##### Scheme of Examination for M.Sc. Zoology (Semester system) as per Choice Based Credit System (CBCS) to be implemented w.e.f. session 2016-2017 onwards

## Semester wise distribution of course and credits in Zoology

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Paper****No.**  | **Title of the Paper** | **Nature of paper** | **Credits** | **Contact hours per week****T + S + P** | **Total Marks****(T+IA)** | **Exam duration****(Hours)** |
| **Semester I** |
| Z 101 | Cell Biology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 102 | Biochemistry and Bio-techniques  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 103 | Biosystematics and Biostatistics | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 104 | Biology of Invertebrates  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 105 | Practical (Based on Papers Z 101 & Z 102)  | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
| Z 106 | Practical (Based on Papers Z 103 & Z 104) | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
|  | **Total** |  | **24** | **16 + 0 + 16** | **480+120=600** |  |
| **Semester II** |  |
| Z 201 | Population and Community Ecology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 202 | Comparative Physiology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 203 | Population Genetics & Evolution  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 204 | Biology of Vertebrates  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| **Z 205** | **Economic Zoology** | **Open elective** | **2** | **2 + 0 + 0** | **40+10** | **3** |
| Z 206 | Seminar  | Core | 1 | 0 + 1 + 0 | 25 | - |
| Z 207 | Practical (Based on Papers Z 201 & Z 202) | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
| Z 208 | Practical (Based on Papers Z 203 & Z 204)  | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
|  | **Total** |  | **27** | **18 + 1 + 16** | **545+130=675** |  |

|  |
| --- |
| **Semester III** |
| Z 301 | Molecular Biology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 302 | Molecular Endocrinology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 303 | Applied Zoology | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 304  | Molecular Cytogenetics – I | Any one from Z 304 to Z 307 | Elective | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 305 | Reproduction and Aging-I | Elective | 4 | 4 + 0 + 0 | 3 |
| Z 306 | Animal Behaviour & Wildlife Conservation – I | Elective | 4 | 4 + 0 + 0 | 3 |
| Z 307 | Fish, Fisheries and Aquaculture – I  | Elective | 4 | 4 + 0 + 0 | 3 |
| **Z 308** | **Animal Diversity & Conservation** | **Open Elective** | **2** | **2 + 0 + 0** | **40+10** | **3** |
| Z 309 | Seminar  | Core | 1 | 0 + 1 + 0 | 25 | - |
| Z 310 | Practical (Based on Papers Z 301 to Z 303) | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
| Z 311 | Practical(Based on Papers Z 304/Z 305/Z 306/Z 307) | Elective | 4 | 0 + 0 + 8 | 80+20 | 4 |
|  | **Total** |  | **27** | **18 + 1 + 16** | **545+130=675** |  |
| **Semester IV** |
| Z 401 | Developmental Biology  | Core  | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 402 | Vertebrate Immunology  | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 403 | Environmental Toxicology | Core | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 404 | Molecular Cytogenetics – II  | Any one from Z 404 to Z 407 | Elective | 4 | 4 + 0 + 0 | 80+20 | 3 |
| Z 405 | Reproduction and Aging – II  | 3 |
| Z 406 | Animal Behaviour & Wildlife Conservation – II  | 3 |
| Z 407 | Fish, Fisheries and Aquaculture – II  | 3 |
| Z 408 | Practical (Based on Papers Z 401 to Z 403) | Core | 4 | 0 + 0 + 8 | 80+20 | 4 |
| Z 409 | Practical (Based on Papers Z 404 /Z 405/Z 406/Z 407) | Elective | 4 | 0 + 0 + 8 | 80+20 | 4 |
|  | **Total** |  | **24** | **16 + 2 + 16** | **480+120=600** |  |
| **Grand Total** | **2550** |  |

**T – Theory; S– Seminar; P– Practical**

**Total Credits: Core 80 + Elective 16 + seminar 2 + open elective 4 = 102**

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 101 (Core)**

**Cell Biology**

**Credits: 4**

**Objective:** To make students learn the deeper aspects of cell structure and function at molecular level.

**Outcomes**: The studies will make the students reveal elegance, dynamics and economy in the living cell and a gratifying unity in the principles by which a cell functions.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (A & B). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Biomembranes

1.1 Molecular composition and arrangement, functional consequences.

1.2 Transport – Recapitulation of the plasma membrane; diffusion, active transport and pumps, uniports, symports and antiports.

