semester-I, the students would develop an aptitude for classical Zoology which is integral part for understanding the life forms with a vision of comparative account of different systems of the animals. Without having wide spectrum knowledge of life forms, the concept of biodiversity will be hard to understand and especially, their identification. This paper will enable the students to create interest in animal world who will carry forward their knowledge to the future generations to unravel many mysteries of animal forms.

U.G. SEM-II

MJ-ZOO-02, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objectives: The primary objective of the course in semester-II is to make acquaintance with different life forms (Chordates/ Vertebrates) on earth and drive home the relationship between different living forms both at the genetic and the ecological level. It will provide an opportunity to have a novel branch of science dealing with identification and assigning exact position in animal kingdom.

CHORDATES

UNIT-I
1.1 General characters and classification up to orders

Phylum Urochordata:
1.2 Type study: *Herdmania* (Retrogressive metamorphosis)

Phylum Cephalochordata:
1.3 Type study: *Amphioxus* (Morphological and Anatomical features)

Phylum Chordates:

Class Cyclostomes:
1.4 Type study: *Petromyzon* (Morphological and Anatomical features)

Class Pisces:
1.5 Type study: *Scoliodon* and *Labeo* (Morphological and Anatomical features)
1.6 Dipnoi (Affinities, Morphological features)
1.7 Respiratory organs in fishes

UNIT-II
Class Amphibia:
2.1 Neoteny
2.2 Origin and ancestry of Amphibia

Class Reptiles:
2.3 Study of skull
2.4 Biting mechanism of snakes
2.5 Poisonous and Non-Poisonous snakes

Class Aves:
2.6 Origin of birds
2.7 Flight adaptations in birds

UNIT-III

Class Mammals:

3.1 Prototheria (distinctive characters, distribution and affinities)
3.2 Metatheria (distinctive characters, distribution and affinities)
3.3 Aquatic mammals (adaptations)
3.4 Dentition

PRACTICAL of MJ-ZOO-02

DISSECTION:

1. *Scoliodon*: General anatomy, Afferent blood vessel, Efferent blood vessels
2. Rat: General Anatomy

MOUNTING:

1. Scales of fishes: Placoid, Cycloid, Ctenoid
2. *Amphioxus:* Oral hood, Velum

STUDY OF MUSEUM SPECIMENS:

1. Urochordata: *Herdmania*
2. Cephalochordate: *Amphioxus*
3. Cyclostomes: *Petromyzon*, *Myxine*
4. Cartilaginous Fish: *Sphyrna*, *Dasyatis, Rhinobatos*
5. Bony Fish: *Labeo, Catla, Heteropneusteous, Hippocampus,*
6. Amphibia: *Ichthyophis, Hyla*
7. Reptiles: *Testudo, Crocodylus palustris*, *Draco, Chameleon, Naja, Python*
8. Aves: *Pavo cristatus*, *Columba livia*
9. Mammal: *Balaenoptera musculus*, *Oryctolagus cuniculus*

STUDY OF MUSEUM SPECIMENS:

1. Types of bird feathers
2. Types of teeth in Mammals

Examination pattern for ZOO-MJ-02 Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Dissection	06
02	Mounting	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Recommended books:

1. RL Kotpal: Modern Textbook of Zoology VERTEBRATE
2. Young, J. Z: Life of Vertebrates (Oxford University Press)
3. Hildebrand: Analysis of Vertebrates Structure (Wiley)
4. Practical Zoology VERTEBRATE- S.S. LAL
5. Nigam: Biology of Chordates (1997, S Chand)
6. Parker & Haswell: Text Book of Zoology, Vol. II (2005, Macmillan)

Course Learning Outcomes: Having completed Semester-II, the students would develop an aptitude for classical Zoology which is integral part for understanding the life forms with a vision of comparative account of different systems of the animals. Without having wide spectrum knowledge of life forms, the concept of biodiversity will be hard to understand and especially, their identification. This paper will enable the students to create interest in animal world who will carry forward their knowledge to the future generation to unravel many mysteries of animal forms.

U.G. SEM-III

MJ-ZOO-03, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objectives: Course Objectives: The Cell Biology aims at deciphering the intricate organization of cells, including their organelles, membranes and macromolecules, and how these organelles work together. Their communication with each other and the environment through signaling pathways will be conveyed to the students. Emphasis on membrane structure and function including membrane potential, cytoskeleton and cell signaling has been incorporated in cell biology paper as a corollary to the in-depth teaching of this paper at graduation level.

CELL BIOLOGY, CELL SIGNALING AND COMMUNICATION, CELL DIVISION

UNIT-I
CELL BIOLOGY:
1.1 Prokaryotic and eukaryotic cell

Ultra structure and function of cell organelles
1.2 Nucleus
1.3 Mitochondria
1.4 Golgi complex
1.5 Endoplasmic reticulum
1.6 Lysosome
1.7 Ribosome

Cell membrane / Plasma membrane
1.8 Structure and composition
1.9 Cell junction (Occluding junctions (Tight junctions), anchoring junctions (desmosomes) and communicating junctions (gap junctions).
1.10 Ion channels and gates
1.11 Transport of molecules

UNIT-II
CELL SIGNALING AND COMMUNICATION
2.1 Cell signaling molecules (Hormone, Neurotransmitter, Local Transmitter and Pheromones)
2.2 Types of signaling (Autocrine, Paracrine, Endocrine, Juxta-Crine)

2.3 Types of cell receptors (Plasma Membrane Receptor, Nuclear Receptor)
2.4 Signaling pathway types (Introduction)

UNIT-III
CELL DIVISION
3.1 Cell cycle
3.2 Mitosis
3.3 Meiosis

PRACTICAL for MJ-ZOO-03

TEMPORARY SLIDE PREPARATION:

Identification of Mitochondria in human buccal epithelium-vital staining by Janus green.

CELL BIOLOGY: STUDY OF PERMANENT SLIDES

1. Stages of Mitosis
2. Stages of Meiosis

CELL BIOLOGY: SLIDE PREPARATION

1. Stages of mitosis by acetocarmine staining in onion root tip (squash preparation)
2. Different stages of meiosis by acetocarmine staining in grass hopper testis (squash preparation)
3. Polytene chromosome in *Chironomous* larva

Examination pattern for MJ-ZOO-03 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Temporary slide preparation	06
02	Spotting	3×3=09
03	Project (Assignment/Model/Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course Outcomes: The cell biology taught in this semester further enables the students to venture out in some interesting fields like bioenergetics, cell signaling, membrane transport system etc. Students will be able to identify and describe the structure and functions of various organelles which will boost their efforts in pursuing research in these fields.

Recommended Books:

CELL BIOLOGY, CELL SIGNALLING

1. Cell and Molecular Biology. De Robertis
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell (4th ed.). Garland Science.
3. Cell Communication and signaling, evidence of design. (n.d.). Reason and science. Catsboard.Com
4. Cooper, G. M. (2000a). Pathways of Intracellular Signal Transduction. In The Cell: A Molecular Approach. 2nd edition. Sinauer Associates.
5. Cooper, G. M. (2000b). Signaling Molecules and Their Receptors. In The Cell: A Molecular Approach. 2nd edition.
6. Campbell Biology, 12th edition, (Urry, Cain, Wasserman, Minorsky, Orr)- Pearson
7. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
8. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Ed, W.H. Freeman and Co., New York.
9. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009,). Harper's Biochemistry (25th ed. 2000, Appleton & Lange)
10. Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
11. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
12. Boyer: Concepts in Biochemistry (3rd ed. 2006, Brooks/Cole)

Conn, Stumpf, Bruening & Doi: Principles of Biochemistry (5th ed. 1987, Wiley)

MJ-ZOO-04, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objective: to explain the evolution of species along with biochemical evolution is of utmost importance and therefore this section has been incorporated to experience evolutionary time scale which is fundamental in understanding evolution of various life forms over time with respective driving force. Predicting future evolution will be possible, based upon a comprehensive understanding of evolutionary theories and forces as well.
Paleontology will enable the students in reconstructing the past environment and earth's history with periodical mass extinction events. The exploration of natural resources like oil & gas in this endeavor will be proved as additional privilege for the learners.

EVOLUTION AND PALAEONTOLOGY

UNIT-I
EVOLUTION
Origin and evolution of life on earth
1.1 The evolutionary time scale: Eras, Periods and Epoch
1.2 Major events in the evolutionary time scale
1.3 Origins of unicellular and multi cellular organisms
1.4 Theories of Evolution - Darwinism, Neo Darwinism, Lamarckism, Neo Lamarckism, Synthetic theory of Evolution
1.5 Homologous and analogous organs
1.6 Adaptive modification
1.7 Convergent and Divergent evolution
Principles of Population genetics
1.8 Population genetics, Gene pool, Gene Frequency
1.9 Hardy – Weinberg law (statement and derivation of equation, application of law to human population),
1.10 Natural selection
1.11 Genetic Drift

UNIT –II
Evolutionary process
2.1 Macro and Micro evolution
2.2 Species concept
2.3 Isolating mechanism
2.4 Modes of speciation- Allopatric, Sympatric, Parapatric

UNIT-III
Paleontology
3.1 Types of fossils
3.2 Formation of fossils
3.3 Evolution of Horse
3.4 Evolution of Man.

PRACTICAL for MJ-ZOO-04

1. Study of Analogous organs (wings of butterfly, bird and bat)
2. Study of Serial Homology in appendages of prawn
3. Study of Adaptive Radiation in beaks of birds
4. Study of Adaptive Radiation in feet of birds
5. Study of Adaptive Radiation in dentition of mammal

Examination pattern for MJ-ZOO-04 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Evolution	06
02	Spotting	3×3=09
03	Project (Assignment/Model/Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course outcome: The molecular explanation of evolution can be better explained for future utility among the beneficiary groups. Both the topics will enable the students to conceptualize the importance of conservation and protection of biodiversity. Understanding earth's history, tracing lineage, adaptation and extinction will bring about breakthrough in evolutionary science in hypothesizing a new concept of evolution.

