RAMAKRISHNA MISSION VIDYAMANDIRA

BELURMATH, HOWRAH, WEST BENGAL

DEPARTMENT OF ZOOLOGY

PROGRAMME OFFERED : B.Sc. ZOOLOGY HONOURS

PROGRAMME CODE : ZOOA

DURATION : 6 SEMESTERS

TOTAL CREDIT : 148

FULL SYLLABUS WITH COURSE OUTCOME

VALID & ONGOING AS ON 30TH JUNE, 2019

Following is the credit distribution for B.Sc. Zoology Hons. Programme:

	CR SEM 1	CR SEM 2	CR SEM 3	CR SEM 4	CR SEM 5	CR SEM 6	Total Credit
Core Course / Hons.	14	14	14	14	26	26	**108**
Generic Elective	6	6	6	6	--	--	**24**
AECC-Lang.	2	2	2	2	--	--	**4**
AECC-ENVS	--	--	--	--	--	--	**4**
SEC- ICSH	1	1	1	1	2	2	**8**
	23	**23**	**23**	**23**	**28**	**28**	**148**

Following is the Grade Point distribution:

% of Marks	Descriptor	Grade	Grade Point
85 - 100	OUTSTANDING	**O**	**10**
70 - 84.99	EXCELLENT	**A+**	**9**
60 - 69.99	VERY GOOD	**A**	**8**
55 - 59.99	GOOD	**B+**	**7**
50 - 54.99	ABOVE AVERAGE	**B**	**6**
40 - 49.99	AVERAGE	**C**	**5**
35 - 39.99	PASS (HONOURS)	**P**	**4**
30 - 34.99	PASS (OTHERS)	**P**	**4**
LESS THAN 35	FAILED (HONOURS)	**F**	**0**
LESS THAN 30	FAILED (OTHERS)	**F**	**0**

Name of the Core Course	Credit for the Core Course	Generic Elective Course and the Credit
Zoology Hons	108	Total Credit : 24 Guidelines to make Choice : While Generic Elective subject Course 'a' is to be taken by all students, any one from Generic Elective subject Course 'b' may be chosen by the students a) Chemistry & b) Physics / Microbiology

B.Sc. Zoology Hons. Programme has introduced Discipline Specific Elective Course (DSE) and/or Project in 5h and/or 6th semester:

Sl. No.	Name of the Programme	Discipline Specific Elective / Project
13	Zoology Hons	Project & Field Study

Students of B.Sc. Zoology Hons. Programme must take following courses :

- Ability Enhancement Compulsory Courses (AECC):
  - Environmental Science : 4 Credit
  - English Language and MIL (Bengali Language/ Alternative English) : 4 Credit
- Value-Oriented Course (Indian Cultural and Spiritual Heritage) : 8 Credit

Total Credit to be earned by a student to complete B.Sc. Zoology Hons. Programme: 148 Credit

Mark sheet after each semester will be given both with SGPA and detailed marks obtained by the examinee.
Similarly Mark sheet after the final semester will be given with CGPA and detailed marks obtained by the examinee.

Calculation of SGPA = (Total Credit X Total Grade Point = Total Credit Point);
Total Credit Points / Total Credits
Calculation of CGPA = (Total SGPA X Total Credits in each Sem.) / Total Credits earned in all the semesters

Sl No	Name of the Course	Semster	Course Code	Credit	Marks in the Course	Course outcome
1	General Characters, Diversification and Outline Classification of different Non-Chordate Phyla, Ultrastructure of a Cell	1	ZOOA-P1T	10	100	1. Development of clear concept on different invertebrate forms and their physiology. 2. Describing general taxonomic rules of non-chordate classification. 3. Classifying Protista up to phylum using examples from parasitic adaptation. 4. Development of concise ideas about the molecular aspects of cell functioning.
2	Demonstration including mounting & preparation; identification of non-chordate specimens; Cytology	1	ZOOA-P1P	4	50	1. Identification & knowledge gathering on cellular & sub-cellular levels of organisation. 2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Invertebrate Zoology as well as cell biology.

3	Functional anatomy of Chordates & Major aspects of Developmental Biology, Genetics	2	ZOOA-P2T	10	100	1. Development of clear concept on different vertebrate forms and their physiology. 2. Classifying from Protochordates to Mammals properly. 3. Understanding complex vertebrate interactions.
4	Demonstration including mounting & preparation; Identification of Chordate Specimens; Genetics; Developmental Biology & Osteology	2	ZOOA-P2P	4	50	1. Gathering knowledge on different developmental processes & genetic mechanisms 2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Vertebrate Zoology by considering their skeletal systems.
5	Principles of Ecology; Biodiversity; Wild life Management & Conservation, Molecular Biology	3	ZOOA – P3T	10	100	1. Learning the basic biological principles and processes to understand ecology and environment and their proper functioning. 2. Understanding distribution of fauna in different realms and their mutual interaction. 3. Studying interaction between biotic and abiotic factors. 4. Developing idea on numerous protected zones in wildlife, different conservation

						strategies and WPA. 5. Developing knowledge of underlying molecular mechanisms of various genetic and cellular phenomena.
6	Ecology, Genomics & Proteomics, Field Study Project	3	ZOOA – P3P	4	50	1. Conducting a local excursion to obtain and record various data and their subsequent analysis to holistically understand Ecology in silico. 2. Perform modern molecular genetic techniques to co-relate theoretical molecular genetics knowledge.

7	Animal Physiology & Functional Histology, Biochemistry and Biochemical Instrumentation	4	ZOOA – P4T	10	100	1. Learning principles and concepts of basic physiological processes to relate the various levels of organization and interaction amongst them to ensure proper functionality of an individual. 2. Development of bio-chemical background in various life sustaining processes. 3. Developing physiological and biochemical understanding through scientific enquiry into the nature of mechanical, physical, and biochemical functions of humans, their organs, and the cells of which they are composed. 4. Understanding interactions and interdependence of physiological and biochemical processes.
8	Animal physiology and Histology, Enzymology, Qualitative Biochemical Assays	4	ZOOA – P4P	4	50	1. Learning the practical knowledges to analyse different biochemical samples and assess the presence of macro and/or micro molecules therein. 2. Estimation of various haematological and physiological parameters by means of elementary

						equipment's
9	Immunology & Human diseases	5	ZOOA – P5T	5	50	1. Learning the fundamental basis of how organisms react to biological foreign agents. 2. Understanding different types of immunity. 3. Studying interactions of antigens, antibodies, complements and other immune components. 4. Understanding of immune mechanisms in disease control, vaccination, process of immune interactions. 5. Understanding the basis and mechanism of various parasite mediated and physiological diseases.
10	Integration Biology & Homeostasis	5	ZOOA – P6T	5	50	1. Development of precise knowledge on how an individual react to various internal and external conditions by means of chemically integrating and modulating various physiological processes. 2. Understanding

						principles of bioluminescence & biological rhythm.
11	An Approach to Biotechnology	5	ZOOA – P7T	6	50	1. Learning how the basic molecular genetic mechanisms can be modulated for various bio-medical, research and economic benefits. 2. Learning principles of animal cell & tissue culture.
12	Immunology; Integration Biology & Homeostasis; Bioinformatics; Tools & Techniques of Biotechnology	5	ZOOA – P8P	5	75	1. Performing sophisticated experimentations using advanced Biotechnological tools & techniques 2. Develop the practical skills analyse different haematological and immunological samples to assess various parameters. 3. Learning basic principles of Bioinformatics
13	Internship in Laboratory/Industry	5	ZOOA – P9P	5	75	An exposure to pursue a project under a functioning laboratory condition. Developing expertise to handle different instruments.

14	Biostatistics and Economic Zoology	6	ZOOA – P10T	8	75	1. Learning the theoretical skills to establish any biological phenomena by statistically assessing the experimental data 2. Learning the basis to understand life cycle & physiology of various bioresources and applying such knowledge scientifically for human welfare. 3. Understanding concepts of fisheries, fishing tools and site selection. 4. Understanding processes of Silk moth rearing, silk production & Mulberry cultivation, Lac culture, Apiculture etc. and their economic values. 5. Developing clear idea about pest management and its importance.
15	Elementary ideas on Systematics; Evolution and Adaptation; Animal Behaviour as a process of life	6	ZOOA – P11T	8	75	1. Learning the theoretical skills to taxonomic assessment of different animals correlating their evolutionary background as well as behavioural pattern. 2. Gaining knowledge regarding the various theories of evolution, evolutionary process such as variation, speciation, natural

						selection, origin of primates and man. 3. Learning basic principles of animal taxonomy, systematics, classification, speciation etc.
16	Adaptation, dissertation, local excursion and grand viva voce	6	ZOOA – P12P	5	75	Presentation & defence of any zoological problem in a scientific and structured manner. Correlating the theoretical strategies of rearing & managing economically important animals by visiting such centres.
17	Biology of Insects	6	ZOOA – P13DTA	4	50	1. Developing a clear idea on physiology, taxonomy & social behaviour of insects. 2. Understanding the mechanism of pollination in details. 3. Understanding the importance of insects as different vectors.
18	Detailed study of Insect Morphology	6	ZOOA – P13DPA	1	25	1. Developing a clear idea on anatomy of insects. 2. Developing skill on morphotaxonomy based on insect body. 3. Understanding insect diversity based on field study.

19	Endocrinology	6	ZOOA – P13DTB	4	50	1. Development of precise knowledge how an individual react to various internal and external conditions by means of chemically integrating and modulating various physiological processes. 2. Understanding how the actions of different hormones are regulated in cellular as well as molecular levels.
20	Study of Endocrine System	6	ZOOA – P13DPB	1	25	1. Developing clear idea on structure & function of different mammalian endocrine glands.

B.Sc. Zoology Honours

6 Semester Course

List of courses

New Courses have been marked with Red Colour

Sl No	Name of the Course	Semster	Course Code	Employability/Skill enhancement / Enterpreneurshipdevelopment
1	General Characters, Diversification and Outline Classification of different Non-Chordate Phyla, Ultrastructure of a Cell	1	ZOOA- P1T New course vide BoS dt 15.05.2017	1. Regular class tets/continuous assesments are conducted to correlate between different bauplans of various invertebrate phyla and their utilities which is helpful for clear understanding. 2. Students are asked to prepare short write-ups on different topics from the syllabus to generate baseline knowledge for further multiple biological/medical disciplines.
2	Demonstration including mounting & preparation; identification of non-chordate specimens; Cytology	1	ZOOA- P1P New course vide BoS dt 15.05.2017	1. Students get chance for hands-on lab based training on microscopy & micrometry, which is helpful for forensic study or getting jobs in biomedical, pharmaceutical, pharmacological industries in future. 2. Students are trained to be more independent to generate new ideas for further academic research studying different physiological systems of invertebrates in-vivo and justifying the systematic positions of selected preserved invertebrate specimen based on their morphological features

3	Functional anatomy of Chordates & Major aspects of Developmental Biology, Genetics	2	ZOOA- P2T New course vide BoS dt 15.05.2017	1. Students may correlate between different bauplans of various vertebrate taxa and their utilities and may gather a fundamental knowledge on principles of development-life cycle. 2. Various genetic crosses to are desingned in classes to develop skill for analysing numerous biological phenomena, mostly adopting short question-answer mathod. 3. Evaluation by periodic tests & mock tests etc.
4	Demonstration including mounting & preparation; Identification of Chordate Specimens; Genetics; Developmental Biology & Osteology	2	ZOOA-P2P New course vide BoS dt 15.05.2017	1. Lab based training is conducted to enhance skill for gathering knowledge on vertebrate anatomy, different developmental processes & genetic mechanisms. Evaluation includes regular submission of write-ups on each topic culminating lab note books finally.
5	Principles of Ecology; Biodiversity; Wild life Management & Conservation, Molecular Biology	3	ZOOA – P3T New course vide BoS dt 05.02.2018	1. Students get exposure for developing analytical skills to implement ecological knowledge in designing conservational strategies and wild life management. This, in turn, is beneficial for getting admission to national institutes like FRI, WII etc. for higher studies and research. 2. Foundation is built for the students to theoritically understand various genetic mechanisms and abnormalities by means of cutting edge molecular techniques. This serves as a 'concept building block' when evaluation is done through class tests and mock tests.

