(*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

PROGRAMME BROCHURE

(Proposed to be implemented from July 2020)

Head, Department of Zoology
15 February 2021

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’ are conducted 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 having holistic 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			**48**
Second year	Semester III	Semester IV	
Preferred and Final Exit point 2 with a Masters' Degree in Zoology			**96**

Course Credit Scheme

Semester	**Core Course/ MOOCs****			**Elective Course**			**Inter/ Intra-Departmental Course**			**Credit/ Non Credit Value added 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+8L	**20**	-	-	-	-	-	-	**1**	**4**	**4**	**24**
II	4	16T+8L	**24**	-	-	-	-	-	-	**1**	-	-	**24**
III	2	8T+4F	**12**	2	8T	**4**	1	4	**4**	-			**24**
IV	-	4T+8D	**12**	2	4T+4L	**8**	1	4	**4**	-			**24**
Total Course Credits													**96**

- 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 Intradepartmental Courses will 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				
INTRADEPARTMENTAL COURSE				
ELECTIVE				
INTERDEPARTMENTAL COURSE				
MASTER THESIS/ DISSERTATION				

6. Course Structure:

The course structure of the 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**
ZOOLCC-102	Animal Physiology	**04**	**Core Course**
ZOOLCC-103	Biochemistry and Cell Biology	**04**	**Core Course**
ZOOLCC-104	Lab based on ZOOLCC-101	**04**	**Core Course**
ZOOLCC-105	Lab based on ZOOLCC102-103	**04**	**Core Course**
ZOOLVC-101	Biodiversity and Conservation	**04**	**Value added course (Credited)**
	Semester Total	**24**	
	Semester II		
ZOOLCC-201	Chordata	**04**	**Core Course**
ZOOLCC-202	Developmental Biology and Immunology	**04**	**Core Course**
ZOOLCC-203	Quantitative biology and Bioinstrumentation	**04**	**Core Course**
ZOOLCC-204	Animal Behaviour and Chronobiology	**04**	**Core Course**
ZOOLCC-205	Lab based on ZOOLCC201-202	**04**	**Core Course**
ZOOLCC-206	Lab based on ZOOLCC203-204	**04**	**Core Course**
ZOOLVNC-201	Physiology of Stress and Yoga	**00**	**Value added course (Non Credited)**
	Semester Total	**24**	
	Semester III		
ZOOLCC-301	Biosystematics, Evolutionary Biology and Biodiversity	**04**	**Core Course/ MOOC**
ZOOLCC-302	Environmental Biology, Wildlife and Toxicology	**04**	**Core Course**
ZOOLEL-301A	Principles of Endocrinology	**04**	**Elective**
ZOOLEL-301B	Insect Taxonomy, Morphology and Ecology		
ZOOLEL-301C	Fish Biology and Genetic Resources		
ZOOLEL-301D	General parasitology		
ZOOLEL-302A	Biology of Reproduction	**04**	**Elective**
ZOOLEL-302B	Insect Physiology		
ZOOLEL-302C	Fish Ecology, Aquaculture and Capture Fisheries		
ZOOLEL-302D	Biology of Parasites		
ZOOLIN-301	Summer Internship/ Field Work	**04**	**Summer Internship**
ZOOLIER-301	Public Health	**04**	**Interdepartmental Course**
	Semester Total	**24**	
	Semester IV		
ZOOLCC-401	Molecular Biology and Genetics	**04**	**Core Course**
ZOOLEL-401A	Endocrine disorders and their diagnostics	**04**	**Elective**
ZOOLEL-401B	Applied Entomology and Pest Management		
ZOOLEL-401C	Applied Fish and Fisheries		
ZOOLEL-401D	Parasitological Techniques		
ZOOLEL-402A	Lab based on ZOOLEL301A, 302A, 401A	**04**	**Elective**
ZOOLEL-402B	Lab based on ZOOLEL301B, 302B, 401B		
ZOOLEL-402C	Lab based on ZOOLEL301C, 302C, 401C		
ZOOLEL-402D	Lab based on ZOOLEL301D, 302D, 401D		
ZOOLMT-401	Master Thesis/ Dissertation	**08**	**Master Thesis**
ZOOLIRA-401	Scientific Writing and Communication	**04**	**Intradepartmental Course**
	Semester Total	**24**	
	GRAND TOTAL	**96**	