Recommended Books:

EVOLUTION

1. Strik Berger, M.W. Evolution, Jones & Bartett. Publishers, Boston, London
2. An Introduction to Paleontology –A.P. Tyagi (S. Chand & Com. LTD)
3. Hall and Hallgrimsson: Strickberger's Evolution (2008, Jones and Bartlett)
4. Moody: Introduction to Evolution (1978, Kalyani).
5. Rastogi: Organic Evolution (2007, Kedarnath & Ramnath)
6. Futuyma: Evolutionary Biology (2005, Sinauer)

U.G. SEM-IV

MJ-ZOO-05, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The maiden effort of NEP 2020 to glorify the ancient knowledge system of India in the field of science and rest academic realm, is a welcome step. This has been introduced with an objective to foster a deeper connection with the past to assess the milestone and pace of development in academic world in order to bridge the gap between ancient wisdom and modern scientific & educational approaches. It will be helpful in revitalizing our ancient treasures concealed in ancient practices such as Ayurveda & Yoga and sacred scriptures out of which some are made part of zoology at undergraduate level.

INDIAN KNOWLEDGE SYSTEM

UNIT-I
1.1 Introduction to Indian Knowledge System (IKS)
1.2 Overview of IKS
1.3 Classification, Unique features and importance
1.4 Relevance of the IKS in modern Zoology

UNIT-II
2.1 Splendid geographical isolation of India and its unique faunal diversity
2.2 IKS of animal keeping to human socio- economic and ecological welfare
2.3 Use of Animal parts and products to cure common human ailments (home remedies) in Ancient Indian texts

UNIT-III
Ethno-Zoology in Indian Traditions
3.1 Animal reference in ancient Indian texts
3.2 Cultural significance of animals highlighted by traditional arts and festivals
3.3 Cultural aspect: tribal totem culture in India

PRACTICAL for MJ-ZOO-05

Examination pattern for MJ-ZOO-05 Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01.	Case study / Project to be assigned by teacher	15
02.	Viva	10
	TOTAL	**25**

Course Outcomes: The Indian Knowledge System (IKS) offers valuable insights into zoology encompassing traditional classification systems, ecological principles and conservation techniques rooted in Indian texts and practices. This will enable the students in integrating traditional ecological knowledge and conservation techniques to evolve as a tool for sustainable development and balanced ecosystem around us with cost-effective methods enriched with plethora of knowledge since the ancient time.

Recommended Books:

INDIAN KNOWLEDGE SYSTEM

1. Indian Knowledge Systems Vol. I & II – IGNCA, Delhi
2. Animals in Indian Tradition – Kapila Vatsyayan
3. Cow in Indian Culture and Ayurveda- Vaidya B. Gokhale
4. Environment and Ecology in Ancient India- D.N. Jha

MJ-ZOO-06, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The course has been designed to throw light upon the structures and functions of various endocrine glands with occurrences of maladies associated with their malfunctioning. A wide range of hormones has been incorporated to make a coherence with their interplay in metabolic pathways.
The fundamental understanding of race continuation with intricacies of reproductive processes with evolution in the animal world has been underscored. The hormonal interactions during implantation, pregnancy and parturition need to be understood to break the shackles of taboo associated with such discussion. Many social issues related to reproduction such as population growth and gender equality can be addressed by having comprehensive knowledge of this section.

ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

UNIT-I
ENDOCRINOLOGY

1.1 Overview of endocrinology
1.2 Hypothalamus (releasing hormone and inhibitory hormones with function)
1.3 Structure, location and function of Endocrine glands (Pituitary, Pineal, Thyroid, Parathyroid, Islet of Langerhans, Adrenal, Testis, Ovary)
1.4 Hormonal dysfunction and diseases (Dwarfism, Acromegaly and Acromicria, Goiter, Grave's Disease, Addison's disease, Cushing syndrome, Diabetes mellitus, Diabetes insipidus)

UNIT-II

2.1 Hormone and its classification

2.2 Modes of hormone delivery: Endocrine, Apocrine, Paracrine and Merocrine

2.3 Mechanism of Peptide hormone (Insulin)

2.4 Mechanism of Steroid Hormone

UNIT-III

HUMAN REPRODUCTIVE BIOLOGY

3.1 Male reproductive system

3.2 Female reproductive system

3.3 Reproductive cycle and their hormone regulation: Menstrual cycle, Estrous cycle

PRACTICAL for MJ-ZOO-06

1. **Model**: Location of Endocrine glands in rat.
2. Study of estrous cycle in laboratory female rat.
3. **Study of permanent Slides:**
   - T.S. of Pituitary
   - T.S. of Parathyroid
   - T.S. of Thyroid
   - T.S. of Pancreas (Islets of Langerhans)
   - T.S. of Adrenal
   - T.S. of Testis
   - T.S. of Ovary
4. **Hormone testing:**
   - Test for hCG in urine sample of mammal
   - Test for LH in urine sample of mammal

Examination pattern for MJ-ZOO-06 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Hormone test	03
02	Spotting	4×3=12
03	Project (Assignment/Model/Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course Outcomes: This course will help in advancing our knowledge on comparative endocrinology to reveal the course of evolution of endocrine system in different vertebrate groups. It also enables the students to develop a concept of endocrine control of metabolism and significance of hormones as neurotransmitter. Understanding the hypo and hyper activities of endocrine glands will have clinical significance as well. Reproductive biology on the other hand will utilize the pre-existing knowledge of hormones as taught in the previous section. Particularly the male and female reproductive systems details ought to be understood for understanding the complexity involved in the developmental process.

Recommended Books:

ENDOCRINOLOGY AND REPRODUCTIVE BIOLOGY

1. Endocrinology - Hadley.
2. General Endocrinology - Bagnara, and Turner (W.B. Saunders)
3. Endocrinology - Hadley'(Prentice Hall)
4. E.J.W. Barrington - General & Comparative Endocrinology, Oxford, Clarendon Press.
5. P.J. Bentley, Comparative Vertebrate Endocrinology, Cambridge University Press.
6. R.H. Williams - Text Book of Endocrinology. W.B. Saunders.
7. C.R. Martin - Endocrine Physiology, oxford.
8. A Gorbman et al. Comparative Endocrinology. John Willey & Sons

MJ-ZOO-07, CREDIT=04 (100 Marks)

THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: This paper is pivotal in understanding any branch of zoology as the structure as well as function of biomolecules provide a solid substratum which encourage the students to think on molecular basis to reach a logical conclusion. Bioenergetics, metabolism, molecular biology, bioinformatics and even evolution call for solid background of biochemistry to explain and decipher the hidden complexity of the concerned topic. This encompasses exploration in acquiring chemistry of biomolecules like proteins, lipids, carbohydrates and nucleic acids, as well as their roles in cellular and metabolic processes. The primary objectives of teaching physiology are to make the students understand how a living organism functions from molecular and cellular levels to the organ and whole-body levels. It will also throw light on the functioning of different systems such as digestive, circulatory, respiratory, excretory, nervous etc. as individual entities and integrated whole.

BIOCHEMISTRY AND MAMMALIAN PHYSIOLOGY

UNIT-I

BIOCHEMISTRY:

1.1 Composition, structure, classification and function of biomolecules (Protein, Carbohydrate and Lipid

1.2 Enzyme: Classification and function

1.3 Vitamins: Types, Sources and Deficiency Diseases

1.4 Minerals: Types and Deficiency Diseases

UNIT-II

METABOLIC PATHWAYS:

2.1 Glycolysis

2.2 Glycogenesis

2.3 Gluconeogenesis

2.4 Krebs Cycle

2.5 β-oxidation of fatty acids.

UNIT-III

MAMMALIAN PHYSIOLOGY

3.1 Digestion (GIT and associated glands) and Absorption (Carbohydrate, Protein and Lipid)

3.2 Respiration (Anatomy of respiratory system, Mechanism and Control of Breathing, Transport of Gases)

3.3 Circulation (Anatomy of Mammalian heart, Cardiac cycle and ECG, Composition of Blood and Lymph, Blood Clotting mechanism, Blood Group – ABO)

3.4 Nervous System (Structure of Neuron, Nerve conduction, Reflex action)

3.5 Excretion (Structure and function of Kidney, Mechanism of Urine formation, electrolyte balance, acid-base balance)

3.6 Muscle contraction

3.7 Nerve conduction

PRACTICAL of MJ-ZOO-07

BIOCHEMISTRY

1. Test for Carbohydrate – Iodine test, Benedict's test
2. Test for Protein - Biuret test, Millon's test
3. Test for Lipid – Solubility test, Acrolein test
4. Effect of temperature and pH on salivary amylase enzyme activity

MAMMALIAN PHYSIOLOGY

1. Preparation and staining of blood film.
2. RBC total count.
3. WBC total count
4. Estimation of Haemoglobin
5. Bleeding and clotting time.
6. Blood pressure estimation by using sphygmomanometer.
7. Blood sugar estimation by using Glucometer

Examination pattern for MJ-ZOO-07 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Biochemistry test	2×4=8
02	Mammalian physiology	2×3.5=7
03	Project (Assignment / Model / Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course Outcomes: In-depth knowledge of biochemistry enables the students to understand the entire molecular biology in analytical way. They can reveal and correlate the entire phenomenon in respect of structure and function of biomolecules and metabolic pathways in a lucid manner. This seems to be the genesis of all molecular biology. The fundamentals of physiology along with intricacy involved in sustaining the life have given importance in this

paper. This is of utmost importance to understand the functioning of different organ systems which will be very beneficial for future research and even makes the students better equipped in dealing with present sporadic epidemiological outbreaks in the world.

