Maharaja's College Ernakulam

A GOVERNMENT AUTONOMOUS COLLEGE

Re-Accredited by NAAC with 'A Grade'
Affiliated to Mahatma Gandhi University
Centre of Excellence under Govt. of Kerala
Identified by UGC as College with Potential for Excellence

POST GRADUATE DEPARTMENT OF ZOOLOGY

Post Graduate Curriculum and Syllabus

MSc - ZOOLOGY

For 2019 Admission Onwards

Maharaja's College, Ernakulam

A Government Autonomous College

Affiliated to Mahatma Gandhi University, Kottayam

Post Graduate Programme in Zoology with Entomology

w.e.f. 2019 Admission Onwards

Board of Studies

Sl. No.	Name of Member	Designation
1	**Dr. Shyla.M.H**	Chairman, BoS Commerce
2	**Dr. John Samuel**	External Member
3	**Prof. P. Radhakrishnan**	External Member
4	**Dr. Sunish.K.S**	Internal Member
5	**Smt. Anitha Abraham**	Internal Member
6	**Sri. Janish.P.A**	Internal Member
7	**Dr. Prakasan.K**	Internal Member
8	**Smt.Dhanya Balakrishnan**	Internal Member
9	**Smt. Sandhya Krishnan.K.R**	Internal Member
10	**Smt. Sharmila.P.S**	Internal Member

MAHARAJA'S COLLEGE, ERNAKULAM

(A GOVERNMENT AUTONOMOUS COLLEGE)

REGULATIONS FOR POST GRADUATE PROGRAMMES

UNDER CHOICE BASED CREDIT SYSTEM

(2019) Admission onwards)

1. SHORT TITLE

1.1. These Regulations shall be called as Post Graduate Regulations (2019) of Maharaja's College (Autonomous) under the Choice Based Credit System.

1.2. These Regulations shall come into force from the Academic Year 2019-2020 onwards

2. SCOPE

2.1. The regulation provided herein shall apply to all regular post-graduate programmes,MA/MSc/M.Com, conducted by Maharaja's College(Autonomous) with effect from the academic year 2019-2020 admission onwards.

3. DEFINITIONS

3.1. 'Programme' means the entire course of study and Examinations.

3.2. 'Duration of Programme' means the period of time required for the conduct of theprogramme. The duration of post-graduate programme shall be of 4 semesters.

3.3. 'Semester' means a term consisting of a minimum of 90 working days, inclusive ofexamination, distributed over a minimum of 18 weeks of 5 working days each.

3.4. 'Course' means a segment of subject matter to be covered in a semester. Each Course is to be designed variously under lectures / tutorials / laboratory or fieldwork / seminar / project / practical training / assignments/evaluation etc., to meet effective teaching and learning needs.

3.5. 'Credit' (Cr) of a course is a measure of the weekly unit of work assigned for that course in a semester.

3.6. 'Course Credit' One credit of the course is defined as a minimum of one hour lecture /minimum of 2 hours lab/field work per week for 18 weeks in a Semester. The course will be considered as completed only by conducting the end semester examination. The total minimum credits required for completing a PG programme is 80.

3.7. 'Programme Core course' Programme Core course means a course that the studentadmitted to a particular programme must successfully complete to receive the Degree and which cannot be substituted by any other course.

3.8. 'Programme Elective course' Programme Elective course means a course, which can be substituted, by equivalent course from the same subject and a minimum number of courses is required to complete the programme.

3.9. 'Programme Project' Programme Project means a regular project work with stated credits on which the student undergo a project under the supervision of a teacher in the parent department / any appropriate research center in order to submit a dissertation on the project work as specified.

3.10. 'Seminar' seminar means a lecture expected to train the student in self-study, collection ofrelevant matter from the books and internet resources, editing, document writing, typing andpresentation.

3.11. 'Evaluation' means every student shall be evaluated by 20% in-semester assessment and 80% end- semester assessment.

3.12. 'Repeat course' is a course that is repeated by a student for having failed in that course inan earlier registration.

3.13. 'Audit Course' is a course for which no credits are awarded.

3.14. 'Parent Department' means the Department which offers a particular post graduate programme.

3.15. 'Department Council' means the body of all teachers of a Department in a College.

3.16. 'Faculty Advisor' is a teacher nominated by a Department Council to coordinate thecontinuous evaluation and other academic activities undertaken in the Department.

3.17. 'Letter Grade' in a course means a letter symbol (S,A,B,C,D, etc.) which indicates the broad level of performance of a student in a course.

3.18. Each letter grade is assigned a 'Grade point' (GP) which is an integer indicating the numerical equivalent of the broad level of performance of a student in a course.

3.19.Credit Point (CP) of a course is the value obtained by multiplying the grade point (GP) by the Credit (Cr) of the course CP=GP x Cr.

3.20. Extra Credits are additional credits awarded to a student over and above the minimum credits required for a programme for achievements in co-curricular activities carried out outside the regular class hours as directed by the Mahatma Gandhi University

3.21. Cumulative Grade Point Average (CGPA) is the value obtained by dividing the sum of credit points in all the courses taken by the student for the entire programme by the total number of credits and shall be rounded off to two decimal places.

3.22.Grace Marks means marks awarded to course/s, as per the UO's issued from time to time, in recognition of meritorious achievements in NSS/Sports/Arts and cultural activities.

4. PROGRAMME STRUCTURE

4.1. Students shall be admitted into post graduate programme under the various faculties.

4.2. The programme shall include two types of courses, Program Core (C) courses and Program Elective (E) Courses. There shall be a Program Project (P) with dissertation to be undertaken by all students. The Programme will also include assignments, seminars / practical, viva (V) etc., if they are specified in the Curriculum.

4.3. There shall be various groups of Programme Elective courses for a programme such asGroup A, Group B etc. for the choice of students subject to the availability of facility andinfrastructure in the institution and the selected group shall be the subject of specialization ofthe programme.

4.4. **Project work**

4.4.1. Project work shall be completed by working outside the regular teaching hours.

4.4.2. Project work shall be carried out under the supervision of a teacher in the concerned department.

4.4.3. A candidate may, however, in certain cases be permitted to work on the project in an Industrial / Research Organization on the recommendation of the Supervisor.

4.4.4. There should be an in-semester assessment and end-semester assessment for the project work.

4.4.5. The end-semester evaluation of the Project work is followed by presentation of work including dissertation and Viva-Voce.

4.5. Seminar Lectures

4.5.1 Every PG student shall deliver one seminar lecture as an internal component for every course. The seminar lecture is expected to train the student in self-study, collection of relevant matter from the books and Internet resources, editing, document writing, typing and presentation.

4.6 Test Papers

4.6.1 Every student shall undergo at least two class tests as an internal component for every course.

4.7 Assignments

4.7.1 Every student shall submit one assignment as an internal component forevery course.

4.8 Attendance

4.8.1 The attendance of students for each course shall be another component of in-semester assessment.

4.8.2 The minimum requirement of aggregate attendance during a semester for appearing theend semester examination shall be 75%.

4.8.3 Condonation of shortage of attendance to a maximum of 10 days in a semester subject to a maximum of two times during the whole period of post graduate programme.The last date of submitting application form shall be the cut-off date for calculating attendance for determining the condonation of shortage of attendance at the time of registering for end semester examinations

4.8.4 If a student represents his/her institution, University, State or Nation in Sports, NSS or Cultural or any other officially sponsored activities such as college union / university union activities, he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a Semester based on the specific recommendations of the Head of the Department and Principal of the College.

4.8.5 A student who does not satisfy the requirements of attendance shall not be permitted to take the end-semester examinations.

4.8.6 Those students who are not eligible even with condonation of shortage of attendance shall repeat the course along with the next batch.

4.9 Maximum Credit

4.9.1 No course shall have more than 4 credits.

4.10 Viva-Voce

4.10.1 Comprehensive Viva-voce shall be conducted at the end semester of the programme. Comprehensive Viva-Voce covers questions from all courses in the programme.

4.11 Alpha numeric code

4.11.1 Each course shall have an alpha numeric code number which includes abbreviation of the subject in two letters, the semester number, the code of the course and the serial number of the course (‘C’ for Program Core course, ‘E’ for Program Elective course, ‘O’ for Open Elective course, ‘P’ for Practicals, ‘D’ for Project/ Dissertation and ‘V’ for comprehensive Viva).

5. REGISTRATION

5.1. A student shall be permitted to register for the programme at the time of admission.

5.2. A student who registered for the course shall complete the course within a period of 8 semesters from the date of commencement of the programme.

6. ADMISSION

6.1. Eligibility and Norms for admission and reservation of seats for various Degree Programmes shall be according to the rules framed by the Mahatma Gandhi University/State Government from time to time.

6.2. Candidates for admission to the first semester of the PG programme shall be required to have passed an appropriate Degree Examination of any recognized University or authority accepted by the Academic council of the Maharaja's College.

6.3. The candidate has to register all the courses prescribed for the particular semester.

6.4. Cancellation of registration is applicable only when the request is made within two weeks from the time of admission.

6.5. Students admitted under this programme are governed by the Regulations in force.

7. PROMOTION

7.1. A student who registers for the end semester examination shall bepromoted to the next semester.

8. EXAMINATION

8.1. There shall be end semester examination at the end of each semester.

8.2. The answers must be written in English except for those coming under Faculty of Languages.

8.3. Practical examinations shall be conducted by the college at the end of even semesters only.

8.4. Project evaluation and Viva -Voce shall be conducted at the end of the programme only.

8.5. Practical examination, Project evaluation and Viva-Voce shall be conducted by two external examiners.

9. **END-SEMESTER EXAMINATION**

9.1. The examinations shall normally at the end of each semester. There shall be one end-semester examination of 3 hours duration in each lecture based course and practical course.

9.2. A question paper may contain short answer type/annotation, short essay type questions/problems and long essay type questions.

10. EVALUATION AND GRADING

10.1. Evaluation

10.1.1 The evaluation scheme for each course shall contain two parts; (a) in-semester evaluation and (b) end-semester evaluation. 20 marks shall be given to in-semester evaluation and the remaining 80 marks to end-semester evaluation. Both in-semester and end semester evaluation shall be carried out by using in mark system. Both internal and external marks are to be mathematically rounded to the nearest integer.

10.1.2 **Internal evaluation**

10.1.2.1 The internal evaluation shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance in respect of

theory courses and based on written tests, lab skill/records/viva and attendance in respect of practical courses. The marks assigned to various components for in-semester evaluation is as follows.

Components of In-semester Evaluation (For theory)

Components	ComponentMarks
Assignment	4
Seminar	4
Two Test papers*	8
Attendance	4
Total	20

*Marks of Test Papers shall be the average

Components of In-semester Evaluation (For Practical)

Components	ComponentMarks
Attendance	4
Laboratory Involvement	4
Written/Lab Test	4
Record*	4
Viva	4
Total	20

*Marks awarded to Record should be related to number of experiments recorded

a)Evaluation of Attendance

% of attendance	Mark
91 and above	4
81 to 90	3
76 to 80	2
75	1
< 75	0

(Decimals are to be rounded to the next higher whole number)

b) Evaluation of Assignment

Components	Marks
Punctuality	1
Content	1
Conclusion	1
Reference/Review	1
Total	**4**

c) Evaluation of Seminar

Components	Marks
Content	1
Presentation	2
Reference/Review	1
Total	**4**

d) Evaluation of Project

Components of Project Evaluation	Marks
In Semester evaluation	20
End Semester Dissertation	50
End Semester Viva-Voce	30
Total	100

e) In-semester Evaluation of Project

Components	Marks
Topic/Area selected	2
Experimentation/Data collection	4
Punctuality	2
Compilation	4
Content	4
Presentation	4
Total	**20**

10.1.2.2 To ensure transparency of the evaluation process, the in-semester marks awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for in semester marks.

10.1.2.3 The course teacher and the faculty advisor shall maintain the academic record of each student registered for the course and a copy should be kept in the college for at least one year for verification.

10.1.3 End-Semester Evaluation:

10.1.3.1 The end-semester evaluation in theory courses is to be conducted by the college with question papers set by external experts. The answers must be written in English except those for the Faculty of Languages. There shall be double evaluation for all the answer script, the first valuation shall be carried out by the internal examiner and the second by the external examiner. The answer scripts valued by the Internal Examiner should be rechecked by the Chairman/chief examiner of the concerned subject. The final mark is taken as the average of the above two marks. Any decimal in this case shall be rounded off to the next higher digit."The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The end-semester evaluation shall be done immediately after the examination preferably through Centralized Valuation.

10.1.3.2 In case double valuation system, the candidates can request for Challenge Valuation on the payment of fee. The fee will be refunded if the difference in mark in the second valuation (done jointly by two examiners) is more than 15% of the

maximum mark for the paper. However, candidates will be awarded the marks scored in the revaluation if it is higher than the existing marks."

10.1.3.3 Photocopies of the answer scripts of the external examination shall be made available to the students for scrutiny on request and revaluation/scrutiny of answer scripts shall be done as per the request of the candidate by paying fees.

10.1.3.4 The question paper should be strictly on the basis of model question paper set by BOSand there shall be a combined meeting of the question paper setters for scrutiny and finalization of question paper. Each set of question should be accompanied by its answer scheme for valuation.

10.1.3.5 **Pattern of Questions**

10.1.3.5.1 The question setter shall ensure that questions to course should satisfy weightage to objectives and weightage to difficulty levels.

