(*Revised syllabus based on CBCS, NEP 2020 and on the inputs from the Board of Studies and Departmental Committee*)

UNIVERSITY OF LUCKNOW

MASTERS IN ZOOLOGY

(TWO YEARS)

PROGRAMME BROCHURE

(Proposed to be implemented from July 2025)

Department of Zoology

13 January 2025

CONTENTS

About the Department

The Department of Zoology, University of Lucknow, shares its birth with that of the university itself, the year 1921. Zoology is one of the founding departments and main stays of the university and was formed as a result of the bifurcation of the Department of Biology, Canning College. The roots of the department were strengthened by the initial leadership of the officiating head, Dr. G.S. Thapar (Ph.D. London, 1925), and then by the first Head of Department, Dr. K.N. Bahl (D.Sc., D.Phil., Oxford, 1921) in 1923. He successfully nurtured the department till 1950 into an establishing ground and leading light for many Zoology departments of the country. He was succeeded by Prof. G.S. Thapar, who laid the foundation for Helminthology in the country. The next Head, Prof. M.B. Lal, added new heights to the field of Physiology and Experimental Zoology. Later the other faculty also joined the department and carried forward the tradition. The department has been identified as UGC-SAP (DRS-I & II), DST-FIST, DST-PURSE and Centre of Excellence (Dept. of Higher Education, Govt. UP) department.

Current faculty members are contributing in the areas of Protozoology, Parasitology, Environmental Toxicology, Entomology, Chronobiology, Endocrinology, Neurobiology, Fisheries, Human Genetics, Molecular Biology, Bone Biology and Wildlife.

Introduction to CBCS (Choice Based Credit System)

The curriculum based on CBCS pattern provides an opportunity to the students to choose from a range of prescribed courses based on their interests. The CBCS course structure comprises of the core and elective/minor or skill-based content and the evaluation is based on the grading system, which is considered better than the conventional marks system. The grading system provides uniformity in evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, which may help students to move across institutions of higher learning. The uniformity in evaluation system can be helpful to employers in assessing the performance of the candidates.

Definitions

1. 'Academic Programme' means an entire course of study that comprises of its structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre.
2. 'Course' is part of an Academic Programme.
3. 'Programme Structure' means a list of courses (Core, Elective, Value added: credited and non-credited, Interdepartmental and Intradepartmental Course) that makes up an academic programme, describing the syllabus, credits, teaching hours, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University rules.
5. 'Core Course' is a particular programme in which the student is admitted to, and which must be successfully completed to receive the degree. The core course cannot be substituted by any other course.
6. 'Elective Course' is an optional departmental course. Each Elective has multiple papers within it, which cannot be substituted or changed. Once the student opts for an Elective, they would be required to study all the included papers across semesters.

‘Interdepartmental Course’ is an elective course which is available for students of faculties other than Faculty of Science.

‘Intradepartmental Course’ is an elective course which is available for students of same as well as departments other than Zoology but of the same faculty (here Faculty of Science).

‘Value added Courses; Credited and Non-Credited’ areconducted by the department to complement the students' knowledge and skills in their field of study. The Courses offered are chosen based on the current trends and relevance havingholistic approach.

7. ‘Credit’ means the value assigned to a course which indicates the level of instruction; One hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. The credit for practical could be proposed as part of a course or as a separate practical course.

8. ‘SGPA’ means Semester Grade Point Average calculated for individual semester.

9. ‘CGPA’ is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

10. ‘Grand CGPA’ is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age is given in the Transcript.

University of Lucknow
Masters of Science Programme
Regulations 2020

1. Applicability

These regulations shall apply to the Master in Zoology programme from the session 2020 – 21.

2. Minimum Eligibility for admission:

A three/ four-year Bachelor's degree or equivalent in Zoology awarded by a University or Institute established as per law and recognised as equivalent by this University with minimum 45% percentage marks or equivalent grade, shall constitute the minimum requirement for admission to the Master in Zoology programme.

3. Programme Objectives (POs):

The Department of Zoology at University of Lucknow is known for the classical Zoology courses such as Taxonomy, Entomology, Parasitology and Physiology. In later times, modern courses such as Genetics, Cell and Molecular Biology, Chronobiology and Endocrinology were also introduced. Keeping in mind that tradition, the course has been designed in such a way to equip the students with both classical and modern aspects of Zoology. It aims to enable the students to study the animal diversity in Indian subcontinent and appreciate other areas of Zoology such as Aquaculture, Reproductive health, Behavior and Biological time keeping, Cancer Biology, Parasites, and their roles in health and diseases, Bioremediation of pollutants and pesticides, etc.

The elective courses are divided into 4 groups specific to the department and the students will opt one of them. Besides these, there are (a)interdepartmental course of interfaculty nature, (b) intradepartmental course of inter-department nature. The department also offers value added credit/ non-credit courses of general importance for the students.

The dissertation in the courses provided will be allotted to the students in Semester III and will be evaluated in Semester IV.

The Master's program in Zoology is designed to:

- make students aware of and appreciate the animal diversity at different levels (behavioural, physiological, biochemical and molecular levels etc.)
- develop a comprehensive understanding of the field through an array of classes (lectures, tutorials, demonstration, group discussion, assignments etc.)
- cope up with the challenges arising out of the complexities and limitations of biological system.
- help the students to give a holistic view of subject and prepare them for next level of learning.
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4. Programme Specific Outcomes (PSOs)

- Help students to understand life-environment interaction.

- Help them in understanding the intricacies of the subject at advanced level and develop the skills to opt for research programs.
- Help students to explore newer areas such as conservation and management of animal kingdom.
- Zoological knowledge and theories are applicable to maintain health and to control the epidemic diseases.
- Students can venture into the industry e.g. various animals such as coral, pearl, honey, wax, silk, lac, shell of turtle, bones, feather, tusk, leather and fur are of high demand.
- equip them to disseminate the knowledge at different levels of education.

5. Programme Structure:

The M.Sc. in Zoology programme is a two-year course divided into four semesters, each semester is of six months duration. Students would have the option of exiting after successful completion of first year of the programme, with a Diploma Degree in Zoology. To earn a Diploma Degree, a student would need to successfully complete 48 credits of First Year (two semesters) of the Programme. The 2-year full-time Masters' degree in Zoology with 96 credits shall be the preferred option as it provides the full range of subject education including Internship and Master Thesis.

Year	**Semester**	**Semester**	**Credits**
First year	Semester I	Semester II	
Optional Exit point 1 with a Diploma Degree in Zoology			**40**
Second year	Semester III	Semester IV	
Preferred and Final Exit point 2 with a Masters' Degree in Zoology			**80**

Course Credit Scheme

Semester	**Core Course/ MOOCs****			**Elective Course**			**Inter/ Intra-Departmental Course**			**Internship/Educational Tour/ Dissertation Courses**			**Total Credits**
	No. of Papers	Credits (T+L)	**Total Credits**	No. of Papers	Credits (T+L)	**Total Credits**	No. of Papers	Credits (T)	**Total Credits**	No. of Papers	Credits (T)	**Total Credits**	
I	4	12T+6L	**18**	-	-	**-**	1	2	**2**				**20**
II	4	12T+6L	**18**	-	-	**-**	1	2	**2**				**20**
III	2	12T+2L	**12**	2	4T+2L	**6**				**-**	**2**	**2**	**20**
IV	-	4T	**4**	2	8T	**8**				**-**	**8**	**8**	**20**
Total Course													**80**

Credits		

- For each Core and Elective Courses (4 credit each), there will be 4 hours of theory teaching per week. For lab (1 credit) there will be two hours of lab work every week. Therefore, for 8 credit lab, there will be 16 hours of lab work every week.
- Summer Internship/ Field Work will be of 4 credit and Dissertation of 8 credit.
- Inter- and IntradepartmentalCourseswill be of 4 credits each in Semester III and IV respectively.
- 1 Credit (4 credits) and 1 Non Credit Value added course is offered in each semester I and II respectively.
- **Codes**: T, L, F or D defines as Theory, Lab, Summer Internship/ Field Work or Master Thesis/ Dissertation, respectively.

Distribution Scheme of Credits

SEMESTER	SEM I	SEM II	SEM III	SEM IV
CORE COURSES				
VALUE ADDED CREDIT COURSE				
VALUE ADDED NON-CREDIT COURSE				
MOOC				
SUMMER INTERNSHIP/ FIELD WORK				
INTERDEPARTMENTAL COURSE				
ELECTIVE				
INTRADEPARTMENTAL COURSE				
MASTER THESIS/ DISSERTATION				

6. Course Structure:

The course structure of TWO YEARS Master in Zoology programme shall be as under:

Semester wise Details of M.Sc. Zoology Course

Course No.	Name of the Course	Credit	Remark
	Semester I		
ZOOLCC-101	Non Chordata	**04**	**Core Course 1**
ZOOLCC-102	Animal Physiology	**04**	**Core Course 2**
ZOOLCC-103	Biochemistry and Cell Biology	**04**	**Core Course 3**
ZOOLCC-104	Lab based on ZOOLCC102-103	**04**	**Core Course 4**
ZOOLCC-105	Lab based on ZOOLCC101	**02**	**Core Course5**
ZOOLVC-101	**Bioinstrumentation**	**02**	**Value Added Credited Course (Intradepartmental)**
	Semester Total	**20**	
	Semester II		
ZOOLCC-201	Chordata	**04**	**Core Course 6**
ZOOLCC-202	Animal Behaviour and Chronobiology	**04**	**Core Course 7**
ZOOLCC-203	Molecular Biology and Genetics	**04**	**Core Course 8**
ZOOLCC-204	Lab based on ZOOLCC202-203	**04**	**Core Course 9**
ZOOLCC-205	Lab based on ZOOLCC201	**02**	**Core Course 10**
ZOOLIER-201	Public Health Care and Management	**02**	**Interdepartmental Course**
	Semester Total	**20**	
	Semester III		
ZOOLCC-301	Biosystematics, Biodiversity and Evolutionary Biology	**04**	**Core Course 11**
ZOOLCC-302	Developmental Biology and Immunology	**04**	**Core Course 12**
ZOOLCC-303	Ecology, Environmental Biology and Toxicology	**04**	**Core Course 13**
ZOOLEL-301A	Wildlife: Animal Diversity	**04**	**Elective Course 13**
ZOOLEL-301B	Principles of Endocrinology		
ZOOLEL-301C	Insect Taxonomy, Morphology and Ecology		
ZOOLEL-301D	Applied Fish and Fisheries		
ZOOLEL-301E	Advanced Genetic Analysis		
ZOOLEL-301F	General Parasitology		
ZOOLEL-302A	Lab based on ZOOLEL301A	**02**	**Elective Course 14**
ZOOLEL-302B	Lab based on ZOOLEL301B		
ZOOLEL-302C	Lab based on ZOOLEL301C		
ZOOLEL-302D	Lab based on ZOOLEL301D		
ZOOLEL-302E	Lab based on ZOOLEL301E		
ZOOLEL-302F	Lab based on ZOOLEL301F		
ZOOLIN-301	Internship/Educational Tour	**02**	**Internship/Field Work**
	Semester Total	**20**	
	Semester IV		
ZOOLCC-401	Quantitative Biology and Bioinformatics	**04**	**Course Course 16**
ZOOLEL-401A	Wildlife: Ecology, Behaviour and Techniques	**04**	**Elective Course 17**
ZOOLEL-401B	Biology of Reproduction		
ZOOLEL-401C	Insect Physiology		
ZOOLEL-401D	Fish Biology and Genetic Resources		
ZOOLEL-401E	Human Genetics		
ZOOLEL-401F	Biology of Parasites		
ZOOLEL-402A	Wildlife: Conservation and Management	**04**	**Elective Course 18**
ZOOLEL-402B	Endocrine disorders: Diagnosis, Techniques and Ethical considerations		
ZOOLEL-402C	Applied Entomology and Pest Management		

ZOOLEL-402D	Fish Ecology, Aquaculture and Capture Fisheries		
ZOOLEL-402E	Parasitological Techniques		
ZOOLEL-402F	Clinical and Cancer Genetics		
ZOOLMT-401	Dissertation	**08**	**Dissertation**
	Semester Total	**20**	
	GRAND TOTAL	**80**	

ZOOL – Zoology; ZOOLCC – Core Course; ZOOLVC – Value added course (Credited); ZOOLEL –Elective; ZOOLIN – Internship/Educational tour; ZOOLIER – Interdepartmental Course; ZOOLMT – Master Thesis/ Dissertation; ZOOLIRA – Intradepartmental Course.

I. Electives

A. Biodiversity, Wildlife Conservation and Management

ZOOLEL-301A Wildlife: Animal Diversity
ZOOLEL-302A Lab based on ZOOLEL-301A
ZOOLEL-401A Wildlife: Ecology, Behaviour and Techniques
ZOOLEL-402A Wildlife: Conservation and Management

B. Endocrinology and Reproductive Physiology

ZOOLEL-301B Principles of Endocrinology
ZOOLEL-302B Lab based on ZOOLEL-301B
ZOOLEL-401A Biology of Reproduction
ZOOLEL-402B Endocrine disorders: Diagnosis: Techniques and Ethical considerations

C. Entomology

ZOOLEL-301C Insect Taxonomy, Morphology and Ecology
ZOOLEL-302C Lab based on ZOOLEL-301C
ZOOLEL-401C Insect Physiology
ZOOLEL-402C Applied Entomology and Pest Management

D. Fish and Fisheries

ZOOLEL-301D Applied Fish and Fisheries
ZOOLEL-302D Lab based on ZOOLEL-301D
ZOOLEL-401D Fish Biology and Genetic Resources
ZOOLEL-402D Fish Ecology, Aquaculture and Capture Fisheries

E. Molecular Genetics

ZOOLEL-301E Advanced Genetic Analysis
ZOOLEL-302E Lab based on ZOOLEL-301E
ZOOLEL-401E Human Genetics
ZOOLEL-402E Clinical and Cancer Genetics

F. Parasitology

ZOOLEL-301F General Parasitology
ZOOLEL-302F Lab based on ZOOLEL-301F
ZOOLEL-401F Biology of Parasites
ZOOLEL-402F Parasitological Techniques

II. MOOCs

Some of the links for MOOCs are as follows:
https://www.swayam.gov.in
https://www.edx.org/course/subject/biology-life-sciences
https://online-learning.harvard.edu/subject/biology
https://online.stanford.edu/courses
http://www.openculture.com/freeonlinecourses

II. Dissertation

ZOOLMT-401A	Chronobiology
ZOOLMT-401B	Endocrinology and Reproductive Physiology
ZOOLMT-401C	Entomology
ZOOLMT-401D	Evolutionary Biology
ZOOLMT-401E	Fish and Fisheries
ZOOLMT-401F	Human Genetics
ZOOLMT-401G	Molecular Biology
ZOOLMT-401H	Parasitology
ZOOLMT-401I	Toxicology
ZOOLMT-401J	Wild life and Biodiversity
ZOOLMT-401K	Public Health and Management
ZOOLMT-401L	Biomusicology (Music Therapy)

Allotment and evaluation of dissertation will be done in Semester III and Semester IV, respectively.
The student will submit dissertation preferably supported by short publications.
The dissertation will be evaluated at the end of Semester IV in two stages.
Stage I: The Evaluation Committee will consist of supervisor, one senior faculty member and the Head of the Department. After evaluation, this three member committee will provide 'Grade' which will cover 70% of the total marks.
Stage II: The candidate will present his work to the external examiner appointed by the BOS and will cover 30% of the total marks.