6	Ecology, Genomics & Proteomics, Field Study Project	3	ZOOA – P3P New course vide BoS dt 05.02.2018	1. In field project, learning how to obtain ecological data in silico and their analysis using various statistical tools, students gather experience of assessing numerous parameters of different ecosystems. Moreover, while preparing GIS maps for different flora and fauna in field note books, they get training of handling software like Google Earth, QGIS 3.10, DIVA etc. 2. Developing skills in isolation of biomolecules (DNA and Protein) and their quantitative analysis using modern tools and techniques in labs help learners to move further to Molecular Biology research and to other biomedical industries.
7	Animal Physiology & Functional Histology, Biochemistry and Biochemical Instrumentation	4	ZOOA – P4T New course vide BoS dt 05.02.2018	1. Students develop skills by theoretically understanding how and/or why an individual physiologically responds to various situations. Moreover, they become competent knowing how various physio-chemical techniques can be utilized to manoeuvre biomolecules, involved in life sustaining processes.
8	Animal physiology and Histology, Enzymology, Qualitative Biochemical Assays	4	ZOOA – P4P New course vide BoS dt 05.02.2018	1. Students develop skills by performing quantitative and qualitative biochemical estimations of unknown biochemical samples. 2. Hands-on training on routine assessment of human physiological parameters (viz. TC/DC/BP/Hb%) help students to get absorbed in various pathological labs.

9	Immunology & Human diseases	5	ZOOA – P5T New course vide BoS dt 03.12.2018	1. Skill development for the students is achieved by theoretically learning how humans resist pathogenic interference and how individuals can be benefitted by various immuneopreventive and immunotherapeutic approaches. 2. Evaluation includes periodic tests,mock tets, classroom quiz, write-up submission etc.
10	Integration Biology & Homeostasis	5	ZOOA – P6T New course vide BoS dt 03.12.2018	1. Foundation is built for theoretically understanding the release, mode of action, regulation and abnormal manifestation of various chemical messengers in vivo. 2. Evaluation includes periodic tests,mock tets, classroom quiz, write-up submission etc.
11	An Approach to Biotechnology	5	ZOOA – P7T New course vide BoS dt 03.12.2018	1. Students become efficient to theoretically correlate the ideas of the cutting edge molecular and advanced biological tools with techniques and application of those in various aspects of human welfare.
12	Immunology; Integration Biology & Homeostasis; Bioinformatics; Tools & Techniques of Biotechnology	5	ZOOA – P8P New course vide BoS dt 03.12.2018	Students develop practical skill to perform the followings: 1. Human blood group determination from blood samples. 2. Quantitative estimation of various antigens from various biological samples. 3. Designing primer to clone the gene of interest by means of various biotechnological software. 4. Perform all the steps to clone the sequence of interest using advanced Biotechnological tools & techniques. All of the skills mentioned above are useful to get employment in pharmaceutical & biomedical sectors, especially at their R & D divisions.

13	Internship in Laboratory/Industry	5	ZOOA – P9P New course vide BoS dt 03.12.2018	1. Students inculcating basic ideas of fundamental research under able guidance.
14	Biostatistics and Economic Zoology	6	ZOOA – P10T New course vide BoS dt 03.12.2018	1. Learning to assess & analyse biological data as per need. 2. Theoretically learners can correlate the physiology, behaviour, problems of various bio-resources (fish, annelids, arthropods etc.) and their manipulation for earning revenues and/or human welfare.
15	Elementary ideas on Systematics; Evolution and Adaptation; Animal Behaviour as a process of life	6	ZOOA – P11T New course vide BoS dt 03.12.2018	Development of skill to determine 'Evolutionary justification' of a group of organisms under investigation by means of their behavioural pattern and taxonomic status.
16	Adaptation, dissertation, local excursion and grand viva voce	6	ZOOA – P12P New course vide BoS dt 03.12.2018	1. Development of professional skill to present & scientifically defend a zoological problem. 2. Methodical preparation of taxonomic keys to determine the appropriate status of a selected specimen. 3. An interdisciplinary viva voce to groom and train the students for facing such interviews in future.
17	Biology of Insects	6	ZOOA – P13DTA New course vide BoS dt 03.12.2018	1. Development of skill by theoritically learning 'Insect Biology' in details to assess the roles of different insect group as casuing agents/control agents etc.
18	Detailed study of Insect Morphology	6	ZOOA – P13DPA New course vide BoS dt 03.12.2018	1. Better idea on insect anatomy is helpful for the students to pursue entomological research further and also to address different insect mediated problems affecting humans at large,
19	Endocrinology	6	ZOOA – P13DTB New course vide BoS dt 03.12.2018	1. Skill enhancement by in depth understanding of the release, mode of action, regulation and abnormal manifestation of various chemical messengers in vivo.

20	Study of Endocrine System	6	ZOOA – P13DPB New course vide BoS dt 03.12.2018	1. Understanding of proper functioning of different endocrinal pathways help learners to develop better ideas of mode of physiological actions in different organ systems.
21	Gr. A. Non-Chordates Gr. B. Cell Biology, Genetics & Molecular Biology	1	ZOOG-P1T New course vide BoS dt 12.03.2015	1. Regular class tets/continuous assesments are conducted to correlate between different bauplans of various invertebrate phyla and their utilities which is helpful for clear understanding. 2. Students are asked to prepare short write-ups on different topics from the syllabus to generate baseline knowledge for further multiple biological/medical disciplines.
22	Laboratory Course	1	ZOOG-P1P New course vide BoS dt 12.03.2015	1. Students are trained to be more independent to generate new ideas for further academic research studying different physiological systems of invertebrates in-vivo and justifying the systematic positions of selected preserved invertebrate specimen based on their morphological features
23	Gr. A. Chordates Gr. B. Developmental Biology	2	ZOOG-P2T New course vide BoS dt 12.03.2015	1. The students may correlate between different bauplans of various vertebrate taxa and their utilities and may gather a fundamental knowledge on principles of development-life cycle. 2. Various genetic crosses to are desingned in classes to develop skill for analysing numerous biological phenomena, mostly adopting short question-answer mathod.

24	Laboratory Course	2	ZOOG-P2P New course vide BoS dt 12.03.2015	1. Lab based training is conducted to enhance skill for gathering knowledge on vertebrate anatomy, different developmental processes & genetic mechanisms. Evaluation includes regular submission of write-ups on each topic culminating lab note books finally.
25	Gr. A. Histology, Endocrinology, Animal Physiology & Biochemistry Gr. B. Ecology, Animal Behavior, Biodiversity & Wildlife	3	ZOOG-P3T New course vide BoS dt 12.03.2015	1. Students develop skills by theoretically understanding how and/or why an individual physiologically responds to various situations. Moreover, they become competent knowing how various physio-chemical techniques can be utilized to manoeuvre biomolecules, involved in life sustaining processes. 2. Students get exposure for developing analytical skills to implement ecological knowledge in designing conservational strategies and wild life management. This, in turn, is beneficial for getting admission to national institutes like FRI, WII etc. for higher studies and research.
26	Laboratory Course	3	ZOOG-P3P New course vide BoS dt 12.03.2015	1. Skills on Immunology, Animal Physiology, Ecology & Environment etc. are helpful for further studies and research
27	Gr. A. Applied Zoology Gr. B. Evolutionary Biology, Parasitology & Immunology	4	ZOOG-P4T New course vide BoS dt 12.03.2015	1. Gaining theoritical knowledge in different fields of Economic Zoology like Aquaculture, Sericulture, Lac Culture, Poultry etc. is helpful for getting jobs in organizations like Central Silk Board etc. and related industries. 2. Konwledge on host-parasite interaction and various immune cells, immune responses etc. are helpful for further study and research.

28	Laboratory Course	4	ZOOG-P4P New course vide BoS dt 12.03.2015	1. Hands-on training on routine assessment of human physiological parameters (viz. TC/DC/BP/Hb%) help students to get absorbed in various pathological labs. 2. In depth knowledge on pest management is also essential either to get jobs in related industries or freelance activities.

Course Content for Choice Based Credit System for Three Years B.Sc. (Honours Course), Zoology (2017 - 2020)

Ramakrishna Mission Vidyamandira, Belur Math

CORE COURSES

Semester -I: **Marks**

ZOOA- P1T

Gr A:	General characters and outline classification of different Non-Chordate phyla	50	10 Cr
Gr B:	Ultrastructure of a Cell	50	
Laboratory Course: (ZOOA – P1P) Demonstration including Mounting, Preparation & Identification of Non-Chordate specimens; Cytology		50	4 Cr
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		150	

Semester –II. **Marks**

ZOOA- P2T

Gr A:	Functional Anatomy of Chordates	40	10 Cr
	Major aspects of Developmental Biology	35	
Gr. B.	Genetics	25	
Laboratory Course: (ZOOA – P2P) Demonstration including Mounting, Preparation; Identification of Chordate Specimens; Genetics; Developmental Biology & Osteology		50	4 Cr
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		150	

Semester –III: **Marks**

ZOOA- P3T

Gr. A: 1.	Principles of Ecology	30	10 Cr
2.	Biodiversity, Wild life Management & Conservation	20	
Gr. B:	Molecular Biology	50	
Laboratory Course: (ZOOA – P3P) Ecology, Genomics & Proteomics, Field Study & Project		50	4 Cr
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		150	

Semester –IV: **Marks**

ZOOA- P4T

Gr A. Animal Physiology & Functional Histology	50	10 Cr
Gr B: Biochemistry and Biochemical instrumentation	50	
Laboratory course: (ZOOA – P4P) Animal Physiology & Histology; Enzymology Qualitative Biochemical Assays	50	4 Cr
	150	

Semester –V:	**Marks**	
ZOOA- P5T: Immunology and human diseases	50	6 Cr
ZOOA – P6T: Integration Biology & Homeostasis	50	5 Cr
ZOOA - P7T: An Approach to Biotechnology	50	5 Cr
Laboratory course: (ZOOA P8P**)** Immunology; Integration Biology & Homeostasis; Bioinformatics; Tools & Techniques of Biotechnology	75	5 Cr
Internship in Lab/Industry (ZOOA – P9P)	75	5 Cr
	300	

Semester –VI:	**Marks**	
ZOOA – P10T: Biostatistics and Economic Zoology	75	6 Cr
ZOOA – P11T Elementary ideas on Systematics, Evolution & Adaptation, Animal Behaviour as a process of life	75	6 Cr
Laboratory course: ZOOA – P12P Adaptation, dissertation, local excursion and grand viva voce	75	8 Cr
Discipline Specific Elective (ZOOA – P13DTA/P13DTB)	50	4 Cr
Laboratory course: (ZOOA – P13DPA/P13DPB)	25	2 Cr
	300	

Zoology Honours (Core Course content in details)

Semester –I: (150 Marks)

Core Course No. ZOOA- P1T: General Characters, Diversification and Outline Classification of different Non-Chordate Phyla, Ultrastructure of a Cell

Course Outcome (CO):

1. Development of clear concept on different invertebrate forms and their physiology.
2. Describing general taxonomic rules of non-chordate classification.
3. Classifying Protista up to phylum using examples from parasitic adaptation.
4. Development of concise ideas about the molecular aspects of cell functioning.

Course Details:

Group-A: Non Chordates (Full Marks - 50)

1. Early earth and the origin of life; Unicellularity to multicellularity and further advancement of body plan.Understanding life forms; Phylogeny and the tree of life; Darwin's theory of the evolution of populations; Concepts of species; Speciation.