Weightage to Objectives	
Objectives	**%**
Understanding	25
Critical Evaluation	50
Application	25

Weightage to difficulty levels	
Level of difficulty	**%**
Easy	20
Average	60
Difficult	20

10.1.3.5.2 Question paper setters shall also submit a detailed scheme of evaluation along with the question paper. A question paper shall be a judicious mix of objective type, short answer type, short essay type /problem solving type and long essay type questions.

Pattern of questions for end semester examination

	Total no. of questions	Number of questions to be answered	Marks of each question	Total marks	Remarks
TOTAL	12	10	2	20	Answer of each question shall not exceed 3 sentences
	10	6	5	30	Answer of each question shall not exceed 1 page
	4	2	15	30	Answer of each question shall not exceed 4 pages
	26	**18**	x	**80**	

10.2 Grades for Courses

For all courses (theory & practical), grades are given on a 10-point scale based on the total percentage of marks ***(ISA+ESA)*** as given below

GPA	Grade	Grade Point(GP)
Equal to 9.5 and above	S Outstanding	10
Equal to 8.5 and below 9.5	A^+ Excellent	9
Equal to 7.5 and below 8.5	A Very Good	8
Equal to 6.5 and below 7.5	B+ Good	7
Equal to 5.5 and below 6.5	B Above average	6
Equal to 4.5 and below 5.5	C+ Average	5
Equal to 4.0 and below 4.5	C Pass	4
Below 4.0	F Failure	0

11. CREDIT POINT AND CREDIT POINT AVERAGE

Credit Point (CP) of a course is calculated using the formula

CP = C × GP, where C = Credit; GP = Grade point

Semester Grade Point Average (SGPA) of a Semester is calculated using the formula

SGPA= TCP/TC, where TCP = Total Credit Point of that Semester

TC = Total Credit of that Semester

Cumulative Grade Point Average (CGPA) of a Programme is calculated using the formula

$$CGPA = \sum(TCP \times TC) \div \sum TC$$

CGPA shall be rounded off to two decimal places

12. Grades for the different semesters and overall programme are given based on the corresponding CPA as shown below:

GPA	Grade
Equal to 9.5 and above	S Outstanding
Equal to 8.5 and below 9.5	A^+ Excellent
Equal to 7.5 and below 8.5	A Very Good
Equal to 6.5 and below 7.5	B+ Good
Equal to 5.5 and below 6.5	B Above average
Equal to 4.5 and below 5.5	C+ Average
Equal to 4.0 and below 4.5	C Pass
Below 4.0	F Failure

12.1. A separate minimum of 40% marks each for in-semester evaluation and end semester examination (for both theory and practical) and aggregate minimum of 40% (**C** Grade) are required to pass for a course. For the successful completion of semester, a student should pass all courses and score a minimum SGPA of 4.0. However, a student is permitted to move to the next semester irrespective of his/her SGPA. To pass in a programme, a separate minimum of Grade **C** is required for all the individual courses. If a candidate secures **F** Grade for any one of the

courses offered in a Semester/Programme only **F** grade will be awarded for that Semester/Programme until he/she improves this to **C** grade or above within the permitted period. Candidates who secures **C (CGPA)** grade and above shall be eligible for higher studies.

12.2.A candidate who has not secured minimum marks/credits in internal examinations can re-do the same registering along with the end-semester examination for the same semester, subsequently.

12.3. A student who fails to secure a minimum marks/grade for a pass in a course will be permitted to write the examination along with the next batch.

12.4. There will be no supplementary examinations. A candidate will be permitted to improve the marks/CGPA of a programme within a continuous period of four semesters immediately following the completion of the programme. If a candidate opts for the betterment of a programme, he/she has to appear for the entire semester. The consolidation of marks/grade/grade points after the betterment examination is limited to one time

13. AWARD OF DEGREE

The successful completion of all the courses with CGPA of 'C' (40%) shall be the minimum requirement for the award of the degree.

14. GRIEVANCES REDRESS COMMITTEE

The College shall form a Grievance Redress Committee in each Departmentcomprising of course teacher and one senior teacher as members and the Head of theDepartment as Chairman. The Committee shall address all grievances relating to the in-semester assessment grades of the students. There shall be a college level Grievance Redress Committeecomprising of Faculty advisor, two senior teachers and the Principal as Chairman.

MSc ZOOLOGY **TOTAL CREDITS : 80**

	COURSE CODE	COURSE	CREDIT	MARKS			CONTACT HRS/WEEK
				INTERNAL	EXTERNAL	TOTAL	
SEMESTER I	PG1ZOOC01	BIOSYSTEMATICS & ANIMAL DIVERSITY	4	20	80	100	5
	PG1ZOOC02	EVOLUTIONARY BIOLOGY & ETHOLOGY	4	20	80	100	5
	PG1ZOOC03	BIOCHEMISTRY	4	20	80	100	5
	PG1ZOOC04	BIOSTATISTICS,COMPUTER APPLICATION & RESEARCH METHODOLOGY	4	20	80	100	5
	PG1ZOOP01	PRACTICAL-1- BIOSYSTEMATICS, ANIMAL DIVERSITY,EVOLUTIONARY BIOLOGY & ETHOLOGY, BIOCHEMISTRY, BIOSTATISTICS,COMPUTER APPLICATION RESEARCH METHODOLOGY	–	–	–	–	5
		TOTAL	16	80	320	400	25

SEMESTER II	COURSE CODE	COURSE	CREDIT	MARKS			CONTACT HOURS
				INTERNAL	EXTERNAL	TOTAL	
	PG1ZOOC05	ECOLOGY, PRINCIPLES & PRACTICES	4	20	80	100	5
	PG1ZOOC06	GENETICS & BIOINFORMATICS	4	20	80	100	5
	PG1ZOOC07	DEVELOPMENTAL BIOLOGY	4	20	80	100	5
	PG1ZOOC08	BIOPHYSICS, INSTRUMENTATION& BIOLOGICAL TECHNIQUES	4	20	80	100	5
	PG1ZOOP01	PRACTICAL-1- BIOSYSTEMATICS, ANIMAL DIVERSITY,EVOLUTIONARY BIOLOGY & ETHOLOGY, BIOCHEMISTRY, BIOSTATISTICS,COMPUTER APPLICATION RESEARCH METHODOLOGY	3	20	80	100	–
	PG1ZOOP02	PRACTICAL-2- ECOLOGY PRINCIPLES & PRACTICES, GENETICS & BIOINFORMATICS, DEVELOPMENTAL BIOLOGY, BIOPHYSICS INSTRUMENTATION &BIOLOGICAL TECHNIQUES	3	20	80	100	5
		TOTAL	22	120	480	600	25

SEMESTER III	COURSE CODE	COURSE	CREDIT	MARKS			CONTACT HOURS
				INTERNAL	EXTERNAL	TOTAL	
	PG1ZOOC09	ANIMAL PHYSIOLOGY	4	20	80	100	5
	PG1ZOOC10	CELL & MOLECULAR BIOLOGY	4	20	80	100	5
	PG1ZOOC11	MICROBIOLOGY & BIOTECHNOLOGY	4	20	80	100	4
	PG1ZOOC12	IMMUNOLOGY	3	20	80	100	3
	PG1ZOOP03	PRACTICAL-3 – CELL & MOLECULAR BIOLOGY, MICROBIOLOGY & BIOTECHNOLOGY	_	_	_	_	4
	PG1ZOOP04	PRACTICAL-4- ANIMAL PHYSIOLOGY & MMUNOLOGY	_	_	_	_	4
		TOTAL	15	80	320	400	25

SEMESTER IV	COURSE CODE	COURSE	CREDIT	MARKS			CONTACT HOURS
				INTERNAL	EXTERNAL	TOTAL	
	PG1ZOOC13	ELECTIVE-ENTOMOLOGY-I-MORPHOLOGY & TAXONOMY	4	20	80	100	5
	PG1ZOOC14	ELECTIVE-ENTOMOLOGY II-ANATOMY & PHYSIOLOGY	4	20	80	100	5
	PG1ZOOC15	ELECTIVE-ENTOMOLOGY III-APPLIED ENTOMOLOGY	4	20	80	100	5
	PG1ZOOP03	PRACTICAL-3 – CELL & MOLECULAR BIOLOGY, MICROBIOLOGY & BIOTECHNOLOGY	2	20	80	100	_
	PG1ZOOP04	PRACTICAL-4- ANIMAL PHYSIOLOGY & MMUNOLOGY	2	20	80	100	_
	PG4ZOOP05	PRACTICAL-5- MORPHOLOGY, ANATOMY & TAXONOMY	2	20	80	100	5
	PG4ZOOP06	PRACTICAL-5- INSECT PHYSIOLOGY & APPLIED ENTOMOLOGY	2	20	80	100	5
	PG4ZOOD01	PROJECT	4	20	80	100	
	PG4ZOOD02	COMPREHENSIVE VIVA	3	_	100	100	
		TOTAL	27	160	740	900	25

Semester I

PG1ZOOC01 M.Sc. ZOOLOGY

BIOSYSTEMATICS AND ANIMAL DIVERSITY

90 Hours **Credit – 4**

Objectives:

- To give a thorough understanding in the principles and practice of systematics
- To help students acquire an in-depth knowledge on the diversity and relationships in animal world
- To develop an holistic appreciation on the phylogeny and adaptations in animals

UNIT 1 BIOSYSTEMATICS (27 hrs)

Module I. **Definition and basic concepts in Systematics and Taxonomy** 2 Hrs

- Historical resume of systematic
- Importance and applications of taxonomy

Module II .**Classification** 3 hrs

- Theories of biological classification- hierarchy of categories
- Types of classification—evolutionary & phylogenetic classification – typological classification, Phenetic classification.

Module III **Taxonomic Procedures**- 4 hrs

- Collection, preservation, curetting
- Recording of field data, storage of collection, labelling and cataloging of collections
- Process of identification- Use of keys- kinds of keys, their merits and demerits
- Taxonomic publications

Module IV **Taxonomic characters** – 3 hrs

- Characters
- Functions
- Taxonomic characters and classification

Module V **Species concepts** 4 Hr

- Species - different species concepts: typological, biological and evolutionary
- Taxonomic diversity within species, different kinds of species, sub species and other infra specific categories, hybrids.

Module VI Classical and Modern trends in Systematics 6 hrs

- Typological,Phenetics, Evolutionary, Phylogenetic

- Chemo and Serotaxonomy
- Cytotaxonomy
- Numerical taxonomy
- Cladistics
- Molecular Systematics
- DNA bar coding *vs* traditional taxonomy

Module VII Zoological nomenclature 5 Hr

- International Code of Zoological Nomenclature, development of Codes of Zoological Nomenclature: its operative principles, interpretation and application of important rules in the formation of scientific names of various taxa.
- Principle of priority
  Homonymy and Synonymy
  Type, method and its significance
- Different kinds of types in descriptive taxonomy

UNIT 2 ANIMAL DIVERSITY **(63 hrs**.)

Module I**. Introduction** 1 hrs.

- Origin of Protists

Module II. **Multi-cellularity** 8 hrs.

- Ediacaran and Burgess Shale fauna.
- Cambrian explosion- causes and consequences. Cropping and Red Queen Principle
- Symmetry, Coelom and Metamerism-evolutionary advantages.
- Classification of animal groups based on different criteria

Module III. **Lower Metazoans** 6 hrs.

- Mesozoa Placozoa Porifera, Cnidaria-Polymorphism, Ctenophora,
- Acoelomata and Pseudocoelomata ,
- Coelomata and their evolutionary relationships and adaptive modifications only.

Module IV. **Protostomes and Deuterostomes** 10 hrs.

- Phylogeny of Arthropod-Monophyly and Polyphyly, Reasons for the success of Arthropods. Major classes under Arthropoda and adaptive radiation.
- Phylogenetic position of Molluscs
- Adaptive Radiation in Molluscs and Annelids.

Module V. **Lesser Protostomes** 4 hrs.

- Sipuncula, Echiura, Phoronida, Brachiopoda, Tardigrada, Onychophora and Chaetognatha-(Phylogeny only).

Module VI. **Echinoderms** 3 hrs.

- Classification, Phylogeny and adaptive radiation.
- Impact of sedentary life on the organization of Echinoderms (Brief account)

Module VII. **Hemichordates** 2 hrs.

- Position in the animal kingdom,
- Phylogeny and evolutionary significance

Module VIII. **Ancestry of Chordates** 9 hrs.

- Cephalochordates and Urochordates.
- Vertebrate Phylogeny-Agnatha, Ostracoderms and Gnathostomes, Placoderms and Acanthodians, Chondrichthyes and Osteichthyes.

Module IX. **Terrestrial Vertebrates** 8 hrs.

- Tetrapod phylogeny - modern Amphibians diversity, distribution,
- Reptiles – origin, phylogeny and adaptive radiation.
- Skull of reptiles and its importance in biosystematics.
- Mesozoic world of reptiles and extinction.

Module X. Birds and Mammals 12 hrs.

- Origin, phylogeny and adaptive radiation of birds and mammals.
- Class Aves: Phylogeny of Avian Orders
- Structural and functional modifications for aerial life.
- Class Mammalia: Prototheria and Theria, Phylogeny of Mammalian orders.