V: Interdepartmental/Intradepartmental Courses

Semester	Course	TOPIC		Credits	Total Lectures
		Interdepartmental Course	Intradepartmental Course		
I	ZOOLVC-101	-	Bioinstrumentation	2	30
II	ZOOLIER-201	Public Health Care and Management	-	2	30
TOTAL				**4**	**60**

Semester wise Details of M.Sc. Zoology Course

Paper Codes: The first four letters (ZOOL) define the Subject, ZOOLCC is meant for Core Course, ZOOLVC defines the Value added course (Credited), ZOOLEL defines the Elective course, ZOOLIER stands for Interdepartmental Course, ZOOLIN defines the Summer Internship/ Field Work,ZOOLIERstands for Interdepartmental Course,ZOOLMT defines the Master Thesis/ Dissertation, and ZOOLIRA defines the Intradepartmental Course. The First numeral defines the semester and the remaining two numerals defines stream and the paper number. **Theory includes:Lectures, Mentoring, Tutorials, Group Discussion, Assignments and Quizzes.				
Semester I				
Core courses		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-101	Non–Chordata	**4**	**-**	**4**
ZOOLCC-102	Animal Physiology	**4**	**-**	**4**
ZOOLCC-103	Biochemistry and Cell Biology	**4**	**-**	**4**
ZOOLCC-104	Lab based on ZOOLCC-101	**-**	**4**	**4**
ZOOLCC-105	Lab based on ZOOLCC102-103	**-**	**2**	**2**
Core course 5 (total number)		**12**	**06**	**18**
Credit Value Added Course		**Credits**		
ZOOLVC-101	Biodiversity and Conservation	**2**	**-**	**2**
Total credits in Semester I (Core and Intradepartmental Course) – 20				
Semester II				
Core courses		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-201	Chordata	**4**	**-**	**4**
ZOOLCC-202	Animal Behaviour and Chronobiology	**4**	**-**	**4**
ZOOLCC-203	Molecular Biology and Genetics	**4**	**-**	**4**
ZOOLCC-204	Lab based on ZOOLCC201	**-**	**2**	**4**
ZOOLCC-205	Lab based on ZOOLCC202-203	**-**	**4**	**2**
Core course 5 (total number)		**12**	**06**	**18**
Non Credit Value Added Course		**Credits**		
ZOOLIER-201	Public Health Care and Management	**2**	**-**	**2**
Total credits in Semester II (Core and Interdepartmental Course) – 20				
Semester III				
Core + Elective Courses		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-301	Biosystematics and Evolutionary Biology	**4**	**-**	**4**
ZOOLCC-302	Developmental Biology and Immunology	**4**	**-**	**4**
ZOOLCC-303	Ecology and Toxicology	**4**		**4**
ZOOLEL-301 (A-F)	Elective I	**4**	**-**	**4**
ZOOLEL-302 (A-F)	Elective II Lab based on ZOOLEL301 (A-F)	**-**	**2**	**2**

ZOOLIN-301	Internship/Educational Tour	**-**	**2**	**2**
Core course 3 (total number)		**16**	**4**	**20**
Total credits in Core + Elective courses + Tour		**20**		
Total credits in Semester III (Core and Elective and Educational Tour) – 20				
Semester IV				
Core + Elective		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-401	Quantitative biology and Bioinformatics	**4**	**-**	**4**
ZOOLEL-401 (A-F)	Elective III	**4**	**-**	**4**
ZOOLEL-402 (A-F)	Elective IV	**4**	**-**	**4**
ZOOLMT-401	Dissertation (D)	**8**	**-**	**8**
Course 3 (total number)		**20**	**-**	**20**
Total credits in Core + Elective courses + Master Thesis		**20**		

1. In the third and fourth semesters, a student has to choose one of the four electives. Each elective (**Electives: Biodeiversity, Wildlife Conservation and Management:** ZOOLEL-301A, 302A, 401A, 402A; **Endocrinology and Reproductive Physiology:** ZOOLEL-301B, 302B, 401B, 402B; **Entomology:** ZOOLEL- 301C, 302C, 401C, 402C; **Fish and Fisheries:** ZOOLEL- 301D, 302D, 401D, 402D;**Molecular Genetics:**ZOOLEL- 301D, 302D, 401D, 402D;**Parasitology:** ZOOLEL- 301F, 302F, 401F, 402F) has Three papers and a practical based on these theory papers.

2. **Dissertation** – There is a list of available titles from which the student will make his preferred choices and accordingly, he may opt to do a dissertation in the research laboratory of the concerned Faculty members. This will be purely on mutual agreement between the student and the Faculty member. Upon successful completion of the dissertation (as certified by the concerned faculty member), the department would issue a certificate to the student.

Selection of Elective Courses:

1. Elective courses in Zoology:

The number of seats in each elective would be limited and will be announced before the commencement of the course in each year. The Selection of Elective papers in 3rd and 4th Semesters would be based on merit (performance in the First Semester Examination) and choice.

2. Interdepartmental and Intradepartmental Courses in Zoology:

There shall be total of 50 seats in both Interdepartmental and Intradepartmental Courses in Zoology. This number is the maximum intake of students in M.Sc. programme of the department. The selection of students shall be based on the merit prepared from the marks

obtained in First and Second semesters of Masters' programme of their respective department.

Teaching:

There shall be 90 instructional days excluding examination in a semester.

The teaching methodology will include classroom lectures, seminars/ presentations, group discussions, mentoring, tutorials, field study/ report, case study, assignments, project writing, quiz, etc. and the theory should be atleast 70% of the total workload.

Assessment of Students' Performance and Scheme of Examinations:

1. The medium of instruction and examination shall be English.
2. Assessment of students' performance shall consist of two components (i) Internal assessment (mid-semester) and (ii) end-semester examination. The timing shall be decided for these as per the Academic Calendar notified by the University of Lucknow.

A. The break-up of marks for credit course examinations will be:

Assessment Type	**Theory course (mark distribution) 4 credits**
Internal Assessment	
(a) Examinations	15
(b) Assignment/ Seminar/ Presentation	10
(c) Attendance	05
External Assessment	
(a) End semester Examination	70
Total Marks	**100**

B. Each two and four credit lab course shall be evaluated at the end-semester examination for 50 and 100 marks respectively.

C. Internal assessment will be broadly based on attendance in Theory and Lab (5 marks), assignments, seminars, presentations, quizzes and tests in the theory component (25 marks). These criteria are tentative and could be modified based on guidelines approved by the academic council.

D. The question papers will be comprised of short, long and essay type questions.

E. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examinations. Regular as well as Ex-students shall be permitted to appear/re-appear/improve in courses of Odd Semesters only at the end of Odd Semesters and courses of Even Semesters only at the end of Even Semesters.

Pass Percentage & Promotion Criteria

As per the rules of University of Lucknow.

Part I to Part II Progression
As per the rules of the University of Lucknow.

Conversion of Marks into Grades
As per the rules of the University of Lucknow.

Grade Points
Grade point table as per University Examination rule.

CGPA Calculation
As per University Examination rule.

SGPA Calculation:
As per University Examination rule.

Grand SGPA Calculation:
As per University Examination rule.
Conversion of Grand CGPA into Marks
As notified by competent authority the formula for conversion of Grand CGPA into marks is:
Final %age of marks = CGPA based on all four semesters × 9.5

Division of Degree into Classes
Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.

Attendance Requirement
No student shall be considered to have pursued a regular course of study unless he/she is certified by the Head of the Department of Zoology, University of Lucknow, to have attended 75% of the total number of theory and lab classes conducted in each semester, during his/her course of study.

Span Period
As per University rule.

Guidelines for the Award of Internal Assessment Marks in M.Sc. Zoology Programme (Semester Wise)
Internal assessment will be broadly based on attendance in Theory and Lab (5 marks), assignments, seminars, quizzes and tests in the theory component (25 marks). These criteria are tentative and could be modified based on guidelines approved by the academic council.

Semester I

Core Course-1
ZOOLCC-101: Non–Chordata

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To create in the student an appreciation of non-chordate diversity
- To develop in the student an understanding of structural and functional diversity
- To develop in the student the understanding of evolutionary relationship amongst non-chordate groups

Unit I

Protozoa

Ultrastructure	01
Osmoregulation	01
Locomotion	01
Nutrition	01
Reproduction	01

Porifera

Cell types	01
Skeleton	01
Reproduction	01

Cnidaria

Origin of metazoan	01
Polymorphism	01
Metagenesis	01
Corals	01
Pigments	01

Unit II

Platyhelminthes

Origin and evolution of bilateria	0 2
Parasitic adaptations	0 1
General organization of Trematoda and Cestoda	0 4
Larval stages of Trematoda and Cestoda	0 2
Life cycle patterns in Platyhelminthes	0 2

Aschelminths

General organization	02
Economic importance of nematodes in animals and plants	02

Unit III

Annelida

Coelom & Metamerism	0 1
Adaptive radiation in Polychaeta	0 1
Segmental organs	0 1
Filter feeding	0 1

Arthropoda

Organisation and affinities of Onychophora	0 2
Larval forms in Crustacea	0 1
Parasitism in Crustacea	0 1
Respiratory organs in Arthropods	0 1
General organization of Tardigrada	0 1
General organization of Pycnogonida	0 1
General organization of Trilobitomorpha	0 1

Unit IV

Mollusca

Foot and Radula	0 2
Respiration	0 1
Nervous system	0 1
Torsion in gastropods	0 2
Shell types	0 1

Echinodermata

Origin of Deuterostomia	0 2
Water vascular system	0 1
Larval forms & affinities	0 2

Unit V

Minor phyla

General Organization and affinities of Rotifera	0 3
General Organization and affinities of Phoronida	0 2
General Organization and affinities of Ectoprocta	0 2
General Organization and affinities of Endoprocta	0 2
General Organization and affinities of Ctenophora	0 2

Student learning outcomes

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of non-chordate diversity
- describe structural and functional diversity of non-chordate
- explain evolutionary relationship amongst non-chordate groups

Suggested readings

1. Barnes et al (2009). The Invertebrates: A synthesis. Wiley Backwell
2. Hunter: Life of Invertebrates (1979, Collier Macmillan)

3. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
4. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
5. Brusca and Brusca (2016) Invertebrates. Sinauer
6. Jan Pechenik (2014) Biology of the invertebrates. McGraw Hill
7. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

Core Course-2
ZOOLCC-102: Animal Physiology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop in the student an understanding of functioning of an organisms body
- To develop in the student an understanding of the various homeostatic systems of the body
- To develop in the student an understanding of regulation of function in the body

UnitI

Physiology of Digestion

Digestion and absorption of proteins	01
Digestion and absorption of carbohydrates	01
Digestion and absorption of lipids	01
Digestion and absorption of nucleic acids	01
Regulation of digestion and absorption	01

Physiology of Excretion

Homeostasis	01
Ion regulation	01
Regulation of excretion	01
Physiological responses to salinity changes	01

Physiology of Thermoregulation

Thermoregulation	01
Thermoregulation based animal categories	02
Acute and chronic metabolic responses to temperature change	01
Thermal limits of individuals	
Mechanism of thermoregulation	

Unit II

Physiology of respiration

External respiration	01
Internal respiration	02
Gaseous exchange in terrestrial and aquatic animals	02
Respiratory pigments	02
Mechanism and regulation of respiration	02

Physiology of circulation

Pattern of circulation among different animal groups	02
Haemodynamics	02
Regulation of circulation	01

Cardiac cycle	01

UnitIII

Physiology of muscular system

Types, function and properties of muscle tissue	01
Molecular organization of sarcomere	01
Molecular mechanism of striated muscle contraction	01
Molecular mechanism of smooth muscle contraction	01
Muscle metabolism	01
Regulation of muscle contraction	01

Neurophysiology

Neuronal tissue	01
Structural Organization of Nervous System	01
Functional Organization of Nervous System	01
Ionic and Physical Basis of Membrane Potential	01
Electrotonic and Action Potential Conduction	01
Molecular mechanism of Synaptic transmission, vesicle fusion and recycling	01
Neurotransmitters and Neuro Modulators	01
Synaptic Plasticity	01

UnitIV

Physiology of sense organs

Organization of Sensory System	01
Mechanoreception and Touch	01
Vestibular Organ and Hearing	01
Chemoreception and Taste	01
Olfaction	01
Vision	01

Physiology of endocrine system

Overview of endocrine glands	02
Mechanism of action of hormones	02
Neuroendocrine feedback	02

Unit V

Physiology of stress

Mechanism of stress	01
Stress disorders	01
Secondary effects	01

Physiology of Aging

Aging and Senescence	01
Physiological and Cellular Manifestations of Aging	03

Theories of Aging 03

Evolutionary Theories of Aging

Programmed Theories of Aging

Damage Theories of Aging

Beyond Molecular Biology of Aging

Molecular Mechanisms of Aging 02

Student learning outcomes

The student at the completion of the course will be able to

- understand various functional components of an organism body
- analyse the complexities and interconnectedness of these functional components
- identify the mechanism underlying maintenance of homeostasis of the body
- infer the regulatory mechanisms for maintenance of function in the body

Suggested readings

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. HercourtAsiaPTE Ltd. /W.B. Saunders Company.

2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons

3. Christopher D. Moyes, Patricia M. Schulte 2016 Principles of Animal Physiology. 3rd Edition, Pearson Education

4. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, 2004.

5. Chatterjee C C (2016) Human Physiology Volume 1 & 2. 11th edition. CBS Publishers

Core Course-3
ZOOLCC-103:Biochemistry and Cell Biology

Total Credits: 04 **Teaching Hours: 60**

Objective: To develop an understanding of biochemical basis of life, role of stabilizing interaction and biomolecular complexity and biochemical processes as the foundation of all physiological events occurring in animals.