2. Classification up to Phylum of Protozoa (according to Levine *et. al.,* 1981); from Phylum to living Subclass with reasons of other non-chordates (according to Ruppert and Barnes, 1994) (Invertebrate chordates excluded)

3. Locomotion - Microfibrils (*Amoeba*), (b) Flagella (*Euglena*), (c) Cilia (*Paramoecium*); Feeding & digestion – Microphagy (*Amoeba*), Nutrition in Protozoa; Reproduction - Fission (*Amoeba*); Conjugation (*Paramoecium*)

4. Structural organisation of *Sycon*; Canal system in sponges.

5. Polymorphism in Siphonophores and its evolutionary significance; Locomotion in *Hydra*; Reproduction – Budding (*Hydra*); Metagenesis (*Obelia*); Coral reefs – Types, distribution in India, conservation

6. *Fasciola:* life history, parasitic adaptations and evolution of parasitism; Excretion – Flame Cells (*Taenia*).

7. *Ascaris*: life history and parasitic adaptations.

8. Adaptive radiation in Polychaeta; Evolutionary significance of metamerism; Closed circulation and Excretion (Nephridia) in earthworm.

9. Feeding & Digestion - Macrophagy (*Periplaneta*); Foraging strategies in spiders; Respiration - respiratory pigments (Haemoglobin & Haemocyanin); gills, traechea and booklung (prawn, cockroach, spider); Open Circulation in Cockroach; Excretion - Malpighian tubules (cockroach), green gland (prawn); Sexual Reproduction (cockroach); Social life, moulting and metamorphosis in Insects.

10. Torsion and detorsion; modifications of shell and foot; Respiration - Ctenidium & pulmonary sac (*Pila*); Nervus system *Pila*; Neural Integration- integration of simple & complex nerve nets.

11. Larval forms, Water vascular system in *Asterias*.

12. Structural organization of Placozoans

Suggested readings:

a. Campbell, N.A. and Reece, J. B. (2008) Biology 8th Ed. Pearson Benjamin Cummings, San Francisco.
b. Raven, P.H et al (2006) Biology 7th edition Tata McGrawHill Publications, New Delhi.
c. Griffiths, A.J.F et al (2008) Introduction to Genetic Analysis, 9th edition, W.H. Freeman & Co. NY.
d. Barnes, R.D. Invertebrate Zoology (1982) 4th Edition. Holt Saunders International Edition.
e. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) The Invertebrates: A New Synthesis. 3rd Edition. Blackwell Science.
f. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. 2nd Ed. E.L.B.S. and Nelson.
g. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
h. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.

Group-B: Ultrastructure of a Cell (Full Marks - 50)

Course Details:

1. **Introduction to Cell Biology:** Overview of prokaryotic and eukaryotic cells; cell size and shape; Phages, Viriods, Mycoplasma and *Escherichia coli*. Prokaryotes, Eukaryotes & Archea; Molecule to cell; Properties & polarity of water molecule; Biomolecules; Macromolecules & Polymers; The study of carbon compounds & its importance; Chemical reactions; make or break chemical bonds; Cell metabolism.

2. **Tools and techniques of Cell Biology**
   Microscopy-Principles of Light microscopy; Phase contrast microscopy; Confocal microscopy; Electron microscopy (EM)- scanning EM and scanning transmission EM; Fluorescence microscopy.
   Analytical - Flow cytometry- flurochromes, fluorescent probe and working principle.

   Separation - Sub-cellular fractionation- differential and density gradient centrifugation.

3. **Composition of Cells:** Cell wall, Molecules of cell, cell membranes and cell Proteins.

4. **The Nucleus:** Nuclear Envelope - structure of nuclear pore complex, nuclear lamina; Transport across Nuclear Envelope; Chromatin: molecular organization, Nucleolus and rRNA processing.

5. **Protein Sorting and Transport:** The Endoplasmic reticulum; The Golgi Apparatus; Mechanism of Vesicular Transport; Lysosomes.

6. **Mitochondria, Chloroplasts and Peroxisomes:** Structural organization, Function, Marker enzymes, Mitochondrial biogenesis; Protein import in mitochondria; Semiautonomous nature of mitochondria and chloroplast; Chloroplast DNA; Peroxisomes' assembly.

7. **Cytoskeleton and Cell Movement:** Extracellular Matrix; Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules.

8. **Cell Signalling:** Signalling molecules and their receptor; functions of cell surface receptors; Intracellular signal transduction pathways

9. **Cell Death:** Brief outline and comparison between necrosis and apoptosis, Apoptotic signalling pathways (extrinsic and intrinsic) and significance.

Remarks:

1. Correlation between different bauplans of various invertebrate phyla and their utilities.
2. Formation of baseline knowledge for further multiple biological/medical disciplines.

Suggested readings:

a. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons.Inc.
b. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.

c. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

d. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

Laboratory Course
(Full Marks – 50)

Core Course No. ZOOA- P1P: Demonstration including mounting & preparation; identification of non-chordate specimens; Cytology

Course Outcome (CO):

1. Identification & knowledge gathering on cellular & sub-cellular levels of organisation.

2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Invertebrate Zoology as well as cell biology.

Course Details:

Cytology: (Two) Demonstration and description of compound microscope; Measurement of size (length/breadth) by micrometry of any Cell/organ/protozoa; Study of meiotic stages from Grasshopper. Separation of nucleic acid bases by Thin Layer chromatography (15 marks)

Study of internal organ systems of two non-chordate specimens (*Periplaneta & Pila)* (***Periplaneta***: Nervous system, Digestive system, Reproductive systems; ***Pila***: Digestive system, Nervous system). (10 marks)

Mounting and preparation (one): Mouth parts of cockroach; Radula & Osphradium of *Pila.* (5 marks)

Identification of Non Chordate Specimens with systematic position upto Genus (two) *Plasmodium vivax, Paramoecium,* Scypha, *Obelia,* Sea-anaemone, *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Ascaris, Hirudinaria,* Scorpion, *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Hirudo, Lamellidens, Achatina, Loligo, Chiton, Dentalium,* Starfish, *Cucumaria, Antedon* (7 marks)

Identification of the Larval Forms: (one) (3 marks)
Ephyra, Nauplius, Zoea, Mysis, Megalopa, Glochidium, Trochophore, Veliger, Bipinnaria

Lab Note Book and **Viva voce** (5+5 marks)

Remarks:

1. Developing skill on microscopy & micrometry.

2. Study of different physiological systems of invertebrates in-vivo.

3. Justifying the systematic positions of selected preserved invertebrate specimen based on their morphological features.

Semester –II: (150 Marks)

Core Course No. ZOOA- P2T: Functional anatomy of Chordates & Major aspects of Developmental Biology, Genetics

Course Outcome (CO):

1. Development of clear concept on different vertebrate forms and their physiology.
2. Classifying from Protochordates to Mammals properly.
3. Understanding complex vertebrate interactions.

4. Development of precise idea on early, late & post embryonic developmental phenomena in various model organisms.
5. Medical complications & their solutions during human development.
6. Learning principles and concepts of numerous elementary cytogenetic mechanisms including Mendelian and non Mendelian inheritance.

Course Details: Group-A (Full Marks - 65)

Unit 1: Functional anatomy of Chordates (40 marks)

1. **Chordate:** Introduction & Origin; Basic concept of chordate classification; Protochordate - General features and Phylogeny of Hemichordates, Urochordates and Cephalochordates; Agnatha - General features of living Agnathans and classification upto classes.
2. Classification up to living Subclass of Fish; up to living Order of Amphibia, Reptilia and Aves; up to Infra-class of Mammals (according to J. Z. Young 1981).
3. Structure of pharynx and feeding mechanism in *Branchiostoma* sp.
4. Metamorphosis in *Ascidia* – justification in the light of survival of the species
5. Comparative anatomy & structural organization of aortic arches in vertebrates.
6. Accessory respiratory structure in teleosts.
7. Receptor Biology: lateral line in fish.
8. Paedomorphosis with special reference to Axolotl larva.
9. Non-poisonous and poisonous snakes; Poison apparatus and biting mechanism of poisonous snake.
10. Distinguishing features of Ratites and Carinates; Feather of Birds – its type, development, structure, colour variations as adaptive feature and function.
11. Exoskeletal structure in Mammals – hair, horns and antlers; distinguishing features of Artiodactyla and Perissodactyla.
12. Functional anatomy of ruminant stomach in cow.
13. Evolution of urinogenital system in vertebrates
14. Echolocation in Bat

Suggested readings:

a. Kardong, K.V. (2005) Vertebrates Comparative Anatomy, Function and evolution. 4th Edition. McGraw-Hill Higher Education.
b. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. 9th Edition. The McGraw-Hill Companies.
c. Young, J.Z. (2004). The life of vertebrates. 3rd Edition. Oxford university press.
d. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. 4th Edition. Jones and Bartlett Publishers,Inc.

Unit 2: Major aspects of Developmental Biology (35 marks)

1. **Introduction:** History, Principles of development, developmental patterns; Role of genes in development; Major signalling pathways during early development (Notch, Hedgehog, Wnt); Developmental plasticity and polyphenism; Experimental embryology; Amniocentesis.
2. **Early Embryonic Development:** Gametogenesis- Spermatogenesis and oogenesis; Types of eggs; Fertilization- changes in gametes, mono- and polyspermy; The early development of *C. elegans*; The early development of *Xenopous*- cleavage, Gastrulation, Embryonic induction and organizers; The early development of chick-cleavage; Gastrulation.
3. **Later Embryonic Development:** Differentiation of germ layers- Formation of neural tube (development of CNS and eye), skin, notochord, somites, coelom and digestive tube (up to

rudiments); Fate Map; Extra embryonic membranes in birds and human; Implantation of embryo; Placentation – structure, types and physiology of placenta.

4. **Post-Embryonic Development:** Metamorphosis- changes and hormonal regulation of metamorphosis in insects and amphibians, Regeneration - modes of regeneration- epimorphosis; Morphallaxis and compensatory regeneration (with one example), Concept of Ageing and model (*C. elegans*).
5. **Implications of Developmental Biology:** Medical implications: Infertility –Diagnosing Infertility, IVF, Teratogenesis – teratogenic agents and effect of teratogens on embryonic development.
6. **Stem Cell:** ES and adult stem cell - characteristic features; definition of potency and niche; markers in human stem cell; potential application of stem cells as regenerative medicine.

Suggested readings:

a. Gilbert, S. F. Developmental Biology, 11th Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
b. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
c. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

Group - B (Full Marks – 25)

Genetics

Course Details:

1. **Mendelian Genetics and its Extension:** Principles of Inheritance; Chromosome theory of inheritance; Laws of Probability; Pedigree analysis; incomplete dominance and co-dominance; Multiple alleles; Lethal alleles; Epistasis; Pleiotropy; Environmental effects on phenotypic expression; sex linked inheritance; Polytene Chromosome & Lampbrush Chromosome.

2. **Linkage, Crossing Over and Chromosomal Mapping:** Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over; Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence; Somatic cell genetics – an alternative approach to gene mapping.

3. **Mutations:** Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Attached X method, DNA repair mechanisms.
4. **Chromosomal Aberration**: Types and examples from *Drosophila* and human only.

5. **Population Genetics**: Brief idea of Hardy-Weinberg equilibrium; calculating allele & genotype frequency, mathematical calculation of frequency changes in mutation, migration.

6. **Sex Determination:** Chromosomal mechanisms, Environmental factors effecting sex determination, Barr bodies, Dosage compensation - *Drosophila*: Hyper activation of ♂*X* by *msl, mle* and *roX* RNA followed by *histone Ac16* acetylation; Human: Inactivation of ♀*X* by *XIST* RNA followed by DNA methylation

Remarks:

1. Correlation between different bauplans of various vertebrate taxa and their utilities.

2. Fundamental knowledge formation on principles of development-life cycle.

3. Theoretical skill development to design various genetic crosses to establish numerous biological phenomena.

Suggested readings:

a. Strickberger,M.., Genetics 3rd edition.
b. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). 8th Ed. Principles of Genetics. Wiley India.
c. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. 5th Edition. John Wiley and Sons Inc.
d. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. 9th Edition. Benjamin Cummings.
e. Russell, P. J. (2013). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
f. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
g. Pevsner, J. (2009). Bioinformatics and Functional Genomics. 2nd Edition. John Wiley & Sons.
h. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. 9th Edition. Introduction to Genetic Analysis. W. H. Freeman and Co.