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Semester I

M.Sc. ZOOLOGY

PG1ZOOC02 - EVOLUTIONARY BIOLOGY AND ETHOLOGY

90 Hours **Credit- 4**

Objectives:

- To provide an understanding on the process and theories in evolutionary biology
- To help students develop an interest in the debates and discussion taking place in the field of evolutionary biology
- To equip the learners to critically evaluate the debates and take a stand based on science and reason
- To expose students to the basics and advances in ethology, and generate an interest in the subject in order to understand the complexities of both animal and human behavior

UNIT 1 EVOLUTIONARY BIOLOGY 55 hrs.

Module I. Concepts in Evolution 10 hrs.

- Pre-Darwanian - Lamarckism.
- Darwinian - Concepts of variation, adaptation, struggle, fitness and natural selection.
- Post Darwinian - Mutation and the evolutionary synthesis.
- Neutral Evolution, Molecular Evolution, Molecular evolution in Darwinian finches,
- Punctuated equilibrium.

Module II. Origin and Evolution of Life 10 hrs.

- Origin of basic biological molecules - abiotic synthesis of organic monomers and polymers, concept of Oparin - Haldane, Miller-Urey Experiments.
- The First Cell, RNA world, Idea of Panspermia.
- Evolution of Prokaryotes.
- origin of eukaryotic cells- evolution of unicellular eukaryotes, Endosymbiotic theory, Invagination theory, genome evolution.
- Evolution of Anaerobic metabolism,origin of photosynthesis and aerobic metabolism.

Module III. Geological Time scale 6 hrs**.**

- Geological time scale – Eons, Eras, Periods and Epochs , Major events in evolutionary timescale. Anthropocene.
- Tools and techniques in estimating evolutionary time scale. Mass extinction and its consequences.

- Fossils- types, fossilization and its significance.

Module IV. Population Genetics 10 hrs**.**

- Gene pool, gene frequency, Hardy-Weinberg Law. Rate of change in gene frequency through natural selection, migration and random genetic drift.
- Founder effect, Bottleneck effect.
- Isolating mechanisms - geographic and reproductive- Prezygotic and Postzygotic.
- Speciation- allopatric, peripartric, parapatric and sympatric speciation.
- Micro, Macro, Mega Co-evolution and biochemical evolution.

Module V. Developmental and Evolutionary Genetics 7 hrs.

- The idea of Evo-Devo, Heterochrony, Heterotopy, Heterometry and Heterotypy.
- Developmental genes and gene co-option.
- Evolution of plasticity and complexity. Evolution of sex.

Module VI. Primate Evolution and Human Origins 12 hrs.

- Stages in Primate evolution- Prosimians, Anthropoideans and Hominids.
- Factors in human origin, hominid fossils.
- Cytogenetic and molecular basis of origin of man-African origin of modern man.
- Mitochondrial Eve, Y chromosomal Adam.
- Early migration, hunter- gatherer societies.
- Evolution of human brain, communication, speech and language.
- Evolution of family and culture.

UNIT 2 ETHOLOGY 35 hrs.

Module I. Introduction **3 hrs.**

- Approaches and method of study in behavior.
- Historical background, Stimulus-Response, Causal factors, Quantitative aspects – Duration, interval frequency. Behaviour bouts. Darwinian Perspective on Animal behaviour,
- Ethological concepts-Sign Stimulus, Stimulus Filtering ,Fixed Action Plan

Module II. Neurophysiological Aspects of Behaviour **3 hrs.**

- Reflex action, Kinesis, Taxes, Fixed action patterns. Sherrington's neuro-physiological concepts in behaviour – Latency, summation, fatigue.

Module III. Motivation **4 hrs.**

- Goal oriented drive, internal causal factor, Hormones and behaviour, Psycho-hydrologic model of motivation.
- Motivation studies in Guppies.

Module IV. Learning **4 hrs**.

- Short and long term memory, Habituation, Classical conditioning (Pavlov's experiments), Operant conditioning, Instrumental conditioning, Latent learning, Trial and error learning, Instinct, Imprinting.

Module V. Communication **5 hrs.**

- Evolution of communication, Sensory mechanisms: Electrical, Chemical, Olfactory, Auditory and Visual. Dance language of honey bees, Mechanical and Pheromonal mechanism of communication (Insects and mammals).

Module VI. Reproduction and Behaviour **4 hrs.**

- Reproductive strategies, Mating systems, Courtship, Sexual selection- patterns, parental care and investment.

Module VII. Complex Behaviour **5 hrs.**

- Orientation
- Navigation
- Migration (Fishes and birds), Navigation cues.
- Biological rhythms – Circadian, Circannual, Lunar periodicity, Tidal rhythms. Genetics of biological rhythms. Neuro-hormonal influence and Genetics of Biological Rhythms.

Module VIII. Social Behaviour **5 hrs**.

- Sociobiology (Brief account only) Aggregations – schooling in fishes, herding in mammals, Group selection, Kin selection, altruism, reciprocal altruism, inclusive fitness, co-operation, territoriality, alarm call, social organization in insects and primates.

Module IX. Stress and Behaviour **2 hrs.**

- Adaptations to stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance.

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Semester I

M.Sc. ZOOLOGY

PG1ZOOC03 - BIOCHEMISTRY

90 Hours **Credit- 4**

Objectives:

- To understand the chemical nature of life and life process
- To provide an idea on structure and functioning of biologically important molecules
- To generate an interest in the subject and help students explore the new developments in Biochemistry

Module I. Introduction **2 hrs.**

- Atoms, molecules and chemical bonds.
- Importance of Carbon- Physico-chemical and biological peculiarities of 'Carbon'
- Water: Biological importance, pH and acid - base balance. Buffers - biological importance.

Module II. Carbohydrates
Classification with examples **10 hrs.**

Monosaccharides:

- Structural representations of sugars-Acetal and hemiacetal, ketal and hemiketal linkages.
- Structure of Glucose, fructose, galactose, mannose and ribose.
- Isomerism – structural isomerism and stereoisomerism, optical isomerism, epimerism and anomerism.
- Mutarotation
- Biological importance of monosaccharides
- Glycosidic bond.
- Disaccharides: Structure and biological roles of Sucrose, Lactose, Maltose, Cellobiose and Trehalose.

Polysaccharides**:**

- Homopolysaccharides- Structural and biological roles of Starch, Glycogen, Cellulose, Chitin and Inulin.
- Heteropolysaccharides- Hyaluronic acid, Heparin, Chondroitin sulphate, Keratan sulphate, and Agar-agar.
- Glycoproteins and Mucoproteins.

Module III. Proteins **10 hrs.**

- Classification and properties of amino acids.
- Amphoteric properties of amino acids.
- p*K* value and iso-electric point of amino acids.
- Peptide bond formation and peptides
- Peptide bond formation and peptides.

- Primary structure of protein (*e.g.* insulin).

  Classification and properties of proteins. Conformation of proteins- chemical bonds involved,
- Secondary structure- Alpha helix, Collagen helix, Beta pleated sheet, Ramachandran angles and Ramachandran map. Fibrous proteins- examples (Keratin, Collagen, Elastin, Resilin, Fibrous muscle proteins). Chaperons.
- Tertiary structure- *e.g.* Myoglobin.
- Quaternary structure – *e.g.* Haemoglobin.

Module IV. Lipids

10 hrs.

Classification of lipids

- Simple lipids: Triacylglycerol (Triglycerides) - Physical properties.
- Reactions-Hydrolysis, Saponification, Rancidity. Acid number, Saponification number, Iodine number, Polenske number and Reichert-Meissl number of lipids. Waxes.

- Compound lipids: Phospholipids- Lecithin, Phosphatidyl inositol, Cephalins, Plasmologens. Glycolipids, Sphingolipids.
- Derived Lipids, Steroids: Biologically important steroids-cholesterol, Vitamin D, Bile acids, Ergosterol, Terpenes, Lipoproteins.
- Fatty acids: classification with examples

- Prostaglandins- structure, types, and functions.
- Biological importance of lipids.

Module V. Nucleic Acids and Nucleic acid metabolism **10 hrs.**

- Structure of nucleic acids and nucleotides: Structural organization of DNA (Watson – Crick model)
- Characteristic features of A, B, C and Z DNA.
- Structural organization of tRNA;
- Protein-nucleic acid interaction , Stabiilty of proteins and nucleic acids.
- DNA regulatory proteins, folding motifs, conformation flexibilities, denaturation, renaturation, DNA polymerases, Restriction endonucleases.
- Biological roles of nucleotides and nucleic acids.
- Catabolism of purines and pyrimidines.

Module VI. Enzymes **12 hrs.**

- Classification- (I.U.B.system),
- co-enzymes, iso-enzymes, ribozyme.
- Enzyme specificity.
- Mode of action of enzymes. Formation of enzyme-substrate complex. Lowering of activation energy, Various theories, Active site.

- Enzyme kinetics: Michaelis-Menten equation. Km value and its significance. Enzyme velocity and factors influencing enzyme velocity.
- Kinetics of enzyme inhibition, suicide inhibition and feedback inhibition. Enzyme regulation: Allosteric regulations- Key enzymes, Covalent modification. Enzyme engineering**.**

Module VII. Carbohydrate Metabolism 12 hrs.

Major metabolic pathways-

- Glycolysis – Fate of pyruvate. Citric acid cycle and its significance; Central role of citric acid cycle. Oxidative and substrate level phosphorylation.
- Gluconeogenesis, Cori cycle.
- Glycogen metabolism- Glycogenesis, Glycogenolysis, Adenylate cascade system, Ca^{+2} Calmodulin-sensitive phosphorylase kinase. Regulation of glycogen synthesis .

- Minor metabolic pathways of carbohydrates: Pentose Phosphate pathway, Glucuronic acid metabolism, Galactose metabolism.
- Inborn errors associated with carbohydrate metabolism. Glycogen storage diseases,Lactose intolerance, Galactosuria.

Module VIII. Metabolism of Proteins 10 hrs.

- Amino acid metabolism-Deamination, Transamination and Trans-deamination.
- Formation and disposal of ammonia. Urea cycle.
- Fate of carbon skeletons of aminoacids: glucogenic, ketogenic, partly glucogenic and ketogenic with examples.
- Synthesis of biologically significant compounds from different aminoacids with special reference to glycine, glutamic acid, phenylalanine, tyrosine and tryptophan.

Module IX. Metabolism of Lipids 10 hrs.

- Beta oxidation, alpha oxidation and omega oxidation of fatty acids.
- *De novo* synthesis of fatty acids.
- Metabolism of cholesterol, synthesis and its regulation.
- Biosynthesis of triglycerides.
- Metabolism of ketone bodies - Ketogenesis, Ketolysis, Ketosis.

Module X. Free radicals and antioxidants 4 hrs.

- Free radicals and antioxidants, Generation of free radicals. Reactive oxygen species. Free radical scavenger systems.
- Lipid peroxidation. Preventive antioxidants.

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Semester I

M.Sc. ZOOLOGY

PG1ZOOC04. BIOSTATISTICS, COMPUTER APPLICATION AND RESEARCH METHODOLOGY

90 Hours **Credit-4**

Objectives:

- To impart concepts, generate enthusiasm and make awareness about the tools/gadgets and accessories of biological research
- To equip the learner to carry out original research in biology
- To help the students to improve analytical and critical thinking skills through problem solving
- To provide hands on training in the use of various tools and techniques suggested in the course

UNIT 1 BIOSTATISTICS 40 hrs.

Module I.Basics of Biostatistics 6 hrs.

- Steps in Statistical Investigation, Data and Variable (Collection, Types, Sources).
- Population, Sample, Sampling Methods (Random, Cluster, Stratified and Geographical) and Sampling Errors/Bias.
- Organization of Data - Classification, Tabulation (forming a frequency distribution from raw data and types and characteristics of a Frequency table).
- Presentation of Data - Types and Characteristics of Tables and Visual aids – Graphs, Charts, Diagrams, Flow charts, Cartographs.
- Statistical Analysis Tools - Parametric and Non-Parametric; Bivariate and Multivariate Analysis. Interpretation and Forecasting.
- Prerequisite: Statistics and Biostatistics – scope and significance.

Module II. Measures of Central Tendency 4 hrs.

- Merits and Demerits of Mean, Median and Mode. Calculations/Problems for different data (raw, frequency table). Harmonic and Geometric Mean (Brief account only).

Module III. Measures of Dispersion 5 hrs.

- Merits and Demerits of Range, Quartile Deviation, Mean Deviation and Standard Deviation. Calculations/Problems for frequency table. Standard Error and Relative Measures of Dispersion, Skewness and Kurtosis (Brief account only).

Module IV. Correlation Analysis 3 hrs.

- Correlation - types and methods of correlation analysis, Problems for Karl Pearson's correlation coefficient and Spearman's rank correlation.

Module V. Regression Analysis 7 hrs.

- Regression and Line of Best Fit , Types and methods of regression analysis. Graphic Methods (Scatter method, Curve fitting). Algebraic method (Fitting of strait line through regression equation). Probit Analysis (Brief account only), Mathematical Models in Biology (Brief account only). Length - Weight Relationship, Von- Bertalanffy's Growth (VBG) Model.

Module VI. Theory of Probability 4 hrs.

- Measures of Probability and Theorems in Probability. Probability distributions – Binomial, Poisson and Normal (Brief Account only).

ModuleVII. Testing of Hypothesis 7 hrs.