Unit I

Biomolecules

Introduction to biomolecules (carbohydrates, lipids, proteins, nucleic acids) 03
Stablizing interactions (van der waals, electrostatic, hydrogen bonding, hydrophobic interaction *etc.*) 01
Types and structure of amino acids 02
Secondary structure of Proteins (α-helix, β-sheet, motifs, folds, domains, Ramachandran plot) 02
Tertiary and quaternary structure 02
Nucleic acids: DNA structure, DNA supercoiling, forms of DNA, chromatin organization
Types of RNA 02

Unit II

Enzyme Kinetics and Bioenergetics

Enzymes

- Introduction to enzymes: Apoenzyme, holoenzyme, prosthetic group, cofactors, coenzymes, abzymes, ribozymes. 02
- Enzyme kinetics: Michaelis-Menten equation, LB Plots, enzyme inhibition, Related calculations 03
- Enzyme regulation: Allosteric regulation, covalent modification, zymogens, proenzymes, isozymes 03

Bioenergetics

- Thermodynamic principles: standard Free energy change, equilibrium constant, actual free energy change, Related calculations 04

Unit III

Metabolism

- Carbohydrates: glycolysis, citric acid cycle, gluconeogenesis, glycogenesis, glycogenolysis, phosphate pentose pathway, oxidative phosphorylation, and their regulation 04
- Lipids --- Biosynthesis of saturated and unsaturated fatty acids Catabolism of fatty acids and ketone bodies 04
- Amino acids: Oxidation and production of urea 02
- Nucleic acids: Biosynthesis and degradation of pyrimidines and purines 02

Unit IV

Structure and function of Membrane & Cytoskeleton

- Biomembranes and architecture: lipid bilayer and protein components 02
- Microfilaments: actin structures, myosin powered cell movements 01

- Intermediate filaments: Organization & function 01
- Microtubules: Organization and dynamics, Kinesin and dynein powered movements 01

Endomembrane system and intracellular trafficking

- Compartmentalization in eukaryote cells 01
- Gated transport between nucleus & cytosol 01
- Structure of nuclear pore complex 01
- Signal sequences & sorting transporters 01
- Role of monomeric GTPases in protein sorting 01
- Protein sorting to ER and mitochondria. 01
- Vesicular trafficking, secretary pathways, receptor mediated endocytosis 01

Unit V

Cellular communication

- General principles of cell communication 01
- Extracellular matrix and Cell adhesion 02

Cell signaling

- Signaling molecules and cell-surface receptors 02
  (G-protein coupled receptors, Ion-channel linked receptors, Enzyme linked receptors
- Second messengers 01
- Regulation of signaling pathways, JAK-STAT pathway, MAP Kinase pathway 02

Cell cycle and Cell division

- Cell cycle overview and control 01
- Checkpoints in cell-cycle regulation 01
- Regulation of Mitosis and Mieosis 01
- Cancer and apoptosis 01

Student learning outcomes

The course will lay down the foundation of biochemistry among students where they will develop a deep understanding of structure of biomolecules like proteins, lipids and carbohydrates and how simple molecules together form complex macromolecules. They will be able to understand the thermodynamics of enzyme catalyzed reactions and mechanisms of energy production at cellular and molecular levels. In addition, the application of Biochemistry in understanding disease and medicine will be apprised.

Suggested readings

1.	Nelson & Cox	Lehninger's Principles of Biochemistry	McMillan	2000
2.	Zubay *et al*	Principles of Biochemistry	WCB	1995
3.	Voet &Voet	Biochemistry Vols 1 & 2	Wiley	2004
4.	Murray *et al*	Harper's Illustrated Biochemistry	McGraw Hill	2003
5.	Wilson and Walker	Practical Biochemistry– Principles and Techniques	Cambridge University Press	
6.	Elliott and Elliott	Biochemistry and Molecular Biology	Oxford Universitypress	

Core Course-4

ZOOLCC104 Lab based on ZOOLCC102-103 Credits 04

Core Course-5

ZOOLCC105 Lab based on ZOOLCC101 Credits 02

Value Added Credited Course

(Intradepartmental)

Semester	Course	Intradepartmental Course		Credits	Total Lectures
I	**ZOOLVC-101**	Bioinstrumentation		2	30

ZOOLVC-101: Bioinstrumentation

Total Credit: 02 **Teaching Hours: 30**

Course objectives

- To explain the principle and working of instruments in a biology laboratory.

Unit I **06**

Microscopy

Basic principles of microscopy
Phase contrast microscope
Fluorescence microscope
Confocal microscopes
Electron microscope: SEM, TEM

Unit II **06**

Chromatography and Centrifugation

Centrifuge: principle, types of rotors, high speed and ultracentrifuge
Chromatography: Paper, Thin Layer, Gel Filtration, Ion exchange,
Column-ion-exchange

Unit III **06**

Histology & Cell Culture

Types of Microtome,
Hybridization methods: ChIP, FISH and GISH ,Western Blot
Cell and tissue culture: Laminar Flow, CO_2 inubator, BOD incubator
Autoclave

Unit IV **06**

Biochemistry

Colorimetry and spectrophotometry: Beer-Lamberts' law, absorption coefficient
Biochemical Analysers, Lyophilizer, Electronic balance
pH Meter, Water purification system

Unit V **06**

Molecular Biology

PCR Machine, Gel Documentation System, Gel Apparatus

Flow cytometer, DNA sequencer

Student learning outcomes

The present course will enable the students to:

- solve the biological problems during data analysis using various statistical methods such as uni-variate analysis, bi variate analysis, correlation, regression and various tests of significance.
- learn the working of various equipments which will be useful in the final semester for their experimental work.

Suggested readings

Biostatistical Analysis (Fourth Edition) by Jerrold H. Zarr, Pearson Education Inc., Delhi.

Statistical Methods (Eighth Edition) by G. W. Snecdecor and W. G. Cochran, Willey Blackwell

Biostatistics (Tenth Edition) by W.W. Daniel and C. L. Cross, Wiley

Introductory Biological Statistics (Fourth Edition) by John E. Havel, Raymond E. Hampton and Scott J. Meiners

Suggested readings

1.	Sambrook*et al*	Molecular Cloning vols I, II, III	CSHL	2001
2.	Primrose	Molecular Biotechnology	Panima	2001
3.	Clark & Switzer	Experimental Biochemistry	Freeman	2000

Semester II

Core Course-6
ZOOLCC-201: Chordata

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To create in the student an appreciation of chordate diversity
- To develop in the student an understanding of structural and functional diversity
- To develop in the student the understanding of evolutionary relationship amongst chordates

UnitI

Protochordates and Pisces

General organization and affinities of Hemichordata	01
General organization and affinities of Urochordata	01
General organization and affinities and Cephalochordata	01
General organization of fishes	03
General organization and affinities of Ostracoderms	02
General organization and affinities of Dipnoi andHolocephali	01
General organization and affinities of Coelacanthiformes	01

UnitII

Amphibia

Origin of tetrapods	03
General organization of Anura	02
Neoteny	01
Peculiarities of Urodela	01
Peculiarities of Apoda	02
Adaptive Radiation	01
Extinct Amphibians	01

Unit III

Reptilia

Origin and evolution	0 2
Adaptive radiation	0 2
Dinosaurs	0 2
General organization and affinities of *Chelonia*	0 2
Crocodilia	0 2
Squamata	0 2
Rhynchocephalia	0 2

UnitIV

Aves

Origin and evolution	0 3
Flightless birds	0 2
Adaptations for flight	0 3

Adaptive radiation	0 2

Unit V

Mammalia

Origin of mammals	0 3
Adaptive radiation of Mammalia	0 2
Structural peculiarities and phylogenetic relations of *Prototheria* and *Metatheria*	0 2
Dentition	0 2
Stomach	0 1
Uterus modifications	0 1
Aquatic mammals	0 2

Student learning outcomes

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of chordate diversity
- explain structural and functional diversity of chordate
- explain evolutionary relationship amongst chordate

Suggested readings

1. Harvey et al: The Vertebrate Life (2006)
2. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002,Wiley - Liss)
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
5. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

Core Course-7
ZOOLCC-202: Animal Behaviour and Chronobiology

Credits: 04 **Teaching Hours: 60**

Course objectives

The course is so designed that students will learn:

- animal behaviour in the context of evolutionary and ecological biology,
- historical background and theory for animal behaviour concepts,
- recent approaches in animal behaviour,
- techniques used to study animal behaviour in a variety of different organisms and identify potential research questions from discussions of current literature,
- how the rhythmic geophysical environment impacts the internal rhythms,
- how environmental cues are perceived by the organisms and modulate the circadian physiology at molecular, cellular and systems levels,
- diagnosis of clock disruption and related disorders, and
- time dependent treatment to different lifestyle disorders.

Unit I

Behavioural evolution and regulation

History of behavioural studies	01
Regulation of behaviour	02
Proximate and ultimate causes of behavioural evolution	01

Learning and memory

Types of learning (non–associative and associative)	01
Social learning (cultural transmission)	01
Survival value of learning	
Molecular basis of learning	01
Molecular basis of memory	

Communication

Communication modes	02
Evolution of communication	
Deceit versus honest signalling	02
Game theory and communication	
Adaptive value of communication	

Sexual selection

Intra and intersexual selection	02
Pre–and post–copulatory sexual selection	
Sperm competition	
Cryptic female choice	
Evolutionary models of mate choice	01

Unit II

Reproductive strategies

Different mating systems	01
Ecology and evolution of mating systems	02
Neuroendocrine control of mating systems	

Parental care

Parental investment	01
Origin and evolution of parental care	
Patterns of parental care	02
Parent–offspring conflict	
Sibling conflict	
Brood parasitism	

Territorial behaviour

Aggression, dominance and territorial behaviour	01
Habitat choice	
Ideal free and despotic distribution	
Types of territories	
Economic defendability	02
Territory size determinants and defense measure	
Evolution of territoriality	
Adaptive value of territoriality	

Social behaviour and kin selection

Levels of cooperation	02
Paths to cooperation (reciprocity, byproduct, mutualism, group selection)	
Types of social structure	
Adaptive value and evolution of sociality	01
Social symbioses	
Hamilton's rule for kin selection	01
Evolution of kin selection	

Unit III

Clock, rhythms and calendar

Introduction, milestones and scope of chronobiology	03
Geophysical environment seasons	01
Proximate and ultimate factors	
Biological clocks, types, constant conditions, model systems	03
Entrainment theory: masking, synchronization	02
Photoreception, phototransduction	03
Photoperiodic time measurement	

Unit IV

Clock, underlying events and misalignments

Anatomy and physiology of the time keeping system	03
Cellular and Molecular basis of circadian timekeeping in *Drosophila* and mammals	03
Seasonal migration	01
Sleep and neural relation	02
Clock misalignment; jet lag, shift work,	01
Lifestyle disorders: depression and sleep disorders, social jetlag	01
Clock repair, chronotherapy and chronomedicine	01

Unit V

Study and analysis of animal behavior

Evolution by natural selection	01
Genetics and inheritance	01
Comparative method	01
Tinbergen's four questions (proximate and ultimate causes)	02
Observational	
Experimental	
Comparative	

Study and analysis of Chronobiology

Activity and rest calculations	01
Phase shift	01
Phase response curves (PRC) and Phase transition curves (PTC)	01
Questionnaires (sleep logs, chronotype, fatigue, RNAS)	02
Monitoring of physiological variables (temperatures, blood pressure, heart rate)	01

Student learning outcomes

After successful completion of this course in animal behaviour and chronobiology the students should be capable of:

- Understanding and identify behaviours in a variety of taxa
- discussing the proximate and ultimate causes of various behaviours
- designing and implementing experiments to test hypotheses relating to animal behaviour
- understanding about the molecules, cells, and systems of biological timing systems
- conceptualizing how species profitably inhabit in the temporal environment and space out their activities at different times of the day and seasons.
- studying and analysing the scientific literature
- planning studies on biological rhythms in both human and non-human species
- interpreting the cause and effect of lifestyle disorders

- contributing to public understanding of biological timing

Suggested readings

1. Alcock, J. 2013. Animal Behavior: An Evolutionary Approach. Tenth Edition. ISBN-13: 978-0878939664 2)
2. Sherman, P.W. and J. Alcock. 2013. Exploring Animal Behavior: Readings from American Scientist. Sixth Edition. ISBN-13: 978-1605351957
3. Dugatkin, L. A. (2013). Principles of animal behavior: Third international student edition. WW Norton & Company.
4. Breed, M. D., & Moore, J. (2015). Animal behavior. Academic Press.
5. Mellgren, R. L. (Ed.). (2000). Animal cognition and behavior (Vol. 13). Elsevier.
6. Bolhuis, J. J., Giraldeau, L. A. E. (2005). The behavior of animals: Mechanisms, function, and evolution. Blackwell Publishing.
7. Hazlett, B. (Ed.). (2012). Quantitative methods in the study of animal behavior. Elsevier.
8. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J.
9. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
10. The Physiological Clock (3rd edition), Erwin Bunning, The English Universities Press Ltd. London, Springer- Verlag New York, Berlin Heidelberg
11. Circadian Physiology: Roberto Refinetti, CRC Press (3rded) 2016
12. Introducing Biological Rhythms: Willard L. Koukkari, Robert B. Sothern, 2006, Springer
13. Biological Timekeeping: Clock, Rhythms and Behaviour, Vinod Kumar (ed. 2017) Springer India Pvt Limited.
14. Insect Photoperiodism: Stanley D. Beck, Academic Press, New York and London
15. Chapter 1, The Clocks that Time Us, Moore-Ede, MC, Sulzman, FM and Fuller, CA (1982) Harvard University Press, Cambridge.
16. C. S. Pittendrigh, S. Daan (1976c) A functional analysis of circadian pacemakers in nocturnal rodents. V. Pacemaker structure: a clock for all seasons. J. Comp. Physiol. [A]106:333-355.
17. M. Menaker (1968) Extraretinal light perception in the sparrow. I. Entrainment of the biological clock. *Proc. Natl. Acad. Sci.* 59:414-421.
18. J.C. Dunlap (1999) Molecular bases for circadian clocks. *Cell* 96:271-290.

Core Course-8
ZOOLCC-203: Molecular Biology and Genetics

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To study the structure of gene and learn how the information contained within them gets transferred from one generation to another.
- Human genetics will impart knowledge about the human chromosome constitution that would help in applying basic principles of chromosome behavior to disease context.
- To create awareness of genetic diseases
- To learn molecular diagnostic means for multiple diseases
- Overall, this course will highlight evolution of the concept of gene and its amalgamation with molecular biology and study

Unit I: **12**

DNA replication

DNA polymerases & Enzymes involved in replication
Origin of replication and formation of primosome
Unit of replication, Replication fork and replisome
Fidelity of replication
Termination of replication

Unit II: **12**

Transcription & Translation

Fine structure of gene, transcription unit
Initiation, elongation and termination of transcription in prokaryotes and eukaryotes
RNA polymerases, Transcription factors and machinery
Initiation, elongation and termination of translation in prokaryotes and eukaryotes
Aminoacylation of tRNA, tRNA-identity, aminoacyltRNAsynthetase

Unit III: **12**

Regulation of gene expression

Regulation at transcriptional level: Operon system, *lac, trp,* operons
Post-transcriptional modifications: Capping, Splicing, Polyadenylation,
RNA editing
Role of chromatin in gene expression
Regulation at translational level
Post- translational modifications: Protein folding, Intracellular protein degradation
Gene silencing, RNAi

Unit IV: **12**

Mendelian Genetics

Mendel's laws and their chromosomal basis
Extension of Mendel's principles: complete, incomplete dominance and co-dominance
Dominant and recessive mutations, complementation test, Multiple alleles, pseudoalleles
Gene action- from genotype to phenotype–penetrance and expressivity
Gene-gene interaction,epistasis, pleiotropy, phenocopy

Genomic imprinting, genetic anticipation
Sex linkage, sex-limited and sex-influenced characters
Extra chromosomal inheritance: Mitochondrial genes, maternal inheritance
Dosage compensation: hyperactivation of X-linked gene in Male *Drosophila*
Inactivation of X-linked genes in female mammals

Unit V: **12**

Gene mutation and DNA repair

Types of gene mutations
Methods for detection of induced mutations
P-element insertional mutagenesis in *Drosophila*
DNA damage and repair mechanisms
Mutant types (lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis)

Course Outcome

- The course offers a detailed and conceptual understanding of molecular processes *viz.* Replication, transcription, translation *etc.* underlying survival and propagation of life at molecular level. It will help students to understand how genes are ultimately expressed as proteins which are responsible for the structure and function of all organisms. To learn how four sequences (3 letter codons) generate the transcripts of life and determine the phenotypes of organisms.