ZOOL – Zoology; ZOOLCC – Core Course; ZOOLVC – Value added course (Credited); ZOOLVNC - Value added course (Non Credited); ZOOLEL – Elective; ZOOLIN – Summer Internship/ Field Work; ZOOLIER – Interdepartmental Course; ZOOLMT – Master Thesis/ Dissertation; ZOOLIRA – Intradepartmental Course.

I. Electives

A. Endocrinology and Reproductive Physiology

ZOOLEL-301A	Principles of Endocrinology
ZOOLEL-302A	Biology of Reproduction
ZOOLEL-401A	Endocrine disorders and their diagnostics

B. Entomology

ZOOLEL-301B	Insect Taxonomy, Morphology and Ecology
ZOOLEL-302B	Insect Physiology
ZOOLEL-401B	Applied Entomology and Pest Management

C. Fish and Fisheries

ZOOLEL-301C	Fish Biology and Genetic Resources
ZOOLEL-302C	Fish Ecology, Aquaculture and Capture Fisheries
ZOOLEL-401C	Applied Fish and Fisheries

D. Parasitology

ZOOLEL-301D	General parasitology
ZOOLEL-302D	Biology of Parasites
ZOOLEL-401D	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

III. 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

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.

IV: Value Added Course Scheme

Semester	Course	Value Added Credited Course	Value Added Non-Credited Course	Credits	Total Lectures
I	ZOOLVC-101	Biodiversity and Conservation	-	4	60
II	ZOOLVNC-201	-	Physiology of Stress and Yoga	-	60
TOTAL				**4**	**120**

V: Interdepartmental/ Intradepartmental Courses

Semester	Course	TOPIC		Credits	Total Lectures
		Interdepartmental Course	Intradepartmental Course		
III	ZOOLIER-301	Public Health	-	4	60
IV	ZOOLIRA-401	-	Scientific Writing and Communication	4	60
TOTAL				**8**	**120**

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), ZOOLVNC defines the Value added course (Non Credited), ZOOLEL defines the Elective course, ZOOLIER stands for Interdepartmental Course, ZOOLIN defines the Summer Internship/ Field Work, ZOOLIER stands 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	**-**	**4**	**4**
Core course 5 (total number)		**12**	**08**	**20**
Credit Value Added Course		**Credits**		
ZOOLVC-101	Biodiversity and Conservation	**4**	**-**	**4**
Total credits in Credit Value Added Course		**4**		
Total credits in Semester I (Core and Credit Value Added Courses) – 24				
Semester II				
Core courses		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-201	Chordata	**4**	**-**	**4**
ZOOLCC-202	Developmental Biology and Immunology	**4**	**-**	**4**
ZOOLCC-203	Quantitative biology and Bioinstrumentation	**4**	**-**	**4**
ZOOLCC-204	Animal Behaviour and Chronobiology	**4**	**-**	**4**
ZOOLCC-205	Lab based on ZOOLCC201-202	**-**	**4**	**4**
ZOOLCC-206	Lab based on ZOOLCC203-204	**-**	**4**	**4**
Core course 6 (total number)		**16**	**08**	**24**
Non Credit Value Added Course		**Credits**		
ZOOVNC-201	Physiology of Stress and Yoga	**-**	**-**	**-**
Total credits in Semester I (Core and Non Credit Value Added Courses) – 24				
Semester III				
Core + Elective Courses		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-301	Biosystematics, Evolutionary Biology and Biodiversity	**4**	**-**	**4**