* 1. Donnan equilibrium; ion movements and cell function: acidification of cell organelles and stomach
	2. Maintenance of cellular pH; cell excitation; bulk transport; Receptor mediated endocytosis
	3. Transepithelial transport

2 Cytoskeleton and cell movement

2.1 Structure and organization of actin filaments

2.2 Actin, myosin and cell movements

2.3 Structure and dynamic organizations of microtubules

2.4 Microtubule motors and movement

2.5 Intermediate filaments

2.6 Cilia and flagella

3 The Extra Cellular Matrix and Cell interactions

 3.1 Cell walls

 3.2 The ECM and cell-matrix interactions

 3.3 Cell-cell interactions: adhesion junctions, tight junctions, gap junctions, plasmodesmata

 3.4 Ca++ dependent and Ca++ independent Homophilic cell-cell adhesion

4 Cell matrix adhesion

4.1 Integrins

4.2 Collagen

 4.3 Non-collagen components

 4.4 Auxin and cell expansion

 4.5 Cellulose fibril synthesis and orientation

5 Protein sorting and transport

5.1 Protein uptak into the ER

5.2 Membrane proteins and Golgi sorting

5.3 Mechanism of vesicular transport

5.4 Lysosomes

5.5 Molecular mechanism of secretory pathway

**Section – B**

6 Cell cycle

 6.1 The eukaryotic cell cycle

 6.2 Regulators of cell cycle progression

 6.3 The events of M phase

 6.4 Meiosis and fertilization

7 Genome organization

7.1 Chromosomal organization of genes and non-coding DNA

7.2 Mobile DNA

7.3 Morphological and functional elements of eukaryotic chromosomes

8 Cell – Cell signaling

 8.1 Signaling molecules and their receptors

 8.2 Function of cell surface receptors

 8.3 Pathways of intracellular signal transduction

 8.4 Signaling networks

9 Cell death and cell renewal

 9.1 Programmed cell death

 9.2 Stem cells and the maintenance of adult tissues

 9.3 Embryonic stem cells and therapeutic cloning

10 Biology of Cancer

 10.1 The development and causes of cancer

 10.2 Oncogenes

 10.3 Tumor suppressor genes

 10.4 Molecular approaches to cancer treatment

11 Biology of Ageing

**Suggested Reading Material**

1. Molecular Cell, Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Book, Inc., USA.
2. Molecular Biology of the Cell, B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. Garland Publishing Inc., New York.

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 102 (Core)**

**Biochemistry and Bio-techniques**

**Credits: 4**

**Objective:** To develop understanding of biological processes at chemical, biochemical and molecular level to perform wide range of analytical techniques to explore biological activities.

**Outcomes**: It will provide the students a basic appreciation of the underlying principles and practical strategy of the analytical and preparative techniques that are fundamental to study and understanding of life processes.

**Note:**

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3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. General Principles of Biochemistry and chemical composition of life.
2. Glycolysis, citric acid cycles its regulation and role as metabolic hub.
3. Hexose monophosphate pathway its regulation and significance.
4. Cholesterol biosynthesis, its metabolism steroid genesis, Bile acids and their metabolism derrayed cholesterol level.
5. Saturated and unsaturated fatty acid and their metabolism.
6. Primary, Secondary, tertiary and quaternary structure of proteins (Domain, Reverse turn of Ramachandran plot).
7. Enzyme: classification and nomenclature, co-enzymes, induced fit and Molecular Mechanism of Enzyme action, Enzyme feedback mechanism, Isozymes.
8. DNA, RNA, structure and functions, DNA chroeography.