- The student will have awareness about genetic diseases, their types and causes. Also the understanding of molecular techniques will provide improved diagnosis and management of these diseases.
- The principles of inheritance, linkage and crossing over which lead to variations will be made clear as well as the application thereof in gene mapping

Suggested Reading

1.	Strickberger	Genetics	Mcmillan	1985
2.	Griffiths *et al*	Modern Genetic Analysis: Integrating Genes and Genomes,	Freeman& Co	2004
3.	Gardner *et al*	Principles of Genetics	John Wiley	1991
4.	Hartl and Jones	Genetics-Principles and Analysis	Jones & Bartlett	1998
5.	Hartwell *et al*	Genetics: From Genes to Genomes	McGraw-Hill	2004
6.	Gilbert	Developmental Biology	Sinauer	2003
7.	SnustadaandSimmons	Principles ofGenetics	JohnWiley& Sons	
8.	Russell	Genetics	Benjamin-Cummings	
9.	Albert*set al*	Molecular Biology of the Cell	Garland	2002
10.	Lodish*et al*	Molecular Cell Biology	Freeman	2004
11.	Cooper	Cell: A Molecular Approach	ASM Press	2000
12.	Karp	Cell and Molecular Biology	Wiley	2002
13.	Watson et al	Molecular Biology of the Gene	Pearson	
14.	Nelson & Cox	Lehninger Principles of Biochemistry	Freeman & Co, USA	
15.	Pierce	Genetics	Freeman	

Core Course-9

ZOOLCC204 Lab based on ZOOLCC202-203 Credits 04

Core Course-10

ZOOLCC205 Lab based on ZOOLCC201 Credits 02

ZOOLIER-201: Value added Interdepartmental course

Semester	Course	Interdepartmental Course		Credits	Total Lectures
II	**ZOOIER-201**	Public Health Care and Management		2	30

ZOOLIER-201: Public Health Care and Management

Total Credits: 02 **Teaching Hours: 30**

Course objectives

- Providing conceptual knowledge of different diseases and their prevention
- Explaining measures for healthy life
- Discussing Government's role in disease management
- Discussing epidemiology of diseases

Unit I **06**

Human diseases

Communicable/Vector borne diseases- Malaria, Sleeping sickness
Non–Communicable diseases- Cancer, AIDS
Metabolic diseases - Diabetes, BP, Thyroid
Genetics diseases- PKU, Sickle Cell Anaemia, Thalassemia

Unit II **06**

Disease prevention

Tackling antimicrobial resistance
Measures for reduced maternal & child/infant mortality rate
Prevention of environmental pollution & its degradation

Unit III **06**

Measures for healthy life

Micronutrients, their role, deficiency & related problems
Improved nutrition for all age groups
Application of yoga & physical exercise for healthy life (their role)
Obesity, Non-alcoholic fatty liver
Hazards of tobacco chewing & smoking
Importance of personal & public hygiene & better sanitary habits

Unit IV **06**

Government's role in public health

Strong Government's accountability for enforcement of quality health measures

Regular immunization/vaccination programmeseg., pulse polio
Adequate measures for preventing spread of vector borne diseases
Government's role in propagation of family planning measures, AIDS awareness

Unit V **06**

Epidemiological studies

Epidemiology & statistical analysis of difference diseases
Population genetics

Student learning outcomes

At the end of the course the student will have

- Enhanced awareness towards various human diseases, their control and prevention.
- Information on improvement of life style& health via quality health measures.

Suggested readings

1. Public Health and Hygiene by Sorna Raj and KumaresanSaras Publication
2. Public Health Management: Principle and Practice by SundarLal, Vikas, CBS Publishers, 2018
3. A practical guide for PG course in Community medicine, Public Health and Health management by Sudip Bhattacharya and SaileshTripathi, 2018
4. Park's Textbook of Preventive and Social Medicine by K. Park 2017

Semester III

Core Course-11
ZOOLCC-301: Biosystematics, Biodiversity and Evolutionary Biology

Total Credit: 04 **Teaching Hours: 60**

Course objective

- To provide the basic concepts, importance, status and interaction between organisms and environment

UnitI **12**

Taxonomy and classification

Concepts, terminology and types of taxonomy and classification
Principles of classification
Concept and preambles of ICZN
Proteins and nucleic acids in modern taxonomy

Unit II **12**

Biodiversity: concept, types and measurement
Indian Biodiversity: geographical distribution
Biodiversity hotspots in India
Significance of biodiversity

Unit III **12**

Threats to wildlife
Wildlife protection Act, Biodiversity Act
Wildlife conservation strategies (ex situ and in situ)
Role of government and NGOs in wildlife conservation
Community participation and movements for wildlife conservation

Unit IV **12**

Evolutionary theories
Mechanisms of speciation
Evolutionary forces
Adaptive radiation

UnitV **12**

Co-evolution
Convergent and divergent evolution
Molecular evolution
Phylogenetic gradualism and punctutated equilibrium

Student leaning outcome

The student at the completion of the course will be able to understand:

- basic concepts of biosystematics, evolutionary biology and biodiversity which will enable the students not only to understand the subjects but also to solve the biological problems related to the environment, and
- principles of taxonomy for identification, classification and naming the organisms scientifically.
- origin and modification of various life forms during various time scales.

Suggested readings

1. Principles of Systematic Zoology by Ernst Mayr, McGraw Hill, New York
2. Principles of Animal Taxonomy by G.G.Simpson, Columbia University Press, Scientific Publisher.
3. Evolution: An Introduction by S.C.Stearns and R.F.Hoekstra, Oxford University Press, New York
4. Evolution by N. H. Barton, D.E.G. Briggs, J.A. Eisen, D. B. Goldstein and N.H. Patel, Cold Spring Harbor Laboratory Press, New York.
5. Ridley,M (2004) Evolution III Edition Blackwell publishing Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett
6. What is biodiversity by James Maclaurin and Kim Sterelny, U.Chicago.Edu.
7. Schuh, R.T., and A.V.Z. Brower. 2009. Biological Systematics: Principles and Applications, 2nd Ed. Cornell University Press. 311+xi pp.
8. Wiley, E. O. and B. S. Lieberman. 2011. Phylogenetics: Theory and Practice of Phylogenetic Systematics, 2nd Ed. Wiley-Blackwell. 406+xvi pp.
9. Williams, D. M. and M. C. Ebach. 2010. Foundations of Systematics and Biodiversity. Springer. 309+xvii pp.
10. Biodiversity and Ecosystem Functioning by E.D. Shulze and H. A. Moonthy, Spriger Publication.
11. Methods and Practice in biodiversity Conservation by David Hawks worth, Springer publication
12. A Text Book of Biodiversity by K.V. Krishnamurthy, CBS Publication
Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
18. Pushpesh. J. Wildlife & Forest Conservation A Status Report. Swastik
19. Anderson Stanley.Managing Our Wildlife Resources. Prentice Hall, 3rd Edition
20. Martin Winter. Wildlife Biology. Syrawood Publishing House
21. Kasen Hurst. Wildlife Conservation & Management. Larsen & Keller
22. Martin Winter. Wildlife Conservation &Management .Syrawood Publishing House
23. Martin Winter. Wildlife Protection & Management. Callisto Reference
24. Kendall W.L . Wildlife Study Design . SJ
25. Andrew Wright. Forest Ecology. Black Prints
26. Rajesh Gopal. Fundamental of Wildlife Management. Natraj Publishers
27. Biodiversity and Ecosystem functioning. edited by Michel Lorean ,ShahidNaureen and Pablo Inchausti (Oxford University Press.)

28. Biodiversity and Conservation in Forests. By Diana. F. Tomback. Publication MDPI-Multidisciplinary Digital Publishing Institute.
29. Methods and Practice in Biodiversity Conservation by David Hawks-worber. (Springer Publication)
30. Recent Studies in Biodiversity and Traditional Knowledge in India. By Chandra Ghosh and A.P. Das (Publisher: Levant Books)
31. Biodiversity and Protected Areas by Beazley, Karen, Baldwin, Robert. (Publishers: MDPI)
An Advanced Text book on Biodiversity (Principle and Practice) by K.V. Krishnamurthy. (Publication-CBS)
32. Biodiversity Hotspots edited by VittoreRescigrio and SavarioMoletta. (Publishers: Nova Science Publishers)

Core Course-12
ZOOLCC-302:Developmental Biology and Immunology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

The objective of this course is to provide insight on:

- how the single cell formed at fertilisation forms an embryo and then a fully formed adult organism.
- integration of genetics, molecular biology, biochemistry, cell biology, anatomy and physiology during embryonic development, and
- the treatment of birth defects and infertility in humans.
- To develop basic understanding about Immunity, its organization and their mechanisms.
- To understand in detail the basic immune mechanism related to different Immunological diseases & disorders.
- To create and develop the ideology about different vaccines, immune treatment mechanisms, cancer immunotherapy and latest experimental immune system.

Unit I

Gamete fertilization and early development

Structure and recognition of the gametes	02
Sperm capacitation and acrosomal reaction	02
Gamete binding and fusion, and the prevention of polyspermy	02
Cleavage patterns	02
Gastrulation	02
Neurulation	02

Unit II

Comparative account of underlying mechanisms in vertebrate development

Morphogenesis and cell adhesion	02
Evidence for genomic equivalence	02
Differential gene expression	02
Cell-cell communication in development	02
Primary organizers, induction and competence	02
Early development of fish, birds, and mammals	02

Unit III

Later developmental processes

The dynamics of organ development	03
Development of eye	
Development of kidney	
Development of limb	
Metamorphosis: the hormonal reactivation of development	03
Amphibian metamorphosis	

Metamorphosis in insects
Regeneration 03
Epimorphic regeneration of salamander Limbs
Compensatory regeneration in the mammalian Liver
Morphallactic regeneration in hydras
Aging: the biology of senescence 03

Unit IV

Immune system & responses

Types of Immunity (Innate, Adaptive, humoral, cell-mediated) 02
Cells of Immune system (B & T lymphocytes, Phagocytes, Granulocytic cells, Mast cells, NK Cells, Dendritic cells) 02
Organs of Immune system- (Primary and secondary lymphoid organs-Thymus, marrow, Bone lymph nodes, spleen, MAST) 02
Generation of B &T cell responses 06
Immunoglobulins (structure, Types/Classes & functions)
Epitopes
Maturation, differentiation and activation of BCR and TCR
Monoclonal and polyclonal antibodies
Antibody diversity
Organization & Expression of Immunoglobulin genes

Unit V

Immune mechanisms

Antigen antibody interactions (AgglutinatonRn's, Precipitation Rns', cross reactivity, Antibody affinity and avidity, immune florescence, flow cytometry, western blotting, immune electron microscopy, RIA, ELISA and it's types) 03
Antigen: types, processing & presentation 02
Major Histocompatibility complex: classes, structure, expression, immune responsiveness, and disease susceptibility (HLA) 03
Complement system–classical, alternative, lectin pathways 02
Vaccine 02

Student learning outcomes

The student at the completion of the course will be able to understand:

- a variety of interacting processes, which generate an organism's heterogeneous shapes, size, and structural features,
- how a cell behaves in response to an autonomous determinant or an external signal, and
- the scientific reasoning exhibited in experimental life science.
- an in depth understanding about Immune System & it's elaborate mechanisms.
- state of art information about recent trends in Immune therapy in case of several diseases like cancer, hepatitis etc

Suggested readings

1. Developmental Biology: T. Subramaniam, (Reprint) 2013, Narosa Publishing House Pvt. Ltd., New Delhi
2. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.) 2012, Wiley-Blackwell.
3. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook:Russ Hodge, 2009, Infobase Publishing.
4. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, 1998 Elsevier.
5. Developmental biology: Werner A. Müller, 2012, Springer Science & Business Media.
6. Human Embryology and Developmental Biology E-Book:Bruce M. Carlson, 2018, Elsevier Health Sciences.
7. Developmental Biology:Michael J. F. Barresi, Scott F. Gilbert, 2019, Oxford University Press.
8. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
9. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
10. Immunology by Ian. R. Tizard Saunders college Publishing Chicago, New York.
11. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.

Core Course-13

ZOOLCC-303: Ecology, Environmental Biology and Toxicology

Total Credits: 04 **Teaching Hours: 60**

Course objectives

- To develop in the student an understanding of environmental structure and function
- To develop in the student an understanding of global environmental issues
- To develop in the student an understanding of significance and conservation of wild life
- To develop in the student an understanding of xenobiotics, their mode of action and damage caused

Unit I **12**

Ecosystem and Population ecology

Concept, production and decomposition
Biosphere and biomes
Biogeochemical cycles
Population ecology

Unit II **12**

Community ecology

Community ecology and ecological succession
Concept of habitat ecology and ecological niche
Island biogeography

Unit III **12**

Global environmental problems

Environmental pollution
Waste management
Environmental monitoring
Acid rain
Greenhouse effect and global warming
Depletion of ozone layer
Climate change

Unit IV **12**

Exposure of toxicants

Different routes/methods of exposure, frequency & duration of exposure
Dose-response relationship
Selective toxicity:
concept, significance
Basic mechanisms of selective toxicity

Toxicity Tests: Bioassay, Acute toxicity tests for terrestrial and aquatic animals, Chronic toxicity tests
Concept of maximum acceptable toxicant concentration (MATC) and safe concentration
Factors affecting toxicity
Factors related to the chemical exposure
Surrounding medium and the organisms

Unit V **12**

Toxic effects of Xenobiotics
Local and systemic effects
Immediate and delayed effects
Reversible and irreversible effects
Biochemical and physiological effects of xenobiotics
Nanotoxicology
Toxicogenomics
Bioaccumulation of Xenobiotics
Concept of bioconcentration, bioaccumulation and biomagnifications; Bioconcentration factor
Process of bioaccumulation in the biological system
Biotransformation of Xenobiotics
Concept of biotransformation and metabolism
Sites of biotransformation
Biotransformation enzymes and general biotransformation reactions
Factors affecting biotransformation
Safety evaluation of xenobiotics
Antidotal therapy

Student learning outcomes
The student at the completion of the course will be able to explain:

- complexities and interconnectedness of various environmental levels and their functioning
- global environmental issues, their causes, consequences and amelioration
- significance and conservation of wild life
- xenobiotics, their mode of action and damage caused

Suggested readings
1. Ecology: Theories & Applications. Peter D. Stiling, 2001, Prentice Hall.
2. Ecological Modeling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
3. Ecology: The Experimental Analysis of Distribution and Abundance. Charles J. Krebs, 2016, Pearson Education Inc.
4. Elements of Ecology. T.M. Smith and R.L. Smith, 2014, Pearson Education Inc.
5. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.

6. Environment. Raven, Berg, Johnson, 1993, Saunders College Publishing.
7. Essentials of Ecology. G.T. Miller, Jr. & Scott. E. Spoolman, 2014, Brooks/Cole, Cengage Learning.
8. Freshwater Ecology: A Scientific Introduction. 2004. Closs, G., Downes, B. and Boulton, A. Wiley-Blackwell publisher, Oxford.
9. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
10. Fundamentals of Ecology. E.P. Odum&Gray. W. Barrett, 1971, Saunders.
11. Principles of Terrestrial Ecosystem Ecology. 2011. Chaplin, F.S., Matson, P.A. &Vitousek, P.M. Springer.
12. Omkar and Pervez, A.(2017). Concepts of Toxicology. A Textbook for U.G. and P.G. students. Publ. by Vishal Publishing Co. Jalandhar.
13. Derelanko&Auletta. Handbook of Toxicology, 3rd Ed. CRC Press
14. Casarett&Doull's Toxicology: The Science of Poisons" 8th Ed. Edited by Curtis A. Klaassen& John B. Watkins III
15. Principles of Biochemical Toxicology" by J.A.Timbrell, 4th Ed. Informa Press
16. Mechanistic Toxicology", U.A.Boelsterli, 2nd Ed. CRC Press.