- Hypothesis and types, Confidence Interval, Sampling, Methods and Errors.
- Tests of significance (For large and small samples – Critical Ratio and P value). Z Test (Problem for small samples), Chi- Square Test (Problem for 2×2 table only). Student's 't' test (Problem for small samples comparing mean of two variable). F-test and Analysis of Variance (ANOVA - One way) (Brief account only).
- Non-parametric tests: Mc Nemar and Mann Whitney U test (Brief account only).

Module VIII. Vital Statistics **4 hrs**

- Introduction, uses, records and system of classification of vital statistics. Sample registration system, Sample design, Survey of causes of death and Age classification. Measures of Vital Statistics and Measures of Population (Mortality rates, Fertility rates). Life tables (Brief account only).

UNIT 2 COMPUTER APPLICATIONS **30 hrs.**

Module I. Basics of Computers **6 hrs.**

- Types of Computers. Binary Number System, Digital and Analog systems. Hardware/Software/Firmware.
- Basics of Computer Functioning- Booting; Formatting;
- File, File Extensions; Temporary Files; Folder; GUI, Icon;
- Installation of Programs, Commands, Biossetup, Date and Time, Memory Partitions, Registry, Default Operations; Defragmentation (Brief account only).

Module II.Hardware Basics **7 hrs.**

- Memory -Classification and Types of memory; memory devices; Units.
- Input Devices -Types, working and functions. Output Devices –Types, working and functions.
- CPU components - Processors, Mother boards, SMPS, Accessory Cards – Graphic /Sound/ Networking/ Bluetooth/Wifi (Brief account only).
- New Generation Computers - Servers, Laptop; Palmtop; Cyborgs; Robotics, Zoobotics (Brief account only).

Module III. Software Basics **7 hrs**.

- System Software/Operating System -System Files; Working of OS; DOS, Widows, Linux and UNIX (Brief account only).

- Application Software -Programs and Packages- Publisher, Acrobat Reader, E Book Reader, Explorer, Photoshop.
- Virus and Antivirus (Brief account only).
- Statistical Software (MS Excel, PH Stat, SPSS), Databases -MS Access (Brief account only).

Module IV. Computer Language and Programming 5 hrs.

- Computer language -Classification and types, HTML, C and Java Programming concepts -Algorithm, Codes (Brief account only).

Module V. Networking, Internet and Information Technology 5 hrs.

- Computer Communication -Network Topology, Media of networking,
- Networking Protocols, PAN, LAN, WAN, MAN, INFLIBNET, Modem and Gateway.
- Internet and Internet Services -World Wide Web, Uploading, Downloading, Hosting, Portal, Open access initiatives and open access publishing, Firewall. Global Information System -BIOSIS, Medline and Medlars, AGRIS; E Journals and E Books Publishing.
- Cyber Crime and Cyber Laws,
- Futuristic IT- Robotics and Artificial Intelligence, virtual reality, biocomputing (Brief account only).

UNIT 3 RESEARCH METHODOLOGY 20 hrs.

Module I. Science and Life Sciences 2 hrs.

- Basic concepts - Science, Pseudoscience, Life Science. Scientific temper, Empiricism, Rationalism and Units of measurements.

Module II. Concepts of Research 4 hrs.

- Basic concepts of research -Meaning, Objectives, Motivation and Approaches.
  Types of Research (Descriptive/Analytical, Applied/ Fundamental, Quantitative/Qualitative, Conceptual/ Empirical
  Research methods versus Methodology, Research and scientific method. Research Process.

Module III. Research Formulation 4 hrs.

- Research formulation -Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating the research problem, Selecting the problem and necessity of defining the problem.
- Literature review -Importance of literature reviewing in defining a problem, Critical literature review, Identifying gap areas from literature review.

Module IV. Research Designs 4 hrs.

- Research Design -Basic principles, Meaning, Need and features of good design, important concepts. Types of research designs. Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Data collection techniques.

Module V. Scientific Documentation and Communication 3 hrs.

- Project proposal writing, Research report writing (Thesis and dissertations, Research articles, Oral communications). Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference.

Module VI. Information Science, Extension and Ethics 3 hrs.

- Sources of Information -Primary and secondary sources. Library - books, journals, periodicals, reference sources, abstracting and indexing sources, Reviews, Treatise, Monographs, Patents.
- Internet -Search engines and software, Online libraries, e-Books, e-Encyclopedia, TED Talk, Institutional Websites. Intellectual Property Rights - Copy right, Designs, Patents, Trademarks, Geographical indications.
- Safety and precaution - ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, radiation hazards.
- Extension: Lab to Field, Extension communication, Extension tools. Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

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SEMESTER I

M.Sc. ZOOLOGY PRACTICAL I
PG1ZOOP01: BIOSYSTEMATICS AND ANIMAL DIVERSITY, EVOLUTIONARY BIOLOGY AND ETHOLOGY, BIOCHEMISTRY, BIOSTATISTICS, COMPUTER APPLICATION AND RESEARCH METHODOLOGY

90 Hours (5hrs./week) **Credit-3**

Biosystematics and Animal Diversity, Evolutionary Biology and Ethology

- Study of museum specimens - 70 invertebrates and 30 vertebrates (List the studied items with brief descriptions. Diagrams not necessary).
- Larval forms – any 10 larvae from different taxa
- Study of the skull of vertebrates – Shark, Frog, Varanus, Crocodile, Bird, Dog, Rabbit/ Rat
- Preparation of dichotomous key of 4 specimens up to family (insects/ fishes/ snakes of any three taxa).
- Preparation of Cladogram based on the specimens provided (at least five museum specimen).
- Calculating gene frequencies and genotype frequencies in the light of Hardy-Weinberg Law in human/ other populations.
- Study of fish in response to three temperatures (Normal ,+ 5^0 and -5^0C) of water in a microenvironment and preparation of an ethogram
- Study of the grooming behaviour in insects/bird

Biochemistry

- Quantitative estimation of blood glucose by Folin-Wu/Anthrone /DNS/ O-Toluidine/Enzymatic method .
- Estimation of proteins by Biuret/ Lowry *et al.* method
- Quantitative estimation of blood urea/ creatine/ uric acid
- Quantitative estimation of cholesterol in the blood
- Estimation of alkaline and acid phosphatases

Biostatistics

(Problems can be solved using scientific calculator).

These exercises can be done as assignments of the theory sessions

- Calculation of mean, median and mode from grouped data
- Calculation of mean deviation and standard deviation from grouped data Calculation of

Pearson correlation coefficient.

- Calculation of regression coefficient and regression equation ('x' on y' only) Calculation of length-weight relationship

- Calculation of 'Z' value (small sample only) Calculation of Chi square value (2×2 table only)
- Calculation of 't' value (for small sample comparing two variable)

- Draw line graph, vertical bar diagram, horizontal bar diagram, histogram, frequency polygon, frequency curve, pie diagram and ogives on graph paper for simple grouped data.

Computer Applications

- MS Excel: Formula writing (Addition, Subtraction, Multiplication, Division, Power and Root) MS Excel: Correlation Analysis

- MS Power Point: Preparation of a presentation with minimum 5 slides based on First Semester theory topics

Semester II

M.Sc. ZOOLOGY

PG2ZOOC05- ECOLOGY: PRINCIPLES AND PRACTICES

90 Hours **Credit- 4**

Objectives:

- To provide an understanding on the basic theories and principles of ecology
- To help study various disciplines in ecology
- To learn current environmental issues based on ecological principles
- To gain critical understanding of human influence on environment

Module I. Ecology and Environment **15 hrs.**

- Physical Environment- biotic and abiotic factors, effect of light and temperature on animals
- Concept of Homeostasis; Concepts of habitats and niche, niche width and overlap, fundamental and realized niche.
- Resource partitioning, character displacement.
- Cybernetic nature of ecosystem, stability through feedback control and redundancy of components; resistance and resilience stability. Gaia hypothesis.
- Concept of limiting factors- Liebig's law, Shelford's law.
- Ecological indicators.
- Ecological Foot prints

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Module II. E**cosystem** **15 hrs.**

Structure and Function

- Laws of thermodynamics, energy flow in the ecosystem.
- Primary productivity, Biomass and productivity measurement, Secondary production
- Trophic levels, Food chain, food web,. Ecological efficiencies.
- Ecological pyramids
- ,Biogeochemical cycles- patterns and types (CNP).

Module III. Population Ecology **15 hrs.**

- Population group properties- density ,natality ,mortality ,population age structure, Growth forms and concept of carrying capacity, population fluctuations, density dependent and density independent factors. Population age structure, aggregation, Allee's principle, isolation, dispersal and territoriality.
- Life history strategies, *r & k* selection.
- Population interactions- types, positive and negative, interspecific and intraspecific interactions. Ecological and evolutionary effects of competition.
- Concept of metapopulation.Characteristics of metapopulation. Levin's model of metapopulation. Comparison of metapopulation and Logistic population model.

Module IV.Community Ecology **10 hrs.**

- Concept of community - community structure and attributes, ecotone and edge effect.
- Ecological succession, concept of climax.
- Species diversity in community and it's measurement-Alpha diversity,Simpson's diversity index, Shannon index, Fisher's alpha, rarefaction. Beta diversity-Sorensen's similarity index,Whittaker's index, Evenness, Gamma diversity, Guild and its functioning in the community.
- Drivers of species diversity loss and conservation.

Module V. Resource Ecology **15 hrs.**

- Natural Resources: Soil-soil formation, physical and chemical properties of soil. significance of soil fertility.Mineral resources with reference to India. Impact of mining on environment; Forest resources-deforestation, Aquatic resources - Freshwater and water scarcity, water conservation measures - case studies from India; Wetlands and its importance, international initiatives for wetland conservation - Ramsar sites. Sand mining and its impacts. Wetland reclamation- causes and consequences. Depletion of resources and impacts on quality of life.
- Energy Resources- solar, fossil fuels, hydro, tidal, wind, geothermal and nuclear.Energy use pattern in different parts of the world, recent issues in energy production and utilization; Energy audit, Green technology and sustainable development.

- Ecosystem monitoring- GIS, Physics of remote sensing, role of remote sensing in ecology, GPS and its application; EIA- tools and techniques, Ecosystem Modelling (Brief account only).

Module VI. Applied Ecology **10 hrs.**

- Environmental Pollution-types, causes and consequences.
- Concept of waste, types and sources of solid wastes including e-waste; Environmental biotechnology and solid waste management- aerobic and anaerobic systems. Concept of bioreactors in waste management. Liquid wastes and sewage.
- Bioremediation- need and scope of bioremediation in cleaning up of environment. Phytoremediation, bio-augmentation, biofilms, biofilters, bioscrubbers and trickling filters.
- Radiation Biology - natural and man-made sources of radioactive pollution; radioisotopes of ecological importance; effects of radioactive pollution; nuclear disasters (two case studies), Disposal of radioactive wastes.

Module VII. Biogeography and Conservation **10 hrs.**

- Biogeographical zones of India. Western Ghats and its significance.
- Theory of island biogeography
- Principles and major approaches to conservation and environmental management- Role of UN- conventions, protocols; Role of UNFCC and IPCC. Country specific laws-mention major environmental/ conservation laws and rules in India-Wildlife Protection Act 1972 amended 1991, Forest Conservation Act, 1980, Air (Prevention and Control of Pollution) Act 1981, Water (Prevention and Control of Pollution) Act 1974, amended 1988, The Environment Protection Act, 1986 and Rules, 1991. The Biological Diversity Act 2002, Rules 2004.

- Restoration Ecology- need and policies, case studies and success stories - global and national.

- Participatory resource management, community reserves, sacred groves, biovillages.

- Role of Intergovernmental and Non-governmental organizations in conservation-IUCN, WCMC,WRI,WWF, CI and Green Peace. National and Local NGOs**.**

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Semester II

M.Sc. ZOOLOGY

PG2ZOOC06- GENETICS AND BIOINFORMATICS

90 Hours (5hrs/week) **Credit- 4**

Objectives:

- To give an in-depth understanding on the principles and mechanisms of inheritance
- To help study the fine structure and molecular aspects of genetic material
- To provide an opportunity to learn the importance of inheritance in Man
- To expose the learners to the emerging field of bioinformatics and equip them to take up bioinformatics studies

UNIT 1 GENETICS 65 hrs

Module I. Principles of Genetic Transmission 5 hrs.

- Extension of Mendel's principles: - incomplete dominance and co-dominance.
- Gene action-from genotype to phenotype-penetrance and expressivity,
- Gene interaction-epistasis, pleiotropy, genomic imprinting, phenocopy.

Module II.Molecular Organization of Chromosomes 6 hrs.

- Structure of eukaryotic chromosome, nucleosome model.
- Chromosome condensation - euchromatin and heterochromatin.
- Genome size and C-value Paradox.
- Kinetics of renaturation: Cot and Cot curve.
- Unique and repetitive sequences.-Mini and micro satellites.
- Molecular structure of centromere and telomere.
- Polytene chromosomes and Lampbrush chromosomes.Chromosome banding techniques.

Module III. Gene Fine Structure 10 hrs.