Recommended Books:

PHYSIOLOGY

1. Human Physiology- C.C. Chatterejee
2. Review of Medical Physiology, Ganong (Lange)
3. Animal Physiology - Neilsen (Cambridge)
4. Animal Physiology - Eckert, R. (W. H. Freeman)
5. Review of Medical physiology, Ganong (Lange)
6. Reproductive Physiology - (Nalbandov, A.V.)
7. General & Comparative Physiology - Hoar (Prentics Hall)
8. Animal Physiology - Neilsen (Cambridge)
9. Comparative Animal Physiology - Progser (Satish Book Enterprise)

BIOCHEMISTRY

1. Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
2. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Ed, W.H. Freeman and Co., New York.
3. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009,). Harper's Biochemistry (25th ed. 2000, Appleton & Lange)
4. Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
5. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
6. Boyer: Concepts in Biochemistry (3rd ed. 2006, Brooks/Cole)
7. Conn, Stumpf, Bruening & Doi: Principles of Biochemistry (5th ed. 1987, Wiley)

UG SEM-V

MJ-ZOO-08, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: Development biology course has manifold impact on the students in unravelling mystery of life and arrival on the earth from a single cell to a gigantic organism having billions and trillions of cells. This will further unfold the intricacies of genetic, cellular and molecular processes involved in this transformation.

DEVELOPMENT BIOLOGY

UNIT-I
1.1 Types of eggs and cleavage patterns
1.2 Gametogenesis: spermatogenesis and oogenesis
1.3 Fertilization
1.4 Parthenogenesis

UNIT II
2.1 Gastrulation: Invagination, Involution, Ingression, Delamination, Epiboly
2.2 Types of coelom and its theory
2.3 Extra embryonic membranes (chick)
2.4 Fate of Germ Layers

UNIT-III
3.1 Implantation of embryo in humans
3.2 Gestation period in vertebrates
3.3 Placenta: Structure, Types and Function
3.4 Metamorphosis in frog and insect

PRACTICAL of MJ-ZOO-08

1. Study of permanent slide: Morula, Blastula, Gastrula stages of frog embryo
2. Study of whole mounts of developmental stages of chick through permanent slides:
   - Primitive streak (13 and 18 hours),
   - 24 hours

- 36 hours
- 48 hours
- 72 hours
- 96 hours

3. Study of different types of placenta (photomicrograph/ slides)
4. Study of Oogenesis (photomicrograph)
5. Study of spermatogenesis (photomicrograph)

Examination pattern for MJ-ZOO-08 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Study of model through photomicrograph	06
02	Spotting	3×3=09
03	Project (Assignment/Model/Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course outcome: After successful completion of this course, students will be able to develop practical skills using model organisms in developmental biology. Not only this, students will also be able to see developmental programs of different organisms. They will be able to find fundamental concept of embryogenesis and organogenesis.

Recommended Books:

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

MJ-ZOO-09, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objective: This course has been designed to provide a comprehensive understanding of molecular basis of life, focusing on the structure, function, and interactions of DNA, RNA and Proteins as well as their cellular functions they govern. The fundamentals of molecular biology are essential as they pave the way to understand almost all molecular processes of the cell including its departure from normal function leading to so many morbidities including cancer itself. A composite idea of genetics and molecular biology seems necessary to explain the evolution of species along with biochemical evolution.

MOLECULAR BIOLOGY

UNIT I:

1.1 Structure of nucleic acids (DNA & RNA): N-bases, Pentose sugar, Nucleosides & Nucleotides

1.2 DNA: Watson-Crick model of DNA, Types of DNA (A, B & Z), Base pairing

1.3 DNA synthesis in Prokaryotes & Eukaryotes: Semi-conservative DNA replication, Replication fork, DNA polymerases, Phases- initiation, elongation and termination.

1.4 Errors in DNA and their repair (base excision repair & nucleotide excision repair), Homologous recombination.

UNIT II:

2.1Transcription in Prokaryotes & Eukaryotes: Consensus sequences, Promoter, RNA polymerases

2.2 Phases- initiation, elongation and termination.

2.3 RNA processing of mRNA. Regulation genes. Introduction of peripheral dogma.

2.4 RNA: RNA hypothesis, Chemistry of RNA, types of RNA (mRNA, rRNA, tRNA, snRNA), Structure of mRNA & tRNA (clover-leaf model), Basics of RNA edit, RNAi.

UNIT III:

3.1 Genetic codes: History of genetic codes, Features of genetic codes, Wobble hypothesis, Central dogma.

3.2 Translation in E. coli: Translation factors, charging of tRNAs, Phases-initiation, elongation and termination.

3.3 Operon concept: Operon and its types, Lac operon – inducible, constitutive & non-inducible.

PRACTICAL of MJ-ZOO-09

1. Model study: N-bases, Pentose sugar, Nucleosides & Nucleotides in DNA
2. Study of DNA model
3. Isolation of DNA from blood sample
4. Spectrophotometric analysis of given sample (protein)

5. Separation of amino acids from mixture by chromatography

Examination pattern for MJ-ZOO-09 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Molecular Biology	3×5=15
02	Project (Assignment/Model/Collection)	03
03	Practical Records	04
04	Viva	03
	TOTAL	**25**

Course Outcomes: The key learning outcomes include fundamental knowledge of biomolecules such as DNA, RNA., Proteins, DNA replication, and repair, gene expression and central dogma concept. Students will be able to analyze and interpret experimental data related molecular biology and undertake research in this field as their future endeavor.

Recommended Books:

CELL BIOLOGY AND MOLECULAR BIOLOGY

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Molecular Biology of the Gene - Watson, J.D et al (Benzamin / Commings)
5. Lehninger Principles of biochemistry: Cox & Nelson, MacMillan & Freeman, USA
6. Cell Biology- C.B. Pawar (Himalaya publishing house)

MJ-ZOO-10, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objective: The objective of this course is to make awareness among the young students about the surrounding environment, the impact of climate change and its mitigation, and biodiversity. This will enable them to tide over the adverse environmental situation and their participation in disaster management.

ECOLOGY AND TOXICOLOGY

UNIT-I
ECOLOGY

1.1 Concept of ecology
1.2 Biosphere: Lithosphere, Hydrosphere, Atmosphere
1.3 Ecosystem: Structure and function of ecosystem
1.4 Types of ecosystems, Food chain, Food web, Ecological pyramids
1.5 Introduction to Biome: Ecological features of Tundra, Desert, Savannah and Tropical Rain Forest Biomes.

UNIT-II

2.1 Energy flow through the ecosystem
2.2 Nutrient and Biogeochemical cycle (carbon, nitrogen, phosphorus)
2.3 Population: Population Density, Natality, Mortality, Life tables, Fecundity tables, Survivorship curves, Age ratio, Sex ratio, Dispersal
2.4 Community: Species richness, Dominance, Biodiversity, Abundance, Vertical stratification; Ecotone and Edge effect
2.5 Types of interaction: commensalism, proto-cooperation, symbiosis, mutualism, parasitism, predation and competition
2.6 Ecological succession: Definition, Process, types, theories of succession.
2.7 Pollution and their control: Water, Air, Noise and Soil

UNIT-III
TOXICOLOGY

3.1 Basic concepts of Toxicology
3.2 Basic terminology: Toxin, Toxicity, Dose
3.3 Different routes of exposure of toxicants
3.4 Toxic agents and their classification: Chemicals, Pesticides, Herbicides, Fertilizers, Heavy metals, Food additives, Radioactive substances

ECOLOGY

1. Limnological studies of Pond- Temperature, pH, Dissolved oxygen, Turbidity
2. Study of Zooplankton in pond ecosystem
3. Characteristics of soil samples: color, texture,
4. Analysis of soil sample: pH, Moisture and water holding capacity of soil samples
5. General ecological survey of- Pond / Riverine / Grass land/ Forest ecosystems of your locality -survey report

TOXICOLOGY

1. Study of surfacing time and opercular beating of *Clarius batracus* under the different doses of any toxicants
2. Study of surfacing time and opercular beating of *Clarius batracus* under the two different toxicants
3. List the common food additives present in packaged food you purchase.
4. List the common household Chemicals toxic to living beings.

Examination pattern for MJ-ZOO-10 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Ecology	06
02	Toxicology	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course outcome: Course Outcomes: Students will be exposed to the fundamental aspects of ecology. They will get idea about the impact of anthropogenic activities on the environment. Students will get idea about the natural resources and their conservation. Above all, once they finish their courses, they are supposed become crusaders of sustainability of the environment and its conservation. They would feel connected with the environment. It will provide an opportunity in finding place in government bodies which are looking after environmental management besides probable job opportunity in industrial sector.

Recommended Books:

ECOLOGY

1. Odum and Barrett, Thomson, Ed. Brooks/Cole, Fundamentals of Ecology, Cengage Learning
2. Ecology, Environment and Resources Conservation: Singh, Singh and Gupta Ed., Anamaya Pub., New Delhi

3. Odum, E.P., Basic Ecology, Ed. Saunders College Pub.
4. Fundamentals of Ecology - Odum - (Saunders)
5. Krebs. C.J. Ecology - Harper & Row-N. York.
6. BIOS Instant Notes ECOLOGY
7. Concept of ecology- Kormondy
8. Textbook of environmental studies-Bharucha
9. Fundamentals of Environmental Biology-B. Mukherjee
10. Fundamentals of ecology- MC Das

TOXICOLOGY

1. Paul Schmid-Hempel. The Integrated Study of Infections, Immunology, Ecology, and Genetics (Oxford Biology), 2011
2. Paul Schmid-Hempel. The Integrated Study of Infections, Immunology, Ecology, and Genetics (Oxford Biology), 2011

MJ-ZOO-11, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objective: This section chiefly includes various ways of inheritance and enable the students to understand how the traits are passed through generations and how these traits are expressed. This will also enable the students in gene mapping and speculate interactions of genes as well. The comprehensive knowledge will help the students to find niche in the fields of medicine and agriculture and thus becoming a potential means of livelihood.