**Section – B**

1. Chemical and Biological assays (*in* *vitro* and *in vivo* assays)
2. Principles and uses of analytical instruments: Spectrophotometers, NMR spectrophotometer, ultra centrifuge, Microscopes.
3. Microbiological Techniques:
	1. Media preparation and sterilization.
	2. Inoculation and growth monitoring.
4. Cell culture techniques:
	1. Design and functioning of tissue culture laboratory.
	2. Cell proliferation measurements.
	3. Cell viability testing.
	4. Culture media preparation and cell harvesting methods.
5. Cryotechniques :
	1. Cryopreservation for cells, tissue, organisms.
	2. Cryotechniques for microscopy.
6. Separation techniques in biology.
	1. Molecular separations by chromatography, electrophoresis, precipitation etc.
	2. Organelle separation by centrifugation.
	3. Cell separation by flow cytometery, density gradient centrifugation, unit gravity centrifugation, affinity adsorption, anchorage based techniques etc.

1. Radioisotope and mass isotope techniques in biology :
	1. Sample preparation for radioactive counting.
	2. Autoradiography.
	3. Metabolic labeling.
	4. Magnetic resonance Imaging
2. Biosensors.

# Suggested Reading Materials:

1. Animal Cell Culture – A practical approach, Ed. John R.W. Masters, IRL Press.
2. Introduction to Instrumental analysis, Robert Braun, McGraw Hill International editions
3. A Biologists guide to Principles and Techniques of Practical Biochemistry, K. Wilson and K.H. Goulding, ELBS Edn.

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 103 (Core)**

**Biosystematics and Biostatistics**

**Credits: 4**

**Objective:** First section of the paper deals with theory and practice of taxonomic arrangement and classification of animal diversity, while, the second section impart knowledge about statistical assessment of the biodiversity w.r.t. quantitative and qualitative status and population dynamics.

**Outcomes:** Both the sections are significant for understanding the overall biodiversity of the world and their application in all the fields of biological sciences.

**Note:**

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2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Definition and basic concepts of biosystematics and taxonomy.

 1.1 Historical resume, Importance and applications of systematics in biology.

1. Trends in biosystematics – concepts of different conventional and newer aspects
	1. Chemotaxonomy
	2. Cyotaxonomy
	3. Molecular taxonomy
2. Dimensions of speciation and taxonomic characters
	1. Species concepts – species category, different species concepts; sub-species and other intra-specific categories.
	2. Theories of biological classification, hierarchy of categories.
	3. Taxonomic characters – different kinds, weighing of characters
3. Methodology
	1. Taxonomic collections, preservation, curetting process and identification.
	2. Taxonomic keys-different kinds of taxonomic keys, their merits and demerits.
	3. Systematic publications – different kinds of publications.

5.0 International code of Zoological Nomenclature (ICZN)

5.1 Operative principles

5.2 Interpretation of the following :

Stability, Priority, Concept of availability, formation of names, synonymy, homonymy, the type method, kinds of type specimen, type-designation.

## Section – B

6.0 Measures of central value

Arithmetic mean, mode and median, Definition, calculation and its properties.

7.0 Measures of Dispersion:

* 1. Range, Interquartile range, Quartile deviation.
	2. Mean deviation and standard deviation, Standard error

8.0 Correlation:

Methods studying correlation – Scatter diagram method, Graphic method, Karl Pearson coefficient of correlation, Rank correlation.

9.0 Regression analysis (Regression lines and regression equation.)

10.0 Concept of sampling and sampling methods:

Definition and law of sampling, judgment sampling, Random sampling, stratified sampling, systematic sampling, multi-stages sampling and quota sampling.

11.0 Test of significance for large samples and small samples (student t-test; ANOVA).

12.0 Chi-square analysis

13.0 Probability and law of probability, Theoretical probability distribution: Binomial distribution, Poison distribution, Normal distribution.

14.0 Computer in Biometrics

14.1 Components of computers

14.2 Statistical Software in Biology

**Suggested Reading Material:**

1. M. Kato. The Biology of Biodiversity, Springer.
2. E.O. Wilson, Biodiversity, Academic Press, Washington.
3. G.G. Simpson, Principle of animal taxonomy, Oxford ISH Publishing Company.
4. E. Mayer, Elements of Taxonomy.
5. E.O. Wilson, The Diversity of Life (The College Edition), W.W. Northerm & Co.
6. S.K. Tikadar, Threatened Animals of India, ZSI Publication, Calcutta.
7. Batschelet, E. Introduction to mathematics for life scientists, Springer-Verlag, Berling.
8. Jorgensen, S.E. Fundamentals of ecological modeling. Elsevier, New York.
9. Swartzman, G.L. and S.P.O. Kaluzny. Ecological simulation primer, Macmillan, New York.
10. Lendren, D. Modeling in behavioral ecology. Chapman and Hal, London, UK.
11. Sokal, R.R. and F.J. Rohlf. Biometry. Freeman, San Francisco.
12. Snedecor, G.W. and W.G. Cochran, Statistical methods. Affiliated East-West Pres, New Delhi (Indian ed.).
13. Murray, J.D. Mathematical biology. Springer-Verlag, Berlin.
14. Pielou, E.C. the Interpretation of ecological data:A primer on classification and ordination.