- The definition of gene. The standard genetic code, redundancy and Wobble.
- Gene synthesis (in vitro synthesis) – works of Khorana and Kornberg.
- Modern findings on the nature of gene: Interrupted genes in eukaryotes, exons and introns-R loops, significance of introns. Genes-within-genes (overlapping genes) Bacteriophage Ö X174.
- Transposable elements in Bacteria –IS elements, composite transposons, Tn3 elements,medical significance. Transposable elements in Eukaryotes-P elements, Retrotransposons, significance of transposons.

Module IV. Genetic Linkage, Recombination and Chromosome Mapping 12 hrs.

- Chromosome theory of heredity, Linkage and recombination of genes in a chromosome, crossing over as the physical basis of recombination,

- Stern's Experiment; molecular mechanisms of recombination (Holliday model), Gene conversion,
- Recombination mapping with two-point and three –point test cross in *Drosophila*, Coincidence and Interference.
- Genetic mapping by tetrad analysis in *Neurospora*..
- Mapping with molecular markers and mapping using somatic cell.

Module V. Gene Mutation 6 hrs.

- Molecular basis of gene mutation; mutant types- lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants. Induced mutation,
- The Ames test for mutagen/carcinogen detection.
- DNA damage and repair mechanisms

Module VI. DNA Replication 9 hrs.

- The Meselson-Stahl experiment, semi conservative replication of DNA in chromosomes, Theta replication, rolling-circle replication, molecular mechanisms of eukaryotic replication. Enzymes involved in DNA replication

Module VII. Human Genetics 5 hrs.

- Karyotype, pedigree analysis, Lod score for linkage testing, genetic analysis of complex traits - complex pattern of inheritance, quantitative traits, threshold traits..

.**Module VIII. Extra Chromosomal Inheritance 2 hrs.**

Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

Module IX. Epigenetics 5 hrs.

- Epigenetics - from phenomenon to field, a brief history of epigenetics - overview and concepts; chromatin modifications and their mechanism of action, concept of 'histone-code' hypothesis, epigenetics in *Saccharomyces cervisiae*, position effect variegation, heterochromatin formation and gene silencing in *Drosophila.*

Module X. Quantitative and Population Genetics 5 hrs.

- Polygenic inheritance, analysis of quantitative traits, quantitative traits and natural selection, estimation of heritability, QTL mapping, genotype-environment interactions, molecular analysis of quantitative traits, phenotypic plasticity .

UNIT 2 BIOINFORMATICS 25 hrs

Module I.Introduction to Bioinformatics 2 hrs.

- Definitions of bioinformatics, applications of bioinformatics and scope of bioinformatics.

Module II. Biological Databases 7 hrs.

- Primary databases - Nucleotide sequence databases: GenBank, EMBL, DDBJ ; Protein sequence databases: SWISSPROT, PIR; Structure databases: PDB, NDB; Secondary databases: PROSITE, Pfam, CATH; Composite databases: OWL; Literature database: PubMed; Database searching – Entrez; Database sequence submission – BankIt.

Module III.Sequence Analysis 6 hrs.

- Types of sequence alignment, methods of sequence alignment, scoring schemes, gaps

and gap penalties, construction of phylogenetic trees.

Module IV.Genomics and Proteomics **7 hrs.**

- Structural genomics, functional genomics, comparative genomics, data mining in proteomics – Microarrays
- Significance of proteomics and drug design.

Module V. Systems Biology **3 hrs.**

- Introduction, metabolomics, gene network, synthetic biology.

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SEMESTER II

M.Sc. ZOOLOGY

PG2ZOOC07- DEVELOPMENTAL BIOLOGY

90 Hours (5hrs/week) **Credit - 4**

Objectives:

- To introduce the concepts and process in developmental biology
- To help students understand and appreciate the genetic mechanisms and the unfolding of the same during development
- To expose the learner to the new developments in embryology and its relevance to Man

Module I. Introduction: Basic Concepts of Development **14 hrs.**

- Potency of embryonic cells
- Commitment, Specification (Autonomous and Conditional)
- Induction and Competence
- Determination and Differentiation
- Cell fate and cell lineages
- Genomic equivalence
- Cytoplasmic determinants
- Morphogenetic gradients

Module II. Gametogenesis,Fertilization and Early development **12 hrs.**

- Fertilization-(biochemical and molecular aspects), Polyspermy.
- Mechanisms and significance of cleavage, Blastulation, Embryonic fields and Gastrulation.

Module III. Embryogenesis of Model organisms
(cleavage, midblastula-transition, gastrulation). **5 hrs.**

- Axis formation in Amphibia –primary embryonic induction
  Anterior-posterior patterning in Amphibia- Hox code hypothesis
- Axis formation in *Drosophila*
  Anterior-posterior patterning in *Drosophila (Maternal effect genes,zygotic genes, gap genes, pair rule genes,segment polarity genes; homeotic selector genes,realisator genes*), Dorsal-ventral patterning and left right patterning, Dorsal protein gradient.

Module IV.Organogenesis of Model organisms **15 hrs.**

- Limb development in chick
- Insect wings and legs
- Vulva formation in *Caenorhabditis elegans*

Module V. Cellular Interactions in Development **14 hrs.**

- Cellular interaction during blastulation and gastrulation
  Nieuwkoop centre and mesodermal polarity, Molecular basis of mesoderm induction. Transcription factors induced in the organizer,Neural induction
- Cellular interaction during organogenesis
  Epithelial- mesenchyme interaction, Regional specificity of induction, Genetic specificity of induction
- Paracrine factors - Hedgehog family, Wnt family, TGF- β family and BMP family
- Surface receptors and signal transduction pathway - RTK pathway,Smad pathway,Wnt

pathway, Hedgehog pathway and cell death pathway.

Module VI. Differential Gene Expression 13 hrs.

- Differential gene transcription
  Exons and introns, promotors, silencers, enhancers, transcription factors, DNA methylation, genomic imprinting, dosage compensation, differential RNA processing
- Control of gene expression
  Translational and post translational control of gene expression.
- Models of cell differentiation (anyone one example)

Module VII. Metamorphosis and Regeneration 8 hrs.

- Metamorphosis of Amphibians and Insects- Hormonal control of metamorphosis.
- Heterochrony- neoteny, progenesis (Brief accounts)
- Regeneration
  Different types of regeneration;
  Histological processes during regeneration;
  Polarity and Metaplasia in regeneration;
- Lens regeneration in amphibia; Bone and neural regeneration (Medical -Advances in regeneration).

Module VIII. Teratogenesis 4 hrs.

- Malformations and disruptions,
- Gene – Phene relationship- Autophene, Allophene and Pleiotrophy;
- Teratogenic agents (*Retinoic acid, pathogens, alcohol, drugs and chemicals, heavy metals*); Environmental oestrogens.

Module IX Human welfare and developmental biology 5hrs

- Infertility-Causes, ART -Test tube babies (*In vitro* fertilization and embryo transfer).
- Cloning experiments- (Amphibians,Mammals and Human)
- Stem cells and their applications, ethical issues.

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SEMESTER II

M.Sc. ZOOLOGY

PG2ZOOC08- BIOPHYSICS, INSTRUMENTATION

AND BIOLOGICAL TECHNIQUES

90 Hours **Credit- 4**

Objectives:

- To learn the biophysical properties and functioning of life processes
- To introduce the tools and techniques available for studying biochemical and biophysical nature of life
- To equip the learner to use the tools and techniques for project work/ research in biology

UNIT 1 BIOPHYSICS 42 hrs

Module I. Diffusion and Osmosis 8 hrs.

- Diffusion -Kinetics of diffusion, Fick's law of diffusion and diffusion coefficient, Biological significance in animals and plants, Electrochemical gradient, Stokes-Einstein equation and Graham's law, Facilitated diffusion, Gibbs-Donnan equillibrium.
- Osmosis- osmotic concentration and osmotic pressure, Van't Hoff's laws. Biological significance of osmosis in animals and plants.

Module II. Biophysics of Cell Membrane 10 hrs.

- Physico-chemical properties of cell membrane, conformational properties of cell membranes,Membrane Transport – endocytosis, exocytosis, Nutrient transport across membranes, porins facilitated diffusion, porter molecules; Facilitated transport:symport,antiport, uniport,anion porter,glucose porter; Active transport: proton pumps, Na^+ K^+ pumps and Ca^{++} pumps, ionic channels. Functions of cell membrane.Artificial membranes.

Module III. Bioenergetics 14 hrs.

- Thermodynamics- Laws of thermodynamics, Entropy, Enthalpy, Free energy.

- Reversible thermodynamics and irreversible thermodynamics; Systems – open, closed and isolated. Photo bioenergetics. Photosynthesis – light and dark reactions, Redox couple and redox potential. Chemo-bioenergetics: electron transport and oxidative phosphorylation, Chemiosmotic theory and binding change mechanism of ATP synthesis.

Module IV. Radiation Biophysics 10 hrs.

- Ionizing radiation, units of radioactivity, exposure and dose.

- Interaction of radiation with matter – Photoelectric effect, ion pair production, absorption and scattering of electrons.

- Biological effects of radiation: effect on nucleic acids, proteins, enzymes and carbohydrates. Cellular effects of radiation : somatic and genetic. Safety guidelines

- Nuclear medicine : Internally administered radioisotopes. Radioiodine in thyroid function analysis. Renal, liver and lung function analysis.

- Application of radioactive tracers, Radiation protection and therapy.

UNIT 2 INSTRUMENTATION & BIOLOGICAL TECHNIQUES

Module I. Microscopy 6 hrs.

- Light microscope and dark field microscope, Phase contrast microscope, Polarizing microscope, birefringence fluorescence microscope and camera lucida
- Differential Interference contrast (Nomarsky) microscopy, Confocal microscope, Electron microscope – TEM, SEM, Scanning Tunnelling and Atomic Force Microscopes, Near field Object Microscopy and Foldscope

Module II. Chromatography 7 hrs.

- Paper chromatography,Thin layer chromatography, Ion exchange chromatography.
- Gel permeation chromatography,Affinity chromatography,Gas chromatography
- High pressure liquid chromatography (HPLC).

Module III. Electrophoresis 6 hrs.

- Paper electrophoresis,Gel electrophoresis, Polyacrylamide gel electrophoresis (PAGE) – SDS and non SDS , Agarose gel electrophoresis , Disc electrophoresis, High voltage electrophoresis, immuno-electrophoresis, isoelectric focusing.

Module IV. Colorimetry, Spectrophotometry and Spectroscopy 8 hrs.

- Principle and applications of colorimetry and spectrophotometry. Spectroscopy :Flame emission spectroscopy, Atomic absorption spectroscopy, Nuclear Magnetic-resonance spectroscopy (NMR), Circular dichroism spectroscopy, ESR spectroscopy, Mass spectroscopy. Surface Plasma Resonance methods

Module V. Centrifugation 3 hrs.

- Basic principles of sedimentation, Types of centrifuges, Analytical and Preparative centrifugation, Differential and density gradient centrifugation.

Module VI. Radioisotope Detection and Measurement 2 hrs.

- Dosimetry: Ionization chamber, GM counter, Solid and liquid scintillation counters, Autoradiography.

Module VII. Nanotechnology 3 hrs.

- Introduction to Nanobiology. Nanosensors and Nanomedicines.

Module VIII. Assays 2 hrs.

- Radio ImmunoAssay, Enzyme Linked Immuno Sorbant Assay (ELISA).

Module IX. pH meter 1 hr.

- Principle and working. Types of pH meters.

Module X. Biological and Histological Techniques 10 hrs.

- Fixation, preparation of temporary and permanent slides, whole mounts, smears, squashes and sections. Specimen preparation for TEM, SEM, PET, CTE shadow casting, freeze fracturing, freeze etching, negative staining. Microphotography.
- Cytochemical and histological methods- Microtome techniques, fixation, staining. Cytochemistry of nucleic acids, detection of carbohydrates, proteins and lipids.

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SEMESTER II

M.Sc. ZOOLOGY PRACTICAL II

PG2ZOOPO2: ECOLOGY, GENETICS AND BIO-INFORMATICS, DEVELOPMENTAL BIOLOGY, BIOPHYSICS, INSTRUMENTATION AND BIOLOGICAL TECHNIQUES.

90 Hours (5 hrs./week) **Credit-3**

Ecology

- Study of Pond/ wetland/ River ecosystem- Food web and food chain (no museum specimen). Record the date, time, methodology, and observations in the record book.
- Determination of soil organic carbon and chlorides.
- Separation and identification of soil arthropods using Berlese funnel.
- Qualitative and Quantitative study of marine/freshwater planktons. Estimation of primary productivity.
- Quantitative estimation of salinity, phosphates and nitrates in water samples.
- Study of pH and conductivity using pH and conductivity meter (2different samples).
- Principles and application of the following instruments: Rain Guage, Plankton Net, Secchi Disc, GPS.
- **Field Study Report:** Three days field study covering River/ Wetland/ Marine and forests/ grassland.
- Record ecosystem components (Soil, water, flora, fauna) and interactions. Viva based on Field study.

Developmental Biology

- Identification of different developmental stages of frog (egg, blastula, gastrula, neurula, tadpole, with external gill and internal gill).
- Vital staining of early gastrula of chick – window method.
- Blastoderm mounting of chick embryo using vital stains.
- Morphological and histological studies of different types of placenta in mammals.
- Study of serial sections of embryo - chick).
- Regeneration studies in animals. (Zebra Fish/ Earth worm).