Laboratory Course
(Full Marks – 50)

Core Course No. ZOOA-P2P: Demonstration including mounting & preparation; Identification of Chordate Specimens; Genetics; Developmental Biology & Osteology

Course Outcome (CO):

1. Gathering knowledge on different developmental processes & genetic mechanisms

2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Vertebrate Zoology by considering their skeletal systems.

Course Details:

a) Study of internal organ systems of a chordate specimens (*Oreochromis*: Digestive & Urinogenital systems). (10 marks)

b) Mounting and preparation (one) (5 marks)

i) Placoid scale of *Scoliodon* sp, and Ctenoid scale of fin fish.
ii) Olfactory apparatus of *Oreochromis.*

c) Identification of Chordate Specimens with systematic position upto Genus (two)
Branchiostoma, Petromyzon, Labeo, Anabas, Exocoetus, Scolidon, Rhacophorous, Ichthyophis, Necturus, Varanus, Draco, Axolotl larva, *Tylototriton, Hemidactylus, Naja,* Chiroptera. (5 marks)

d) Identification of bones with reasons: (a) Skull of *Calotes*, a poisonous snake, *Chelonia, Columba, Cavia* (b) Vertebrae of *Columba* & *Cavia* (c) Appendicular bones of *Columba* & *Cavia* (d) Girdle bones of *Columba* & *Cavia* (5 marks)

1. a) Chick - Study of developmental stages - primitive streak 24h, 48h, 72h, 96h by raising chick embryo in the laboratory. (7.5 marks)

b) Fish – Study of developmental stages

2. a) Mendelian laws and gene interaction using *Drosophila* crosses. (10 marks)
   b) Study of Linkage, recombination, gene mapping using marker based data from *Drosophila*.
   c) Study of Human and *Phlox/Allium* Karyotype (normal and abnormal).
   d) Pedigree analysis of some human inherited traits.
   e) Preparation of Polytene Chromosome form *Drosophila* larva

3. **Lab Note Book & Viva-voce** (7.5 marks)

Remarks:

1. Predicting inheritance pattern of different genetic trait by means of pedigree analysis.

2. Study of different physiological systems of vertebrates' in-vivo.

3. Justifying the systematic positions of selected preserved vertebrate specimen based on their morphological features.

Semester –III: (150 Marks)

Core Course No. ZOOA – P3T: Principles of Ecology; Biodiversity; Wild life Management & Conservation, Molecular Biology

Course Outcome (CO):

1. Learning the basic biological principles and processes to understand ecology and environment and their proper functioning.
2. Understanding distribution of fauna in different realms and their mutual interaction.
3. Studying interaction between biotic and abiotic factors.
4. Developing idea on numerous protected zones in wildlife, different conservation strategies and WPA.
5. Developing knowledge of underlying molecular mechanisms of various genetic and cellular phenomena.

Course Details:

Group-A (Full Marks - 50)

Unit 1: Principles of Ecology **(30 marks)**

1. **Introduction to Ecology:** Relevance of studying ecology, its history, autecology, Population, Community.

2. **Ecosystem, Biome, Biosphere and Ecosphere:** Definition, types and examples of ecosystems; Abiotic Factors: Laws of limiting factors- Liebig's law of minimum and Shelford's law of tolerance; a brief account of light and temperature as limiting factors; soil types and soil erosion; Energy flow through an ecosystem- food chains, food web, trophic levels, grazing and detritus type of food chains, Y-shaped food chain in forest; one example of food web- Terrestrial or Aquatic.

3. **Population & its Growth:** Unitary and modular populations, its unique and group attributes - population density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio. Population dispersal and distribution; Exponential/Malthusian and Sigmoid growth patterns, Verhulst-Pearl growth equation, 'r' and 'k' strategies; Animal's space and resource use; Resource partitioning; Coupled oscillations of predator and prey population – modelling.

4. **Population Growth Regulation:** Intrinsic mechanism- Density dependant fluctuations and oscillations; Extrinsic mechanism- Density independent, environmental and climatic factors; Population interactions- types in a tabular form with examples; Niche concept, Gause's principle of competitive exclusion with laboratory and fied examples, Lotka Volterra Equation for prey predator interaction.

5. **Community Structure & Function:** Characteristics of community diversity, diversity index, types of biodiversity species richness, abundance, species area relationship, community stratification, ecotone/edge effect; Succession, stages of primary succession, climax community, Connell and Slatyer' model of succession; Tilman's resource-ratio hypothesis; brief idea on El nino, La nina and their consequences.

Unit 2: Biodiversity; Wild life Management & Conservation: (20 marks)

1. Types of biodiversity, biodiversity and human welfare, mega diversity zones and biodiversity hot spots with special reference to India

2. Nature & natural resources; Depletion of resources; Generation of waste; types (agricultural, municipal, industrial); Management of wastes and disposal (emphasis on concepts of reduce, reuse and recycle); Pollution of air, water, soil, noise, and due to radioactive substances; Causes and methods of prevention and control; Eutrophication; Bioremediation.

3. Concept of wildlife, wildlife heritage of India, reasons for wildlife depletion in Indian context; Concept of threatened fauna – IUCN categories.
4. Protected area concept – Sanctuary, National Park, Biosphere reserve, Core Zone, Buffer Zone, Corridor concept; Conservation reserves; Principles of GPS.
5. Animal cruelty and prevention act; Scheduled I of wild life protection Act, 1972 and importance of schedules in conservation.

6. JFM & Arabari model for conservation – key stone, flagship and umbrella species; Special management program with special reference to Tiger project.
7. Man–animal conflict (man-tiger and man-elephant) – causes and concern.
8. Basic idea of Ecotoxicology and Xenobiotics; Environmental audit and impact assessment; Role of NGO's in wildlife conservation in India.

Suggested readings:

a. Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.
b. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
c. Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
d. Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
e. Joseph, B., Environmental studies, Tata Mc Graw Hill.
f. Mohapatra Textbook of Environmental Biotechnology IK publication.
g. Thakur, I. S., Environmental Biotechnology, I K Publication.
h. Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
i. Michael Allabay, Basics of environmental science, Routledge Press.
j. Rana SVS, Environmenta lpollution – Health and Toxicology, Narosa Publication.
k. Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5th edition) Books/Cole, ThompsonLearning, Inc.
l. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and applications (2nd edition) Cambridge UniversityPress.
m. Ghosh, S.K., Singh, R. 2003. Social forestry and Forest Management. Global Vision Pub

Group-B (FM - 50)

Molecular Biology

Course Details:

1. **Properties of DNA:** Chargaff's rule, Renaturation and Denaturation, Hyper-chromic shift, c-value paradox.
2. **DNA Replication: In prokaryotes:** Semi-conservative replication; unit of replication; enzymes involved, replication origin, replication fork, replication slippage; **In eukaryotes:** Origin, polymerase enzymes and telomeric replication.

3. **Transcription in prokaryotes and eukaryotes**: Transcription factors: Transcription activators, Repressors, Motifs (only Basic helix loop helix [BHLH], Leucine zipper – definition and example).
   ii. Formation of initiation complex (in Prokaryotes and RNA Polymerase II in Eukaryotes).
   iii. RNA polymerase, chain elongation and termination.

4. **RNA processing**: Polyadenylation, methyl capping, splicing.

5. **Protein synthesis in prokaryotes**: Formation of initiation complex, initiation factors, elongation and elongation factors, termination.

6. **Regulation of gene expression**: Operon concept (inducible and repressible viz. Lac and Tryptophan operon).
7. **Epigenetic regulation of gene expression**: DNA methylation (CpG) and histone acetylation. Genomic imprinting, Human Disease.
8. **Recombination**: Homologous recombination, Holliday Model of recombination, definition and example of site specific and transpositional recombination; Gene conversion.

9. **DNA repair mechanism**: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.
10. **Transposable Genetic Element**: Concept of transposon and retrotransposon, Characteristic features of IS element in bacteria, SINE and LINE element in mammals and their role in chromosomal aberration.
11. **Cell cycle & cancer genetics**: Concept of cell cycle check points and molecular regulation; concept of normal and transformed cell; role of proto-oncogene, tumour suppressor genes, Molecular mechanism of proto-oncogene activation.
12. **Molecular basis and detection technique for human genetic disorders**: Sickle cell Anemia, Thalassemia, Hemophilia.

Remarks:

1. Development of analytical skills to implement ecological knowledge in designing conservational strategies and wild life management.
2. Foundation for theoretical understanding of various genetic mechanisms and abnormalities by means of cutting edge molecular techniques.

Suggested readings:

a. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Ed. John Wiley & Sons.Inc.
b. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th Ed. Lippincott Williams and Wilkins, Philadelphia.
c. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
d. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., 2008 Molecular Biology of the Gene 8th edition. Cold Spring Harbour Lab. Press, Pearson Pub.

Laboratory Course
(Full Marks – 50)

Core Course No. ZOOA – P3P: Ecology, Genomics & Proteomics, Field Study:

Course Outcome (CO):

1. Conducting a local excursion to obtain and record various data and their subsequent analysis to holistically understand Ecology in silico.

2. Perform modern molecular genetic techniques to co-relate theoretical molecular genetics knowledge.

Course Details:

1. (a) Determination dissolved oxygen & carbon dioxide in a water sample **(15 marks)**
   (b) Use of pH meter for estimation of pH in water and soil samples

(c) Identification of soil arthropods & Zooplanktons

2. (a) Protein isolation & gel electrophoresis (SDS & Native PAGE); Western Blot Technique
(b) Isolation of DNA & quantification by Agarose Gel Electrophoresis

(15 marks)

3. **Lab Note Book & Viva-voce** **(10 marks)**
4. **Field Note Book & Viva-voce** **(10 marks)**

Remarks:

1. Learning how to obtain ecological data in silico and their analysis by means of various statistical tools.

2. Learning isolation of biological molecules (DNA and Protein) and their quantitative analysis using modern tools and techniques.

Semester –IV: (150 Marks)

Core Course No. ZOOA – P4T: Animal Physiology & Functional Histology, Biochemistry and Biochemical Instrumentation

Course Outcome (CO):

1. Learning principles and concepts of basic physiological processes to relate the various levels of organization and interaction amongst them to ensure proper functionality of an individual.
2. Development of bio-chemical background in various life sustaining processes.
3. Developing physiological and biochemical understanding through scientific enquiry into the nature of mechanical, physical, and biochemical functions of humans, their organs, and the cells of which they are composed.
4. Understanding interactions and interdependence of physiological and biochemical processes.

Group-A (Full Marks - 50)

Course Details:

1. **Introduction:** Introduction to animal physiology - Elementary ideas of size & scaling

2. **Digestive System:** Outlines of structure & functions of gastrointestinal tract and histology of liver & pancreas; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins.

3. **Respiratory System:** Structure & function of trachea and lung; Pulmonary ventilation; Respiratory volumes and capacities; Structure & function of haemoglobin; Transport of oxygen in the blood (oxygen-haemoglobin dissociation curve and its influencing factors), Carbon monoxide poisoning; Carbon dioxide transport in the blood; Bohr and Haldane effect, Chloride shift.

4. **Excretory System:** Histology of kidney; Mechanism and regulation of urine formation; Regulation of acid-base balance; nitrogenous wastes- ammonia, urea, uric acid, creatinine.

5. **Heart:** An outline structure of heart; Outlines of systemic, pulmonary and coronary circulations; Cardiac cycles; Blood pressure and its regulation; Electrocardiogram, portal circulation, Coagulation of blood.

6. **Muscle:** Comparative account of different types of muscles; Ultrastructure of skeletal muscle; Molecular and chemical basis of muscle contraction

7. **Reproductive System:** Structure & physiology of male and female reproductive systems; Histology of testis & ovary; puberty, pregnancy

8. Neuron resting membrane potential and its basis; Origin of action potential and its propagation in myelinated and unmyelinated nerve fibers, Synaptic transmission and types of synapsis, Neuromuscular junction; Reflex activity-reflex arc; Types of reflexes.