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 104 (Core)**

**Biology of Invertebrates**

**Credits: 4**

**Objective:** Make students to understand how life evolved from simple to complex organization by division of labour & enhancing efficiency in Invertebrates.

**Outcomes**:The study of invertebrates reveals progressive evolutionary history and adaptations together which forms the basis of huge complex and diverse life forms.

**Note:**

1. Nine questions will be set in all.
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3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section - A**

1. Introduction to invertebrates with their general characters and classification up to class level.
2. Minor Phyla:
	1. Concept and significance
	2. Organization and general characters of Acoelomate, Pseudocoelomates and Coelomates minor phyla (with special emphasis on Ctenophora, Rotifera, Endoprocta, Ectoprocta, Phoronida, Sipunculida and Echiuroidea).
3. Organization of coelom
	1. Concept and structure of Acoelomate, Pseudocoelomates and Coelomates.
	2. Protostomia and Deuterostomia
	3. Metamerism in Annelida, Pseudometamerism.
4. Locomotion
	1. Flagella and ciliary movement in Protozoa
	2. Hydrostatic movement in Coelenterata, Annelida and Echinodermata

1. Nutrition and Digestion
	1. Patterns of feeding and digestion in lower metazoa
	2. Filter-feeding in Polychaeta, Mollusca and Echinodermata
2. Respiration
	1. Organs of respiration : Gills, lungs and trachea
	2. Respiratory pigments
	3. Mechanism of respiration

**Section – B**

1. Excretion
	1. Organs of excretion: Coelom, coelomoducts, Nephridia and Malpighian tubules.
	2. Mechanism of excretion and osmoregulation

1. Nervous system
	1. Primitive nervous system: Coelenterata and Echinodermata
	2. Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda).
	3. Trends in neural evolution.

1. Invertebrate larvae
	1. Larval forms of free living invertebrates
	2. Strategies and Evolutionary significance of larval forms
	3. Conservation of invertebrates.
2. Introduction to insects
	1. Mouthparts of Insects
	2. How are insects able to fly?
	3. Mechanism of insect flight.
	4. Metamorphosis in insects
	5. Hormonal control of moulting.
3. Social life in insects
4. Economic importance of Invertebrates; Various Adaptations in Invertebrates

**Suggested Reading Materials:**

1. Hyman, L.H. The invertebrates, Vol. I. Protozoa through Ctenophora, McGraw Hill Co., New York.
2. Barrington, E.J.W. Invertebrate structure and function. Thomas Nelson and Sons Ltr J. London.
3. Jagerstein, G. Evolution of Metazoan life cycle, Academic Press, New York & London.
4. Hyman, L.H. The Invertebrates. Vol.2. McGraw Hill Co., New York.
5. Hyman, L.H. The Invertebrates. Vol.8. McGraw Hill. Co., New York.
6. Barnes, R.D. Invertebrate Zoology, IIIrd edition. W.B. Saundrs Co., Philadelphia.
7. Russel-Hunter, W.D. A Biology of higher invertebrates, the Macmillin Co. Ltd. London.
8. Hyman, L.H. the Invertebrates smaller coelomate groups, Vol. V. McGraw Hill Co., New York
9. Read, C.P. Animal Parasitism. Prentice Hall Inc., New Jersey.
10. Sedgwick, A.A. Student text book of Zoology. Vol. I, II and III Central Book Depot, Allahabad
11. Parker, T.J., Haswell, W.A. Text book of Zoology, McMillan Co., London.