Genetics and Bioinformatics

- Culture, sexing and etherization of *Drosophila.* Study of Mutants in *Drosophila.*
- Genetics problems (Di hybrid cross, test cross and sex linked inheritance). Abnormal human karyotypes (any five).
- Data base search and data retrieval-using NCBI, SWISS-PROT, PDB, Expasy. Methods of sequence alignment-BLAST and ClustalW.
- Phylogenetic tree using PHYLIP.
- Gene Prediction using GENSCAN/GRAI. Protein structure visualization using RASMOL.

Biophysics/Instrumentation/Biological Techniques

- Micrometry- principle and measurement of microscopic objects: Low power and high power.
- Camera Lucida drawing with magnification and scale.
- Principle and working of phase contrast microscope, micro-photographic equipment

and pH meter.

- TLC using amino acids from purified samples and biological materials.
- Study of Enzyme kinetics - Salivary amylase on maltose standards- influence of temperature and Substrate concentration on enzyme activity (Lineweaver Burk Plot) on enzyme activity.

SEMESTER III

M.Sc. ZOOLOGY

PG3ZOOC09- ANIMAL PHYSIOLOGY

90 Hours. (5hrs/week) **Credit-4**

Objectives:

- To study and compare the functioning of organ systems across the animal world
- To give an over view of the comparative functioning of different systems in animals
- To learn more about human physiology

Module I. Nutrition, Digestion and Absorption **8 hrs.**

- Nutrition in animals, mechanisms of food intake in different animals.
- Physiology of digestion and absorption. Structural and biochemical adaptations to special dietary pattern, symbiotic digestion.
- Neuronal and hormonal regulation of nutritional intake, hunger drive, thirst.
- Obesity- causes and consequences, outline of hormonal involvement, Leptin: synthesis, secretion and its role in adipogenesis.

Module II. Circulation **10 hrs.**

- Circulatory mechanisms and fluid compartments, movement of body fluids by somatic muscles, open system, closed system, lymph channels.
- Circulatory shock, Circulatory arrest.
- Types of hearts- chambered heart, tubular heart, ampullar heart, lymph heart, neurogenic and myogenic heart. Pace makers and specialized conducting fibers.
- Cardiac cycle, cardiac output, blood pressure, effect of drugs on heart beat, effects of exercise on cardiaovascular physiology.
- ECG - its principle and significance. Blood buffers**,** Human congenital heart diseases.

Module III. Respiration **8 hrs.**

- Respiration in invertebrates and vertebrates.
- Pulmonary ventilation, respiratory muscles, surfactants. Respiratory centers and periodic breathing.
- Regulation of respiration. Respiration in unusual environment – foetal and neonatal respiration, high altitude, diving..

Module IV. Osmoregulation and Excretion **6 hrs.**

- Osmoregulation in fresh water, marine and terrestrial animals.
- Excretion in vertebrates. Physiology and regulation of urine formation, Hormonal regulation of urine formation.
- Regulation of water balance, electrolyte balance and acid-base balance.
- Dialysis, artificial kidney, kidney transplantation.

Module V. Nerve Physiology 10hrs.

- Neuroanatomy of the central and peripheral nervous system.
- Synaptic transmission- Electrical and chemical transmission Modifications of synaptic transmission during fatigue, acidosis, alkalosis, hypoxia and drugs.
- Mechanism of excitatory and inhibitory pathway.
- Neuromuscular Junction: organization and properties of neuromuscular junction,
- Neurotransmitters, Neuromodulators.
- Brain activity recording , PET, MRI, fMRI, CAT, Single neuron recording, patch clamp recording

Module VI. Sensory and Effector Physiology 12 hrs.

- Classification of somatic senses and somatic receptors, exteroceptors, interoceptors,
- Modality of sensation, , transduction, relationship between stimulus, intensity and response, sensory coding.
- Chemical senses: taste, smell, mechanism of reception.
- Mechanoreceptors: hair cell, organs of equilibrium, vertebrate ear, mechanism of hearing, electro and thermoreceptors.
- Vision: Structure of vertebrate eye. Physiology of vision.
- Pain: pain receptors, headache and thermal senses, pain suppression (analgesia).
- Tactile sensation: touch receptors, transmission of signals,
- special problems of premature infants, Physiological role of touch and environment in premature infants- Kangaroo care, infant massage, supportive environment.

Module VII. Muscle Physiology 8 hrs.

- Comparative physiology of skeletal, smooth and cardiac muscles.
- Skeletal muscle- ultra structure and molecular organization.
- Red and white muscles, muscle proteins.
- Mechanism of muscle contraction and relaxation. Energetics of muscle contraction.
- Effect of exercise on muscles. Catch muscle and fibrillar muscle.

Module VIII. Thermoregulaion 5 hrs

- Comfort zone, body temperature-oral,skin and core. physical, chemical, neural regulation, acclimatization.
- Impact of temperature on the rate of biological functions. Arrhinius equilibrium, Q 10.
- Temperature compensation and temperature regulation in poikilotherms and homiotherms.
- Adaptations for extreme environments, aestivation and hibernation.

Module IX. Endocrinology 15 hrs.

- Invertebrate and vertebrate endocrine system. Endocrine glands. Synthesis, physiologic role, control and mechanisms of hormone action
- Neuro-endocrine regulation of hormone action. Bioamines, Ecosanoids, Chalones, Lumones, Synthetic hormones.

Module X. Reproductive physiology 8 hrs

- Anatomy and histology of adult testis and ovary.
- Reproductive cycles of mammals and their hormonal control.
- Physiology of implantation, pregnancy, parturition, and lactation.
- Impact of senescence and age on reproduction.

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SEMESTER III

M.Sc. ZOOLOGY

PG3ZOOC10 - CELL AND MOLECULAR BIOLOGY

90 Hours **Credit-4**

Objectives:

- To help study the structural and functional details of the basic unit of life at the molecular level
- To motivate the learner to refresh and delve into the basics of cell biology
- To introduce the new developments in molecular biology and its implications in human welfare

Module I. Cellular Membranes **6 hrs.**

- Membrane structure, dynamic nature of the plasma membrane, liposomes and its application.
- Chemical nature and membrane functions, membrane potentials, ion channels
- Membrane transport– Diffusion, Osmosis, Facilitated diffusion, Active transport, Bulk transport.
- Nucleus and nuclear membrane

Module II.Cell junctions, Cell adhesion and Extracellular matrix **10 hrs.**

- Extracellular matrix: Basal membrane and laminin, Collagen, Proteoglycan,Fibronectin.
- Interaction of cells with extracellular matrix: Integrins.
- Focal adhesion and hemidesmosomes.
- Interaction of cells with other cells: Selectins, Immunoglobulins, Cadherins.
- Adherens Junctions and desmosomes.
- Tight junctions,Gap junctions and Plasmodesmata.

Module III. Cell Organelles **6 hrs.**

- Endoplasmic reticulum, Golgi complex, Ribosome, Mitochondria.
- Lysosome, Chloroplasts, Peroxisomes and Glyoxysomes.

Module IV. Cytoskeleton and Cell Motility **5 hrs.**

- Microtubules, Microfilaments, Intermediate filaments, Molecular motors, Non muscle motility and contractility.

Module V. Cell Signaling **15 hrs.**

- Basic principles of cell communication
- Extracellular messengers (signaling molecules), role of Calcium and Nitric oxide (NO) as intracellular and intercellular messengers.
- Receptors: G- Protein coupled receptors, Receptor tyrosine kinases (RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors).

- Second messengers: Cyclic-AMP, Cyclic-GMP, Inositol 1,4,5-trisphosphate (IP3), Di-acyl glycerol (DAG).
- Signaling pathways: G-protein coupled receptor (GPCR) and cyclic AMP pathway – role of protein kinase A (PKA), GPCR pathway in rod cells, Receptor protein tyrosine kinase and Ras-MAP kinase pathway, JAK-STAT pathway, Calcium phosphatidyl- inositol pathway, PhosphoInositide 3-kinase (PI-3 kinase),Transforming growth factor (TGF) signaling pathway.
- Regulation of signaling pathways.Convergence, divergence and crosstalk among different pathways.Bacterial chemotaxis and quorum sensing

Module VI.Cellular Reproduction 5 hrs.

- Cell cycle: Steps in cell cycle, Control of cell cycle, Checkpoints in cell cycle. Control of cell division and cell growth.
- Apoptosis- extrinsic and intrinsic pathways, significance

Module VII. Cancer 8 hrs

- Basic properties of a cancer cell, Types of cancer, Causes of cancer, Genetics of cancer, Tumour suppressor gene, Oncogene. Cancer and cell cycle.

- New strategies for combating cancer: Immunotherapy, Gene therapy, Inhibiting cancer promoting proteins, Inhibiting formation of new blood vessels.

Module VIII.Gene Expression 20 hrs.

- Gene and Genetic code
- Relationship between genes and proteins.Transcription in prokaryotes and eukaryotes-Hn RNA and mRNA. rRNA, tRNA
- RNA processing in prokaryotes and eukaryotes.
- Translation in prokaryotes and eukaryotes, initiation, elongation and termination.
- Post transcriptional modifications, protein sorting, signal sequences and signal hypothesis.

Module XI.Gene Regulation 15 hrs.

- Fundamentals of gene regulation.
- Regulation of gene expression in *E. coli* :Catabolite repression, *Trp* operon in *E.coli*-repression and attenuation, *Ara* operon in *E.coli*-positive and negative controls.
- Riboswitches.
- General introduction to gene regulation in eukaryotes at transcriptional, post transcriptional and translational levels, transcription factors, enhancers and silencers,
- Chromatin-remodelling complexes, RNA interference (RNAi).

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SEMESTER III

M.Sc. ZOOLOGY

PG3ZOOC11-MICROBIOLOGY AND BIOTECHNOLOGY

72 Hours (4hrs/week) **Credit- 4**

Objectives:

- To provide an over view of the microbial world, its structure and function
- To familiarize the learner with the applied aspects of microbiology
- To give students an intensive and in-depth learning in the field of biotechnology
- To understand the modern biotechnology practices and approaches with an emphasis in technology application, medical, industrial, environmental and agricultural areas
- To familiarize the students with public policy, biosafety, and intellectual property rights issues related to biotechnology

UNIT 1 –MICROBIOLOGY 30hrs.

Module I. Introduction to Microbiology 3 hrs.

- Methods of Microbiology,
- Main group of microorganisms, general characters. Classification, approaches to microbial classification,outline classification, Bergey's manual.

Module II. Functional Anatomy of Prokaryotic Cells 3 hrs.

- Cell structure, plasma membrane, cytoskeleton, cytoplasm, nucleoid, cytoplasmic inclusions.
- The prokaryotic cell envelope, peptidoglycan structure, gram positive and negative cell walls.Components outside the cell wall: capsules, slime layers and s- layers, pili and fimbriae, flagella and motility.
- The endomembrane system, mitochondria and chloroplasts, cell wall and pellicle in protists.

Module III. Microbial Metabolism 4 hrs.

- Energy acquisition by chemotrophs and phototrophs, glycolysis (Embden- Meyerhof pathway). Fermentation, anaerobic oxidations, chemosynthesis. Photosynthesis, carbon assimilation.
- Regulation of metabolism.

Module IV. Nutrition and Growth 3 hrs.

- Common nutrient requirements, nutritional types, growth factors, uptake of nutrients by the cell.
- Culture media.
- Reproduction and exponential growth, the growth curve.
- Physical requirements for bacterial growth and influence of environmental factors on

growth.

Module V. Microbial Interactions and Microbial Ecology 4 hrs.

- Symbiosis, commensalism. Mutualism between microbes, microbes and plants, microbes and animals. Cooperation, competition, predation, antagonism.
- Parasitism, animal parasites.

Module VI. Virology 3 hrs.

- Properties of viruses**,** structure and chemical composition, genetic composition, eclipse, host interaction and specificity.
- Classification, RNA virus , DNA virus, plant virus, animal virus ,bacteriophage, lysis and lysogeny,
- Viral replication. Virioids and prions.Nature and significance. Pathogenic virus, oncovirus, Emerging viral threats

MODULE VII. Applied Microbiology 10 hrs.

- Bacteria of air, water and soil.
- Microbes associated with food production and spoilage, microbiology of milk and dairy products
- Epidemiology of human diseases, Mechanism of microbial pathogenicity.Normal microbial population on human body, microbial diseases, Nosocomial infections, Drug resistance in Bacteria
- Medical mycology. Control of microorganism- physical, chemical and antimicrobial agents.
- Biological weapons and bioterrorism.

UNIT 2 BIOTECHNOLOGY 42 hrs.

Module I.Introduction to Biotechnology 2 hrs.

- Historical aspects, definitions and scope of Biotechnology. Biotechnology in India.

Module II. Tools and Techniques in Recombinant DNA Technology 14 hrs.

- Vectors: cloning and expression vectors - Plasmids, Ti and Ri plasmids, cosmids, phasmids, phagemids, bacteriophage, SV40, vectors with combination features; PUC19 and Bluescript vectors, shuttle vectors, viral vectors, BAC and YAC vectors.
- Restriction enzymes and DNA modifying enzymes.
- Polymerase chain Reaction- Types (Inverse PCR, Anchored PCR, Assymmetric PCR, Real time PCR, Solid Type PCR) and applications.
- Chromosome walking, chromosome jumping, DNA foot printing.
- Molecular Markers -SNP, VNTR, RAPD, RFLP, SSR, STMS, FISH and GISH.
- Molecular Probes-Production labeling and application
- DNA sequencing methods- Maxam and Gilberts chemical degradation method, Sanger and Coulson method, Automated DNA sequencers. Site directed mutagenesis, molecular chimeras.
- Cloning Methodologies - Gene isolation : Shot gun method, Genome libraries, cDNA libraries, Chemical synthesis. Splicing and integration of isolated gene- cohesive end ligation, homopolymer tailing, extending linkers.