Elective Course 14 a

ZOOLEL-301A: Wildlife: Animal Diversity

Theory Credit: 04 **Teaching Hours: 60**

Course Objectives:

The paper aims to understand taxonomy of wildlife fauna, its requirement and importance in wildlife studies. It intends to overview distribution of wild animals in different geographic regions of India.

Course Outcome:

The course is expected to help students to understand:

1. significance of taxonomy in biodiversity and wildlife studies.
2. significance of geographical regions in the distribution of animals across India.

Unit-I **12**

Arthropod Diversity

Taxonomical diversity of Indian:
Lepidoptera- Butterflies and Moths (up to family level)
Arachnida- Spiders (up to family level)

Unit-II **12**

Ichthyofaunal Diversity

Classification of fishes up to order level.
An overview of economically important fish groups.
Ecological services rendered by fishes.

Unit-III **12**

Herpetofaunal Diversity

Classification of Amphibia and Diapsid reptiles up to order with special reference to Indian assemblage.
Amphibian 'hotspots' in India.
Areas of high reptilian diversity with special reference to India.

Unit-IV **12**

Avian diversity

Classification and distribution of Indian avian fauna up to order level.
Bird species identification through morphological studies.
Flight adaptations.
Threatened birds of India.

Unit-V **12**

Mammalian Diversity

Classification of mammals with detailed treatment of orders represented in the

Indian sub-continent,

Status and distribution of major mammalian taxa like, cervids, bovids, carnivores and primates.

References:

1. Dr. V. Shubha Laxmi., field guide to Indian moths
2. Isaac Kehimkar., Butterfly of India
3. Peter Smetacek., Butterfly of India
4. Anuraddha Dhamorikar., A field guide to insects and spiders
5. Gupta, General & Applied Ichthyology: Fish and Fisheries June 2006
6. M. A. Smith.,The fauna of British India (Reptilia and Amphibia- Vol. -III, Serpentes Vol. IV)
7. George R. Zug. Herpetology: An Introductory Biology of Amphibians and reptiles
8. Ornithology by Frank, B. Gill 4. The book of Indian birds by Salim Ali
9. Mammalogy by Terry A. Vaughan 5. Social behavior in mammals byT.Poole

Elective Course 14 b

ZOOLEL-301B: Principles of Endocrinology

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

The course focuses on helping the students to understand the basics of endocrinology and impart knowledge about the endocrine regulation of different body functions. Besides, it aims to understand the integrative working of signaling system in maintaining homeostasis

Unit I

Fundamentals of Endocrinology

Introduction and evolutionary perspective	03
Endocrine hypothalamus, structure and function	04
SON, PVN, POA, Arcuate nucleus	
Hypophysiotropic hormones	
Pituitary gland, structure and function	05
(adenohypophysis, Neurohypophysis, pars intermedia)	

Unit II

Hormones and metabolic regulation

Thyroid gland	06
Biosynthesis and chemistry of thyroid hormones	
Mechanism of action	
Biological actions	
Endocrine Pancreas	03
Insulin, glucagon and other secretions	
Chemical regulation of feeding, digestion	03

Unit III

Endocrine regulatory molecules

Hormones	07
Chemical classification of hormones	
Hormone receptors	
Mechanism of hormone action	
Neurotransmitters and neuropeptides	03
Regulatory pathways	02

Unit IV

Neuroendocrine integration

Hypothalamo–hypophyseal axis	03
Feedback mechanisms	02
Adrenal gland, cellular organization	04
Catecholamines and General Adaptation Syndrome	03

Unit V

Endocrine regulation of homeostasis

Hormones and Homeostasis 06

Electrolytes and water balance (Renin-Angiotensin system)

Energy homeostasis

Parathyroid gland 06

Calcium homeostasis

Endocrine regulation of bone

Student learning outcome

The course will enable the students:

- To develop an understanding of the basic endocrinology
- To study the endocrine regulatory molecules mediating physiology and behavior
- To study the neural and endocrine components of physiological function and neuroendocrine regulation
- To understand the role of hormones in metabolic regulation and maintaining homeostasis
- To understand the integrative working of signaling system

Suggested readings

1. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press

2. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier

3. Comparative Vertrebrate Endocrinology: P. J. Bentley, 3rd Edition, Cambridge University Press

4. Neuroendocrinology: Charles B. Nemeroff, CRC, US

5. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press

6. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education

7. Molecular Endocrinology: F. F. Bolander, 3rd Edition, 2004, Elsevier Academic Press

8. Essential Endocrinology: Darville Brook, C.G. & Marshall, Wiley Blackwell

9 Endocrinology at a Glance**:** Greenstein B, Wiley Blackwell

10. Evidence-Based Endocrinology: V. M. Montori (ed.), Humama Press

11. General And Comparative Endocrinology: John B. Allard, CunmingDuan,Intelliz Press LLC (2016)

Elective Course 14 c

ZOOLEL-301C: Insect Taxonomy, Morphology and Ecology

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

- To acquaint students with taxonomical and biological diversity of insects
- To acquaint students with biology and evolutionary history of the hexapod orders.
- To acquaint the students with general external morphology of insects
- To acquaint students with the role that insects play in the ecosystems and to study how the ecosystems influence the insects that live in them

Unit I

Insect taxonomy I

Overview of insect classification 04

Identification of Entognathushexapodes 06

- Protura
- Collembola
- Diplura

Identification of apterygotes 02

- Thysanura

Unit II

Insect taxonomy II

Identification of pterygote orders and their economically important superfamilies 04

- Orthoptera
- Hemiptera

Identification of orders and their economically important superfamilies 04

- Coleoptera
- Hymenoptera

Identification of order and their economically important superfamilies 04

- Lepidoptera
- Diptera

Unit III

Insect morphology

General organization of the insect body 02

General Organization of insect head 04

- Sutures and area of the cranium
- Tentorium
- Gnathal appendages (antenna and mouth parts)

General Organization of insect thorax 04

- Pterothorax
- Legs and their modification

Wing types
Wing venation
General organization of insect abdomen 02

Unit IV
Insect ecological techniques I

Survey and sampling methods	03
Reproductive potential	02
Population growth and dynamics	03
Survivorship curves and life tables and their application to insect biology	04

Unit V
Insect ecological techniques II

Interspecific interactions	02
Prey-predator interactions	02
Functional and numerical response	01
Concept of predator satiation	01
Evolution of life history strategies	03
Insect–plant interactions	03

Student learning outcomes

Upon successfully completing this course students will be able to;

- demonstrate identification skills for all insect orders and some superfamilies
- demonstrate an understanding of the evolutionary history of hexapod orders
- explain and identify the external morphology of insects
- demonstrate understanding of the interactions between the insects and ecosystem.

Suggested references

1. Richards, O. W., & Davies, R. G. (1997). Imms' General Textbook of Entomology, Volume I: Structure, Physiology and Development. London, Chapman and Hall.
2. Imms, A. D., Richards, O. W., & Davies, R. G. (Eds.). (2012). Imms' General Textbook of Entomology: Volume 2: Classification and Biology. Springer Science & Business Media.
3. B. Danforth& C. Marshall. 2003. Eickworth's Manual of Insect Morphology. (Posted PDF files on Carmen.osu.edu.
4. Snodgrass, R.E. 1993 (originally 1935). Principles of Insect Morphology (with new forward by George Eickwort). Cornell University Press. 667pp.
5. Grimaldi, D.A. and M.S. Engel. 2005. Evolution of the Insects. Cambridge University Press. 755 pp.
6. Triplehorn, C.A. and N.F. Johnson. 2005. Borror and DeLong's Introduction to the Study of Insects, 7th edition. Thomson Brooks/Cole, Belmont, CA.
7. Schowalter, T.D. (2016). Insect Ecology: An Ecosystem Approach. Academic Press.
8. Price, P.W., Denno, R.F., Eubanks, M.D., Finke, D.L., and Kaplan, I. (2012). Insect Ecology: Behavior, Populations, and Communities. Cambridge University Press.

Elective Course 14 d

ZOOLEL-301D: Applied Fish and Fisheries

Total Credit:04 **Teaching Hours: 60**

Course objectives

Unit I

Fish biology

Study of morphometric and meristic characteristics	02
Study of length-weight and length-length relationship	02
Determination of age and growth using scale, otolith and operculum	02
Estimation of absolute and relative fecundity	02
Artificial breeding of Indian major carp	02

Unit II

Fish ecology

Physicochemical analysis of pond water	02
Estimation of DO	02
Estimation of hardness	02
Estimation of alkalinity	02
Estimation of pH	02
Estimation of temperature	02

Unit III

Fish biodiversity assessment

Biodiversity: concepts, patterns and measurement	02
Relative abundance	02
Measurement and estimation of species richness and evenness	03
Species diversity indices	03
Phenotypic Plasticity and Genetic Differentiation in Traits	02

Unit IV

Fish taxonomy and biosystematics

Fish collection and preservation	03
Identification of ichthyo-fauna through keys	07
Fish fin formula	02

Unit V

Chromosome manipulation and genotoxicity assessment

DNA isolation of fish	02
Karyotyping of selected fish	02
DNA polymorphism through RAPD	02
Micronuclei test (MNT)	03

Chromosomal aberration test (CAT) 03

Course learning outcome

The present course has been designed to provide students the knowledge of tools and techniques:

to carry out the researches related to the basic and modern aspects of fish and fisheries.

Suggested readings

1. William RD and Matthew G. 1984. Multivariate Analysis, Methods and Applications. John Wiley & Sons.
2. Biradar RS. 2002. Course Manual on Fisheries Statistics. 2nd Ed. CIFE, Mumbai.
3. Welch PS. 2003. Limnological Methods. Narendra Publ. House.
4. Nelson JS. 2006. Fishes of the World, John Wiley and Sons, Inc., New Jersey.

Elective Course 14 e

ZOOLEL-301E: Advanced Genetic Analysis

Total Credit: 04 **Teaching Hours: 60**

Course Objectives

This course provides a comprehensive understanding of the basic concepts of Developmental genetics, Microbial genetics, and molecular techniques used for the study of genetics. Students are expected to gain knowledge of genetic determinants that impact population level biological diversity in the context of evolution. This courseand will also provide a perspective and exposure to medical aspects of bacteriology, and virology.Advanced molecular techniques based on our fundamental understanding of the principles of molecular biology arereflected in the contents of this course. This has revolutionized the way modern biological research is done and has impacted mankind with a number of biological products and processes.

Student Learning Outcomes

After successful completion of this course, students are expected to:

1. understand genetics as a basis of developmental aberrations, bacterial and viral genetics
2. understand about gene silencing and editing tools and methods and appreciate their relevance for investigating specific contemporary biological questions.
3. In conjunction with the practicals in molecular biology and genetic engineering, the students should be able to undertake biological research and find placement in the relevant biotech industry.

Unit I **12**

Developmental Genetics

Cell types and polarity,Axes and Pattern formation in *Drosophila*

Developmental genes; Mutants &transgenics in analysis of development

Genetics of cell determination: vulval development in *Caenorhabditiselegans*

Environmental regulation of normal development and teratogenesis,

Genetics of developmental defects

Stem cells: Basic concept, and role in development, genetic manipulation, genomic reprogramming, and cloning of stem cells, therapeutic applications of stem cells.

Unit II **12**

Microbial Genetics

Methods of Gene Transfer in bacteria: Conjugation, Transformation, Transduction and Sex-duction, Genetic Analysis of mutants

Molecular biology of pathogens, Mechanism of drug resistance

Microbial technology: fermentation technology, synthesis of microbial and recombinant products

Life Cycles and advantages of organisms commonly used in genetic studies

Genomes and gene products in different model systems: T4 and Lambda phages, *Escherechiacoli,Saccharomyces cerevisiae*

Unit III **12**

Evolutionary Genetics&Phylogenetics

Basics of Bioinformatics

Protein and nucleotide sequence analysis
Molecular tools in Phylogeny,classification, and identification
Molecular divergence, and molecular clock
Origin of new genes and proteins;Eukaryotic & Prokaryotic Genome
Gene duplication: Gene family and gene superfamily.

Unit IV **12**

Molecular Techniques

RNA isolation, reverse transcriptase, cDNA synthesis, RNA quantitation.
Introduction of foreign DNA into host cells; transformation, electroporation, transfection; construction of genomic and cDNA libraries,phage display; strategies for library screening; radioactive and non-radioactive probes; hybridization techniques: Northern, Southern, Western, South-western, colony hybridization, Microarray,fluorescence*in situ* hybridization.

Unit V **12**

Gene Silencing and Genome Editing Technologies

Gene knockout, Gene knockdown/mutation, conditional knockouts, gene deletion, gene insertion, Mechanisms of genome editing: CRISPR/Cas9 system; delivery of genome editing tools: Creation of transgenic organisms *e.g.,* mice; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*).

Recommended Textbooks and References:

1. Hartl, D. L., & Jones, E. W. (1998). *Genetics: Principles and Analysis*. Sudbury, MA: Jones and Bartlett
2. Pierce, B. A. (2005). *Genetics: a Conceptual Approach*. New York: W.H. Freeman
3. Tamarin, R. H., & Leavitt, R. W. (1991). *Principles of Genetics*. Dubuque, IA: Wm. C. Brown
4. Smith, J. M. (1989). *Evolutionary Genetics*. Oxford: Oxford University Press
5. KC Carroll, SA Morse, T Mietzner, S Miller. (2016), *Jawetz, Melnick and Adelbergs's Medical Microbiology*, 27th edition, McGraw Hill.
6. J Owen, J Punt and Sharon Stranford; (2012), *Kuby Immunology*, 7th edition W.H. Freeman and Co.
7. IT Kudva, NA. Cornick, PJ Plummer, Q Zhang, TL Nicholson, JP Bannantine and BH Bellaire. (2016), *Virulence Mechanisms of Bacterial Pathogens*, 5th edition, ASM Press.
8. Gilbert SF., Barresi MJF.,Developmental Biology, Sinauer Associates Inc
9. Wolper L., Tickle C, Principles of Development, Oxford University Press, UK
10. Moody SA, Principles of Developmental Genetics, Academic Press
11. Coen E., The Art of the Genes: How Organisms Make Themselves, Oxford University Press
12. Slack JMW.,Essential Developmental Biology, Wiley-Blackwell
13. Sadler et. al., Langman's Medical Embryology, Lippincott Williams and Wilkins
14. Jones, Smith's Recognizable Patterns of Human Malformation, Elsevier Health
15. Lanza R., Atala A., Essentials of Stem Cell Biology, Academic Press
16. Knoepfler, Stem Cells: An Insider's Guide, World Scientific Publishing Company
17. Harris J. Quigley M. Chan S., Stem Cells: New Frontiers in Science & Ethics, World Scientific Publishing Co Pte Ltd.