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 105 (Core)**

**Practical Examination (Based on Papers Z 101 & Z 102)**

**Credits: 4**

**Course Contents:**

1. Preparation of mitotic and meiotic chromosomes.
2. Calculation of morphometric data and preparations of idiogram.
3. Determination of chiasma frequency and terminalization coefficient.
4. Preparation of polytene chromosomes (*Chironomous*/mosquito) and mapping.
5. Colorimetery and spectrophotometry, pH and buffers, isolation of sub-cellular organelles (principles).
6. Proteins: Quantitative estimation of proteins by Biuret method and Lowry’s method.
7. Carbohydrates: quantitative estimation of total carbohydrates and glucose, glucose tolerance test, different tests of urine glucose.
8. Lipids: iodine number, saponification value, extraction of lipids quantitative estimation of total lipids.
9. Nucleic acids: extraction of nucleic acids, estimation of DNA and RNA.
10. Paper chromatography: amino acids and carbohydrates.
11. Thin layer chromatography: neutral and phospholipids.
12. Tools: demonstration of parts and working of the following tools: PCR, GLC, Spectrophotometers, Fluorimeter, various kinds of microscopes, pH meter, Electrophoresis, Centrifuges, Tissue culture unit, Balance and Distillation units, Incubators, Photographic Equipment.
13. Microbiological media preparation, sterilization, dilution, inoculation and standard plant count.

**SEMESTER – I**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 106 (Core)**

**Practical Examination (Based on Papers Z 103 & Z 104)**

**Credits: 4**

**Course Contents:**

1. Slides and Museum specimens of following phyla:

(a) PROTOZOA

 (b) PORIFERA

 (c) CNIDARIA

(d) ANNELIDA

(e) ARTHROPODA

(f) MOLLUSCA

(f) ECHINODERMATA

 (h) HEMICHORDATA

1. Study of mouth parts of different insects.
2. Mounting: Trachea, Crustacean Larva, *Cyclops, Nauplius, Daphnia, Zoea, Mysis, Cercaria.*
3. Demonstration of various systems of Loligo/Sepia, Ak-hopper, Prawn, Cockroach, Earthworm.
4. Preparation and use of different types of taxonomic keys.
5. Statistical analysis of data using manual and computer software methods
	1. Mean, mode & Median
	2. Standard deviation and S.E.
	3. Coefficient of correlation
	4. Tests of Significance

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 201 (Core)**

**Population and Community Ecology**

**Credits: 4**

**Objective:** To expose the students in understanding various types of interactions between

 biotic and abiotic components of environment.

**Outcomes**:

1. Information provided will give an insight about the benefits of ecosystem and can be used in the management of natural resources for sustainable development in ways that leave the environment healthy.
2. Many specialties within ecology such as marine, vegetation and statistical ecology provides students information to better understand the environment around them.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section - A**

1.0 Basic Concepts: Definition, Scope and Significance of Ecology, Concept of biosphere, atmosphere, litho sphere and hydrosphere.

1. Ecological aspects of abiotic, biotic and edaphic factors.

3.0 Ecosystem: Concept, Kinds and components.

4.0 Ecological energetic and energy flow: Food chains, food webs, trophic structure; concept of productivity: primary, secondary, gross and net, Energy flow models.

5.0 Population characteristics

* 1. Population density, methods of population density measurement
	2. Growth rate and growth forms
	3. Natality, mortality, survivorship curves and life tables
	4. Biotic potential – Generation time, net reproductive rate reproductive values
	5. Population and distribution.
	6. Population dispersion

**Section – B**

6.0 Population regulation

6.1 Extrinsic and intrinsic mechanisms

6.2 Concept of density dependent and density independent factors in population regulation.

7.0 Population Interactions

7.1 Concept of intra specific and inter specific population interactions

* 1. Protocooperation, mutualism and commensalisms
1. Competition and niche theory.
	1. Intraspecific and inter specific interactions
	2. History of niche concepts

1. Predation
	1. Model of prey – predatory dynamics
	2. Role of predation in nature
	3. Parasitism
2. Community characteristics
	* 1. Species diversity; Biodiversity indices: Diversity, dominance, Similarity & dissimilarity Index
	1. Ecological Succession
	2. Ecological dominance
	3. Ecotones and Edge effect

**Suggested Reading Materials**

* + - 1. Understanding Evolution by Earl. D. Hanson, Oxford University Press, Oxford, New York.
			2. Oxford Surveys in Evolutionary Biology Vol. I – Vol. VI, Oxford University Press, Walton, Street, Oxford.
			3. Evolution by Theodose H. Eaton (Jr.) Thomes – Nolson & Sona Limited, London.
			4. Evolutionary Theory: (The unfinished synthesis) by Robert G.B. Reid: Croom Helm: London & Sydney.
			5. Dobzhansky, Th. Genetics and Origin of species. Columbia University Press.