GENETICS

UNIT-I

1.1 Concept of gene, gene locus, allele, multiple alleles, pseudo allele

1.2 Mendel's law

1.3 Extension of Mendelism: Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Penetrance, Expressivity

UNIT-II

2.1 Gene inheritance pattern: Sex-linked inheritance, Sex-influenced inheritance, Sex-limited inheritance

2.2 Cytoplasmic inheritance: Criteria for extra-chromosomal inheritance, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium*, Maternal effects in snail

2.3 Environmental and Chromosomal mechanisms of sex determination in animals (*Drosophila*, Reptiles, Fowl, Man)

UNIT-III

3.1 Linkage and crossing-over

3.2 Structural and numerical alterations of chromosomes

3.3 Gene mutation

PRACTICAL of MJ-ZOO-11

GENETICS

1. Study of phenotypic traits in *Drosophila*
2. Demonstration of Mendelian monohybrid cross in *Drosophila*
3. Demonstration of Dihybrid cross in *Drosophila*
4. Demonstration of sex-linked inheritance in *Drosophila* making a cross between white eye and wild type flies
5. Human karyotype
6. Human karyotype disorders:
    - Down syndrome
    - Klinefelter syndrome
    - Turner syndrome

7. Pedigree analysis (Color blindness, Hemophilia, male pattern baldness, plumage patterns in birds-peacock, Sickle Cell Anemia)

Examination pattern for MJ-ZOO-11 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Genetics	2×4.5=09
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course outcome: Since classical genetics is the oldest discipline in the field of genetics, it provides essential groundwork for the development of modern molecular genetics. The greatest outcome will be in contemplating single gene related many diseases, thus equipping the students with this knowledge in counselling for prediction and prevention of many diseases, inborn errors of metabolism besides selective breeding for a desired trait in the field of agriculture.

Recommended books:

GENETICS

1. Molecular biology of Gene: Watson et al., Pearson Publication, USA
2. Strickberger's Genetics, Prinitis Hall of India (PHI), Delhi
3. Principles of Genetics: Snustad& Simmons, John Wiley & Sons, USA
4. Modern Genetics Analysis: Integrating Genes and Genomes, Griffith et al., W. H. Freeman & Company, USA
5. Genetics: Russell & Benjamin, Cummings Publishing Company, USA.
6. Genetics: PK Gupta, Rastogi Publication, New Delhi.
7. Gene regulation: Latchmann, Taylor & Francis, USA
8. Genetics**:** Benjamin A pierce

UG SEM-VI

MJ-ZOO-12, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The lecture-discussion part is conceptualized with the aim that students are taught the basics of immunology to develop understanding of the subject as how the immune system works. The objective lies with resolving a pertinent question, "What are the molecular and cellular components and pathways that protect an organism from various antigenic agents?" The comprehensive course will answer these questions as it explores the structure, function and genetics of the components of immune system.

IMMUNOLOGY

UNIT-I

1.1 Overview of Immune System
1.2 Cells and organs of the Immune system
1.3 Innate Immunity: Anatomical barriers, Inflammation, Cell and molecules involved in Innate Immunity
1.4 Adaptive immunity: Cell mediated and Humoral
1.5 Passive Immunity and Active Immunity

UNIT-II

2.1 Antigen
2.2 Immunoglobulins: Structure and functions of different classes of Immunoglobulins
2.3 Antigen-Antibody interactions
2.4 Major Histocompatibility Complex (MHC): Structure & function of MHC molecules.

UNIT-III

3.1 Cytokines: Types, Properties and functions of Cytokines.
3.2 Immunoassays (ELISA and RIA).
3.3 Vaccines: introduction and various types of vaccines.

PRACTICAL of MJ-ZOO-12

1. Demonstration of lymphoid organs through photomicrograph.
2. Study of Histological slides: T.S. of spleen, T.S. of thymus and T.S. of lymph nodes
3. Preparation of stained blood film to identify various types of white blood cells.
4. ABO blood group determination.
5. Principle and uses of direct, indirect, sandwich, competitive ELISA

6. Principle and applications of RIA
7. List of Vaccine- National Immunization Schedule (NIS) for Infants, Children and Pregnant Women

Examination pattern for MJ-ZOO-12 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Immunology	4.5×2=09
02	Spotting	3×2=06
03	Project (Assignment/Model/Collection)	03
04	Practical Records	04
05	Viva	03
	TOTAL	**25**

Course outcome: The course encourages the students to exploit research and development opportunities for therapeutic intervention arising from recent advances in immunology. Upon completion of the course students have a sound understanding of the essential elements of the immune system, preparing them to engage further in this rapidly evolving field. The students will be able to identify the cellular and molecular basis of immune responses and understand how the innate and adaptive immunities coordinate to fight invading pathogens. It helps in understanding strategies essential for suppressing or activating immune responses as required in hypersensitivity reactions, transplantation, autoimmune diseases and cancer.

Recommended Books:

IMMUNOLOGY

1. Kuby - Immunology W.H. Freeman, USA.
2. BIOS Instant Notes in Immunology
3. Kindit, T.J., Golds by R.A., Osborne, B.A. and Kuby, J (2006). Immunology, VI Edition. W.H. Freeman and Company.
4. David, M., Jonathan, B., David, R.B. and Ivan R. (2006). Immunology, VII Edition, Mosby, Elsevier Publication.
5. Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology. V edition. Saunders Publication.

MJ-ZOO-13, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course objective: This section has been incorporated with an idea of understanding animal behavior, ethology, a bit different from social behavior that is often referred and understood by the people. This underscores the stimuli and respective responses as the core concept for explaining different types of behavior.

ANIMAL BEHAVIOUR, BIOTECHNOLOGY

UNIT-I

ANIMAL BEHAVIOR

1.1 Innate behavior and learned behavior
1.2 Communication in animals (Methods of animal communication, Pheromone)
1.3 Aggressive behavior in animals
1.4 Migration in fishes and birds
1.5 Parental care in fishes and amphibia
1.6 Schooling in fishes
1.7 Nesting and brooding behavior in birds
1.8 Social behavior in insects (honey bee and termite)

BIOTECHNOLOGY

UNIT-II

2.1 Importance and application of biotechnology
2.2 Principle of recombinant DNA technology
2.3 Enzymes in rDNA technology: Restriction endonucleases, polymerases, ligase
2.4 Gene transfer: Transformation, Episomes, Plasmid, other cloning vector
2.5 Polymerase Chain Reaction
2.6 Biotechnological tools and techniques: Basic principles of electrophoresis
2.7 Blotting (Northern and Southern hybridization)

UNIT-III

3.1 DNA fingerprinting and its uses
3.2 DNA sequencing
3.3 Genetically modified animals and their importance
3.4 Therapeutic products produced by genetic engineering- blood proteins, human hormones, vaccines

PRACTICAL of MJ-ZOO- 13

STUDY OF MUSEUM SPECIMEN

1. Specimen showing Parental care in Fish *Hippocampus*
2. Specimen showing Parental care in Amphibia *Ichthyophis*
3. List 5 migratory Fishes
4. List 5 migratory Birds
5. Identification of 5 types of nests of Indian Birds

BIOTECHNOLOGY

1. Study of principle and uses of PCR
2. Study of principle and uses of DNA fingerprinting
3. Study of principle and uses of DNA recombinant technology
4. Study of principle and uses of Northern blotting
5. Study of principle and uses of Southern blotting
6. List of Common Genetically modified animals

Examination pattern for MJ-ZOO-13 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Animal behavior	06
02	Biotechnology	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Learning Outcomes: Knowledge of ethology will enable the students to explore the evolutionary history of behavior as how they evolved over time along with their contribution in survival and reproduction of animals.

Recommended Books:

ANIMAL BEHAVIOUR

1. An introduction to Animal Behavior: Aubrey Manning and Dawkins
2. Animal Behavior: Reena Mathur, (Rastogi Publication)
3. Animal Behavior: VK Agarwal
4. Animal Behavior: Natrajan and Arumugam
5. Alcock: Animal Behavior: An evolutionary approach (9 ed. 2009, Sinauer)
6. Drickamer, Vessey and Jacob: Animal Behavior (5th ed. 2002, McGraw Hill)
7. Goodenough et al.: Perspectives on Animal Behavior (1993, Wiley)
8. Grier: Biology of Animal Behavior (1984, Mosby)
9. Lorenz: The foundation of ethology (1981, Springer)
10. Manning & Dawkins: An Introduction to Animal Behavior (5th ed. 1998, Cambridge).
11. Mcfarland: Animal Behavior, Psychology, Ethology and Evolution (1985, Pitman).
12. Scott: Essential Animal Behavior (2005, Blackwell)
13. Slater: An introduction to ethology (1985, Cambridge)

BIOTECHNOLOGY

1. David M. Sylvia: Principles and Applications of Soil Microbiology, Prentice Hall, 1998.
2. T.A. Brown: Genomes, 2nd Editions, Oxford Willey-Liss, 2002.
3. Suzy Hill: Biotechnology, from sciences to applications
4. Dubey, R.C. (2006) A Text Book of Biotechnology. S. Chand & Co. Ltd., New Delhi

MJ-ZOO-14, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: This paper deals with an idea to infuse significance of statistics in biological science without which research outcome cannot be verified. Especially, biostatistics or quantitative biology has become an integral part of modern research.
Economic zoology enhances resource utilization, promotes growth and ensures species conservation. Overall objective of this section is to provide students with a comprehensive understanding of roles of animals in human societies, including their contribution to food securities, income generation and cultural practices.

BIOSTATISTICS AND ECONOMIC ZOOLOGY

BIOSTATICTICS
UNIT –I
1.1 Data and its type: Discrete and Continuous Data, Frequency and Non-Frequency Data,
1.2 Collection of data: Primary and Secondary Data
1.3 Presentation of data: Pie Chart, Bar Graphs, Histograms
1.4 Measurement of central tendency: Mean, Median, Mode
1.5 Measurement of dispersion: Standard Deviation, Standard Error
1.6 Test of significance: *t*-test

ECONOMIC ZOOLOGY
UNIT-II
2.1 Apiculture
2.2 Sericulture

UNIT-III
3.1 Lac Culture
3.2 Pearl Culture
3.3 Pisciculture

PRACTICAL of MJ-ZOO-14

BIOSTATISTICS
1. Calculate the Mean
2. Calculate the Median
3. Calculate the Median
4. Calculate the Mode
5. Calculate the SD
6. Calculate the SE

ECONOMIC ZOOLOGY
Study of Economic importance of the following:
1. Cocoon of Silk worm
2. Honey
3. Honeycomb

4. Bee venom
5. Twig encrusted with Lac
6. Pearl
7. Fishes – *Labeo rohita, Catla catla, Clarius batracus, Heteropneustes fossilis*

Examination pattern for MJ-ZOO-15 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Biostatistics	06
02	Economic Zoology	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: The capacity building in quantitative biology will strengthen the research base by way of data interpretation capability of the students.
The economic zoology has great potentiality in exploring job opportunity in industries and self-employment as well. Improvement in animal products by selective breeding will unfold new vistas in commercial world.