ZOOLCC-302	Environmental Biology, Wildlife and Toxicology	**4**	**-**	**4**
ZOOLEL-301 (A-D)	Elective I	**4**	**-**	**4**
ZOOLEL-302 (A-D)	Elective II	**4**		**4**
ZOOLIN-301	Summer Internship/ Field Work (FW)	**-**	**4**	**4**
Core course 6 (total number)		**16**	**4**	**20**
Total credits in Core + Elective courses		**20**		
Interdepartmental course A student from other Faculty has to opt for this Interdepartmental Course		**Credits**		
ZOOLIER-301	Public Health	**4**	**-**	**4**
Total credits in Interdepartmental Course		**4**		
Total credits in Semester III (Core, Elective and Interdepartmental Course) – 24				
Semester IV				
Core + Elective		**Credits**		
Code	**Course**	****Theory**	**Lab**	**Total**
ZOOLCC-401	Molecular Biology and Genetics	**4**	**-**	**4**
ZOOLEL-401 (A-D)	Elective III	**4**	**-**	**4**
ZOOLEL-402 (A-D)	Lab based on ZOOLEL301, 302, 401 (A-D)	**-**	**4**	**4**
ZOOLMT-401	Master Thesis/ Dissertation (D)	**8**	**-**	**8**
Course 3 (total number)		**16**	**4**	**20**
Total credits in Core + Elective courses		**20**		
Intradepartmental course A student from other department has to opt for this Intradepartmental Course		**Credits**		
ZOOLIRA-401	Scientific Writing and Communication	**4**	**-**	**4**
Total credits in Intradepartmental Course		**4**		
Total credits in Semester IV (Core, Elective, Dissertation, Intradepartmental Course) – 24				

1. In the third and fourth semesters, a student has to choose one of the four electives. Each elective (**Elective – Endocrinology and Reproductive Physiology:** ZOOLEL- 301A, 302A, 401A, 402A; **Entomology:** ZOOLEL- 301B, 302B, 401B, 402B; **Fish and Fisheries:** ZOOLEL- 301C, 302C, 401C, 402C; **Parasitology:** ZOOLEL- 301D, 302D, 401D, 402D) 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 at least 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

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

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

Unit I

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

Unit III

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

Unit IV

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. Hercourt Asia PTE 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

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 University press	

ZOOLVC-101: Value Added Credited Course

Semester	Course	Value Added Credited Course	Non Credit Value Added Courses	Credits	Total Lectures
I	**ZOOLVC-101**	Biodiversity and conservation	-	4	60

ZOOLVC-101: Biodiversity and Conservation

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

Course Objectives

- To gain knowledge of biodiversity, its threats and conservation.
- To provide skills for identifying common biodiversity in their courtyard.
- To provide knowledge about government bodies &policies related to biodiversity.

Unit I

Biodiversity

What is Biodiversity	02
Biodiversity Types: (a) Species, Ecosystem level, Genetic Level (b) Alpha, Beta, Gamma level	02
Indian Biodiversity & Its Distribution	02
Importance/Significance	02
Biodiversity Hotspots/Parks	02
Keystone species, Indicator Species	02

Unit II

Classification and Diversity

General Classification & Diversity of Lepidopterans and Arachnids with common examples	06
General Classification & Diversity of Amphibians	06

Unit III

Tools/Techniques

Binoculars	02
Cameras- Digital & DSLR	02
GPS, Sound Recorder, Some Common Wildlife Softwares	04
Methods of Census & Biodiversity, Census Technique	02
Biodiversity indices	02

Unit 4

Threats

Major Threats to Biodiversity	02
Natural Threats: Climate Change, Natural Calamity, Desertification	04
Anthropogenic Threats: Pollution, Habitat Fragmentation Degradation, Hunting/Killing/Poaching, Agricultural Practices, Urbanization	06

Unit 5

Conservation Strategies

Wild Life Protection 1972, Biodiversity Act 2000, IUCN Categories, Red Data List, Biodiversity Conservation	02
Govt. Agencies- IWB, MoEF, WII etc., NGO'S – BNHS, ATREE etc.	02
Ex situ, In situ Conservation	02
Tribes and Tradition Societies in Conservator – BISHNOI'S, etc	02
Andolans :- Chipko Movement, Panipanchayat, etc.	02

Biodiversity Register, Sacred Grooves, Traditional Knowledge 02

Student learning outcomes

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

- Appreciate biodiversity, its threats and conservation.
- Identify common biodiversity in their courtyard.
- Comprehend and communicate details of various Government Bodies & Policies related to biodiversity.