- Methods of rDNA transfer to host cells- $CaCl_2$ treatment, Virus delivery. Selection and screening of the transformed cells, Blue-white screening, Colony hybridization methods, Reporter genes, Fusion proteins.
- Gene silencing technique-Antisence RNA,RNAi,

Module III. Animal Biotechnology 10 hrs.

- Animal cell and tissue culture –Culture media -natural and artificial
- Culture methods –Primary explantation technique ,Various methods of cell and tissue culture
- Tissue and organ culture
- Tissue engineering: strategies and developments in tissue engineering,
- Transfection Methods: $CaPO_4$ precipitation, Short Gun, Electroporation, Lipofection, Microinjection, Agrobacterium mediated gene transfer.
- Somatic cell nuclear transfer- reproductive cloning and therapeutic cloning. Gene knockout and knockin technology. Applications of transgenic animals.
- Stem cell culture : General and historical aspects, properties and types of stem cells, advantages and disadvantages, stem cell niche, application of stem cell technology in medicine.

Module IV. Biotechnology in Healthcare 4 hrs.

- Disease prevention – DNA vaccines.
- Disease diagnosis - Probes, Monoclonal antibodies, detection of genetic disorders.
- Disease treatment - Therapeutic proteins, hormones and growth factors.RNAi, Drug targeting, Gene therapy. Forensic medicine.
- Biosensors-different types, applications - medical and non medical.
- Introduction to Biochips and their application in modern sciences.

Module V. Biotechnology in Industry and Agriculture 5 hrs.

- Metabolite production. Antibiotics, Organic acids, Amino acids, Vitamins, Upstream processing, downstream processing.
- Microbial enzymes and biotranformation- Microbial production of enzymes, fermentation,
- Enzyme engineering and applications.
- Food industry- Single cell protein, probiotics.
- Transgenic plants- Plants with resistance to Pests, plants with increased shelf life
- Biofertilizers and microbial inoculants, biotechnology of nitrogen fixation, biocontrol agents, biopesticides, bioinsecticides,
- Terminator gene technology -concept and basics.

Module VI. Environmental Biotechnology 3 hrs.

- Pollution control-Cleaner technologies, Toxic site reclamation, removal of oil spill, reduction of pesticide and fertilizers , Biosensors ,Biomonitoring
- Restoraration of degraded land –Reforestation using micro propagation ,development stress tolerant plants, Bio remediation

Module VII. Intellectual Property Rights, Biosafety and Bioethics 4 hrs.

- Introduction to Intellectual Property Rights, Types of IP: Patents, Trademarks, Copyrights.

- Basics of Patents Types of patents; Indian Patent Act 1970; Recent Amendments, Protection of New GMOs. IPs of relevance to Biotechnology and few Case Studies (Rice, Neem, Curcumin).
- Introduction to History of GATT, WTO, WIPO and TRIPS.
- Biosafety concepts and issues. General guidelines for recombinant DNA research activity. Biosafety protocol 2000

- Bioethics: Principles of bioethics: autonomy, human rights, beneficence, privacy, justice, equity *etc*. Ethics in post genomic era-genetic testing and genetic screening.

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SEMESTER III

M.Sc. ZOOLOGY

PG3ZOOC12- IMMUNOLOGY

Total: 54 Hours. (3hrs./ week). **Credit- 3**

Objectives:

- To provide an intensive and in-depth knowledge to the students in immunology
- To help the learner to understand the role of immunology in human health and well-being
- To familiarize the students the new developments in immunology

Module I. Overview of the Immune System **3 hrs.**

- Types of Immunity- Innate and acquired, Passive and active.
- Cells, tissues and organs involved in immune system.
- Humoral and cell-mediated immune responses.
- Haematopoiesis. B-cell and T-cell maturation and differentiation.
- Pattern recognition receptors- scavenger receptors and Toll – like receptors.

Module II.Antigens and Antibodies **8 hrs.**

- Antigen-structure and properties, Haptens, Adjuvants, Epitopes.
- Immunoglobulins-structure, classes and functions.
- Antigen processing and presentation.
- Monoclonal antibodies and abzymes.
- Multi- gene organization of Ig genes. Variable region gene arrangements.
- Generation of antibody diversity. Expression of Ig genes and regulation of Ig genes transcription.
- Antibody genes and antibody engineering.

Module III.Antigen –Antibody Interactions **2 hrs.**

- Types of antigen-antibody reactions - Cross-reaction, Precipitation, Agglutination.
- Biological consequences of antigen-antibody reaction.

Module IV.The Complement System **5 hrs.**

- Terminal sequence of complement activation (MAC). Classical, Alternate and Lectin Pathways.
- Complement activation, Regulation of complement system.
- Biological consequences of complement activation. Complement deficiencies.

Module V. Immune Effector Mechanisms **5 hrs.**

- Inflammatory Cells. Types of Inflammation- acute and chronic. Chemokines. Role of cytokines in immune system
- Properties and functions of Cytokines. Therapeutic uses of cytokines.

Module VI. Hypersensitivity **4 hrs.**

- Allergy and hypersensitivity. Types of Hypersensitivity
- Genetics of allergic response in humans.

Module.VII. Major Histocompatibility Complex 8 hrs.

- General organization and inheritance of MHC.
- MHC molecules and genes. Genomic map of H-2 Complex in the mouse.
- HLA Complex in humans. MHC-peptide interaction.
- Expression of MHC molecules on different cell types.
- Regulation of MHC expression. MHC and graft rejection. MHC and disease susceptibility.
- Biological significance of MHC. HLA typing

Module.VIII. Immunity in Health and Disease 15 hrs.

- Immune response during bacterial (tuberculosis), Parasitic (Malaria) and viral (HIV) infections.
- Congenital immunodeficiency diseases (SCID, WAS, CVI, Ataxia, CGD, LAD).Acquired Immunodeficiency Disease (AIDS).
- Autoimmunity. Organ- specific autoimmune diseases. Systemic auto-immune diseases.
- Evidences implicating $CD4^+$ T cell, MHC and TCR in autoimmunity. Induction of autoimmunity. Treatment of autoimmune diseases.
- Transplantation immunology. Immunologic basis of graft rejection. Clinical manifestation of graft rejection. General and specific immunosuppressive therapy. Clinical transplantation.
- Tumour immunology.
- Vaccines, Whole organism vaccines, Purified macromolecules as Vaccines, Recombinant vector vaccines, Synthetic peptide vaccines, Multivalent subunit vaccines.

Module IX.Immunological Techniques 4hrs.

- Serological Reactions. Radio-allergosorbent Test (RAST).Immunoprecipitation. Immunofluorescence. Flow cytometry and fluorescence. Immunoelectron microscopy.

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SEMESTER III

PRACTICAL III

PG3ZOOP03: CELL AND MOLECULAR BIOLOGY, MICROBIOLOGY AND BIOTECHNOLOGY

72 Hours (4hrs. /week) **Credit-2**

Cell and Molecular biology and Biotechnology

- Squash preparation of grasshopper testis to study meiotic stages.
- Squash preparation and identification of salivary gland chromosomes in *Drosophila* / Chironomus larva.
- Determination of mitotic index in the squash preparation of onion root tip.
- Effect of drugs on cell division (Colchicine or any other inhibitor)
- Preparation of Microtome section, spreading and histochemical staining of Carbohydrates (PAS), Protein (Bromophenol blue), Lipids (Sudan Black), DNA (Fuelgen stain).
- Cell fractionation and Differential Centrifugation to isolate mitochondria and nuclei
- Isolation of genomic DNA using Agarose gel electrophoresis
- Isolation of Plasmid DNA.

Microbiology

- Sterilization, disinfection and safety in microbiological laboratory.
- Preparation of culture media

(a) liquid media – nutrient broth , peptone water

(b) Solid media – Nutrient Agar, Mac Conkey' Agar.

(c) Semi solid agar

(d) Firm agar.

- Culturing of microorganism –
- broth culture
- pure culture techniques- streak plate, pour plate culture, lawn culture, stab culture

Serial dilution and standard plate count, calculation of Cfu/ml in water samples.

- Isolation and preservation of bacterial culture.
- Identification of microorganisms-

(a) Staining techniques- gram staining of mixed cultures, negative staining

- Antibiotic sensitivity (different natural fluids)

- Oxidase test
- Catalase test
- Oxidation/fermentation (O/F) test
- Staining and enumeration of microorganisms:
  using haemocytometer

Environmental sample analysis.

a) Isolation and enumeration of soil bacteria

b) Identification of symbiotic bacterioids from root nodules of leguminous plants

c) Bacteriological analysis of milk- methylene blue reductase test.

SEMESTER III

PRACTICAL IV

PG3ZOOP04: ANIMAL PHYSIOLOGY AND IMMUNOLOGY

72 Hours (4hrs. /week) **Credit-2**

Animal Physiology

- Rate of salivary amylase activity on starch at different concentration (colorimetry)
- Effect of different pH on salivary amylase activity (colorimetry)
- Influence of temperature on salivary amylase activity – Calculation of Q 10

- Effect of drugs on the heartbeat of cockroach (Result with graphical representation corresponding to different concentration and time intervals expected)

- Oxygen consumption in fish (normal and stressed).Graphical representation and interpretation. Kymograph: working principle and applications.

Virtual Practicals in Physiology

- (Use of PhysioEX 9.0 : *Laboratory Simulations in Physiology* by P.Zao.,T.Stabler., L.A.Smith and E .Griff. 2011.is suggested) for muscle and nerve physiology practical for class room training and for practical examination in order to replace Frog as per UGC guidelines).
- Any four of the following:

(1) Muscle Twitch and the Latent Period -The effect of stimulus Voltage on Skeletal Muscle Contraction
(2) Tetanus
(3) Fatigue
(4) Receptor Potential
(5) The Action Potential Threshold
(6) Importance of Voltage –Gated Na+ Channels

- Total count of Human RBC and WBC
- Haematocrit and ESR of Human blood
- Feeding activity of paramecium

- Effect of different concentration of NaCl solution (0.1%-2%) on the diameter of RBCs (preferably human) and determination of the concentration , which is isotonic to the blood from a plot of diameter of RBC against concentration of NaCl

Immunology

- Separation of lymphocytes from whole blood.
- Separation of T and B lymphocytes
- Blood Typing in Man.
- WIDAL Test.

- Western Blotting –Demonstration
- ELISA -Demonstration
- Rocket Immuno electrophoresis- Demonstration

SEMESTER IV

PG4ZOOC13 ELECTIVE: ENTOMOLOGY I MORPHOLOGY AND TAXONOMY

90 Hours (5 hrs/week) **Credit -4**

Objectives:

• To introduce the insect diveristy and its significance
• To study the economic and medical importance of insects
• To learn about the pests of crops and vectors of diseases and their control measures
• To provide skills for scientific study of insects
• To develop research aptitude among students by introducing frontier areas of entomology

Module I. Introduction 4 hrs

- Scope and importance of insects
- Origin and evolution of insects (including theories)
- Fossil insects.

Module II. Insect Morphology 26 hrs

- **Segmentation and division of the body**: General morphology of head (Opisthognathus, Prognathus,Hypognathus). Head segmentation; Head skeleton; Tentorium; Modifications in head capsule;
- **Cephalic appendages**; Antennae – Structure functions and types.
- **Mouth parts** –various modifications, feeding mechanisms.
- **General morphology of thorax** (thoracic segmentation, thoracic skeleton and thoracic appendages).
- **Wings**– Structure, Venation, Wing articulation,Wing coupling apparatus, Wing modifications.
- **Legs**-structure and adaptive radiation of legs, Locomotion.
- **Morphology of abdomen and its appendages**.
- **External genitalia**-structure and diversity of male and female genitalia. eg. Grasshopper, Drosophila, Cockroach ,Dragonfly.
- **Sense Organs** – Structure and classification of sense organs (Hair organs, Plate organs, Campaniformorgans, Compound eyes and vision.).
- **Light Producing Organs** -Structure of light producing organs, Production of light.
- **Sound Producing Organs** -. Stridulatory organs invarious insects.

Module III. Insect Classification 36 hrs

- **General characters**, **Biology, Habits**. and **Classification** up to families of the following orders of insects with special emphasis on economically important insects
  Apterygota- Protura Collembola, Diplura, and Thysanura.
  Exopterygota- Odonata, Ephemeroptera, Plecoptera, Embioptera Phasmida,Orthoptera, Dermaptera, Isoptera, Blattaria, Mantodea, Zoraptera, Psocoptera, Mallophaga, Anopleura, Thysanoptera, Homoptera, Heteroptera.
  Endopterygota- Coleoptera, Strepsiptera, Neuroptera Mecoptera, Diptera, Siphonaptera , Trichoptera, Lepidoptera, Hymenoptera.

Module IV . Social Organisation and Behaviour 16hrs

- **Social organisation and behaviour:** with reference toTermites, Ants and Honey Bees.
- **Study of Gall forming insects**: features, Gall formation, Types of Galls –open and Closed, Common Gall pests, adaptations for Gall making habits. Economic importance.