Recommended Books:

BIOSTATICTICS

1. W.W. (2012) Biostatistics: A Foundation for Analysis in Health Sciences (10th edition) John Wiley.
2. Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health
3. Sciences (2nd edition) McGraw Hill.
4. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.

ECONOMIC ZOOLOGY

1. Shukla and Upadhyaya: Economic Zoology (Rastogi Publishers, 1999-2000)
2. Shrivastava: Test book of Applied Entomology, Vol. I &II (Kalyani Publishers, 1991)
3. Mani: Insects, NBT, India, 2006.
4. Jabde: Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture,
5. Agricultural Pests and their Control, 2005 Publisher Vedams eBooks (P) Ltd. New Delhi

MJ-ZOO-15, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: After successfully completing this course, the students will be able to know about wildlife and preparation of an inventory of the wildlife of own area, causes of its depletion, the distinction between wildlife Sanctuary, National Park and Biosphere Reserve, Concept of homes, range, territory of big cats. Concept of pugmark, remote sensing and geographic information system, reasons of entry of wild animals (elephant and leopard) in human dwellings and strategies of conservation of wildlife fauna and flora will prove significant in finding jobs in Department of Forest and Environment.

WILDLIFE CONSERVATION

UNIT-I

1.1Definition, value and importance of wildlife
1.2 Causes of depletion of wildlife
1.3 Inventory and classification of wetland and animal in habitants
1.4 Wildlife Sanctuaries, Bioreserves and National Parks in India: General strategies and issues

UNIT-II

2.1 Theories of population dispersal of wildlife.
2.2 Animal movement, concept of home range and territory
2.3 Tracking movement of wildlife by remote sensing and GIS.
2.4 Identification and estimation of wild animals by fecal sample analysis, pug marks and census methods.

UNIT-III

3.1 International Union for Conservation of Nature (IUCN) list: Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct Species, Rare Species, Endangered Species.
3.3 Wildlife Conservation Strategies (captive breeding techniques and translocation and reintroduction, restoration of degraded habitat)
3.4 Wildlife Protection Act, 1972

Practical of MJ ZOO-15

1. Identification of mammalian fauna,
2. Identification of avian fauna,
3. Identification of herpeto-fauna.
4. Identification of Least Concern/ Near Threatened/ Vulnerable/ Endangered/ Critically Endangered/ Extinct species in the Wild.
5. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).

6. Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.

Examination pattern for MJ-ZOO-15 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Spotting	5×3=15
02	Project (Assignment/Model/Collection)	03
03	Practical Records	04
04	Viva	03
	TOTAL	**25**

Course Outcomes: The study of wildlife conservation includes increased awareness of conservation issues, improved population numbers for targeted species, protected and restored habitats, and development of sustainable management practices that balance conservation with human needs. It will further evoke the sense of conservation efforts ensuring benefits are shared among the mass, therefore community engagement will be further enhanced.

Recommended Books:

WILDLIFE CONSERVATION

1. RL Kotpal: Modern textbook of zoology VERTEBRATE
2. Dasmann R F, 1964.Wildlife Biology, John Wiley & Sons, New York, 2 Gilas RH Jr. (ed.), 1984.
3. Wildlife Management Techniques, 3r ded. The Wildlife Society, Washington D.C., Nataraj Publishers, Dehra Dun.
4. Robinson W Land Eric G Bolen, 1984.Wildlife Ecology and Management, Maxmillan Publishing Company, New York
5. Rodgers WA, 1991.Techniquesfor Wildlife Census in India A Field Manual: Technical Manual-T M -2. WII.
6. Silviculture: S S Negi
7. Saharia V B, 1982.Wild life of India, Natraj Publishers, Dehra Dun
8. Teague R D (ed.), 1987. A manual of Wildlife Conservation (The Wildlife Society, Washington D.C.). Nataraj Publishers, Dehra Dun
9. WII.A Guide to Chemical Restraint of Animals.

U.G. SEM-VII

MJ-ZOO-16, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The significance of comparative anatomy lies in its ability to produce insights into evolutionary history of organisms, understanding the development and function of different body parts, and identification of homologous structures. By examining similarities and differences in anatomy, scientists can infer common ancestry, trace evolutionary paths and understand how anatomical structures adapt to different environments.

COMPARATIVE ANATOMY OF VERTEBRATES

UNIT-I

1.1 Integument and its derivatives in vertebrates
- 1.1.1 Comparative anatomy of integument in chordates
- 1.1.2 Derivatives of integument in vertebrates

1.2 Comparative account of brain in vertebrates

UNIT II

2.1 Comparative account of different respiratory organs in vertebrates

2.2 Comparative account of urinogenital system in vertebrates

2.3 Comparative account of heart and aortic arches in vertebrates

UNIT-III

3.1 Comparative study of Forelimb bone, Hind limb bone and Vertebrae
- 3.1.1 Fish
- 3.1.2 Amphibia
- 3.1.3 Reptilia
- 3.1.4 Aves
- 3.1.5 Mammal

PRACTICAL of MJ-ZOO-16

Dissection: Accessory Respiratory Organ in air breathing fishes

Study of Permanent Slide: V.S. of skin: Fish, Amphibia, Reptilia, Aves, Mammal

Comparative study of bones: Fish, Amphibia, Reptilia, Aves and Mammal
- Forelimb bone
- Hind limb bone
- Vertebrae

Examination pattern for MJ-ZOO-16 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Dissection	06
03	Spotting	3×3=09
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: Contents of this course highlights the importance of anatomical structures to assess comparative study from lower to higher vertebrates. This will help students understand the evolutionary relationships among different vertebrate groups by examining their anatomical structures. Students having good grasp over these contents will enable the them to ponder upon correlation between increasing complexity and efficiency of an organ compared down the evolutionary line.

Recommended books:

COMPARATIVE ANATOMY

1. RL Kotpal: Modern textbook of zoology VERTEBRATE
2. Young, J.Z: Life of Vertebrates (Oxford University Press)
3. Hildebrand: Analysis of vertebrates Structure (Wiley)
4. Practical zoology VERTEBRATE- S.S. LAL
5. Nigam: Biology of Chordates (1997, S Chand)
6. Parker & Haswell: Text Book of Zoology, Vol. II (2005, Macmillan)

MJ-ZOO-17, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: This paper has been introduced with objective to equip students with ability to understand, apply and evaluate various methods and instruments used in various fields. The basic idea is to infuse the acumen of handling most sophisticated equipment such as SEM, TEM, Spectrophotometer with some basic lab essentials to carry on advanced research. The quality research in future will require these instruments and their principles as well to increase the horizon ideas to get patented the novel work for community betterment especially, to mitigate morbidity and promote a decent human life.

TOOLS AND TECHNIQUES

UNIT-I

1.1 Principle, components and uses of instruments:
- 1.1.1 pH meter
- 1.1.2 Centrifuge
- 1.1.3 Colorimeter
- 1.1.4 Spectrophotometer
- 1.1.5 Autoclave
- 1.1.6 Electronic Balance

UNIT-II

2.1 Microscopy: concept of magnification, resolution and contrast

2.2 Working principle, components, ray diagram and uses of microscopes:
- 2.2.1 Compound microscope
- 2.2.2 Bright field

UNIT-III

3.1 Working principle, components, ray diagram and uses of microscopes:
- 3.1.1 Phase contrast
- 3.1.2 Fluorescence
- 3.1.3 Electron microscope (TEM and SEM)

PRACTICAL of MJ-ZOO-17

1. Centrifugation**:** Separation of blood corpuscles and plasma from human whole blood using centrifuge.
2. Study of working principle and application of instruments:
   - pH meter
   - Centrifuge
   - Colorimeter
   - Spectrophotometer
   - Autoclave
   - Electronic Balance

3. Study of principle, ray diagram and application of microscopes:
    - Compound microscope
    - Phase contrast
    - Electron microscope (TEM and SEM)

Examination pattern for MJ-ZOO-17 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Working principle, components, ray diagram and application of microscope given	06
02	Working principle and application of any instrument given	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course outcome: Course Outcomes: Medical and Research institutions look for technicians who are at home in using highly sophisticated instruments which are pivotal in diagnosis of diseases and research activities. Besides, this will increase employment opportunity in the field of Medical Laboratory Techniques (MLT).

Recommended books:

TOOLS AND TECHNIQUE

1. Roymahoney: Laboratory Techniques in Zoology (1966, Butterworths).
2. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,)
3. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill- Livingstones)
4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill)
5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)

MJ-ZOO-18, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: Histology and Histochemistry course aim to equip students with the knowledge and skills to understand the microscopic structure of cells, tissues and organs, and to apply this knowledge in various scientific and medical contexts. Mastering histological techniques such as fixation, processing, embedding, sectioning and staining will prove a boon for the researchers in future. The techniques of histochemistry which involve chemical reactions to visualize and localize specific molecules such as carbohydrates, lipids proteins and nucleic acids within cells, can be used to identify any deviation in functioning of cell.