Suggested readings

1. Biodiversity and Ecosystem functioning. edited by Michel Lorean ,ShahidNaureen and Pablo Inchausti (Oxford University Press.)
2. Biodiversity and Conservation in Forests. By Diana. F. Tomback. Publication MDPI-Multidisciplinary Digital Publishing Institute.
3. Methods and Practice in Biodiversity Conservation by David Hawks-worber. (Springer Publication)
4. Recent Studies in Biodiversity and Traditional Knowledge in India. By Chandra Ghosh and A.P. Das (Publisher: Levant Books)
5. Biodiversity and Protected Areas by Beazley, Karen, Baldwin, Robert. (Publishers: MDPI)
6. An Advanced Text book on Biodiversity (Principle and Practice) by K.V. Krishnamurthy. (Publication-CBS)
7. Biodiversity Hotspots edited by Vittore Rescigrio and Savario Moletta. (Publishers: Nova Science Publishers)

Semester II

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

Unit I

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 and Holocephali	01
General organization and affinities of Coelacanthiformes	01

Unit II

Amphibia

Origin of tetrapods	03
General organization of Anura	02
Neoteny	01
Peculiarities of Urodela	01
Peculiarities and affinities 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

Unit IV

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

ZOOLCC-202: 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 (Agglutinaton Rn'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.

ZOOLCC-203: Quantitative Biology and Bioinstrumentation

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.

Unit I

Biological data

Data on a ratio scale	02
Data on an interval scale	02
Data on an ordinal scale	02
Data on a nominal scale	02
Types of statistics: inferential and descriptive	02
Parametric and non-parametric tests (concepts and applications)	02

Unit II

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

Mean (simple and weighted)	02
Median	02
Mode (analysis using group table)	02

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

Range and mean deviation	02
Standard deviation	02
Kurtosis and skewness	02

Unit III

Correlation and regression

Types and methods of studying correlation	02
Karl Pearson's coefficient of correlation and determination	02
Regression equation (X on Y and Y on X)	02
Regression lines	01

Tests of significance and their application

t-test	02
Chi-square test	01

Analysis of variance

One-way and two-way ANOVA	02

Unit IV

Bioinstruments

Basic principles of microscopy	01

Phase contrast microscope	01
Electron microscope	02
Fluorescence microscope	02
Confocal microscopes	02
Centrifuge: principle, types of rotors, high speed and ultracentrifuge	02
pH Meter, Chromatography: Paper, Gel Filtration, Ion exchange, HPLC	02

Unit V

Advanced instrumentation

Colorimetry and spectrophotometry: Beer-lambert law, absorption coefficient	02
Biochemical Analysers, Lyophilizer	02
Water purification system, Laminar flow, Autoclave	02
PCR machine, Gel Documentation System, Gel Apparatus	03
Flow cytometer, DNA sequencer, Microarray, Microplate reader	03

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
4.	Westhead *et al*	Bioinformatics: Instant Notes	Viva Books	2003

ZOOLCC-204: 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.

ZOOLVNC-201: Value added non credited course

Semester	Course	Credit Value Added Courses	Non Credit Value Added Courses	Credits	Total Lectures
II	**ZOOLVNC-201**	-	Physiology of Stress and Yoga	-	60

ZOOLVNC-201: Physiology of Stress and Yoga

Non Credit Course **Teaching Hours: 60**

Unit I: Homeostasis and Its Disruption **12**

- Homeostasis: the maintenance of steady state
- Environmental disruptors of homeostasis
- Lifestyle disruptors of homeostasis

Unit II: Consequences of Homeostasis Disruption **12**

- General Adaptation Syndrome (GAS)
- Mechanism of stress
- Stress disorders
- Secondary effects