Elective Course 14 f

ZOOLEL-301F: General Parasitology

Credits: 04 **Teaching Hours: 60**

Course objectives

This course will acquaint the students with:

- adequate knowledge on parasites and parasitism with an emphasis on the physiology, biochemistry, ecology and evolution of parasites, and
- an understanding of the molecular taxonomy of parasites, and the interface of parasitism/immunity in the context of the host-parasite interactions.

Unit I

Introduction to Parasitology **12**

General introduction; basic definitions and concepts; career in parasitology
Animal associations (phoresy, symbiosis, mutualism, symbiosis, parasitism)
Types of hosts and parasites; Host specificity; Parasitic adaptation
Parasitology and human welfare

Unit II **12**

Taxonomy and diversity

Basic definitions and concepts of taxonomy and systematics
Morphological taxonomic characters of major parasite groups
Kinds of taxonomic literature and databases and their uses
Process of typification and different zoological types
International code of Zoological Nomenclature (ICZN)
Biodiversity of parasites at global and national level

Unit III

Physiology and biochemistry **12**

Ultrastructure of the tegument
Physiology of digestion, excretion and respiration
Metabolism of protein, lipid and carbohydrate
Physiology of reproduction and egg–shell formation

Unit IV

Ecology, evolution and immunology of parasites **12**

Mechanism of infection
Dimensions and saturation of niches of parasites
Parasite manipulation of host behaviour
Host–parasite coevolution
Host–parasite interactions (tissue damage, tissue changes, immunological adaptations of parasitism)

Unit V **12**

Molecular biology and bioinformatics

Extraction, preservation, and amplification of DNA

Quantitative and qualitative analysis of nucleic acid (spectrophotometry and gel electrophoresis)

DNA sequencing

DNA barcoding

Bio–molecular databases in bioinformatics

Phylogenetic tree and its reconstruction (distance-based methods, maximum parsimony, maximum likelihood)

Course learning outcomes

By the end of the semester, students will be able to:

- define variety of animal associations,
- demonstrate an understanding of the physiology, biochemistry, ecology, evolution, and molecular biology of parasites, and
- use the bioinformatics for molecular phylogenetic analysis.

Suggested readings

1.*Animal Parasitology* by JD Smyth. Cambridge University Press.

2. *Essentials of Parasitology* by GD Schmidt. Brown Publishers

3. *Encyclopaedia of Bioinformatics and computational biology* byShobaRanganathan, Michael Gribskov, Kenta Nakai, Christian Schonbach.

4. *Evolutionary Parasitology: The Integrated Study of Infections, Immunology, Ecology, and Genetics* by Paul Schmid–Hempel. OUP Oxford.

5. *Foundation of Parasitology* by GD Schmidt LS Roberts. McGraw Hill Publishers.

6. *General Parasitology* by TC Cheng. Academic Press

7. *Helminths, Arthropods and Protozoa of domesticated animals* byEJLSoulsby.ELBS and BailliereTindall. London.

8. *Human Parasitology* by BJ Bogitsh, CE Carter, TN Oeltmann. Academic Press.

9. *Introduction to Parasitology* by AC Chandler & CP Read. John Wiley & Sons Inc.

10. *Parasite genomics protocols* by SE Melville. Humana Press.

11.*Parasitology* by Chaterjee K.D. Medical Pulisher Calcutta.

12. *Parasitology: The Biology of animal parasites* by ER Noble GA Noble

13. *Modern Parasitology* by FEG Cox. Blackwell Scientific Publications.

14.*Molecular Parasitology* by JE Hyde. Open University Press. London.

Elective Course- 15 a

ZOOLEL302A: Practical Based on ZOOLEL301A **Credits- 02**

Elective Course- 15 b

ZOOLEL302B: Practical Based on ZOOLEL301B **Credits- 02**

Elective Course- 15 c

ZOOLEL302C: Practical Based on ZOOLEL301C **Credits- 02**

Elective Course- 15 d

ZOOLEL302D: Practical Based on ZOOLEL301D **Credits- 02**

Elective Course- 15 e

ZOOLEL302E: Practical Based on ZOOLEL301E **Credits- 02**

Elective Course- 15 f

ZOOLEL302F: Practical Based on ZOOLEL301F **Credits- 02**

Semester IV

Core Course-16

ZOOLCC-401: Quantitative Biology and Bioinformatics

Total Credit: 04 **Teaching Hours: 60**

Course objectives

- To describe the basics and application of Biostatistics.
- To explain the principle and working of instruments in a biology laboratory.
- To learn the basics of bioinformatics

Unit I **12**

Biological data

Data on a ratio scale
Data on an interval scale
Data on an ordinal scale
Data on a nominal scale
Types of statistics: inferential and descriptive
Parametric and non-parametric tests (concepts and applications)

Unit II **12**

Measures of central tendency (individual observations, discrete and continuous series)

Mean (simple and weighted)
Median
Mode (analysis using group table)

Measures of dispersion (individual observations, discrete and continuous series)

Range and mean deviation
Standard deviation
Kurtosis and skewness

Unit III **12**

Correlation and regression

Types and methods of studying correlation
Karl Pearson's coefficient of correlation and determination
Regression equation (X on Y and Y on X)
Regression lines

Tests of significance and their application: t-test, Chi-square test

Analysis of variance: One-way and two-way ANOVA

Unit IV

Bioinformatics I **12**

- Basics of computers (CPU, I/O units and operating systems)
- Concept of homepages, websites, World Wide Web, URLs, and use of search engines
- Databases: nucleic acids, genomes, protein sequences and structures, SNP db, Finding scientific articles.
- Information retrieval from biological databases, Entrez, SRS

Unit V

Bioinformatics II **12**

- Dynamic programming
- Pairwise and multiple sequence alignments (CLUSTALW), BLAST
- Phylogenetic analysis
- Protein structure prediction---visualizing 3D-structures of proteins

Student learning outcomes

The present course will enable the students to:

- solve the biological problems during data analysis using various statistical methods such as uni-variate analysis, bi variate analysis, correlation, regression and various tests of significance.
- learn the working of various equipments which will be useful in the final semester for their experimental work.
- Learn the basics of bioinformatics like databases, sequence analysis tools.

References:

1. Biostatistical Analysis (Fourth Edition) by Jerrold H. Zarr, Pearson Education Inc., Delhi.
2. Statistical Methods (Eighth Edition) by G. W. Snecdecor and W. G. Cochran, Willey Blackwell
3. Biostatistics (Tenth Edition) by W.W. Daniel and C. L. Cross, Wiley
4. Introductory Biological Statistics (Fourth Edition) by John E. Havel, Raymond E. Hampton and Scott J. MeinersDavid Mount, 2004, Bioinformatics: Sequence and Genome Analysis, 2nd Edition, Cold Spring Harbor Laboratory Press
5. Jonathan Pevsner, 2003, Bioinformatics and Functional Genomics, 1st Edition, Wiley- Liss Publications.
6. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.
7. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
8. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes
9. Westhead *et al* (2003). Bioinformatics: Instant Notes Viva Books

Elective Course- 17 a

ZOOLEL-401A: Wildlife: Ecology, Behaviour and Techniques

Theory Credit: 04 **Teaching Hours: 60**

Course Objectives

The paper aims to enhance the knowledge about the basic concept of population and community ecology of wild animals, behavioral aspects such as feeding, breeding and social.

Course Outcome

The course is expected to help students to understand:

1. conceptand role of population and community studies in wildlife management.
2. behavior of wildanimals
3. different equipments and techniques used in wildlife studies

Unit-I **12**

Population Ecology I:

Importance of population in wildlife studies, population attributes, life tables: construction and importance in wildlife management, concept of growth rate, exponential and logistic growth rates. Population sampling techniques.

Unit-II **12**

Population Ecology II:

Population regulation, predator prey models, concept of carrying capacity, Concept of home range and territory. Theories of population dispersal. Minimum viable populations, inbreeding and out-breeding depression,

Unit-III **12**

Community Ecology:

Biological attributes of community: species richness, diversity and dominance. Diversity indices, Community interactions (positive and negative)

Unit-IV **12**

Behaviour of Wild Animals:

An overview of foraging (optimal foraging, food selection & preference), breeding (courtship, parental care) and social behavior of birds and mammals

Unit-V **12**

Equipments:

Types of cameras & binoculars, camera traps, altimeter, field compass, sound

recorders& media players, range finders.

Tracking of Animals: Radio isotopes, Radio collaring, GPS, GIS &remote sensing.

Estimation of Population: Planning census, sample counts, block counts, roadside counts, dung count, pugmark, Capture-mark-recapture techniques.

References:

1. Population Ecology: Begon and Mortinur
2. Ecology of Populations by Boughy and S. Arthur
3. Concept of Ecology by Edward.J. Kormondy
4. Community Ecology: Pattern and Process by Anderson and Kikkawa
5. Morrison, Rodewald, Voelker & Colon, Ornithology, 2018.
6. Faaborg & Faaborg, Book of Birds, Introduction to Ornithology, 2020
7. Research Techniques in Animal Ecology: Controversies and Consequences (2000) by Luigi Boitani and T. K. Fuller (Editors), Columbia University Press, New York, 435 pages

Elective Course- 17 b

ZOOLCC-401B: Biology of Reproduction

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

The main objective of this course is to study the physiology of male and female reproductive axis and reproductive cycles and develop understanding of endocrinology of pregnancy, parturition and lactation. It also emphasizes to understand the interrelationship between reproduction and immunity, and study the seasonality in reproduction.

UnitI

Physiology of male and female reproductive axis

Anatomy of male and female reproductive axis	03
Physiology of reproduction in males and female	03
Gonadal differentiation and theories	02
Gonadogenesis and Differentiation of reproductive tract	04

Unit II

Endocrine regulation of reproduction

Hormones of reproductive axis: Types, Mechanisms and Regulation	04
Neuroendocrine control of reproduction (GnRH/GnIH; pituitary gonadotropins)	04
Sex Steroids: Steroidogenesis and Metabolism	04

UnitIII

Reproductive cycles and pregnancy

Estrus cycle and menstrual cycle	02
Puberty and Menopause	02
Fertilization	01
Pregnancy and its hormonal regulation	04
Implantation window, mechanism of implantation	
Trophoblast differentiation	
Placentation	03
Mechanism of placentation	
Placental transport function	

UnitIV

Endocrinology of parturition and lactation

Parturition and its control	03

Oxytocin and prolactin

Lactation and its hormonal control 06

Anatomical changes in mammary glands Lactogenesis,
Colostrum and its composition
Cellular mechanism of milk secretion

Metabolic homeostasis in human pregnancy and lactation 03

UnitV

Seasonality in reproduction

Pineal gland 06

Melatonin biosynthesis
Melatonin as clock and calendar

Neuroendocrine regulation of seasonality in reproduction 06

Student learning outcome

The course will enable the students:

- To study the physiology of male and female reproductive axis and reproductive cycles
- To develop understanding of endocrinology of pregnancy, parturition and lactation
- To understand the interrelationship between reproduction and immunity
- To study the seasonality in reproduction

Suggested readings

1. Encyclopedia of Reproduction: Ernst Knobil and Jimmy D. Neill, Volumes 1-4, Academic Press
2. The biology of reproduction: Giuseppe Fusco and Alessandro Minelli, Cambridge University Press
3. Biology of reproduction: Peter J. Hogarth, Blackie
4. Williams Text book of Endocrinology: H.M. Kronenberg, S. Melmed, K.S. Polonsky and P.R.Larsen,2008, 11th Edition, Saunders, Elsevier

Elective Course- 17 c

ZOOLEL-401C: Insect Physiology

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

- To acquaint students with the physiological systems of insects
- To acquaint students with habitat dependent change in structure of physiological systems
- To acquaint students with habitat dependent change in physiological functions

Unit I

Digestive system 06

Alimentary canal and its modification
Salivary glands
Nutritionalrequirements of insect
Physiology of digestion
Digestion of special food stuffs (wool,collagen, keratin, pollen, silk, wax)
Intermediary metabolism of carbohydrates, fats and protein, fat body
Ectosymbiotic fungi
Endosymbionts

Circulatory system 0 6

Structure of heart
Mechanism of circulation
Reversal of heart beat
Haemocytes
Type
Origin and longevity
Haemopoietic organs
Changes in haemocyte population

Unit II

Nervous system 0 5

Structure of brain
Nerve chord
Neurotransmitters and neuromodulator system
Cholinergic systems
Biogenic amines
Amino acids
Neuropeptides

Sense organs 07

Mechanoreceptors
Chemoreceptors (Olfactory and gustatory)
Auditory organs &hearing;

Sound and light producing organs
Mechanism of sound and light production
Visual organs and image formation

Unit III

Respiratory system 06

General organization
Types of spiracles
Gaseous Exchange mechanisms and respiratory adaptations in terrestrial insects
Gaseous Exchange mechanisms and respiratory adaptations in aquatic insects
Respiratory adaptations in endoparasitic insects

Excretory system 06

Organs of excretion
Nitrogenous excretion
Excretory products
Storage excretion
Production of urine and its hormonal regulation
Terrestrial and salt water insects
Control of diuresis
Water regulation
Detoxification

Unit IV

Reproductive system 06

Anatomy of reproductive organs
Spermatogenesis and oogenesis
Mating, insemination, oviposition
Various modes of reproduction

Insect Development 06

Development up to three germ layers
Physiological control of moulting and metamorphosis
Various types of larvae and pupae

Unit V

Endocrine glands 05

Historical perspective
Endocrine glands and concept of neurosecretion
Biosynthesis and degradation of hormones
Function of JH and ecdysteroids
Mechanism of action of JH and ecdysteroids
Vertebrate hormones in insects
Eicosanoids and their functions

Integument and cuticularsclerotization 04

Structure of integument

Structure of cuticle
Components of sclerotized cuticle (structural proteins,chitin, catechols, enzymes)
Dityrosine crosslinks
Quinone tanning
β-sclerotization
Differential mechanism of tanning
Combined pathway and cross–linking mechanisms
Free radical formation

Photoperiodism 01

Diapause and its regulation in insects 02

Student learning outcomes

At the end of the course the students will be able to demonstrate:

- an understanding of the various physiological systems of insects
- an understanding of structural differences in the physiological systems of insects from varied habitats
- an understanding of the functional differences in insect physiological systems

Suggested readings

1. Chapman, R. (2012). The Insects: Structure and Function (S. Simpson & A. Douglas, Eds.). Cambridge: Cambridge University Press
2. Gullan, P. J., & Cranston, P. S. (2014). The insects: an outline of entomology. John Wiley & Sons.
3. Marshall, S. A. (2006). Insects: their natural history and diversity: with a photographic guide to insects of eastern North America. Richmond Hill, Ont.: Firefly Books.
4. Nation, J.L. Insect Physiology and Biochemistry 3rd edition. CRC press
5. Klowden: Physiological Systems in Insects (2002, Academic Press)
6. McGavin: Essential Entomology (2001, Oxford Univ Press)
7. Wigglesworth: Principles of Insect Physiology (1972, ELBS)

Elective Course- 17 d

ZOOLEL-401D: Fish Biology and Genetic Resources

Total Credit:04 **Teaching Hours: 60**

Course objectives

The aim is to provide students with the knowledge of:

- biology and physiology of fishes
- fish genetics resources and its use for fish productivity

Unit I

Fish morphology and anatomy

Skin: structure, composition and function	01
Barbels in fishes	01
Scales: Types, structure and composition	02
Tail: structural modifications	01
Fins and locomotion	02
Air breathing organs and swim bladder: (structural modifications)	03
Weberianossicles and sound producing organs	02