HISTOLOGY AND HISTOCHEMISTRY

UNIT-I

1.1 Histology and Histochemistry - Introduction and definition
1.2 Fixatives used in histology: preparation and application.
1.3 Stains used in histology: preparation and application

UNIT-II

2.1 Tissue processing
- 2.1.1 Fixation
- 2.1.2 Dehydration
- 2.1.3 Hydration
- 2.1.4 Clearing
- 2.1.5 Embedding

2.2 Microtomy
- 2.2.1 Sectioning
- 2.2.2 Mounting

UNIT-III

3.1 Staining principle, result and application:
- 3.1.1 Eosin and Hematoxylin
- 3.1.2 Periodic Acid-Sciffs (PAS)
- 3.1.3 Mercury Bromophenol Blue
- 3.1.4 Ninhydrin- Schiff
- 3.1.5 Sudan
- 3.1.6 Methyl Green Pyronin-Y
- 3.1.7 Feulgen reaction

PRACTICAL for MJ-ZOO-18

1. Preparation of different alcohol grades
2. Preparation of different fixatives:

- Aqueous Bouin's solution
- Ethanolic Bouin's solution
- 10% formalin
- Baker's fluid

3. Fixation of tissue in given fixatives:
    - Bouin's solution
    - 10% formalin
    - Baker's fluid
4. Dehydration and Hydration of tissue for staining
5. Tissue block preparation: Embedding of tissues in wax
6. Trimming of tissue block
7. Study of Counter Staining: Hematoxylin & Eosin
8. Staining Principle, result and application:
    - Periodic Acid-Schiffs
    - Mercury bromophenol blue
    - Ninhydrin- Schiff
    - Sudan
    - Methyl green pyronin-Y
    - Feulgen reaction

Examination pattern for MJ-ZOO-18 Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Staining procedure, principle, result and application	09
02	Preparation of fixative / stain	2×3=6
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: Students will develop experimental techniques in histology and histochemistry. This will further equip the students to correlate tissue identification with function and related pathology. The students will become capable of troubleshooting errors in histology through systematic reasoning and problem resolution. The knowledge acquired in this field will be used for sectioning of tissues for Electron Microscopy: TEM or SEM.

Recommended books:

HISTOLOGY AND HISTOCHEMISTRY

1. Pearse A.G.E. - Histochemistry – Theoretical and Applied. vols I – III Churchill
2. Bancroft J.D. & Stevens A. – Theory and Practice of Histological techniques.4th edn. Churchill Livingstone 1996

3. Barka T. & Anderson P.J. – Histochemistry, Theory Practice and Bibliography. Harper and Raw 1965
4. Sharma A.K. & Sharma A. – Chromosome Techniques. Theory and Practice. 3rd edn. Butterworths 1980
5. Copenhaver W.M. – Bailey's Text Book of Histology. Willian and Wilkins/ Scientific Book Agency Indian edn. 1964
6. Carleton H.M. & Short R.M.D. – Schafer's Essential of Histology: Descriptive and Practical. 16th edn. Longmans Green 1954
7. Verma G.P. – Fundamentals of Histology. New Age 2001

U.G. SEM-VIII

MJ-ZOO-19, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The study of microorganisms, including bacteria, viruses, fungi and protozoa is fundamental to understand the pathology of various diseases in animals and plants as well. This course will provide a comprehensive understanding of microorganisms, their characteristics and their interactions with the environment and other organisms. Microbial diversity, microbial genetics, their staining technique, isolation, sterilization etc. are of immense significance. It will be helpful in disease surveillance and infection control which are of utmost importance during outbreak of a disease in population.

MICROBIOLOGY

UNIT-I

1.1 Microbes: History of Microbiology, Naming, Classification and Identification of Microorganisms

1.2 Bacteria: Forms of Bacteria; External Structures: The wall and Membrane(s); Bacterial Internal Structures

1.3 Viruses: viruses and its types

UNIT-II

2.1 Mode of infection, diagnostic features, damages done, prophylaxis and cure:

- 2.1.1 Microbial Diseases of the Upper Respiratory Tract (Streptococcal Pharyngitis, Common Cold),
- 2.1.2 Diseases of the Lower Respiratory Tract (Tuberculosis, Pneumonia)
- 2.1.3 Normal Biota of the Gastrointestinal Tract
- 2.1.4 Bacterial Diseases of the Mouth
- 2.1.5 Bacterial Diseases: Shigellosis (Bacillary Dysentery), Salmonellosis and Typhoid, Cholera, Helicobacter
- 2.1.6 Urinary Tract Infections (UTI)

UNIT-III

3.1 Microbial growth and food spoilage

3.2 Microbes used in food industry

3.3 Biodegradation and bioremediation by microbial community

PRACTICAL of MJ-ZOO-19

1. List at least two bacterial species to be Gram-positive and two species to be Gram-negative

2. Stain the milk/sputum bacterial smear prepared by using Gram staining technique
3. Recognize selected properties of bacterial colonies on agar plates.
4. List several common microbial infections of the skin
5. List several common microbial infections of the gastrointestinal tract.
6. List several common infections of the respiratory tract.
7. List common microbial pathogens and diseases of the genitourinary tract.

Examination pattern for MJ-ZOO-19 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Bacterial identification	06
02	Staining	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: Key outcomes include learning about microbial structure and function, mastering laboratory techniques, understanding microbial diversity and exploring the roles of microbes in different ecosystems and processes. Medical Microbiology, Pharmaceutical Microbiology, Industrial Microbiology, Environmental Microbiology, Food Microbiology are a few fields for venturing employment.

Recommended books:

MICROBIOLOGY

1. Madigan, M.T., Martinko, J.M., Dunlap, P.V., Clark, D.P., 2011. Brock Biology of Microorganisms. 13th edition. Pearson Education Inc.
2. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., Painter, P.R., 1987. General Microbiology. Fifth edition, MacMillan.
3. Talaro, K.P., Chess, B., 2011. Foundation in Microbiology. 8th edition. McGraw-Hill
4. Agrios, G.N., 1988. Plant Pathology, Academic Press, London.
5. Lucas, John, A., 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
6. Tauro P., Kapoor K.K., Yadav K.S., 1996, An Introduction to Microbiology, Wiley Eastern Limited.
7. Frazier W.C. and Westroff D. C. (1988): Fourth Edition, Food Microbiology, McGraw Hill INC.
8. Madigan M.T., Martinko J.M., Dunlop P.V. and Clark D.P. (2011). Brock Biology of Microorganisms. 13th Edition, Pearson Education Inc.
9. Stanier R.Y., Ingraham J.L., Wheelis M.L. and Painter P.R. (1987). General Microbiology. Fifth Edition, MacMillan.
10. Willey J.M., Sherwool L. and Woolverton C.J. (2010). Prescott's Microbiology. 8th
Edition, McGrow-Hill.
11. David M. Sylvia: Principles and Applications of Soil Microbiology, Prentice Hall,

1998.

MJ-ZOO-20, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: This paper has been included with an objective to equip students with the knowledge and skills to understand, diagnose and manage parasitic infections and control strategies. The key objectives include identifying parasites, understanding their life cycles, transmission with focus upon host-parasite relationship and control strategies.

COMMON HUMAN DISEASES, PARASITOLOGY

UNIT-I
COMMON HUMAN DISEASES
1.1 Communicable diseases: CORONA, AIDS, Herpes, Cough & Cold
1.2 Non-communicable diseases: Asthma, Cancer, Heart Attack, Alzheimer,

UNIT-II
PARASITOLOGY
2.1 Introduction to parasitology: basic principles and concepts
2.2 Classes of parasite: endo, ecto, temporary, permanent, facultative, obligatory, aacidental, aberrant, digenetic, monogenetic
2.3 Classes of host: Primary, Secondary, Tertiary, Intermediate, Definitive, Paratenic
2.4 Parasitic adaptations with example
2.5 Organisms of health & agricultural importance: Common parasites and pathogens of human and domestic animals.
2.6 Vector, Zoonosis

UNIT-III
3.1 Life cycle, pathogenesis and disease caused by parasitic protozoans- *Amoebae*, *Entamoeba*, *Plasmodium, Trichomonas, Trypanosoma, Leishmania, Balantidium*
3.2 Life cycle, pathogenesis and disease caused by parasitic Helminths: - *Trichinella spiralis, Taenia solium, Fasciola hepatica, Echinococcus granuloses, Ascaris lumbricoides, Washeteria bancrofti*
3.3 Dynamics of Host-Parasite interaction

PRACTICAL of MJ-ZOO-20

- Identification of *Leishmania* in Blood film
- Identification of *P. malaria* in blood film
- Identification of Helminthic eggs through permanent slides/ photomicrographs.
- Study of permanent slide: *Fasciola hepatica, Leishmania, Plasmodium, Entamoeba*
- Identification of parasites through photographs.

Examination pattern for MJ-ZOO-20 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Identification of parasites in Blood film	06
02	Identification of Helminthic eggs in stool of man.	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: The students having exposure to this field of zoology will strengthen capacity building among the students as health workers in wake of epidemics and natural disaster as they can help in managing the victims of such outbreaks. It will make then capable of differentiating and identifying microscopic parasites and parasitic worms. Parasites' evasive mechanisms against the host defense system can be better understood which will be helpful in diagnosis and treatment of a disease.

Recommended books:

PARASITOLOGY

1. KD Chatterjee: Parasitology
2. Burton J Bogitsh Human Parasitology 3rd edition Elsevier.
3. Roberts, L. S. and J. Janovy, Jr. 2004. Foundations of Parasitology. 7th Edition. McGraw Hill,Boston.
4. Smith. Animal Parasitology 1996. Cambridge University Press.
5. Chandler and Reid. Introduction to Parasitology 1970, Wiley.
6. Marr et al. Molecular Medical Parasitology 2003, Elsevier.
7. Lawrence R. Ash and Thomas C. Orihel. Atlas of Human Parasitology. American Society for clinical pathology press 5th edition, 2007.
8. Alan Gunn. Parasitology: An Integrated Approach Wiley-Blackwell. 2012.
9. Janet Amundson Romich. Understanding Zoonotic Diseases. 2007

SEMESTER-VIII

GUIDELINE AND SYLLABUS FOR 4-YEAR UG DEGREE

ZOOLOGY (HONOURS)

With Advance Major

Bachelor's Degree (Honours): In this course during the 7th and 8th semesters, students will undertake advanced-level courses in both Major and Minor streams to earn a UG Degree (Honours).

The research component required for a Bachelor's Degree (Honours with Research) will be replaced by these Advanced- level courses. Successful completion of these studies, resulting in a total of 164 credits by the end of 8th semester, lead to a Bachelor's Degree (Honours).