Unit III: Yoga: Stress Buster Mechanisms I **12**

- Pranayama
- Nadishuddhi
- Ujjayi
- Sitali/ Sitkari and Brahamari

Unit IV: Yoga: Stress Buster Mechanisms II **12**

- Meditation
- Breath Awareness
- Om chanting and meditation
- Yoga Nidra
- Kundalini Jagriti

Unit V: Yoga: Stress Buster Mechanisms III (Asanas) **12**

- Tadasana
- Katichakrasana
- Pavanamuktasana
- Sarvangasana
- Sarala Matsyasana
- Gomukhasana
- Vakrasana
- Ardhyamatsyaendrasana
- Ushtrasana
- Makarasana
- Bhujangasana
- Dhanurasana
- Shavasana

Semester III

ZOOLCC-301: Biosystematics, Evolutionary Biology and Biodiversity

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

Course objectives

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

Unit I

Taxonomy and classification

Concepts, terminology and types of taxonomy and classification	04
Principles of classification	04
Artificial and natural classification	04

Unit II

Concept and preambles of ICZN	04
Law of priority	04
Proteins and nucleic acids in modern taxonomy	04

Unit III

Concept and type of species	03
Endemic species	03
Mechanisms of speciation	03
Origin of life: Life's beginnings, evolution of eukaryotes	03

Unit IV

Evolutionary theories	03
Natural selection	02
Molecular evolution	03
Adaptation (evolutionary analysis of form and function)	02
Phylogenetics: concept, phylogenetic gradualism and punctutated equilibrium	02

Unit V

Biodiversity: concepts and hierarchical levels	02
Species diversity	02
Species richness and evenness	02
Genetic diversity	02
Ecosystem diversity and services	02
National laws of biodiversity	02

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

ZOOLCC-302: Environmental Biology, Wildlife 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

Ecosystem

Concept, production and decomposition	01
Biosphere and biomes	02
Biogeochemical cycles	02
Population ecology	02
Community ecology and ecological succession	03
Concept of habitat ecology and ecological niche	01
Island biogeography	02

Unit II

Global environmental problems

Environmental pollution	04
Waste management	02
Environmental monitoring	02
Acid rain	01
Greenhouse effect and global warming	01
Depletion of ozone layer	01
Climate change	01

Unit III

Wildlife

Basic concept of wildlife and biodiversity	02
Causes of wildlife depletion	02
Wildlife conservation strategies	02
Wildlife management tools and techniques	02
Conservation genetics	02
Legislative methods of biodiversity conservation	02

Unit IV

Exposure of toxicants

Different routes/methods of exposure, frequency & duration of exposure

Human exposure	0 1
Dose-response relationship	0 1
Selective toxicity: concept, significance Basic mechanisms of selective toxicity	0 2

Toxicity Tests

Bioassay	0 1
Acute toxicity tests for terrestrial and aquatic animals	0 2
Chronic toxicity tests	0 1
Concept of maximum acceptable toxicant concentration (MATC) and safe concentration	0 2

Factors affecting toxicity

Factors related to the chemical exposure Surrounding medium and the organisms	0 1

Unit V

Toxic effects of Xenobiotics

Local and systemic effects Immediate and delayed effects Reversible and irreversible effects	0 1
Biochemical and physiological effects of xenobiotics	0 1
Nanotoxicology	01
Toxicogenomics	01

Bioaccumulation of Xenobiotics

Concept of bioconcentration, bioaccumulation and biomagnifications; Bioconcentration factor	0 1
Process of bioaccumulation in the biological system	0 1

Biotransformation of Xenobiotics

Concept of biotransformation and metabolism	0 1
Sites of biotransformation	0 1
Biotransformation enzymes and general biotransformation reactions	0 1
Factors affecting biotransformation	01
Safety evaluation of xenobiotics	0 1
Antidotal therapy	01

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.
17. 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 Vittore Rescigrio and SavarioMoletta. (Publishers: Nova Science Publishers)

ZOOLEL-301A: 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, Cunming Duan, Intelliz Press LLC (2016)

ZOOLEL-301B: 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.