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 202 (Core)**

**Comparative Physiology**

**Credits: 4**

**Objective:** The aim of this paper is to impart advanced knowledge about the principles of physiology, of both cells and organisms and also with respect to the principal Phyla and Classes of animals

**Outcomes**: An appropriate understanding of functioning of each system of different groups of animals with their comparison will be acquainted.

**Note:**

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3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section - A**

1. Feeding mechanisms and regulation, Comparative physiology of digestion
2. Respiration: organs and respiratory pigments through different phylogetic groups. Physiological response to oxygen deficient stress.
3. Patterns of nitrogen excretion among different animal groups
4. Osmoregulation in different animal groups

1. Thermoregulation
	1. Homeothermic animals
	2. Poikilotherms
	3. Hibernation and Aestivation
	4. Physical, chemical, neural regulation
2. Circulation of body fluids and their regulation among different animal groups
3. Receptor physiology – a comparative study
	1. Mechanoreception
	2. Photoreception
	3. Chemoreception
	4. Equilibrium reception
4. Contractile elements, cells and tissues among different phylogenie groups
	1. Muscle structure and function-correlation
	2. Electric organs and tissues

**Section – B**

1. Heterogamy in eukaryotes
2. Biology of sex determination and sex differentiation a comparative account
3. Comparative account of differentiation of gonads in vertebrates
4. Comparative testicular physiology in animals
	1. Morphology
	2. Differentiation
	3. Function and its regulation
5. Comparative ovarian physiology and differentiation in vertebrates
	1. Morphology
	2. Endocrinolgy
	3. Oogensis vitellogensis
6. Fertilization
	1. Pre-fertilization events
	2. Biochemistry of fertilization
	3. Post fertilization events
7. Multiple ovulation and embryo transfer technology (MOFT)
	1. *In* *vitro* oocyte maturation
	2. Superovulation
	3. *In vitro* fertilization

1. Assisted reproduction technologies
	1. Embryo sexing and cloning
	2. Screening for genetic disorders
	3. ICSI, GIFT etc.
	4. Cloning of animals by nuclear transfer
2. Physiological adaptations to different environments.
3. Concept of Stress and Strain, Stress hormones and stress regulatory mechanisms.

**Suggested Reading Material**

1. C.L. Prosser. Comparative Animal Physiology. W.B. Saunders & Company.
2. R. Eckert. Animal Physiology: Mechanisms and Adaptation. W.H. Freeman & Company.
3. W.S. Hoar. General and Comparative Animal Physiology
4. Schiemdt-Nielsen. Animal Physiology: Adaptation and Environment. Cambridge.
5. C.L. Prosser. Environment and Metabolic Physiology. Wiley-Liss, New York.

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 203 (Core)**

**Population Genetics and Evolution**

**Credits: 4**

**Objective:** To understand the origin and progression of life on earth with conventional and novel evidences and techniques.

**Outcomes**: To provide students the basic insight about the mechanism of evolution and to make them able to relate different forms of life on our planet earth. It will also provide them in-depth knowledge about the changing frequency and distribution of alleles within the population.

Note:

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3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Concepts of evolution and theories of organic evolution with an emphasis on Darwinism.