ZOOLOGY ADVANCE MAJOR
(AMJ-ZOO-01)

AMJ-ZOO-1, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: The chief objectives of imparting education to the students are creation of job and to provide opportunity for earnings so as to lead a respectful and decent life. This course is meant to impart knowledge to students on the most important skill which is required in this era for any scientific worker. Particularly becoming conversant with computer handling can enhance the chances of self-employment and also enable the students to make use of this indispensable acumen in other fields of Zoology like: computational biology, molecular biology, bioinformatics etc.

Since the eligible students will undertake Ph.D. course they must be equipped with the essentials of beginning research work. The contents of research methodology will certainly help them to develop research acumen for successfully completing their assigned synopsis.

COMPUTER APPLICATIONS AND RESEARCH METHODOLOGY

UNIT-I
COMPUTER SCIENCE AND BIOINFORMATICS:
1.1 Computer and its application in life sciences
1.2 Introduction of MS office – Word, Excel and Power point
1.3 Digital library for life sciences (NCBI, Pub Med)
1.4 Bioinformatics and its application in life sciences
1.5 Bioinformatics tools- BLAST, Clustal W, KEGG
1.6 Concepts of digital Library.

UNIT-II
RESEARCH METHODOLOGY
2.1 Collection and grouping of data
2.2 Statistical analysis (Chi-square test, *t*-test & ANOVA)
2.3 Identification and formation of research problem (Hypothesis)

UNIT-III
3.1 Research Design
3.2 Research proposal writing
3.3 Research article writing
3.4 Ideas of Scientific Journals (SJI, ISBBN, ISSN, Thompson, Reuter Index, Impact factor)
3.5 A brief idea of different Research Agencies for funding process

1. Use of MS Office
2. PPT preparation and presentation
3. Applications Digital library- NCBI, Pub Med
4. Applications of BLAST, Clustal W, KEGG in research
5. Calculations of data using t-test & ANOVA
6. Preparation of synopsis- one example to explain
7. List preparation of scientific journals in life sciences

Examination pattern for MJ-ZOO-1 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Research methodology	06
02	Bioinformatics	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: This course is meant to impart knowledge to students on the most important skill which is required in this era for any scientific worker. The course is designed in such a way that the students will get the confidence to use computer programs for the daily design of experiments, data collection, and analysis of results. The mandatory practical exercises in the available computer laboratory in the campus will benefit students to learn all that they require to use their computer for the advance study.

Since research methodology is based upon basic knowledge of computers, therefore these two will have cumulative effect on effective grasping and solution of research work undertaken.

ZOOLOGY ADVANCE MAJOR
(AMJ-ZOO-02)

AMJ-ZOO-2, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

Course Objectives: To understand the patho-physiology of any disease requires a comprehensive understanding of in-depth knowledge in the field of hematology. The detail studies of blood composition and related diseases aim at providing very trivial information about the routine blood tests of the persons referred by the physician. Hence it will be quite handy in research and in joining pathological laboratory instruments.

HEMATOLOGY

HEMATOLOGY:

UNIT-I

1.1 Scope, prospects and history of Hematology.
1.2 Human Blood Composition: Erythrocytes (RBC), Hemoglobin (Hb) Structure and Function, Leucocytes (WBC), Blood Platelets
1.3 Leukocytosis and Leucopenia
1.4 Platelets disorder: Hemophilia A and Hemophilia B
1.5 Hemopoiesis: Process, Stem Cells, Haemopoietic Tissue
1.6 Structure and function of bone marrow
1.7 Human blood groups (ABO system and Bombay system)
1.8 Blood coagulation and Hemostasis, Blood coagulation inhibitors

UNIT-II

2.1 Anemia diagnosis and therapy:
- 2.1.1 Iron metabolism
- 2.1.2 Iron Deficiency Anemia
- 2.1.3 Megaloblastic Anemia
- 2.1.4 Pernicious Anemia
- 2.1.5 Aplastic Anemia
- 2.1.6 Sickle Cell Anemia
- 2.1.7 Thalassemia
- 2.1.8 Erythroblastosis fetalis

2.2 Abnormal Hemoglobin, Spherocytosis, Megakaryopoiesis
2.3 Abnormal blood types: Polycythemia, Methamoglobinemia and its causes

UNIT-III
BIOCHEMICAL ANALYSIS
3.1 Glucose, Protein , Cholesterol, Triglycerides
3.2 Liver function test (SGPT & SGOT)
3.3 Kidney function test (Urea, Creatinine)

PRACTICAL of AMJ-ZOO-2

1. RBC & WBC Count
2. Hb % estimation by hemocytometer
3. Serum analysis of glucose, urea acid and liver function test (SGPT & SGOT)
4. Quantitative estimation of protein by colorimeter
5. Preparation of Phosphate buffer
6. Sample preparation for Scanning Electron Microscope
7. Temporary slide preparation: Preparation of blood smear to identify different WBC

Examination pattern for MJ-ZOO-2 Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Hematology	06
02	Instrumentation	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Outcomes: Hematology dealing with the blood composition incorporates the most fundamental biochemical tests of several diseases and diagnosis of the same by examining the referred parameters associated with them. Such students can contribute as specialized teaching faculty after acquiring the postgraduate degree with this special paper. Such students may also undertake MLT course with the acquired knowledge in this field. The episodes of pandemic have further underscored the significance of hematological tests.

Recommended Books:

TOOLS AND TECHNIQUES

1. Roymahoney: Laboratory Techniques in Zoology (1966, Butterworths).
2. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,)
3. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones)
4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill)
5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)

BIOSTATISTICS

1. Fundamental of biostatistics: Khan and Khanam
2. W.W. (2012) Biostatistics: A Foundation for Analysis in Health Sciences (10th edition) John Wiley.
3. Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health
4. Sciences (2nd edition) McGraw Hill.
5. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.

HEMATOLOGY

1. Hematology: basic principles and practice, 7th ed. – by Ronald Hoffman, Edward J. Benz
2. Harrison's Hematology and oncology, 3rd ed, by Dan L. Longo (McGraw-Hill

ZOOLOGY ADVANCE MAJOR
(AMJ-ZOO-03)

AMJ-ZOO-3, CREDIT=04 (100 Marks)
THEORY (FM 75=60 external exam+15 internal exam)

AMJ-ZOO-03 (GROUP A)

ENTOMOLOGY

Course objective: The main objective of this paper is to give the detailed idea about different types of insects, their taxonomical classification, their anatomical and physiological functions. This paper will help students to gain knowledge about local insect fauna and their benefits and harmful effects.

UNIT-I

General Features of Insects

1.1 Introduction

1.2 Distribution and success of Insects on earth

Insect Taxonomy

1.3 Basics of insect classification

1.4 Classification of insects up to orders

General Morphology of Insects

1.5 Structure of integument

1.6 Structure and type of antennae

1.7 Structure and types of mouthparts w.r.t feeding habits

1.8 Type of legs adapted to diverse habitat

UNIT-II

Physiology of Insects

2.1 Reproductive system.

2.2 Endocrine system

2.3 Nervous system

2.4 Sensory receptors – vision and sound receptors

Insect Animal Interaction

2.5 Social economic insects (honey bees and termites) – Social organization & Social behavior.

2.6 Insects as a vector – Mechanical and biological vectors, (*Musca domestica, Anopheles & Culex*)

UNIT-III

Insect Plant Interaction

3.1 Role of allochemicals & pheromones in host plant mediation.

3.2 Host plant selection by phytophagous insects

3.3 Insect as plant pests

3.4 Integrated pest management (IPM)

3.5 Insect population control (chemical and biological method)

Developmental Biology of Insects

3.6 Developmental biology of Insects – oogenesis & spermatogenesis

3.7 Structure of egg and sperm

3.8 Fertilization, growth and types of metamorphosis and its hormonal regulation

PRACTICAL for AMJ-ZOO-03 (GROUP-A)

1. Dissection: To show Malpighian tubules, salivary glands and nerve cords
2. Mounting: Antenna and legs of insect of different orders.
3. Study of permanent slides:
   - T.S. of ovary
   - T.S. of endocrine glands
   - L.S. of Malpighian tubules.
4. Study of the life cycle of social insects
   - Honey Bee
   - Ants
   - Termites
5. Morphology of different types of mouth parts, antenna, legs and wings of insect of different orders through photomicrographs.
6. Study of museum specimen: insect fauna of different orders.
7. Field study: Insect diversity in local area and insect pests of crops

Examination pattern for AMJ-ZOO-3 Practical (duration=6 hours)

(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Dissection	06
02	Mounting	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course outcome: Class Insecta is a diversified group. This paper will equip the students with the knowledge of major taxonomical groups of insects, morphological features, their physiological details, adaptations and related features along with the benefits and harms caused by insects.

Reference Books:

ENTOMOLOGY:

1. Insect pathology: Shadanand Upadhyay
2. Handbook of Nature study in colour – Insects: Anna Comstock
3. Modern Entomology – D.B. Tembhare
4. A general textbook of entomology. Imms. A. D. Chapman & Hall, UK
5. The insects: Structure and functions. Chapman. R.F. Cambridge University Press, UK
6. Principles of insect morphology. Snodgrass. R.F. Cornell University Press, USA.
7. 7. Introduction to the study of insects. Norro. D. J. Triplehorn. C.A. and Johanson. N.F. Saunders. College, Publication, USA.
8. Developmental Biology. Gilbert. Sinauer Associates, Inc., Publishers. Sunderland, Massachusetts U.S.A.
9. The insect Societies. Wilson. Howard University Press. UK
10. Host selection by Phytophagous insects. Bernays and Chapman. Chapman and Hall. NY, USA.
11. Advances in Insect Physiology. Russell Jurenka. Academic Press, London, UK
12. Insect Physiology and Biochemistry. James L. Nation. CRC Press, London, UK

AMJ-ZOO-3, CREDIT=04 (100 Marks)

THEORY (FM 75=60 external exam+15 internal exam)

MJ-ZOO-03(GROUP-B)

FISH & FISHERIES

Course objective: The study of fish and fisheries includes fish taxonomy, physiology and aquatic adaptations. This course will provide a comprehensive understanding of fish biology, their characteristics and their interactions with the environment.