9. Physiology of vision & hearing in human

10. Physiology of hibernation and aestivation with reference to amphibians, reptilians and gastropods, Thermoregulation & Osmoregulation in vertebrates.

[N.B. Brief account of alterations in respective systems in acoelomate, coelomate, exclusively aquatic vertebrate and mammals.

Suggested readings:

a. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
b. Pevsner J. (2009) Bioinformatics and Functional Genomics. 2nd Ed. Wiley-Blackwell.
c. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. 2nd Ed. Benjamin Cummings.
d. Bialek W. (2012) Biophysics: Searching for Principles. Princeton University Press, NJ.
e. Cotterill R. (2002) Biophysics: An Introduction. John Wiely & Sons Ltd. West Sussex.

Group-B (Full Marks 50)

Biochemistry and Biochemical Instrumentation

Course Details:

1. **Carbohydrates:** Structures and properties of important mono-, di- and polysaccharides.

2. **Lipids:** Structures, properties and functional significance of fatty acids, triglycerides and steroids.

3. **Amino acids and Proteins:** Structure and general properties of amino acids, four levels of structures in proteins; metabolism of amino acids; transamination and oxidative and non-oxidative deamination; Nucleic acid metabolism – Purine salvage pathway.

4. **Carbohydrate Metabolism:** Glycolysis, Fermentation, Citric acid cycle, pentose phosphate pathway, Gluconeogenesis, Shuttle systems (Malate-aspartate shuttle, Glycerol 3-phosphate shuttle, and Cori cycle), Glycogen metabolism.

5. **Lipid Metabolism:** Biosynthesis and β-oxidation of saturated (Palmitic acid) & unsaturated (Linoleic acid) fatty acids, Ketogenesis, Types and properties of lipoproteins.

6. **Protein Metabolism:** Catabolism of amino acids: Transamination, Deamination and Urea cycle, Fate of glucogenic and ketogenic amino acids with examples of serine and leucine respectively.

7. **Intermediary Metabolism:** Inter-relationship of carbohydrates, lipid and protein metabolism.

8. **Enzymes:** Introduction, kinetics, mechanism of action, inhibition, allosteric enzymes.

9. **Oxidative Phosphorylation:** Oxidative phosphorylation in mitochondria, Respiratory chain, ATP synthase, Inhibitors and Uncouplers.

10. **Neuro-transmitter:** Structure and function of neuro-transmitter: **glutamate**, γ-aminobutyric acid (**GABA**), **dopamine** (DA), **norepinephrine** (**noradrenaline**; NE, NA), epinephrine (adrenaline)

11. **Spectrophotometry and separation;** Mass spectrometry; NMR, X-ray diffraction analysis; Chromatography paper, thin-layer, gel-filtration, ion-exchange, affinity and High-Performance Liquid Chromatography (HPLC).

Remarks:

1. Theoretically understand how and/or why individual physiologically responds to various situations
2. Theoretically understand how various physio-chemical techniques can be utilized to manoeuvre biomolecules, involved in life sustaining processes.

Suggested readings:

a. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. 6th Ed. W.H Freeman and Co.

b. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. 4th Ed. W.H Freeman and Co.

c. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry. 28th Ed. Lange Medical Books/McGraw-Hill.

Core Course No. ZOOA – P4P: Animal physiology and Histology, Enzymology, Qualitative Biochemical Assays **(Full marks 50)**

Course Outcome (CO):

1. Learning the practical knowledges to analyse different biochemical samples and assess the presence of macro and/or micro molecules therein.

2. Estimation of various haematological and physiological parameters by means of elementary equipment's

Course Details:

1. Animal physiology and Histology **(Full marks 15)**

(a) Enumeration of red blood cells using haemocytometer.
(b) Estimation of haemoglobin using Sahli's haemoglobinometer.
(c) Recording of blood pressure using a sphygmomanometer.
(d) Identification of stages of oestrous cycle in white rat
(e) Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum, liver, spleen, trachea, lung, kidney.

2. **Enzymology:** **(Full marks 10)**

a. Study of the action of salivary amylase at optimum condition.

b. Effect of pH on the action of salivary amylase.

c. Effect of temperature on the action of salivary amylase.

d. Effect of inhibitor on the action of salivary amylase.

e. Study the activity of Trypsin using fresh tissue extracts.

3. **Qualitative techniques:** **(Full marks 10)**

Qualitative tests for Carbohydrate (Starch, Sucrose, Maltose Fructose, Glucose), Protein (Albumin, Gelatin, Peptone), fat, uric acid (in Alkaline solution) and urea (Tests to be performed – Red Litmus Test, Hypobromite test, Biuret test, Millon's test, Iodine test, Benedict's test, Barfoed test, Seliwanof's test); Quantitative Techniques - Colorimetric estimation of glucose & total protein in the given solution.

4. Lab note Book & Viva voce **(Full marks 15)**

Remarks:

Development of practical skills to perform

1. Quantitative and qualitative biochemical estimation of unknown biochemical samples.

2. Routine assessment of human physiological parameters (TC/DC/BP/Hb%)

Semester –V: (300 Marks)

Core Course No. ZOOA – P5T: Immunology & Human diseases **(Full marks 50)**

Course Outcome (CO):

1. Learning the fundamental basis of how organisms react to biological foreign agents.
2. Understanding different types of immunity.
3. Studying interactions of antigens, antibodies, complements and other immune components.
4. Understanding of immune mechanisms in disease control, vaccination, process of immune interactions.
5. Understanding the basis and mechanism of various parasite mediated and physiological diseases.

Course Details:

1. **Overview & Components of Immune system**
   Historical perspective of Immunology, Early theories of Immunology; Innate, Adaptive (cell mediated and humoral); Passive: Artificial and Natural Immunity, Active; Host parasite interaction

2. **Cells and Organs of the Immune System**
   Haematopoesis and role of haematpoietic factors, Cells of the immune system, Organs of the Immune system; Primary and Secondary lymphoid organs, Lymphatic system.

3. **Antigens:** Antigenicity and immunogenicity, Immunogens, Adjuvants and Haptens, Factors influencing immunogenicity, B and T-cell epitopes.

4. **Immunoglobulins:** Structure and Functions, Basic structure, deducing antibody structure, classes and function, Antigenic determinants on immunoglobulins, Antigen-antibody interactions, Polyclonal sera, Monoclonal antibodies, Hybridoma technology.

5. **Major Histocompatibility Complex:** Structure, polymorphism and functions, MHC and immune responsiveness.

6. **Antigen Processing and Presentation:** The cytosolic pathway: endogenous pathway and the endocytic pathway and exogenous pathway.

7. **Immune Effectors Mechanisms:** Cytokines: properties and functions, general structure of cytokine receptors, Complement system: components, activation and functions.

8. **Hypersensitivity:** Gell and Coombs classification, IgE mediated (type I), antibody mediated (type II), Immune complex mediated (type III) and T- DTH mediated hypersensitivity (type IV).

9. **Immune System in Health & Disease:** Vaccines: bacterial, viral, toxoid and III generation vaccines, Immunodeficiency, Autoimmunity. Allergen

10. Epidemiology of infectious diseases, transmission, prevention and control of diseases: Amoebiasis, Dengue, Leishmaniasis, Cholera.

11. Life history and pathogenicity of *Schistosoma* and *Ancylostoma duodenale*

12. Pathobiology of Liver Cirrhosis, Alcoholic cirrhosis, Biliary cirrhosis, Haemochromatosis, Wilson's disease, Rheumatoid Arthritis.

Remarks:

Theoretically understand how humans resist pathogenic interference. Also, how individuals can be benefitted by various immuneopreventive and immunotherapeutic approaches.

Suggested readings:

a. Kindt, T. J., Goldsby, R. A., Osborne, B. A., Kuby, J. (2006). VI Edition. Immunology. W.H. Freeman and Company.
b. Delves, P. J., Martin, S. J., Burton, D. R., Roitt, I.M. (2006). XI Edition. Roitt's Essential Immunology,Blackwell Publishing.

Suggested readings:

a. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. 9th Ed. Hercourt Asia PTE Ltd. / W.B. Saunders Company.
b. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. 11th Ed. John wiley & sons, Inc.
c. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional Correlations. 12th Ed. Lippincott W. & Wilkins.
d. Arey, L.B. (1974). Human Histology. 4th Ed. W.B. Saunders.

Core Course No. ZOOA – P6T: Integration Biology & Homeostasis **(Full marks 50)**

Course Outcome:

1. Development of precise knowledge on how an individual react to various internal and external conditions by means of chemically integrating and modulating various physiological processes.
2. Understanding principles of bioluminescence & biological rhythm.

Course Details:

1. Structure and functions of endocrine glands; Nature of hormones; Regulation of hormone secretion; Mode of action of hormones; Signal transduction pathways utilized by steroidal and nonsteroidal hormones; Hypothalamus- principal nuclei involved in control of endocrine system, control of anterior pituitary hormones by hypothalamic releasing hormones (neuroendocrine mechanisms); Effects of abnormal secretions of hormones; Placental hormones.

2. **Hormones and their integration**
    a. General concept of hormone action and receptors.
    b. Chemical messengers – kiromones, synomones, info-chemicals, semio-chemicals – their types, mode of action and behavior modulation.
    c. Homeostasis of Ca++ regulation and Blood glucose regulation.
    d. Mechanism of hormone action (cAMP, ip3, DAG, TRK, Steroid hormones and Thyroxine) neuro-hypophysis, adenohypophysis, hypothalamic regulatory peptides, endocrine tissues of the gastrointestinal endoderm.
    e. Biosynthesis, secretion, mode of action, functional significance and regulation of T3, T4, Adrenalin, Nor-adrenalin, Insulin and Glucagon.
    f. Insect hormones – neuro-endocrine regulation of diapauses and metamorphosis.
    g. Environmental signaling in sex reversals in fish and molluscs – role of endocrine disruption and signals.
    h. Endocrine regulation of oestrous and menstrual cycle.
    i. Gut-Brain axis. (Ghrelin and leptin)

3. Biological light production in animals
    a. Chemistry of bioluminescence in insect and it significance
    b. Electric organs in electric rays

4. Biological rhythm – concept, types and its control by pineal and SCN

Remarks:

Foundation for theoretical understanding the release, mode of action, regulation and abnormal manifestation of various chemical messengers in vivo.

Suggested readings:

a. Fox T, Brooks A, Baidya B. (2015). Endocrinology. JP Medical, London.
b. Gardner DG, Shoback D. (2011). Greenspan's Basic and Clinical Endocrinology. McGraw Hill Lange.
c. Goodendocr man HM. (2000). Basic Medical Endocrinology. Academic Press.
d. Jameson JL. (2010). Harrison's Endocrinology. McGraw Hill
e. Melmed S, Conn PM. (2005). Endocrinology: Basic and Clinical Principles. Humana Press.
f. Melmed S, Polonsky K, Larsen PR, Kronenberg H. (2016). William's Text Book of Endocrinology. Elsevier.
g. Molina PE. (2013). Endocrine Physiology. McGraw Hill Lange.

Core Course No. ZOOA – P7T: An Approach to Biotechnology **(Full marks 50)**

Course Outcome (CO):

1. Learning how the basic molecular genetic mechanisms can be modulated for various bio-medical, research and economic benefits.
2. Learning principles of animal cell & tissue culture.

Course Details:

Introduction: Concept and scope of Biotechnology, Tools and techniques in Biotechnology.

Animal Cell and Tissue Culture: Cell lines, Procedure and principles of mammalian Cell culture, Primary cell culture, Cryopreservation of cells.

Transgenic Organisms:
Definition, Process: Retroviral method, DNA microinjection method, Production of transgenic plants: *Agrobacterium* mediated transformation, Applications of transgenic plants and animals, Ethical issues of transgenic animals. Organismal cloning, significance and problems.