ZOOLEL-301C: 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
Weberian ossicles 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 by Ichthyology, 2nd Ed. John Wiley & Sons, New York
2. Santosh Kumar and Manju Tembhre. 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. Gopal Ji 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

ZOOLEL-301D: 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 1

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 2 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 3

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 4

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 5

Molecular biology and bioinformatics 12

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* by Shoba Ranganathan, 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* by EJL Soulsby. ELBS and Bailliere Tindall. 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.

ZOOLCC-302A: 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.

Unit I

Physiology of male and female reproductive axis

Reproductive system

Gonadal differentiation and theories	04
Differentiation of reproductive tract	04
Hormones of reproductive axis (GnRH/ GnIH; luteinizing hormone [LH] and follicle stimulating hormone [FSH]; sex steroids)	04

Unit II

Reproductive cycles and pregnancy

Estrus cycle and menstrual cycle Cellular details and hormonal regulation	04
Pregnancy and its hormonal regulation Implantation window, mechanism of implantation Trophoblast differentiation	04
Placentation Mechanism of placentation Placental transport function	04

Unit III

Endocrinology of parturition and lactation

Parturition and its control Oxytocin and prolactin	03
Lactation and its hormonal control Anatomical changes in mammary glands Lactogenesis, Colostrum and its composition Cellular mechanism of milk secretion	06
Metabolic homeostasis in human pregnancy and lactation	03

Unit IV

Reproduction and immunity

Immunity during pregnancy Suppression of immunity Role of hormones	05
Immune tolerance	03

Autoimmune bases of infertility 04

Unit V

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

ZOOLEL-302B: 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
Nutritional requirements 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 cuticular sclerotization 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 0 1

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)

ZOOLEL-302C: Fish Ecology, Aquaculture and Capture Fisheries

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

Course objectives

Unit I

Ecology of teleostean fishes

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

Unit II

Fish pond management

Construction and lay-out of different types of ponds (nursery, rearing, and stocking)	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

Unit IV

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.

ZOOLEL-302D: Biology of parasites

Credits: 04 **Teaching Hours: 60**

Course objectives

The course will enable 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

Protozoa 12

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

Visceral rhizopods and flagellates: *Entamoeba histolytica* and *Giardia lamblia*

Haemoflagellates: *Trypanosoma brucei rhodesiense*, *Leishmania donovani*

Haemosporina: *Plasmodium vivax*

Unit II

Monogenea 10

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

Polystoma

Diplozoon

Gyrodactylus

Unit III

Trematoda and Cestoda 18

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

Visceral flukes (*Fasciolopsis buski*, *Schistosomo* sp.)

Lung flukes (*Paragonimus westermani*)

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

Intestinal tapeworms (*Taenia solium*, *Diphyllobothrium latum*)

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: *Ancylostoma duodenale, Trichiura trichiura*

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 8

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* by EJL Soulsby. ELBS and Bailliere Tindall. 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.

ZOOLIN-301: Summer Internship/ Field Work

Semester	Course	Summer Internship/ Field Work	Credits	Total Hours
III	**ZOOLIN-301**	-	4	60

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

The aims of Field work are:

Fieldwork is an experiential process in which students will apply the theories learned in the classroom to work in a field setting.

It will include a) study tours to national institutes, diagnostic laboratories, libraries, parks and sanctuaries etc., b) Field exercises in identification of representative animal species, and c) field-based projects and hands-on exposure activities.