UNIT-I

Taxonomy of Fin Fish

1.1 Major taxa of inland and marine fishes up to order.

1.2 Commercially important freshwater and marine fishes of India with their Morphological characteristics.

Biology of Fin fish

1.3 A brief idea of the circulatory, respiratory, nervous, urinogenital system, endocrine system, skeletal system and sensory system of fin fishes.

UNIT-II

Physiology of Fin fish

2.1 Effects of environmental factors on physiology of Fin fish.

2.2 Study of osmoregulation, excretion and stress related changes, bioluminescence, electric organs

2.3 ARO (accessory respiratory organs)

2.4 Lateral line organ system

2.5 Fish pathology and health management

2.6 A brief idea of fish parasites, diseases, and their treatment

Fish and Adaptation

2.7 Hill stream fishes

2.8 Cold-water fisheries of India

UNIT-III

Marine fishery

3.1 Marine fishery resources in India

3.2 Estuarine fishes

Fish culture

3.3 Principles of fish culture: Definition and scope

3.4 Systems of fish culture – Pond culture, Pen culture, Cage culture, Biofloc culture, RAS

3.5 Fishing crafts and gears

Fish technology and research

3.6 Preservation and processing of harvested fish, fishery by-products, transgenic fish, Zebra fish as a model of research

3.7 Introductory Ornamental fish culture and aquarium maintenance

PRACTICAL AMJ-ZOO-3 (GROUP-B)

1. **Dissection:**
   - General anatomy of carp fish.
   - Cranial nerves of carp fish.
   - Oro-hypophyseal dissection of pituitary gland of carp fish.
   - Endocrine glands of carp fish.
   - Dissection of air breathing fish to expose accessory respiratory organs.
2. **Mounting:**
   - Study of scales of major and minor carps.
   - Ampullae of Lorenzini
3. **Study of permanent slides:** T.S. endocrine glands of fish (Pituitary, Ovary, Testis, Kidney, Intestine)
4. **Study of bone:** Study of fused, pre caudal and caudal vertebrae of fish
5. **Bioassay:** Bioassay of gut micro biota of fish.
6. **Study of museum specimen:**
   - Ornamental fish.
   - Carp fishes
   - Air breathing fishes

7. **Morphometric study of some fresh water fishes.**

Examination pattern for AMJ-ZOO-3 (GROUP- B) Practical (duration=6 hours)
(FM=25, Pass Marks=10)

SN	Practical	MARKS
01	Dissection	06
02	Mounting	03
03	Spotting	3×2=06
04	Project (Assignment/Model/Collection)	03
05	Practical Records	04
06	Viva	03
	TOTAL	**25**

Course Learning Outcomes: After completing this course, the students will be able to know the major taxonomical groups of fish, their anatomical and physiological details, fish pathology, adaptations and related features and Aquaculture practices.

Reference Books:

FISH & FISHERIES

1. The Laboratory Fish (A Hand book of Experimental Animals) : Gary Ostrander
2. Fish feeding Experiments: T. Lovell
3. Laboratory Fish in Biomedical Research – Springer. Link
4. Laboratory Zebra Fish: Claudia Harper.
5. Eco-immunotoxic studies on a fish during Experimental plumbism (Pb) clarias batrachus: Dr. P.C. Rout
6. Fish of U.P. and Bihar: C.B.L. Srivastav
7. An Introduction to the Study of Fishes – Albert C.L.G. Gunther, Discovery Publishing House, New Delhi
8. Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
9. D.H. Evans and J. D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
10. C.B.L. Srivastava, Fish Biology, Narendra Publishing House
11. J.R. Norman, A history of Fishes, Hill and Wang Publishers
12. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House
13. Modern Ichthyology, S.M. Shafi, Inter India Publications
14. Feeding and Digestive Functions of Fishes, J.E.P.

SEMESTER-VIII

GUIDELINE AND SYLLABUS FOR 4-YEAR UG DEGREE

ZOOOGY (HONOURS WITH RESEARCH)

Eligibility for Students:

Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students, who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

Infrastructure Requirement for offering this Course:

The Departments offering a 4-year UG Degree (Honours with Research) must have the required infrastructure such as the laboratory, equipment's, glass wares, chemicals, class work materials, library, access to journals and computer lab facilities to carry out the research work, and at least two permanent faculty members who are recognized as Ph.D. supervisors. The Departments already recognized for conducting the Ph.D. Programme may conduct a 4- year UG Degree (Honours with Research) without obtaining any approval from the affiliating University.

ZOOLOGY RESEARCH COURSES
(RC-ZOO-1)

RC-ZOO-1, CREDIT=04 (100 Marks)
THEORY (75 external exam+25 internal exam)

Course Objective: The course aims to inculcate research aptitude among the learners and equip them with knowledge and skills required to successfully undertake various steps in the research process.

RESEARCH METHODOLOGY

UNIT-I:
Introduction of Research
1.1 Research: Meaning, Definition, Nature, Scope, Significance, Steps Types and Methods of Research. Characteristics of Goods Research

Research Process
1.2 Defining Research Problem, Title Formulation; Setting of Hypothesis, Research Design - Exploratory, Descriptive and Experimental Research Designs.

UNIT-II:
Tools and techniques
2.1 PCR, Electrophoresis, Spectrophotometer, Colorimeter, RIA, ELISA.

Data:
2.2 Data, types of data, Methods of Collection of Primary and Secondary Data. Process of Questionnaire Design; Processing of Data-Editing, Coding, Classification and Tabulation.

Sample and Sampling
2.3 Meaning of Sample, Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of Good Sample Design.

UNIT-III:
Analysis of Data
3.1 Chi-square test, *t*-test, ANOVA, Correlation, Regression

Report Writing
3.2 Meaning and Types of Report, Steps of Report Writing, and Characteristics of a good report, Reference and bibliography.

Course Outcomes: After completion of the course, learners will be able to:
- Analyze research concepts, its types and steps in the research process.
- Formulate research problems and assimilate various types of research design.

- Create scales, sampling techniques and design data collection tools.
- Recognize various techniques of data analysis and interpretation.
- Prepare a complete research report in appropriate format.

Recommended Books:

TOOLS AND TECHNIQUES

1. Roymahoney: Laboratory Techniques in Zoology (1966, Butterworths).
2. Boyer: Modern Experimental Biochemistry (1993, Benjamin-Cummings,)
3. Pearse: Histochemistry - Theoretical and applied, Volume I-III (1980-1993, Churchill-Livingstones)
4. Plummer: An Introduction to Practical Biochemistry (1989, McGraw Hill)
5. Wilson & Walker: Experimental Biochemistry (2006, Cambridge)

BIOSTATISTICS

1. Fundamental of biostatistics: Khan and Khanam
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3. Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health
4. Sciences (2nd edition) McGraw Hill.
5. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.

RESEARCH METHODOLOGY

1. Research Methodology – Text and Cases with SPSS Applications, by Dr S.L. Gupta and Hitesh Gupta, International Book House Pvt Ltd
2. Methodology of Research in Sciences, by O.R. Krishnaswami, Himalaya Publishing House
3. Research Methodology, Methods and Techniques by C.R Kothari
4. Research Methodology by Dr Vijay Upagude and Dr Arvind Shende
5. Gupta, Santhosh Research Methodology and Statistical Techniques, Deep and Deep.
6. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
7. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
8. Ruzin, S.E. (1999). Plant micro technique and microscopy. Oxford University Press, New York, U.S.A

ZOOLOGY RESEARCH COURSES
(RC-ZOO-2)

RC-ZOO-02

Total Credits: -08 **Total Marks: 200**

Course Objectives: The objectives of this course is to facilitate students to carry out extensive research and develop as self-guided learning and analytical skills through problem and gap identification, development of research methodology, interpretation of findings and presentation of results.

RESEARCH PROJECT OR DISSERTATION

Course Contents: Students who secure **75% marks or above** in the first six semesters and wish to undertake research at the undergraduate level can choose a **research stream in the fourth year.**

- In **Semester VIII**, students will undertake an **8-credit course** that includes a **dissertation** and the **preparation of a dissertation/thesis**.
- This course may involve **laboratory work, practicums, field projects, survey analyses, or internship-based projects.**
- Students are required to submit a comprehensive **research report** and defend their dissertation/thesis.

The HOD of the department has to allot supervisor to the students from among the permanent faculty members who have Ph.D. degree, after that the students have to select a research problem with the help of the supervisor and they have to submit a summary or research proposal to the department. Thereafter, the HOD of the department will organize a meeting of the Departmental Research Committee and after the presentation of the student the committee will approve or reject his/her synopsis/research proposal. Students will start their research work after getting approval from the department research committee.

At the end of the semester the student has to submit **the project thesis/ dissertation** to the department and after that the department will send that thesis to the external member; after receiving the report from the external member the department will conduct an open viva voce examination for the students in the presence of the external member as well as the internal member.

The Department Research Committee will be constituted from the following persons:

1. HOD of the Department–Chairmen
2. Dean, Faculty of Science- External member
3. HOD, University Department- External member
4. At list two permanent faculty member of the department (Nominated by HOD)- Members

External members can be any of the following:

1. Permanent professors working in the postgraduate department of the university or other colleges who have the qualification to become PhD supervisors.

OR

2. Retired Professor/Associate Professor/Assistant Professor of the university who has been supervise PhD scholar.

OR

3. Professor/Associate Professor/Assistant Professor of the outside university who has been supervise PhD scholar.

Note- Minimum three external examiner lists will be sent by HOD through concern college principal to controller of examination, SKMU, Dumka for final approval. In that list priority will be given as per order mentioned above.

The project thesis will evaluate under the following heads:

1. Project dissertation design
2. Methodology and content depth
3. Participation in an internship Programme with a reputed organization
4. Application of research techniques in data collection
5. Data analysis
6. Report presentation
7. Presentation style
8. Results and discussion
9. Future scope
10. References

Guidelines for distribution of marks may be as follows or as appropriate:

1. Assessment of project synopsis: 50 marks
2. Assessment of project thesis: 100 marks
3. Viva-voce: 50 marks

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

- Gain in-depth knowledge in the major field of study.
- Design and justify research methodology.
- Utilize appropriate research methodology for research.
- Analyze the data and draws conclusions accordingly.