Molecular Cloning: Restriction enzyme: Types and use in gene cloning; Cloning vectors: Characteristic features, Plasmid vector (pBR322, pUC19), Cosmid, phage vector, Yeast artificial chromosome. Concept of expression and Shuttle vector, DNA sequencing (Maxam-Gilbert and Sanger methods), Polymerase chain reaction and DNA microarrays.

Applications of Biotechnology: Molecular diagnosis of genetic diseases (Cystic fibrosis, Huntington's disease, Sickle cell anemia), RFLP, RAPD and DNA fingerprinting, Recombinant DNA in medicines (recombinant insulin and human growth hormone), Gene therapy, Enzymes in detergents and leather industries, Heterologous protein production, Bioremediation.

Patenting & Biosafety: Intellectual property rights, Biosafety levels and guidelines.

Remarks:

Theoretically correlate the understanding of the cutting edge molecular and advanced biological tools and techniques and application in various aspects of human welfare.

Suggested readings:

a. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
b. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. 9th Ed.Freeman & Co., N.Y., USA.
c. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA-genes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.
d. Watson, J.D., Gilman, M., Witkowski, J. and Zoller, M., (1983) Recombinant DNA. 2nd Ed. Freeman and Co., N.Y., USA.
e. Butler, M. (2004). Animal cell culture and technology: The basics. 2nd Ed. Bios scientific publishers.
f. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. 2nd Ed. Academic Press, California, USA.

Laboratory Course (Full Marks – 150)

Core Course No. ZOOA – P8P: Immunology; Integration Biology & Homeostasis; Bioinformatics; Tools & Techniques of Biotechnology: (Full Marks 75)

Course Outcome (CO):

1. Performing sophisticated experimentations using advanced Biotechnological tools & techniques
2. Develop the practical skills analyse different haematological and immunological samples to assess various parameters.
3. Learning basic principles of Bioinformatics

Course Details:

1. **Immunology, Histology & Endocrinology (Full marks 20)**
   a. Dissection and display of lymphoid organs.
   b. Determination of ABO Blood Group
   c. Preparation of single cell suspension of spleen.
   d. Viability and cell counting of peritoneal macrophages.
   e. To perform Enzyme-linked immunosorbent assay (ELISA) (no quantification required)
   f. Identification of stages of oestrous cycle in white rat
   g. H-E staining & mounting of histological tissue sections

2. (a) Preparation of LB Amp plates and LB media **(Full Marks 20)**

(b) Transformation of E. Coli (pUC 18/19) and calculation of competency of bacterial cells; Plasmid DNA isolation (pUC 18/19) by Qiagen midi kit and DNA quantification by spectrophotometry.

(c) PCR amplification of DNA fragments from genomic DNA isolated from animal cell line and confirmation by agarose gel electrophoresis.

(d) DNA purification from agarose gel using gel extraction kit.

(e) DNA ligation in TA cloning vector using DNA ligase, followed by bacterial transformation and selection of transformants on X-gal and IPTG.

(f) Plasmid DNA isolation from positive clones using Qiagen midi kit and DNA quantification by spectrophotometry.

(g) Restriction digestion of TA vector (with the cloned insert) by restriction endonucleases (KpnI/Hind III) and confirmation by agarose gel electrophoresis.

3. **Bioinformatics (Full marks 15)**

1. Biological Sequence Databases (Overview only)
2. National Center for Biotechnology Information (NCBI); DNA Data Bank of Japan (DDBJ); Protein Information Resource (PIR); Swiss-Prot: Introduction and Salient Features.
4. Primer design and validation
5. Sequence Alignments
6. Concept of Alignment, BLAST, FASTA

4. Lab note Book & Viva voce (Full marks 20)

Remarks:

Development of practical skills to perform

1. Human blood group determination from blood samples.
2. Quantitative estimation of various antigens from various biological samples.
7. Designing primer to clone gene of interest by means of various biotechnological software.
8. To perform all the steps to clone the sequence of interest using advanced Biotechnological tools & techniques.
9. All of the skills mentioned above are useful to get employment in pharmaceutical & biomedical sectors, especially at their R & D divisions.

Core Course No. ZOOA – P9P: Internship in Laboratory/Industry (Full Marks 75)

Course Outcome (CO):

10. An exposure to pursue a project under a functioning laboratory condition.
11. Developing expertise to handle different instruments.

Remarks:

1. Inculcating basic ideas of fundamental research under able guidance.

Semester –VI: (300 Marks)

Core Course No. ZOOA – P10T: Biostatistics and Economic Zoology (Full Marks 75)

Course Outcome (CO):

1. Learning the theoretical skills to establish any biological phenomena by statistically assessing the experimental data
2. Learning the basis to understand life cycle & physiology of various bioresources and applying such knowledge scientifically for human welfare.
3. Understanding concepts of fisheries, fishing tools and site selection.
4. Understanding processes of Silk moth rearing, silk production & Mulberry cultivation, Lac culture, Apiculture etc. and their economic values.
5. Developing clear idea about pest management and its importance.

Course Details:

1. Biostatistics: (25 marks)

a. Experimental project work and Data Analysis – Mean, Mode, Median, Probability, Hypothesis testing (Chi-square, t-test. Correlation test)
b. Measures of central tendency. Measures of dispersion; skewness, kurtosis. Elementary Probability and basic laws.
c. Normal distribution. Sample mean and Sampling variance. Hypothesis testing using standard normal variate, ANOVA

2. Economic Zoology: (50 marks)

a. ***Sericulture*:** Characteristics of sericulture industry and its scope; types of silk moths/ worms, (scientific names), host plants and improvement and their variety. Life history and rearing of *Bombyx mori*, harvesting & processing of cocoon, reeling and extraction of silk, pest on mulberry plants and diseases of worms of *Bombyx mori* and control measures. Research & development of sericulture in India.
b. ***Aquaculture*:** Principles, definition and scope. Fisheries resources of India (inland & off-shore) and their important ichthyofauna. Exotic fishes- their merits and demerits. Fish breeding and their application. Different aquaculture processes (Polyculture and integrated farming); pearl culture, culture of prawn and shrimps. Recirculating aquaculture system. Ornamental fish.
c. ***Pest and Management:*** Definition and types of pests with examples. Life history, behaviour, ecology, damage and control of the following pests: i) Paddy *Scirpophaga* (Syn. *Tryporyza*) *incertulas, Heliothis armigera.* ii) Stores grain-*Sitophilus oryzae*/ *Corcyra cephalonica, Trogoderma granarium/ Callosobruchus chinensis.* iii) Termite, iv) Mammalian pest (*Bandicota bengalensis*). Integrated Pest Management, Classification of insect control with reference to chlorinated hydrocarbons, organophosphates, carbamates and synthetic pyrethroid;

d. ***Apiculture*:** Development of Apiary in India. Types of honey bees, modern methods of apiary management, products and its uses. Problems and prospects.
e. ***Lac culture*:** Lac insect (Scientific name). Composition of Lac. Strains of lac insects, cultivation of lac, lac host plants (name only), Processing of lac and uses.
f. ***Poultry*:** Duck and fowl - Types of breeds, rearing and disease management.
g. ***Vermicomposting***
h. ***Ecosystem services***

Remarks:

1. Learning to assess & analyse biological data as per need.

2. Theoretically correlate the physiology, behaviour, problems of various bio-resources (fish, annelids, arthropods etc.) and their manipulation for earning revenues and/or human welfare.

Suggested readings:

a. Park, K. (2007) Preventive and social medicine. XVI Edition. B.B Publisher.
b. Arora, D.R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributers.
c. Chaudhury, S.K. (1996) Practice of fertility Control, A Comprehensive Textbook. B.I.Churchill Livingston Pvt Ltd, India.
d. Hafez, E. S. E. (1962). Reproduction in Farm Animals. Lea & Fabiger Publisher.
e. Hafez, E. S. E. and Evans, T. N. (1973). Human Reproduction: Contraception and Conception. Harper and Row, New York.
f. Atwal, A. S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
g. Pradhan, S (1983) Insect Pests of Crops. National Book Trust, India.
h. Prost, P.J. (1962) Apiculture. Oxford and IBH, New Delhi.
i. Knobil, E. & Neill, J.D. (2006) The Physiology of Reproduction, Vol. 2, Elsevier Pub.
j. Methods in Biostatistics: For Medical Students and Research Workers (9th Ed.), Mahajan, B. K., Jaypee Brothers Medical Publishers

Core Course No. ZOOA – P11T: Elementary ideas on Systematics; Evolution and Adaptation; Animal Behaviour as a process of life **(Full Marks 75)**

Course Outcome (CO):

1. Learning the theoretical skills to taxonomic assessment of different animals correlating their evolutionary background as well as behavioural pattern.
2. Gaining knowledge regarding the various theories of evolution, evolutionary process such as variation, speciation, natural selection, origin of primates and man.
3. Learning basic principles of animal taxonomy, systematics, classification, speciation etc.

Course Details:

1: Elementary ideas on Systematics **(25 marks)**

1. Taxonomy – Levels of taxonomy (alpha, beta and gamma taxonomy, micro and macro taxonomy), scope of taxonomy.
2. Systematics – Place of Systematics in Biology, contribution of Systematics in Biology.
3. Classification (Phenetic and Cladistics); Concept of dendogram and cladogram.
4. Biological Species concept, Subspecies, Polytypic species, Sibling species and Ring species. .
5. Type concept – names of primary and secondary types, their definitions and applications.
6. Basic principle and use of DNA bar coding in species identification.

2: Evolution & Adaptation **(30 marks)**

1. RNA world & Origin of life (Chemical origin only).
2. Modes of speciation – Sympatric, Allopatric and Parapatric; Isolation and its role in speciation (pre mating and post mating).
3. Hardy-Weinberg equilibrium and the factors involved. (theoretical principles)
4. Natural selection, Synthetic theory. Concept of selection: stabilizing, directional and disruptive with example.
5. Genetic drift, founder effect and population bottleneck.
6. Bathymetric and discontinuous distribution; Barriers and dispersals - types and their impact on animal distribution.
7. Zoogeographical realms – names & animal distribution according to Wallace scheme, Avian and Mammalian faunal distribution in different realms.
8. Xeric (camel and lizard); Arboreal (sloth bear) adaptation; Adaptive radiation with special reference to Darwin's finches.
9. Origin of birds.
10. Evolution in Man.

3: Animal Behaviour as a process of life **(20 marks)**

1. Instinctive and learning behaviour, fixed action pattern.
2. Social behaviour & communication in honey bees (dance language and pheromone.)
3. Behavioural strategies: Game theory; Altruism, kinship and selfishness
4. Parental investment (in fishes & amphibians); cost and benefit analysis of parental investment; parent-offspring conflict.
5. Bird migration.
6. Parthenogenesis in insects, Mimicry & Colouration in insects.

Remarks:

Development of skill to determine

'Evolutionary justification' of a group of organisms under investigation by means of their behavioural pattern and taxonomic status.

Suggested readings:

a. Ridley, M. (2004) Evolution. 3rd Edition. Blackwell Publishing
b. Hall, B.K. and Hallgrimsson, B. (2008) Evolution. 4th Ed. Jones and Bartlett Publishers.
c. Alcock J.(2009). Animal Behaviour: An Evolutionary Approach. Sinauer Associates, Inc. Publishers Sunderland, Massachusetts U.S.A.
d. Mayr E. and Ashlock P.D. (1991). Principles of Systematic Zoology. McGraw-Hill, Inc.

Laboratory Course (Full Marks 75)

Core Course No. ZOOA – P12P: Adaptation, dissertation, local excursion and grand viva voce:

Course Outcome (CO):

1. Presentation & defence of any zoological problem in a scientific and structured manner.
2. Correlating the theoretical strategies of rearing & managing economically important animals by visiting such centres.

Course Details:

Adaptation: **(15 marks)**
Study of animals from museum specimens to analyze adaptive features for cursorial, aquatic, desert, volant and deep sea adaptations, Preparation of taxonomic keys.