ZOOLIER-301: Interdepartmental Course

Semester	Course	Interdepartmental Course	Credits	Total Lectures
III	**ZOOLIER-301**	Public Health	4	60

ZOOLIER-301: Public Health

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

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

Human diseases

Communicable/Vector borne diseases- Malaria, Sleeping sickness	04
Non–Communicable diseases- Cancer, AIDS	04
Metabolic diseases - Diabetes, BP, Thyroid	02
Genetics diseases- PKU, Sickle Cell Anaemia, Thalassemia	02

Unit II

Disease prevention

Tackling antimicrobial resistance	04
Measures for reduced maternal & child/infant mortality rate	04
Prevention of environmental pollution & its degradation	04

Unit III

Measures for healthy life

Micronutrients, their role, deficiency & related problems	02
Improved nutrition for all age groups	02
Application of yoga & physical exercise for healthy life (their role)	02
Obesity, Non-alcoholic fatty liver	02
Hazards of tobacco chewing & smoking	02
Importance of personal & public hygiene & better sanitary habits	02

Unit IV

Government's role in public health

Strong Government's accountability for enforcement of quality health measures	02
Regular immunization/vaccination programmes eg., pulse polio	04
Adequate measures for preventing spread of vector borne diseases	02
Government's role in propagation of family planning measures, AIDS awareness	04

Unit V

Epidemiological studies

Epidemiology & statistical analysis of difference diseases	06
Population genetics	06

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 Sundar Lal, Vikas, CBS Publishers, 2018

3. A practical guide for PG course in Community medicine, Public Health and Health management by Sudip Bhattacharya and Sailesh Tripathi, 2018

4. Park's Textbook of Preventive and Social Medicine by K. Park 2017

Semester IV

ZOOLCC-401: 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

DNA replication

DNA polymerases & Enzymes involved in replication	03
Origin of replication and formation of primosome	02
Unit of replication	01
Replication fork and replisome	02
Fidelity of replication	02
Termination of replication	02

Unit II

Transcription & Translation

Fine structure of gene, transcription unit	02
Initiation, elongation and termination of transcription in prokaryotes and eukaryotes	02
RNA polymerases, Transcription factors and machinery	03
Formation of initiation complex	02
Initiation, elongation and termination of translation in prokaryotes and eukaryotes	04
Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase	02

Unit III

Regulation of gene expression

Regulation at transcriptional level: Operon system, *lac*, *trp, arabinose* operons	03
Post-transcriptional modifications: Capping, Splicing, Polyadenylation, RNA editing	
Role of chromatin in gene expression	02
Regulation at translational level	02
Post- translational modifications: Protein folding, Intracellular protein degradation	
Gene silencing, RNAi	02

Unit IV

Mendelian Genetics

Mendel's laws and their chromosomal basis	02

Extension of Mendel's principles: incomplete dominance and co-dominance, basis of dominant and recessive mutations, complementation test, multiple alleles, pseudoalleles	02
Gene action- from genotype to phenotype–penetrance and expressivity, gene interaction,epistasis, pleiotropy, phenocopy, genomic imprinting	02
Linkage and crossing over, sex linkage, sex limited and sex influenced characters	01
Extra chromosomal inheritance: Mitochondrial genes, maternal inheritance	01

Sex determination and dosage compensation

Sex determination- in humans, *Drosophila* and other animals	01
Dosage compensation of X-linked genes–hyperactivation of X-linked gene in Male *Drosophila*	01
Inactivation of X-linked genes in female mammals	01

Unit V

Gene mutation and DNA repair

Types of gene mutations	01
Methods for detection of induced mutations	01
P-element insertional mutagenesis in *Drosophila*	01
DNA damage and repair	02
Mutant types (lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis)	02

Gene mapping methods

Methods of gene mapping: 3-point test cross in *Drosophila*	01
Gene mapping in humans by linkage analysis in pedigrees	02
Mapping with molecular markers, using somatic cell hybrids	01
Gene mapping in bacteria by conjugation, transformation & transduction	01

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.	Snustada and Simmons	Principles of Genetics	JohnWiley& Sons	
8.	Russell	Genetics	Benjamin-Cummings	
9.	Alberts *et 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	

ZOOLEL-401A: Endocrine Disorders and their Diagnostics

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.