Unit II

Fish physiology

Food, feeding habits and digestion	03
Excretion	01
Osmoregulation	01
Respiratory system: gills, physiology of respiration	02
Circulatory system	02
Nervous system	01
Sense organs: eyes, olfactory and gustatory	02

Unit III

Reproduction and development

Gonads: male and female	02
Reproductive cycle and maturation	03
Spawning	01
Development in fishes	02
Parental care	02
Selective breeding and hybridization	02

Unit IV

Endocrinology and behaviour

Endocrine glands: structure and functions	03
Fish behviour (conditioned response and ethological analogies)	02
Fish migration	02
Pigments, colour changes and its significance	02

Electric organ	01
Luminescence organs in different fishes	02

Unit V

Fish genetic resources

Fish Biodiversity	02
Stock (concept and structuring)	03
Fish chromosome and karyotyping	03
Chromosome Banding (C, G and NOR)	02
Chromosome Manipulation (Gynogenesis, Androgenesis and Polyploidy)	02

Student learning outcomes

The present course provides the basic concepts of fish biology and genetic resources, which will enable the students to:

- utilize the knowledge in fish biology researches,
- manage the fish under controlled conditions, and
- understand the status of fish biogenetic resources of India

Suggested readings

1. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. Freshwater Fishery Biology byIchthyology, 2nd Ed. John Wiley & Sons, New York
2. Santosh Kumar and ManjuTembhre. 2011. Fish and Fisheries.
3. Moyle PB. 1982. Fishes: An introduction to ichthyology. Printice-Hall, Englewood cliffs. Jayaram KC. 2008. Fundamentals of Fish Taxonomy.
4. GopalJi Srivastava. 1995. Fishes of U.P. and Bihar.
5. Paul J.B. Hart and John D. Reynolds. 1979. Handbook of Fish Biology and Fisheries.
6. Brown ME. 1966. Physiology of fishes. Vol. I and II Academic Press. New York.
7. Hoar WS, Randall DJ and Donaldson EM. 1983. Fish Physiology. Vol. IX. Academic Press, New York

Elective Course- 17 e

ZOOLEL-401E: Human Genetics

Total Credits: 04 **Teaching Hours: 60**

Course Objectives

The objectives of this course are to take the students through the basics of human genetics and disease gene mapping. This course investigates various modes of inheritance as well as the mapping of monogenic traits and complex traits. It also introduces LOD score and linkage disequilibrium to the students. In addition, mapping and identification of genetic causes underlying complex traits has been included.

Student Learning Outcomes

At the end of this course, students are expected to:

Define and describe important population genetic concepts such as: genetic drift, natural selection, selective sweep, inbreeding, heritability, and quantitative traits.

Unit I **12**

Quantitative Genetics

Qualitative and quantitative characteristics, Alleles at multiple loci, Relation between genotype and phenotype, Types of quantitative characteristics, Complex and multifactorial traits-polygenic inheritanceofcontinuous (quantitative) traits, normal growth charts, Determining gene numberfor polygenic characteristics, Approaches to analysis of complex traits-Statistical methods required for analyzing quantitative characteristics. Genetic susceptibility in complex traits, Heritability:Genetic components of variation; Twin and adoption studies toassess the importance of genes and environment.

Unit II **12**

Population Genetics

Genetic constitution of a population: Gene pool
Calculation of genotypic and allelic frequencies
Hardy-Weinberg law:Assumptions and extensions
Factors for changes in genetic structure: Mutation, Migration
Non-random mating (Inbreeding)
Genetic drift, Natural Selection, Fitness.

Unit III **12**

Eukaryotic Gene Mapping

Gene mapping with recombination frequencies, Constructing a genetic map with the useoftwo-point test crosses, Constructing a genetic map witha three-point test cross, Mapping human genes, Gene mapping in humansby linkage analysis in pedigrees, Mapping with molecular markers,QTL- mapping;Locating genes with genomewide association studies, Physical mapping methods: Deletion mapping, Somatic-cell hybridization, Physical chromosome mapping through molecular analysis.

Unit IV **12**

Identifying human disease genes

Principles and strategies for identifying human disease genes; Position-independent and positional cloning; Candidate gene approaches; Confirming a candidate gene, Testing in animal models; Instability of the human genome and diseases- pathogenicity associated with repeated sequences; Slipped strand mispairing; Unequal crossover and unequal sister chromatid exchange; Gene conversion; Retrotransposition; Illegitimate recombination

Unit V **12**

Pharmacogenetics&Personalized Medicine

Approaches to treat genetic diseases: Pharmacogenetics, recombinant protein, and vaccines; Aptamers

Therapy of genetic diseases -conventional therapy of genetic diseases

Gene Therapy: Strategies, role of viral vectors, non-viral vectors; gene therapy of monogenic diseases, antisense therapy of diseases associated with somatic mutations, cancer, and viral infection

RNAi: General idea and applications.

Personalized therapies/medicines; Ethical issues

Recommended Textbooks and References:

1. Pastemak, 2005, *An Introduction to Molecular Human Genetics*, 2nd Edition, Fitzgerald
2. Mange and Mange, 1999, *Basic Human Genetics*, 2nd Edition, SinauerAssoc
3. Lewis, 2007, *Human Genetics*, 7th Edition, WCB & McGraw
4. Vogel and Motulsky, 1997, *Human Genetics*, 3rd Edition, Springer Verlag
5. Strachen and Read, 2004, *Human Molecular Genetics*, 3rd Edition, Garland Sci. Publishing
6. Maroni, 2001, *Molecular and Genetic Analysis of Human Traits*, 1st Edition, Wiley-Blackwell
7. Howley and Mori, 1999, *The Human Genome*, Academic Press.
8. Haines &Pericak, (2006). *Approaches to Gene Mapping in Complex Human Diseases*. Wiley.

Elective Course- 17 f

ZOOLEL-401F: Biology of Parasites

Credits: 04 **Teaching Hours: 60**

Course objectives

The course willenable the students with the knowledge on:

- parasites of medical importance in humans, livestock, and fish, and
- general morphology, biology, life-cycle, pathogenicity and control of parasites.

Unit I **12**

Protozoa

General morphology, biology, life-cycle, *pathogenicity* and control of:

Visceral rhizopods and flagellates: *Entamoeba histolytica* and *Giardia lamblia*
Haemoflagellates: *Trypanosomabruceirhodesiense*, *Leishmaniadonovani*
Haemosporina: *Plasmodium vivax*

Unit II **12**

Monogenea

General morphology, biology, life-cycle, *pathogenicity* and control of:

Polystoma
Diplozoon
Gyrodactylus

Unit III

Trematoda and Cestoda **12**

General morphology, biology, life-cycle (including larval forms), pathogenicity and control of:

Visceral flukes (*Fasciolopsisbuski*, *Schistosomo*sp.)
Lung flukes (*Paragonimuswestermani*)

General morphology, biology, life-cycle (including larval forms), pathogenicity and control of:

Intestinal tapeworms (*Taeniasolium*, *Diphyllobothriumlatum*)
Extraintestinal tapeworms: Human cysticercosis, Human hydatidosis

Unit IV

Nematoda and Acanthocephala **12**

General morphology, biology, life-cycle (including larval forms), pathogenicity and control of:

Intestinal nematodes:*Ancylostomaduodenale*, *Trichiuratrichiura*
Blood and tissue nematodes: *Wuchereria bancrofti*, *Dracunculus medinensis*

General morphology, biology, life-cycle (including larval forms), pathogenicity and control of:

Pallisentis sp.

Unit V

Arthropoda **12**

Significance of Arthropods as vectors of human pathogens:

Biting dipterans (mosquitoes, tsetse flies)
Non-biting dipterana (common house fly)
Acarians (ticks and mites)
Other insects (fleas, lice)

Course learning outcomes

By the end of the semester, students will be able to:

- recognize significant morphological characteristics for identification of each of the major parasite group,
- value the diversity of parasites,
- describe the basic biology, morphology and life history of selected parasites, and
- apply the knowledge to generate novel ideas for the management of diseases.

Suggested readings

1. *Animal Parasitology* by JD Smyth. Cambridge University Press.
2. *Essentials of Parasitology* by GD Schmidt. Brown Publishers
3. *Foundation of Parasitology* by GD Schmidt LS Roberts. McGraw Hill Publishers.
4. *General Parasitology* by TC Cheng. Academic Press
5. *Helminths, Arthropods and Protozoa of domesticated animals* byEJLSoulsby.ELBS and BailliereTindall. London.
6. *Human Parasitology* by BJ Bogitsh, CE Carter, TN Oeltmann. Academic Press.
7. *Introduction to Parasitology* by AC Chandler & CP Read. John Wiley & Sons Inc.
8. *Parasite genomics protocols* by SE Melville. Humana Press.
9. *Parasitology* by Chaterjee K.D. Medical Pulisher Calcutta.
10. *Parasitology. The Biology of animal Parasites* by ER Noble GA Noble
11. *Modern Parasitology* by FEG Cox. Blackwell Scientific Publications.
12. *Molecular Parasitology* by JE Hyde. Open University Press. London.

Elective Course- 18 a

ZOOLEL-402A: Wildlife: Conservation and Management

Theory Credit: 04 **Teaching Hours: 60**

Course Objectives

The paper aims to enhance the knowledge about the various threats faced by wildlife. International and National agencies, policies, legislations and various movements pertaining to biodiversity and wild life conservation.

Course Outcome

The course is expected to help students to understand:

1. Various threats to wildlife
2. International and national efforts to conserve and manage the wildlife
3. Strategies for conservation and management and wildlife

Unit-I **12**

Threats to Wildlife:

An overview of major threats to wildlife in India.
Concept of IUCN threat categories : Red Data book.
Human-animal conflict

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Unit-II **12**

Introduction to International Policies for Biodiversity Conservation:

Convention on Biological Diversity,
Ramsar convention,
Nagoya and Cartagena Protocols,
AICHI targets, CITES, FAO, UNESCO

Unit-III **12**

Policies for Biodiversity Conservation inIndia:

National Biodiversity Action Plan, 2019 (NBAP),
Salient features of the Biological Diversity Act, 2000,
National Biodiversity Authority: State Biodiversity Boards and Biodiversity Management Committees,
Salient features of Wildlife Protection Act 1972.
Role of NGO's such WWF, BNHS, ATREE etc. Various movements

Unit-IV **12**

In-situ Conservation Strategies:

Concept of National Park, Sanctuaries,
Conservation Reserves, Sacred Groves,

UNESCO World Heritage sites,
Biosphere Reserves

Unit-V **12**

Ex-situ Conservation of Wildlife:

Concept of zoological, botanical parks, and aquaria.
Concept of gene banks, seed banks, tissue culture, captive breeding., cloning.

References:

1. Environmental law in India by P. Leelakrishnan
2. Environmental law case book by P. Leelakrishnan
3. The Wildlife (Protection) Act 1972 (up to latest amendment)
4. Forest Policy and Law by S.S. Negi
5. Environmental Conservation by S.H. Negi

Elective Course- 18 b

ZOOLEL-402B: Endocrine Disorders: Diagnosis, Techniques and Ethical Considerations

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

- To study the endocrine techniques used in endocrine researches
- To understand the endocrine disorders and pathophysiologies
- To study various reproductive technologies in treating infertility
- To understand current state of Endocrinology and Reproductive Biology
- To provide students understanding of conditions resulted from abnormal hormone secretion and the laboratory tests that are used to diagnose these conditions.
- To provide assurance for experimental procedures and care of live vertebrate animals in teaching and research

Unit I

Classical endocrine techniques **12**

Histological methods: Tissue preparation, Microtomy, Staining techniques

Surgical techniques: Perfusion and its applications, Laparotomy, Organ Ablation/ removal (Ovariectomy, Thyroidectomy, Parathyroidectomy, Adrenalectomy, Pinealectomy, Orchidectomy), Parabiosis in Rat.

Exogenous administration Techniques: Injection types, implant types (slow release and pellet implants), Sites and Administration

Sample/specimen collection techniques: Blood collection sites and procedures for small and large animals, Collection of Plasma and Serum, Specimen for endocrine disorder analysis (Blood, Urine, Plasma, Serum, Saliva): relevance and applications

Endocrine Assays: RIA, ELISA, HPLC

Unit II **12**

Modern techniques in endocrinology

Molecular Techniques:

PCR, RT PCR, qPCR

Localization:

Western Blot

ICC, ISH, Mass spectrometry

Cell and Tissue culture

Advanced Imaging Techniques:

Fluorescence Microscopy, Confocal Microscopy, Live cell imaging

Unit III **12**

Endocrine disorders and pathophysiologies

Pituitary Disorders

Thyroid disorders

Adrenal disorders

Diabetes mellitus: type I and type II

Osteoporosis

Polycystic Ovary Syndrome

Oligospermia

Unit IV **12**

Infertility and reproductive technologies

Primary and secondary infertility

implantation failure, recurrent abortions, preeclampsia

Reproductive techniques

In-vitro fertilization, Embryo transfer

GIFT, ZIFT, Cryopreservation of gametes and embryos

Contraceptives, HRT

Unit V **12**

Ethical Issues/Considerations in Research

GLP: Good Laboratory Practices.

SOP for CPCSEA: IAEC

Animal handling

SOP for Human Research: IEC

OECD Guidelines

Student learning outcome

The present course has been designed to:

1. provide students the knowledge and understanding of the concepts and theories related to endocrine disorders.
2. carry out the researches related to the basic and modern aspects of endocrinology.
3. identify and understand key ethical principles in research.

Suggested readings

1. **Williams Textbook of Endocrinology** by H. M. Kronenberg, S. Melmed, K. S. Polonsky, and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier.
2. **Neuroendocrinology** by Charles B. Nemeroff, CRC Press, US.
3. **Endocrinology** by Mac E. Hadley and Jon E. Levine, 2009, 6th Edition, Pearson Education.
4. **Molecular Endocrinology** by F. F. Bolander, 2004, 3rd Edition, Elsevier Academic Press.
5. **Essential Endocrinology** by Darville Brook, C. G. and Marshall, Wiley Blackwell.
6. **Evidence-Based Endocrinology** by V. M. Montori (ed.), Humana Press.
7. **Encyclopedia of Reproduction** by Ernst Knobil and Jimmy D. Neill, Volumes 1-4, Academic Press.
8. **Basic Histology: Text and Atlas** by Junqueira, L. C., and Carneiro, J., 2015, McGraw Hill.
9. **Experimental Endocrinology: A Sourcebook of Basic Techniques** by Zarrow, M. X., Yochim, J. M., and McCarthy, J. L., 2012, Elsevier.
10. **Comparative and Veterinary Pharmacology: Handbook of Experimental Pharmacology** by Cunningham F., Elliott J., and Lees P., Springer.
11. **Principles and Methods of Toxicology** by Hayes, A. W., 2019, CRC Press.
12. **Immunoassays: A Practical Approach** by Gosling, J. P., 2000, Oxford University Press.
13. **Principles and Techniques of Biochemistry and Molecular Biology** by Wilson, K., and Walker, J., 7th edition, 2010, University Press, Cambridge
14. **Textbook of Assisted Reproductive Techniques** by Gardner, D. K., Weissman, A., Howles, C. M., and Shoham, Z., 2018, CRC Press.
15. **Ethics in Science Education, Research, and Governance** by K. Murlidhar, Amit Ghosh, and A. K. Singhvi, 2019, Indian National Science Academy (INSA).
16. **Guidelines for Laboratory Animal Facility** by CPCSEA.