Dissertation: Review assignment and its defence **(25 marks)**
Local excursion: Applied zoology centres **(10 marks)**

Lab Note Book & grand viva voce **(25 marks)**

Remarks:

1. Development of professional skill to present & scientifically defend a zoological problem.
2. Methodical preparation of taxonomic keys to determine the appropriate status of a selected specimen.
3. An interdisciplinary viva voce to groom and train the students for facing such interviews in future.

DISCIPLINE SPECIFIC ELECTIVE COURSES

Elective Course No. ZOOA – P13DTA: Biology of Insects **(50 marks)**

Course Outcome (CO):

1. Developing a clear idea on physiology, taxonomy & social behaviour of insects.
2. Understanding the mechanism of pollination in details.
3. Understanding the importance of insects as different vectors.

Course Details:

Unit I: Introduction
General Features of insects; Distribution and success of insects on earth.

Unit II: Insect Taxonomy
Basis of insect classification; Classification of insects up to orders.

Unit III: General Morphology of Insects
External Features; Head – Eyes, Types of antennae, Mouth parts with reference to feeding habits; Thorax: Wings and wing articulation, Types of Legs adapted to diverse habitat; Abdominal appendages and genitalia.

Unit IV: Physiology of Insects
Structure and physiology of insect body systems - integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system; Sensory receptors; Growth and metamorphosis.

Unit IV: Insect Society
Group of social insects and their social life
Social organization and social behaviour (w.r.t. any one example).

Unit V: Insect Plant Interaction
Theory of co-evolution, role of allelochemicals in host plant mediation; Host-plant selection by phytophagous insects; Insects as plant pests.

Unit VI: Insects as Vectors
Insects as mechanical and Biological vectors, Brief discussion on houseflies and mosquitoes as important insect vectors.

LABORATORY COURSE

Elective Course No. ZOOA – P13DPA: Detailed study of Insect Morphology **(25 marks)**

Course Outcome (CO):

1. Developing a clear idea on anatomy of insects.
2. Developing skill on morphotaxonomy based on insect body.
3. Understanding insect diversity based on field study.

Course Details:

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects

3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.
5. Study of insect spiracles
6. Methodology of collection, preservation and identification of insects.
7. Morphological studies of various castes of *Apis, Camponotus* and *Odontotermes*
8. Study of any three insect pests and their damages
9. Study of any three beneficial insects and their products
10. Field study of insects and submission of a project report on the insect diversity

SUGGESTED READINGS

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK.
2. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK.
3. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA.
4. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F. M Saunders College Publication, USA.
5. The Insect Societies, Wilson, E. O., Harward Univ. Press, UK.
6. Host Selection by Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA.
7. Physiological system in Insects, Klowden, M. J., Academic Press, USA.
8. The Insects, An outline of Entomology, Gullan, P. J. , and Cranston, P. S., Wiley Blackwell, UK.
9. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA.

DISCIPLINE SPECIFIC ELECTIVE COURSES

Elective Course No. ZOOA – P13DTB: Endocrinology (50 marks)

Course Outcome (CO):

1. Development of precise knowledge how an individual react to various internal and external conditions by means of chemically integrating and modulating various physiological processes.
2. Understanding how the actions of different hormones are regulated in cellular as well as molecular levels.

Course Details:

Unit 1: **Introduction to Endocrinology**
History of endocrinology, Classification, Characteristic and transport of Hormones, Neurosecretions and neurohormones.

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis
Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction; Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms; Structure of pituitary gland, Hormones and their functions, Hypothalamohypophysial portal system, Disorders of pituitary gland.

Unit 3: Peripheral Endocrine Glands
Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and testis hormones in homeostasis, Disorders of endocrine glands.

Unit 4: Regulation of Hormone Action

Hormone action at Cellular level: Hormone receptors, transduction and regulation hormone action at molecular level: Molecular mediators, Genetic control of hormone action.

LABORATORY COURSE

Elective Course No. ZOOA – P13DPB: Study of Endocrine System **(25 marks)**

Course Outcome (CO):

1. Developing clear idea on structure & function of different mammalian endocrine glands.

Course Details:

1. Study of Endocrine glands in laboratory bred rat
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/ adrenal hypertrophy *in vivo* bioassay in laboratory bred rat
4. Study of Castration/ ovariectomy in laboratory bred rat
5. Designing of primers of any hormone

SUGGESTED READINGS

1. General Endocrinology: C. Donnell Turner Pub- Saunders Toppan
2. Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
3. Endocrinology, 6th Edition. Hadley, M.E. and Levine J.E. 2007. Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
4. Vertebrate Endocrinology by David O. Norris,

	B.Sc. Zoology Genric Elective					
	Course Structure					
Sl No	Name of the Course	Semester	Course Code	Credit	Marks	Outcome
1	Gr. A. Non-Chordates Gr. B. Cell Biology, Genetics & Molecular Biology	1	ZOOG-P1T	2	50	Development of concept on different non-chordate forms and their physiology. Describing general taxonomic rules of non-chordate classification. Development of precise ideas about the molecular aspects of cell functioning.
2	Laboratory Course	1	ZOOG-P1P	1	25	1. Identification & knowledge gathering on cellular & sub-cellular levels of organisation. 2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Invertebrate Zoology as well as cell biology.

3	Gr. A. Chordates Gr. B. Developmental Biology	2	ZOOG-P2T	2	50	1. Development of concept on different chordate forms and their physiology. 2. Describing general taxonomic rules of chordate classification. 3. Development of basic idea on early, late & post embryonic developmental phenomena in various model organisms.
4	Laboratory Course	2	ZOOG-P2P	1	25	1. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Vertebrate Zoology considering anatomy in specific. 2. Identifying different chordate animals following evolutionary hierarchy.

5	Gr. A. Histology, Endocrinology, Animal Physiology & Biochemistry Gr. B. Ecology, Animal Behavior, Biodiversity & Wildlife	3	ZOOG-P3T	2	50	Learning principles and concepts of basic endocrinal regulations to relate the various levels of organization and interaction amongst them to ensure proper functionality of an individual. Development of bio-chemical background in various life sustaining processes. Developing physiological and biochemical understanding through scientific enquiry into the nature of mechanical, physical, and biochemical functions of humans, their organs, and the cells of which they are composed. Learning the basic biological principles and processes to understand ecology and environment and their proper functioning. Understanding distribution of fauna in different realms and their mutual interaction. Studying interaction between biotic and abiotic factors. Developing idea on numerous protected zones in wildlife,

						different conservation strategies and WPA.
6	Laboratory Course	3	ZOOG-P3P	1	25	1. Develop the practical skills analyse different immunological samples to assess various parameters. 2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on vertebrates by considering their skeletal systems. 3. Understanding various ecological and physiological parameters through hands-on experiments.

7	Gr. A. Applied Zoology Gr. B. Evolutionary Biology, Parasitology & Immunology	4	ZOOG-P4T	2	50	Learning the basis to understand life cycle & physiology of various bioresources and applying such knowledge scientifically for human welfare. Understanding concepts of aquaculture, fishing tools and site selection. Understanding processes of silk moth rearing, silk production & Mulberry cultivation, Lac culture, Apiculture etc. and their economic values. Developing clear idea about pest management and its importance. Learning basic principles of animal taxonomy, systematics, classification etc. Gaining knowledge regarding the various theories of evolution, evolutionary process such as speciation, natural selection etc. Understanding different types of immunity. Studying interactions of antigens, antibodies and other immune components. Understanding the basis and mechanism

						of various parasite mediated and physiological diseases.
8	Laboratory Course	4	ZOOG-P4P	1	25	1. Develop the practical skills to analyse different haematological samples to assess various parameters. 2. Understanding the diversity of protozoa in the gut content of cockroach & their functions. 3. Learning the applied importance of different pests.

Syllabus structure for B.Sc. (Generic Elective) Zoology

Semester -I	Paper –I (Generic Elective 1)	Marks
ZOOG-P1T	Gr. A. Non-Chordates	25
	Gr. B. Cell Biology, Genetics & Molecular Biology	25
ZOOG-P1P	Laboratory Course	25
		75

Semester –II	Paper – II (Generic Elective 2)	Marks
ZOOG-P2T	Gr. A. Chordates	25
	Gr. B. Developmental Biology	25
ZOOG-P2P	Laboratory Course	25
		75

Semester –III	Paper – III (Generic Elective 3)	Marks
ZOOG-P3T	Gr. A. Histology, Endocrinology, Animal Physiology & Biochemistry	25
	Gr. B. Ecology, Animal Behavior, Biodiversity & Wildlife	25
ZOOG-P3P	Laboratory Course	25
		75

Semester –IV	Paper – IV (Generic Elective 4)	Marks
ZOOG-P4T	Gr. A. Applied Zoology	20
	Gr. B. Evolutionary Biology, Parasitology & Immunology	30
ZOOG-P4P	Laboratory course	25
		75

	Total	300

Zoology Generic Elective (Course content in details)

Semester –I : (75 Marks)

Paper I : (Generic Elective 1) **Theory (Full Marks –50)**

Generic Elective Course No. ZOOG-P1T: Non-Chordates, Cell Biology, Genetics & Molecular Biology

Course Outcome (CO):

5. Development of concept on different non-chordate forms and their physiology.
6. Describing general taxonomic rules of non-chordate classification.
7. Development of precise ideas about the molecular aspects of cell functioning.

Course Details:

Group-A: Non Chordates (Full Marks - 25)

1. Classification with distinctive features and suitable examples of sub-kingdom Protozoa (upto Phylum) (Levine *et al*, 1980) and Phylum Porifera, Cnidaria, Platyhelminthis, Annelida, Arthropoda, Mollusca and Echinodermata (up to Class)

2. General structure & function of the following with reference to the specimens mentioned:
   - I) Locomotion (a) Microfibrils (*Amoeba*), (b) Flagella (*Euglena*), (c) Cilia (*Paramoecium*)
   - II) Feeding & digestion (a) Microphagy (*Amoeba*), Macrophagy (*Periplanata*)
   - III) Respiration (a) Respiratory pigments (Hemoglobin & hemocyanin,(b)Ctenidium & pulmonary sac (Pila), gills, Traechea and booklung (prawn, cockroach, scorpion)
   - IV) Excretion (a) Flame cells (Taenia), b) Nephridia (Earthworm), Malpighian tubules (Cockroach), Green gland (Prawn)
   - V) Circulation (a) Open circulation (Cockroach, (b) Closed circulation (Earth worm)
   - VI) Neural Integration : Integration –simple & complex nerve nets, (b)Nervous system, (Cockroach, Apple snail)
   - VII) Reproduction : a) Fission (Amoeba) (b) Budding (*Hydra*) (c) Conjugation (*Paramoecium*), (d) Sexual (Cockroach), (e) Metagenesis in *Obelia* (in Brief)

N.B. Scheme of classification other than Protozoa as per Ruppert and Barnes (1994), 6th Ed., Invertebrate Zoology.

Group –B: Cell Biology, Genetics & Molecular Biology (Full marks –25)

1. Ultrastructure & function of plasma membrane, GERL system, ribosome, lysosome.
2. Chromosome structure, nucleosome concept.
3. Cell cycle, oncogene & cancer (basic idea).
4. Physio chemical properties, types, structures (in brief) and functions of DNA and RNA.
5. Nucleic acids as genetic material.
6. Mechanisms of replication, transcription and translation in *E. coli.*
7. Modes of inheritance of autosomal and sex linked genes in man (Thalassemia & Haemophilia, Colour Blindness).
8. Linkage and recombination.
9. Chromosomal aberrations-in number and structures, point mutation, Down syndrome & Klinefelter syndrome.
10. Sex determination in *Drosophila* and man.
11. Basic concept of genetic engineering & gene cloning, and gene manipulation.