Unit I

Classical endocrine techniques 12

Organ/ Tissue manipulation
- Histological methods
- Surgeries
- Tissue dissection and serum collection
- Subcutaneous injections
- HRT

Hormone assays
- RIA, ELISA, HPLC
- Hormone pellet construction
- Hormone content extraction

Unit II

Modern endocrine techniques 12

RNA extraction
- RT PCR
- qPCR

Hormone localization
- Northern Blot
- ICC, ISH

Unit III

Endocrine disorders and pathophysiologies 12

Disorders of major glands
- Pituitary Disorders
- Thyroid disorders
- Adrenal disorders

Other disorders
- Osteoporosis
- Polycystic Ovary Syndrome
- Polyendocrine disorders
- Oligospermia

Unit IV

Infertility and reproductive technologies 12

Primary and secondary infertility

implantation failure, recurrent abortions, preeclampsia

Reproductive techniques

Invitro fertilization, Embryo transfer

GIFT, ZIFT, Cryopreservation of gametes and embryos

Contraceptives, HRT

Unit V

Current state of endocrinology and reproductive biology 12

Disease patterns across India

Endocrine diseases (Diabetes, PCOD, Thyroid hormones related)

Endocrinology of diseases

Breakthrough researches

Indian contribution in the field

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.

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, xxxx, 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. Encyclopedia of Reproduction: Ernst Knobil and Jimmy D. Neill, Volumes 1-4, Academic Press

ZOOLEL-401B: 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, Commonwealth Publ., 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

ZOOLEL-401C: 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.

ZOOLEL-401D: Parasitological Techniques

Credits: 04 **Teaching Hours: 60**

Course objectives

The course will enable the students to:

- learn and perform technical procedures such as collection of host 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

Sampling and processing of vertebrate hosts (with special reference to fish) 12

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

Unit II

Sampling and processing of parasites 12

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

Unit III

Morphological characterization 12

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 II

Molecular characterization 12

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: automation of DNA sequencing

Unit V

Ecological, behavioural and immunological techniques 12

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* by EJL Soulsby. ELBS and Bailliere Tindall. 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: Master Thesis/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

ZOOLIRA-401: Intradepartmental Course

Semester	Course	Intradepartmental Course	Credits	Total Lectures
IV	ZOOLIRA-401	Scientific Writing and Communication	4	60

ZOOLIRA-401: Scientific Writing and Communication

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

Course objectives

This course aims to demystify the writing process and teach the fundamentals of effective scientific writing and communication. The objectives of this course are:

- to help students to learn technical writing, which is clear, simple and structured logically, so as to communicate their research to others,
- gather published and unpublished sources of information and bring them to bear on scientific questions,
- critically read scientific writing,
- access electronic sources of information, including but not limited to internet searches, library databases, and public information and data,
- learn the structure and functions of different components of scientific papers to effectively communicate scientific findings,
- learn techniques for effective communication of scientific information in oral and poster presentations,
- understand the ethical boundaries associated with scientific communication.

Unit I: Demystifying the Writing process **12**

- Introduction
- Learn the structure and function of a scientific paper
- Writing Basics for the Scientific Manuscript
- How to integrate text, figures and tables into coherent results

Unit II: Scientific Writing Tools

- Literature survey and resources, abstracts, periodicals, search engines
- Computer awareness: drafting, editing, graphical, statistical presentations
- Data search and retrieval: bibliography, biological databases

Unit III: Communicating as a Scientist **12**

- Effective Communication
- Audience and Purpose
- Addressing Specific Audiences

Unit IV: Classrooms/ Conferences and Presentations **12**

- Oral Presentation Structure
- Presentation Slides
- Effective Oral Presentations
- Answering Questions
- Panel Discussions
- Chairing sessions

Unit V: Practical Skills/ Correspondence **12**

- E-mail
- Memos and Progress Reports
- Formal Letters
- Résumés
- Thank You Letter
- https://www.nature.com/scitable/ebooks/english-communication-for-scientists-14053993/118520572/

Course learning outcomes

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

- Understand basic principles of scientific writing
- Correctly use and reference source material according to journal standards
- Use reference databases
- Use graphical representation to effectively convey results
- Understand the publication process
- Effectively present their scientific ideas and findings