Elective Course- 18 c

ZOOLEL-402C: Applied Entomology and Pest Management

Theory Credit: 04 **Teaching Hours: 60**

Course objectives

- an understanding of what is a pest
- an understanding of how insects negatively affect human life
- an understanding of mode of damage by insects
- an understanding of control measures used to manage harmful insect pest populations

Unit I

Agricultural and horticultural pests–1

Characteristic features, biology, nature of damage and management measures of:

Important insect pests of cotton	03
Important insect pests of sugarcane	03
Important insect pests of vegetables	03
Important insect pests of oil seeds	03

Unit-II

Agricultural and horticultural pests–2

Characteristic features, biology, nature of damage and management measures of:

Important insect pests of fruit crops, especially mango	02
Important insect pests of cereals and pulses	03
Important insect pests of stored grains	02
Polyphagous insects	02
Structural Pests	03

Unit III

Urban entomology

Medical Entomology	04
Veterinary Entomology	04
Forensic Entomology	04

Unit IV

Industrial entomology

Apiculture	04
Sericulture	04
Lac-culture	04

Unit V

Pest management

Components of Insect Pest Management including Mechanical, Physical, Cultural, Chemical, Legal,Ecological, Biological, Microbial, Recent trends 06

Concept and Procedure of Integrated Pest Management	02
Mode of action of organochlorine, organophosphorous and carbamate pesticides	02
Pyrethroids and neem products	02

Student learning outcomes

At the end of the course the students will be able to:

- identify insect pests
- understand pest population dynamics
- understand pest management measures

Suggested readings

1. Alford: A textbook of Agricultural Entomology, Blackwell 1999
2. Atwal and Dhaliwal: Agricultural pests of India and South-East Asia, Kalyani Publishers, Byrd and Castner: Forensic Entomology, CRC Press, 2001
3.Dhaliwal and Arora: Principals of Insect pest management, National AgriculturalTechnology Information Centre, Ludhiana, 1996
4. Dhaliwal and Arora: Trends in Agricultural Insect pest Management, CommonwealthPubl.,1994
5. Hill: Pest of stored foodstuffs and their control, Springer, 2002
6. Metcalf and Flint: Destructive and useful insects and their control, McGraw Hill, 1962
7. Mullen and Durden: Medical and Veterinary Entomology, Academic Press, 2002
8. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002
9. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002
10. Pruthi: A Text Book of Agricultural Entomology, ICAR, New Delhi, 1969
11. Purohit: Agricultural Biotechnology (2nd ed.) Agrobios (India), 2003
12. Racheigl and Racheigl: Biological and biotechnological control of insect pests, CRCPress, 1998
13. Schoonhoven et al.: Insect-plant Biology- from physiology to evolution (1st ed.)Chapman& Hall, 1998
14. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ., 2001
15. A Textbook of Applied Entomology Vol. I and II by Srivastava and Dhaliwal
16. Agricultural Pests Of South Asia And Their Management by Atwal and Dhaliwal
17. Industrial Entomology by Omkar. Springer Nature
18. Ecofriendly Pest Management for Food Security by Omkar, Academic Press
19.Introduction to General and Applied Entomology by Awasthi
20. Handbook of Agricultural Entomology by van Emden
21. Pests and Their Management by Omkar, Springer Nature

Elective Course- 18 d

ZOOLEL-402D: Fish Ecology, Aquaculture and Capture Fisheries

Total Credit:04 **Teaching Hours: 60**

Course objectives

Unit I

Ecology of teleosteanfishes

Water quality requirements	02
Temperature, salinity, osmotic pressure, pH, dissolved oxygen, carbon dioxide, nitrogen, alkalinity and turbidity	03
Toxic substances and their effects	02
International water code for responsible fisheries	02
Aquatic weeds and their control	02
Exclusive economic zone	01

UnitII

Fish pondmanagement

Construction and lay-out of different types of ponds (nursery, rearing, andstocking)	02
Formulation and operation of different types of hatcheries	02
Productivity of the pond (planktons and Live food organism)	02

Pond management and stocking materials

Stocking materials (spawn, fry and fingerlings) and their culture	02
Manuring, liming, eradication of predatory and weed fishes, predatory aquatic insects and their control	03
Fish poison	01

Unit III

Capture fisheries

Freshwater fisheries (River, Lakes, and Reservoir)	02
Cold water fisheries and Hill stream adaptation	02
Brackish water fisheries	02
Marine fish resources of India	01
Problems and prospects of Mariculture	01
Capture fisheries of India with reference to Elasmobranchs	02
Bombay duck, Catfishes, Eels, Thread fish, Theropon, Mackerel and Pomfrets, Crustacean and Molluscan Fisheries	02

UnitIV

Aquaculture

Problems and prospects of aquaculture	02

Breeding habits of carps: Induced breeding and Bundh Breeding (Indigenous and Exotic)	02
Polyculture and Monoculture	02
Integrated fish farming and their management	02
Nets, Gears and Boats used for Fishing	02
Aquarium fish and their maintenance	02

Unit V

Fish products and fish diseases

Fish preservation and processing (traditional and advanced methods)	02
Fish by-products	02
Fish marketing and trade	02
Fish pathology: prevention, prophylaxis and treatment of Fungal, Bacterial, Viral and Protozoan Diseases	04
Fisheries Cooperative Societies of India	01
Fish in relation to Man and Human Welfare	01

Course learning outcome

The present course will prepare the students for:

- the self-employment, and
- the jobs related to the fish and fisheries.

Suggested readings

1. Jhingran VG. 1991. Fish and Fisheries of India, Hindustan Publishing Corporation.
2. A Hatchery Manual for the Common, Chinese and Indian Major Carps by V.G. Jhingran and R.S.V. Pullin, Asian Development Bank, ICLARM, Manila, Philippines
3. Reid GR.1961. Ecology and Inland waters and Estuaries. Rein Hold Corp., New York.
4. Pilley, TVR and Dill, WMA. 1979. Advances in Aquaculture. Fishing News Books, Ltd. England. 11.
5. Pillay TVR and Kutty MN. 2005. Aquaculture- Principles and Practices. Blackwell.
6. Nikolsky GV. 1963. Ecology of Fishes, Academic Press.
7. Norman JR and Greenwood PH. 1975. A History of Fishes, Halsted Press.
8. Potts GW and Wootten RJ. 1984. Fish Reproduction: Strategies and Tactics, Academic Press.
9. De Silva SS & Anderson TA. 1995. Fish Nutrition in Aquaculture. Chapman & Hall Aquaculture Series.
10. Ojha JS. 2005. Aquaculture Nutrition and Biochemistry. Daya Publ.
11. Rath RK. 2000. Freshwater Aquaculture. Scientific Publ.
12. Landau M. 1992. Introduction to Aquaculture. John Wiley & Sons.

Elective Course- 18 e

ZOOLEL-402E: Clinical and Cancer Genetics

Total Credits: 04 **Teaching Hours: 60**

Course Objectives

This course has been designed to provide preclinical medical education which has important applications in clinical medicine, public health, and medical research. The objective is to help the students to appreciate the importance of genetics in medicine with emphasis on the general principles of disease inheritance, pathogenesis, diagnosis, and counseling.

Student Learning Outcomes

On completing this course, students should be able to:

• Elicit and document a family history and pedigree;

• Understand the genetic risk assessments of genetic disorders.

• Gain knowledge about molecular, cytogenetic, and biochemical laboratory testing in clinical genetics;

• Understand the role of prenatal screening and testing in pregnancy management and care and the options available when a fetal abnormality is detected;

• Understand the role of genetics in cancer.

Unit I **12**

Basics of Clinical Genetics

Origin of medical genetics, major developments and its impact on clinical practice; Patterns of inheritance, Introduction to Genetic disorders: Classification, Single gene disorders and Multifactorial disorders.

Pedigree analysis of monogenic traits: Autosomal inheritance-dominant, recessive; Sex-linked inheritance- X-linked recessive, dominant; Y–linked; Sex-limited and sex-influenced traits; Mitochondrial inheritance; Complications to the basic pedigree patterns: Non-penetrance, variable expressivity, onset, dominance problem; Anticipation; Compound heterozygosity. Uniparentaldisomy; Consanguinity and its effects in the pedigree pattern

Unit II **12**

Molecular Basis of Genetic Disorders

Nomenclature of mutations and their databases;Principles and mechanisms of chromosome abnormalities; Numerical chromosome aberrations, Structural chromosomal aberrations; Common autosomal and sex chromosomal abnormalities; Common single gene disorders: Disorders of the hematological system- thalassemia, hemophilia, sickle cell disease, Huntington disease, Fragile X syndrome, Duchenne muscular dystrophy. Inborn errors of metabolism, Mitochondrial diseases

Unit III **12**

Cancer Genetics

Cancer Types; Proto-oncogenes;Oncogene, Tumor suppressor genes; Genetics rearrangement of Progenitor cells; DNA-repair genes

Cancer Progression; metastasis, interaction of cancer cells with normal cells,

Chromosome translocation; genomic instability,virus-induced cancers;

Cancer Markers; Therapeutic interventions for uncontrolled cell growth

Unit IV **12**

Clinical Diagnostics

Human Karyotype, Chromosome banding and Nomenclature
Molecular-cytogenetic testing- FISH, MLPA, QFPCR, CMA
Common molecular techniques and advanced techniques for known and unknown mutations; Inherited variation and Polymorphism, PCR-RFLP, ARMS-PCR Multiplex-PCR, SSCP
Genetic screening, carrier testing
Predictive testing—newborn screening; antenatal screening; population screening

Unit V **12**

Management of Genetic Disorders

Calculation of gentic risk through pedigree analysis; and Polulation Screening data.
Genetic counseling and principles in practice,
Case studies, Ethical issues in medical genetics,
Legal and social issues
Genetics and society; Genetic services in India.

Recommended Textbooks and References:

1. Gersen S.L, M.B. Keagle (eds) (2005) *The Principles of Clinical Cytogenetics*, 2nd edition. Humana Press, Totowa, NJ, 596p.
2. Elles RG, Mountford R (eds) (2003) *Molecular Diagnosis of Genetic Disease*s, 2nd Edn. Humana Press, Totowa, NJ.
3. Botstein D1, Risch N. *Discovering Genotypes Underlying Human Phenotypes: Past Successes for Mendelian Disease, Future Approaches for Complex Disease*. Nat Genet. 2003 Mar;33 Suppl:228-37.
4. Peter Turnpenny.Churchill Livingstone, *Emery's Elements of Medical Genetics*, (14th Eds.), Elsevier.
5. Robert L. Nussbaum,Roderick R. McInnes, Huntington F Willard, Thompson & Thompson *Genetics in Medicine*, (8eds), Elsevier.
6. C.R. Scriver, A.L. Beaudet, W.S. Sly, D. Valle, *The Metabolic and Molecular Bases of Inherited Disease*, 7th ed. Vol. 3, McGraw Hill, New York.
7. Peter S Harper, (2010), *Practical Genetic Counselling* 7th Edition.
8. Janice Berliner, *Ethical Dilemmas in Genetics and Genetic Counseling-Principles through Case Scenarios.*

Elective Course- 18 f

ZOOLEL-402F:Parasitological Techniques

Credits: 04 **Teaching Hours: 60**

Course objectives

The course will enable the students to:

- learn and perform technical procedures such as collection ofhost and parasite specimens and preparation of reagent,
- process parasites using a variety of standardized techniques,
- performs microscopic examinations of processed specimens, and
- detect and identify parasites stages using both morphological and molecular taxonomy.

Unit I **12**

Sampling and processing of vertebrate hosts(with special reference to fish)

Types, preparation and applications of reagents usedin parasitology laboratory
Survey and collection of hosts
Humane killing of hosts
Necropsy and examination of hosts for recovery of parasites
Faecal examination

Unit II **12**

Sampling and processing of parasites

Collection, fixationand preservation of ectoparasites
Collection, fixation and preservation of endoparasites
Staining protocols
Preparation of temporary and permanent 'whole mounts'
Histological techniques

Unit III **12**

Morphologicalcharacterization

Microscopic examination
Introduction to optics
Principles of image formation
Principle, components, and applications of Light microscopy, Phase–contrast microscopy, Fluorescence microscopy, Confocal microscopy, and Electron microscopy (SEM, TEM and STEM)
Morphometric analysis
Measurements
Drawing of parasites to scale
Digital image analysis

Unit IV **12**

Molecular characterization

Isolation of DNA
PCR Thermocycler: amplification of DNA
Gel electrophoretic apparatus:qualitative analysis of DNA
Spectrophotometer: quantitative analysis of DNA
Centrifuge: collection of DNA precipitate
DNA Sequencer: automationof DNA sequencing

Unit V **12**

Ecological, behavioural and immunological techniques

Analysis of microhabitat distribution of ectoparasites
Analyses of parasite communities–biodiversity indices
Collection and analysis of water quality parameters for fish parasites
Analysis of behaviour of cercariae
Detection of antibodies by basic indirect ELISA

Course learning outcomes

By the end of the course, students should be able to:

- examine and identify grossly parasites and their stages and parasitic lesions in different organs,
- examine and identify the microscopic morphology of parasites and their larval stages of medical importance in fixed stained smears, and
- use different kinds of microscopes and modern equipments used in Parasitology.

Suggested literature

1. *Animal Parasitology* by JD Smyth. Cambridge University Press.
2. *Essentials of Parasitology* by GD Schmidt. Brown Publishers
3. *Foundation of Parasitology* by GD Schmidt LS Roberts. McGraw Hill Publishers.
4. *General Parasitology* by TC Cheng. Academic Press
5. *Helminths, Arthropods and Protozoa of domesticated animals* byEJLSoulsby.ELBS and BailliereTindall. London.
6. *Human Parasitology* by BJ Bogitsh, CE Carter, TN Oeltmann. Academic Press.
7. *Introduction to Parasitology* by AC Chandler & CP Read. John Wiley & Sons Inc.
8. *Parasite genomics protocols* by SE Melville. Humana Press.
9. *Parasitology* by Chaterjee K.D. Medical Publisher Calcutta.
10. *Parasitology. The Biology of animal Parasites* by ER Noble GA Noble
11. *Modern Parasitology* by FEG Cox. Blackwell Scientific Publications.
12. *Molecular Parasitology* by JE Hyde. Open University Press. London.

ZOOLMT-401: Dissertation
(Project/Assignment/ Case report/ Literature review)

Credits: 08 **Contact Hours: 120**

Course objectives

It will be a unique opportunity for the students to study intensively a biological question of their interest. They will have to make a choice from the available titles from which the preferred choices will be made and then work on it in the guidance of a teacher.

Aims

- Literature searching to research a specific scientific topic.
- Interpretation and analysis of scientific literature.
- Scientific writing to enable production of a comprehensive literature review.
- Allow students to explore in depth a topic that is of interest to them.

Learning outcomes

Students will be able to-

- understand in depth a scientific area of interest
- critically appraise research papers
- develop literature searching and scientific writing skills
- develop lay writing skills (abstract)
- develop organizational and time management skills
- develop oral presentation skills (in tutorials)
- develop written and oral communication skills