Paper I : (Generic Elective 1) Laboratory Course (Full Marks - 25)

Generic Elective Course No. ZOOG-P1P: Demonstration including Mounting & Preparation, Identification of Non-Chordate Specimens

Course Outcome (CO):

1. Identification & knowledge gathering on cellular & sub-cellular levels of organisation.

2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Invertebrate Zoology as well as cell biology.

Course Details:

1. Demonstration (One major) 10
   i) Cockroach: digestive, nervous and female reproductive system

2. Mounting and preparation: 5
   i) Mouth parts of cockroach
   ii) Radula of *Pila*
   iii) Osphradium of *Pila*

3. Identification of Non-Chordate Specimens with systematic position upto taxon as mentionthe theory: 5
   Plasmodium vivax, Paramoecium, Scypha, *Obelia,* Sea-anaemone, *Ascaris, Hirudinaria,* Scorpion, *Bombyx mori, Lamellidens, Achatina, Loligo,* Starfish, *Balanoglossus*

4. Lab Note Book & Viva-voce 5

Semester –II: (75 Marks)

Paper II : (Generic Elective 2) Theory (Full Marks –50)

Generic Elective Course No. ZOOG-P2T: Chordates & Developmental Biology

Course Outcome (CO):

1. Development of concept on different chordate forms and their physiology.
2. Describing general taxonomic rules of chordate classification.
3. Development of basic idea on early, late & post embryonic developmental phenomena in various model organisms.

Course Details:

Group-A: Chordates (Full Marks - 25)

1. Classification of Phylum Chordata with distinctive features and suitable examples –upto living subclass (Amphibia, Reptilia and Mammalia); upto subclass (Fishes and Aves) (Scheme of classification as per J.Z. Young 1980, Life of vertebrates).
2. Functional anatomy in relation to respiration (*Bufo*); Circulation (*Columba*).
3. Structure & function of the followings:
   i) Integument-general structure & function; integumentary derivatives (scales in fishes, horny scales & plates in reptiles; feathers of Columna ; hair of mammals, Camel).
   ii) Pharynx (Branchiostoma); stomach (*Columba* & *Bos*).
   iii) Respiratory structures and Respiration : Gill (Fish), accessory respiratory organs (Fish); lung (*Columba* and *Cavia*), Air sac – *Columba.*
   iv) Circulatory structure and circulation: Single circuit heart (fish); double circuit heart (Amphibia and Mammals).
   v) Excretory system-pro, meso and meta-nephric kidneys.
   vi) Nervous system- Brain in *Cavia*.
   vii) Origin and distribution of cranial nerves (in *Cavia*).

Group –B: Developmental Biology (Full marks –25)

1. Spermatogenesis and Oogenesis.
2. Fertilization in sea urchin.
3. Types of eggs & cleavages; process of cleavage in frog and chick.
4. Gastrulation in frog and chick.
5. Extra-embryonic membranes in chick.
6. Placenta types and function.
7. Organizer concept.
8. Concept of Protostomia & Deuterostomia with reference to metazoan origin.

Paper II : (Generic Elective 2) Laboratory Course (Full Marks - 25)

Generic Elective Course No. ZOOG-P2P: Demonstration including Mounting & Preparation, Identification of Chordate Specimens

Course Outcome (CO):

1. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on Vertebrate Zoology considering anatomy in specific.

2. Identifying different chordate animals following evolutionary hierarchy.

Course Details:

1. Dissection (One major dissection) 10
(*Tilapia*: digestive & urinogenital systems; brain & pituitary).

2. Mounting and preparation: (One) 5
i) Placoid scale; Ctenoid scale of fin fish
ii) Blood film of human

3. Identification of Chordate Specimens with systematic position upto taxon as mentioned in the theory: 5
Branchiostoma, Petromyzon, Scolidon, Lates, Rhacophorous, Axolotl larva, *Tylototriton, Gekko; Hemidactylus,* Turtle, *Naja,* Chiropterans.

4. Lab Note Book & Viva-voce 5

Semester –III: (75 Marks)

Paper III: (Generic Elective 3) Theory (Full Marks –50)

Generic Elective Course No. ZOOG-P3T: Histology, Endocrinology, Animal Physiology & Biochemistry, Ecology, Animal Behaviour, Biodiversity & Wildlife

Course Outcome (CO):

6. Learning principles and concepts of basic endocrinal regulations to relate the various levels of organization and interaction amongst them to ensure proper functionality of an individual.
7. Development of bio-chemical background in various life sustaining processes.
8. Developing physiological and biochemical understanding through scientific enquiry into the nature of mechanical, physical, and biochemical functions of humans, their organs, and the cells of which they are composed.
9. Learning the basic biological principles and processes to understand ecology and environment and their proper functioning.
10. Understanding distribution of fauna in different realms and their mutual interaction.
11. Studying interaction between biotic and abiotic factors.
12. Developing idea on numerous protected zones in wildlife, different conservation strategies and WPA.

Course Details:

Group-A: Histology, Endocrinology, Animal Physiology & Biochemistry
(Full Marks - 25)

1. General characters of hormones : Histology of pituitary, thyroid and pancreas, naming and

function of hormones secreted from Pituitary, Thyroid and Pancreas.
2. Insects endocrine glands (in brief).
3. Composition of vertebrate blood; clotting & coagulation; ABO blood group & Rh factor.
4. Enzyme- classification & characteristics; mechanism of enzyme action; effects on enzymetic action (pH and temperature).
5. Classification of carbohydrate, protein and lipid; concept of glycolysis, neoglucogenesis (aerobic, anaerobic & fermentation).
6. Physiology of nerve impulse & synaptic transmission (in brief).
7. Osmoconformers and Osmoregulators; Osmoregulation in fishes.

Group – B: Ecology, Animal Behaviour, Biodiversity and Wildlife (Full Marks 25)

1. Ecology & Ecosystem-definition, components, energy flow, food chain, food web, ecological pyramids.
2. Population- definition and growth.
3. Community- definition and types.
4. Basic concept of Biodiversity, Biodiversity hotspots.
5. Pollution- air, water and noise (Sources of pollutants, effects on human life and control measures).
6. Honey bee- Hive, castes and their roles.
7. Conservation of wild life- purpose & methods, concept of Biosphere Reserve, importance & strategies of wildlife conservation; conservation act and application.
8. National park & Wildlife Santuary, Animal cruelty and prevention act.
9. Scheduled I of wild life protection Act, 1972 and importance of schedules in conservation.
10. Basic idea of ecotoxicology and xenobiotics, concept of EIA.

Paper III : (Generic Elective 3) Laboratory Course (Full Marks - 25)

Generic Elective Course No. ZOOG-P3P: Ecology, Osteology, Histology & Animal Physiology

Course Outcome:

1. Develop the practical skills analyse different immunological samples to assess various parameters.
2. Correlating the theoretical knowledge with practical curricula to develop a holistic idea on vertebrates by considering their skeletal systems.
3. Understanding various ecological and physiological parameters through hands-on experiments.

Course Details:

1. Identification with reasons: two from bones, two from histological slides
(a) Bones: Skull, vertebrae, limb and girdle bones of *Columba* & *Cavia* 10
(b) Histological slides: Sections of mammalian liver, pancreas, testis, ovary, kidney, thyroid.

2. Mounting and preparation 3
   a. Whole mount of aquatic and soil micro-arthropods
   b. Epithelial cells from buccal smears
   c. Mouth parts of honey bee

3. (a) Estimation of dissolved O_2 content of water 7
   (b) Estimation of dissolved free CO_2 content of water
   (c) Determinant of ABO blood group & Rh factor in man
   (d) Measurement of water pH and handling of pH meter

5. Lab note book and Viva-voce 5

Semester –IV: (75 Marks)

Paper IV: (Generic Elective 4) Theory (Full Marks –50)

Generic Elective Course No. ZOOG-P4T: Applied Zoology, Evolutionary Biology, Parasitology & Immunology

Course Outcome (CO):

6. Learning the basis to understand life cycle & physiology of various bioresources and applying such knowledge scientifically for human welfare.
7. Understanding concepts of aquaculture, fishing tools and site selection.
8. Understanding processes of silk moth rearing, silk production & Mulberry cultivation, Lac culture, Apiculture etc. and their economic values.
9. Developing clear idea about pest management and its importance.
10. Learning basic principles of animal taxonomy, systematics, classification etc.
11. Gaining knowledge regarding the various theories of evolution, evolutionary process such as speciation, natural selection etc.
12. Understanding different types of immunity.
13. Studying interactions of antigens, antibodies and other immune components.
14. Understanding the basis and mechanism of various parasite mediated and physiological diseases.

Course Details:

Group-A: Applied Zoology (Full Marks - 20)

1. *Sericulture* : Characteristics of sericulture industry and its scope; types of silk moths/ worms, (scientific names), host plants and improvement and their variety. Life history and rearing of *Bombyx mori*, harvesting & processing of cocoon, reeling and extraction of silk, pest on mulberry plants and diseases of worms of *Bombyx mori* and control measures. Research & development of sericulture in India.

2. *Aquaculture* : Principles, definition and scope. Fisheries resources of India (inland & off-

shore) and their important ichthyofauna. Exotic fishes- their merits and demerits. Fish breeding and their application. Basic principles of different aquaculture system (Polyculture and integrated farming); marine pearl culture, culture of prawn and shrimps.

3. *Pest and Management* :
a) Definition and types of pests with examples. Life history, behaviour, ecology, damage and control of the following pests : i) Paddy *Scirpophaga* (Syn. *Tryporyza*) *incertulas,* ii) Stores grain-*Sitophilus oryzae,* iii) Termite, iv) Mammalian pest (*Bandicota bengalensis*).

b) Integrated Pest Management

4. *Apiculture* : Development of Apiary in India. Types of honey bees, modern methods of apiary management, products and its uses. Problems and prospects.

5. *Lac culture* : Lac insect (Scientific name). Composition of Lac. Strains of lac insects, cultivation of lac, lac host plants (name only), Processing of lac and uses.

6. *Poultry* : Duck and fowl - Types of breeds, rearing and disease management.

Group – B: Evolutionary Biology, Parasitology & Immunology (Full marks: 30)

1. Definition of systematics & taxonomy.
2. Species as a unit of evolution (definition and types: biological, sibling and polytypic species).
3. Chemical basis of origin of life.
4. Hardy-Weinberg equilibrium in relation to natural selection- a brief idea.
5. Anatomical and Physiological adaptations : Aquatic, Desert and Volant animals.
6. Zoogeographical realms & their subdivisions with characteristic fauna.
7. Parasitism (definition and types) and other interspecific (symbiosis, commensalism and mutualism) interactions.
8. Life history, Pathogenecity and clinical features of *(a) Entamoeba histolytica, (ii) Plasmodium vivax, iii) P. falciparum, iv) Ascaris, v) Fasciola hepatica*

15. Outline structure and classification of immunoglobulin, antigen-antibody reaction, basic principle of vaccination.

Paper IV : (Generic Elective 4) Laboratory Course (Full Marks - 25)

Generic Elective Course No. ZOOG-P4P: Parasitology, Immunology, Applied Zoology & Field Study

Course Outcome:

1. Develop the practical skills to analyse different haematological samples to assess various parameters.
2. Understanding the diversity of protozoa in the gut content of cockroach & their functions.

3. Learning the applied importance of different pests.

Course Details:

1. (a) Haemolymph of cockroach (Leishman/Giemsa stain) (b) Gut contents of cockroach for protozoa (Fixation, staining and identification)	4
2. Identification: (Write specimen characters and applied importance) Microfilaria of *Wuchereria bancrofti, Taenia solium, Scirpophaga (Syn. Tryporyza) incertulas, Sitophilus oryzae, Leptocorisa, Epilachna, Coccinella, Lepisma,* Termite, *Bandicota bengalensis, Labeo rohita, L. bata, Catla catla, Cirrhinus mrigala, Hypophthalmichthyes molitrix, Cyprinus carpio, Ctenopharyngodon idellus,Tenualosa (Hilsa) ilisha, Penaeus sp, Macrobrachium rosenbergi.*	6
3. Report on field study tours	10
4. Lab note book and Viva-voce	5