- **Leaf mining insects** – features, forms of leaf mines, feeding habits, Ecological aspects of leaf mining.
- **Communication** – Acoustic, Visual, Tactile and chemical methods.
- **Adaptations of parasitic and predatory insects**
- **Study of aquatic insects**: factors influencing the aquatic life, food capture – modifications, anchorage, locomotion, respiration, oviposition and adaptations of swimming forms.
- **Insect- host resistance**
- **Insect pollinator** – plant interaction. Modern findings.

Module V. Insect Development 8 hrs

- **Egg**-Types, structure, egg cases and adaptations of eggs Diapause.
- General pattern of embryonic development, Polyembryony, Parthenogenesis, Paedogenesis.
- Types of Metamorphosis, different types of larvae and pupae.

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SEMESTER IV

PG4ZOOC14 ELECTIVE: ENTOMOLOGY II
ANATOMY AND PHYSIOLOGY

90 Hours (5 hrs/week) **Credit -4**

Module I. Integumentary System **4 hrs.**

- Anatomy and histology, Physical and chemical properties
- Moulting and sclerotisation, Role of hormones.

Module II. Digestive System **10 hrs.**

- Anatomy and histology of gut.
- Modifications of gut (filter chamber).
- Physiology of digestion of wood, keratin,wax and silk.
- Extra intestinal digestion.
- Role of microbe in digestion.
- Assimilation.

Module III. Circulatory System **8 hrs.**

- Anatomy and histology of dorsal vessel,dorsal and ventral diaphragms and accessory pulsatile organs.
- Composition and cellular elements in haemolymph;functions.
- Course of circulation and control of heart beat.

Module IV. Respiratory System **10 hrs.**

- Anatomy and histology of trachea, trachiole,spiracles and air- sacs.
- Modifications of respiratory system-cutaneous respiration, diffusion,ventilation,control of ventilation,cyclic release of CO_2,
- respiratory pigments.

Module V. Muscular System **8 hrs.**

- Histo-morphology of muscles,skeletal muscles and visceral muscles.
- Neuromuscular junctions.
- Excitations of muscle fibres,role of fast and slow axons.

Module VI. Fat Body and Intermediary Metabolism **8 hrs.**

- Structure of fat body.
- Role of fat body in storage of reserves.
- Intermediary metabolism-Glycolysis,Glycerol phosphate shuttle,Trehalose-biosynthesis

Module VII. Excretory System **10 hrs.**

- Anatomy and histology of Malpighian tubules (Hemiptera, Coleoptera,Lepidoptera)
- .Nephro-rectal complex and labial glands.

- Physiology of excretion.
- Absorption of water and ions,reabsorption of essential materials.
- Synthesis of uric acid, formation of excreta.

Module VIII. Nervous System 12 hrs.

- Anatomy and histology of brain,ganglia and nerves.
- Physiology-reception and transmission of stimuli,production and conduction of nerve impulses.

- Anatomy and histology of mechanoreceptors, photoreceptors and chemoreceptors.

- Sound production and light production.

Module IX. Endocrine System 12 hrs.

- Histomorhology of neurosecretory cells and endocrine glands (corpora cardiaca,corpora allata and prothoracic glands).
- Hormones and their functions.

- Types of pheromones and behavioural patterns.Pheromonal communications-allelochemicals; allomones, kairomones and synomones.

Module X. Reproductive System 8 hrs.

- Reproductive system in male insects.
- Reproductive system in female insects.
- Fertilization and oviposition
- Formation of blastoderm and differentiation of germ layers
- Polyembryony, pedogenesis, viviparity, oviparity, eclosion

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SEMESTER IV

PG4ZOOC15 ELECTIVE : ENTOMOLOGY III

APPLIED ENTOMOLOGY

90 Hours (5hrs/week) **Credit - 4**

Module I. Insect Pests

10Hrs

- Classification of Insect pests
  Key pests, Potential pests, Occasional pests, Sporadic pests, Seasonal pests, Regular pests, Persistent pests (Based on occurrence)
  Endemic, Epidemic and Pandemic pests (Based on level of infestation)
  Migrant pests and Exotic pests
- Causes of insect assuming pest status
- Causes of pest outbreak
- Pest surveillance and Forecasting pest outbreaks (Short term and long term forecasting)
  Forecasting based on observations – climatic and empirical factors.
- Pest resurgence and replacement (secondary pest outbreak).
  Causes and management of resurgence and replacement.
- Types of damage caused by insect pest to crops
  (Injury by chewing, piercing, sucking insects, internal feeders, subterranean insects, to stored products and indirect effect of feeding)
- Concepts of Economic levels
  Economic injury level, Economic threshold level, Damage boundary
  Pest categories according to EIL, GEP AND DB
  (Key pests, Major, Minor/ Occasional pests, Sporadic pests, and Potential pests)
- Estimation of damage caused by insect to crops

Module II. Insect Pests of Crops **20 hrs**

- Identification, Life history, nature of damage and control measures of major pests of

PADDY

- (Major pests including stem borers, army worm, rice thrips, gall midge, mealy bug, BPH, green & white leaf hoppers, rice caseworm, rice leaf roller, rice hispa, rice earhead bug, root weevil, rice grass hoppers- Any **10**)

SUGARCANE

- (Major pests including shoot, internode & top borers, white grub, leaf hopper,

sugarcane scale, mealy bug, whiteflies, Termites, Black winged bug)

COTTON

- (Major pests - Aphid, leaf hopper, thrips, whitefly, Pink, spotted and American boll worms, stem weevil, Red and Dusky cotton bugs, leaf roller)

COCONUT

- (7 pests - Rhinoceros beetle, red palm weevil, black-headed caterpillar, white grub, Scale

insect, Lace wing bug, coconut skipper)

PULSES

- (8 pests - Gram pod borer, plume moth, red gram pod fly, pod borer, spotted pod borer, Blue butterflies, bean aphid, white fly)

- Pests of Fruit trees
  Mango,Cashew,Citrus and Banana
- Pests of Spices (Specify any two of each)
  Pepper,Cardamom,Turmeric and Ginger
- Pests of other crops
  Coffee, Tea, Tapioca, and Rubber,
- Pests of vegetables
  Brinjal,Gourd,Tomato, and Bhendi
- Identification, nature of damage & control of insect pests of stored products:
  (Rice weevil, sweet potato weevil, Lesser grain borer, tobacco beetle, Drug store beetle, Pulse beetle, Angoumois grain moth, Potato tuber moth, Red flour beetle, Rice moth)
- Locusts –life history and migration, damage and methods of control
- Termites– life history, damage and control measures.

Module III. Principles of Insect pest management 15 hrs

Ecology based pest management

- Prophylactic methods
- Curative methods
  Cultural methods,
  Mechanical methods
  Physical methods
  Legal methods
  Biological control
- History of biological control, ecological basis of biological control

- Natural enemies (Parasites, Parasitoids, Predators), Feasibility of biocontrol
- Applied biological control (Conservation and enhancement, Importation and colonization, Mass culture and release)
- Importance of Systematics, Advantages and disadvantages
- Important biocontrol projects undertaken in India by employing Parasites and predators.
- Autocidal control - Sterile male technique and other methods, Chemosterilants, Methods of sterilization, Application, Dynamics, Advantages and disadvantages Examples of autocidal control
- Insect growth regulators (IGRs) – Brief note on Insect growth hormones and mimics (JH mimic & ecdysone agonists) and chitin synthesis inhibitors as insect control agents

- Behavioural (pheromonal) control (Brief note on Trial, Alarm, Aggregation and sex pheromones and the behavior produced, Mode of application, Pest management with pheromones, Advantages and disadvantages, Examples

- Insect attractants: definition, types of attractants, applications in insect pest mangement, examples, advantages and disadvantages
- Insect repellents: definition, desirable features of good repellent, types of repellents, applications in insect pest management, examples, advantages and disadvantages
- Insect antifeedants: definition, examples, applications in insect pest management, advantages and disadvantages

- Microbial control of crop pests by employing Bacteria, Virus and Fungi - Classification of entomophagus Bacteria, Virus, Fungi, Mode of action, formulation, Application, Examples

- Integrated Pest Management- Definition, IPM in Agroecosystem, Kinds of pest, (Key pests, Occassional pests, Potential pests, Migrant pests) Establishing the need to take action, Guidelines for developing IPM, Tactics in IPM, IPM of Rice.

Module IV Chemical Control **20 hrs**

- Insecticide formulation

(Brief note on Emulsifiable concentrates, Water-miscible liquids, Wettable powders, Water soluble powders, Oil solutions, Flowable powders, Aerosoles, Granulars, Fumigants, Ultra-low volume concentrates, Fogging concentrates, Dusts, Poison bates and Slow release insecticides)
Classification of insecticides

1. Based on mode of entry
2. Based on mode of action
3. Based on chemical nature

- Chemistry, toxicology & mode of action of following class of insecticides; mention examples for each class

- Synthetic Organic compounds

Organochlorine insecticides (DDT, BHC,.Cyclodiene group (special reference to endosulfan; examples:heptachlor, aldrin)
Organophosphorous insecticides (examples: TEPP, Dichloros, monocrotophos, parathion) Carbamates (special mention of carbofuran and Carbaryl)
Inorganic compounds as insecticides - arsenic compounds, fluorides, sulphur compounds

- Fumigants – definition, examples, methods of fumigation, hazards of fumigation, advantages and precautions
- Botanical insecticides- chemical properties, mode of action and toxicity of the following : Nicotine, Rotenone, Pyrethrum and Neem
- Synthetic pyrethroids – definition, uses as insecticides, mode of action (examples:Pyrethrin, allethrin)
- Insecticide synergists – definition, types of synergism, mode of action & examples

Module V Insecticide Application Technology 8 hrs

- Dusting and dusters
- Spraying and sprayers – syringes, knapsack sprayers, foot pump-sprayers, rocker sprayer, pneumatic hand sprayers, pneumatic knapsack sprayers, hand atomizer, hydraulic sprayers
- Aerosols
- Other equipments (mist blower, fog generators, smoke generators, aerosol bombs)

Module VI Insecticides and Environment 7 hrs

- Insecticide resistance -Genetic, Physiological and biochemical mechanism
- Pesticides and the environment- its impact on wildlife and human health
- Microbial and environmental degradation of pesticides

Module VII. Medical and Veterinary Entomology 10 hrs

- Identification, nature of attack & control of Insect pests of domestic animals
  Cattle (any five pests)
  Fowl (any three pests)
  Dog & Goat (any two pests)
- Ticks and Mites of Medical importance – Morphology, biology and control measures
- Major arthropod vectors of human diseases
  (Malaria, Lymphatic Filariasis, Yellow Fever, Dengu Fever, West Nile Disease , Chickungunia,Japanese Encephalitis, Zika,
  Kala-azar,African sleeping disease Plague, Typhus, Kyasanur Forest Disease, Scabies)

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SEMESTER IV

PRACTICAL V

PG4ZOOP05 ELECTIVE: ENTOMOLOGY III

MORPHOLOGY, ANATOMY AND TAXONOMY

90 hours. (5 hrs./week) **Credit- 2**

- Study of mouthparts in insects (Grasshopper, plantbug, mosquito, honeybee, house fly) Study of different types of antennae, genitalia and legs.
- Sting apparatus –honeybee
- Wings and wing venation in insects of 5 orders. Study of sexual dimorphism in insects
- Preparation of dichotomous keys with reference to various insect orders
- Dissection of alimentary canal and associated glands of different insects (plant bug, honey bee, oryctes, grasshopper.
- Dissection of nervous system in different insects (plantbug, honeybee, oryctes, grasshopper) Dissection of reproductive system in insects (cockroach, oryctes ,grasshopper, Plant bug) Dissection of stomatogastric nervous system –cockroach
- Collection and preservation of insects (students are required to submit an insect collection belonging to 50 families-dry collection,wet collection, whole mounts and slides) at the time of practical examination.
- **Field Study Report:**

Visit to two institutions engaged in entomology research and different ecological niches other than local area for collection of insects. The field study is for 3-4 days. Report the study conducted and submit a 10 page write up/ print out giving the dates, day wise itinerary, methodology, results and references. Include photographs of the activities. Group and individual assignments shall be preferred.

SEMESTER IV

PRACTICAL VI

PG4ZOOP06 ELECTIVE: ENTOMOLOGY III

INSECT PHYSIOLOGY AND APPLIED ENTOMOLOGY

90 Hours (5 Hours/week) **Credit-2**

- Survey of digestive enzymes –amylase,invertase,protease and lipase in different parts of the gut in cockroach,grasshopper, dragonfly
- Dye transport by Malpighian tubule using dyes
- Identification of free aminoacids (at least 3) in haemolymph by paper chromatography. Haemocytes –staining and identification.
- Collection and identification of insect pests of different crop plants,fruit trees,vegetables and stored products
- Collection and identification of insect vectors of man and domestic animals.
- Collection and preservation of economically important insects, their life stages, products, damaged parts.
- Collection and identification of insect damages to crop plants. Insecticide appliances.
- Determination of LC_{50} using probit analysis.
- Collection – Students are expected to submit a collection consisting of insect pest of different crops, stored products, domestic animals and man. Useful insects, their life stages and products, parasites and predators.