2.0 Neo Darwinism

 2.1 Hardy-Weinberg law of genetic equilibrium

 2.2 A detailed account of destabilizing forces:

 (i) Natural selection

 (ii) Mutation

 (iii) Genetic drift

 (iv) Migration

 (v) Meiotic drive

3.0 Quantifying genetic variability

 3.1 Genetic structure of natural populations

 3.2 Phenotypic variations

 3.3 Models explaining changes in genetic structure of populations

 3.4 Factors affecting human disease frequency

4.0 Molecular population genetics

 4.1 Patterns of change in nucleotide and amino acid sequences

 4.2 Ecological significance of molecular variations

 4.3Emergence of Neo-Darwinism-Neutral Hypothesis

5.0 Genetics of quantitative traits in populations

 5.1 Analysis of quantitative traits

 5.2 Estimation of heritability

 5.3 Genotype-environment interactions

 5.4 Inbreeding depression and heterosis

 5.5 Molecular analysis of quantitative traits

 5.6 Phenotypic plasticity

**Section – B**

6.0 Genetics of speciation

 6.1 Concept of species

 6.2 Patterns and mechanisms of reproductive isolation

 6.3 Modes of speciation (Allopatric, Sympatric, Parapatric, Peripatric)

7.0 Molecular Evolution

 7.1 Gene Evolution

 7.2 Evolution of gene families, Molecular drive

 7.3 Assessment of molecular variations

8.0 Origin of higher categories

 8.1 Phylogenetic gradualism and punctuated equilibrium

 8.2 Major trends in 'the origin of higher categories

 8.3 Micro-and Macro-evolution

9.0 Molecular phylogenetics

 9.1 Concept of phylogenetic trees.

 9.2 Methods of construction of Phylogenetic trees.

10.0 Population genetics and ecology

 10.1 Metapopulations

 10.2 Monitoring Natural Populations

 10.3 Populations size and extinction

 10.4 Loss of genetic variations

 10.5 Conservation of genetic resources in diverse texa

**Suggested Reading Material**

1. Dobzhansky, Th. Genetics and Origin of Species. Columbia University Press. Dobzhansky, Th., F.J. Ayala, G.L. Stebbines and J.M. Valentine. Evolution. Surjeet Publication, Delhi.
2. Futuyama, D.J. Evolutinary Biology, Suinuaer Associates, INC Publishers, Dunderland.
3. Hartl, D.L. A Primer of Population Genetics. Sinauer Associates, Inc, Massachusetts.
4. Jha, A.P. Genes and Evolution. John Publication, New Delhi.
5. King, M. Species Evolution-The role of chromosomal change. The Cambridge University Press, Cambridge.
6. Merrel, D.J. Evolution and Genetics. Holt, Rinehart and Winston, Inc.
7. Smith, J.M. Evolutinary Gentics. Oxford University Press, New York.
8. Strikberger, M.W. Evolution. Jones and Bartett Publishers, Boston London.

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 204 (Core)**

**Biology of Vertebrates**

**Credits: 4**

**Objective:** This paper deals with the comparative and evolutionary trends in structure and function of the organ systems of the vertebrate series.

**Outcomes**: To understand various biological functions, the evolution of life from most primitive to most advanced form with respect to their habit and habitat.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Introduction to Chordates with their general characters.

1.1 Origin of Chordates

 1.2 Concept of Protochordata or pre-vertebrates

 1.3 Classification of Vertebrates upto orders

2.0 Integument and its derivatives

 2.1 Development, general structure and functions of skin and its derivatives

 2.2 Glands, scales, horns, claws, nails, hoofs, feathers and hair

3.0 Skeletal system

 3.1 Form, function, body size and skeletal elements of the body

 3.2 Comparative account of jaw suspensorium, Vertebral column

 3.3 Limbs and girdles

4.0 Digestive system: Dentition, Stomach, Digestive Glands

5.0 Respiratory system

 5.1 Characters of respiratory tissue

 5.2 Internal and External Respiration

 5.3 Comparative account of respiratory organs

**Section – B**

6.0 General plan of circulation in various groups

 6.1 Blood

 6.2 Evolution of heart

 6.3 Evolution of aortic arches, and Portal systems

7.0 Evolution of Urinogenital system in vertebrate series

 7.1 Structure and functions of different types of kidney

 7.2 Urino-genital ducts

8.0 Nervous system

 8.1 Comparative anatomy of the brain in relation to its functions

 8.2 Comparative anatomy of spinal cord

 8.3 Nerves-Cranial, Peripheral and Autonomous nervous systems

9.0 Sense organs

 9.1 Simple receptors

 9.2 Organs of Olfaction and taste

 9.3 Lateral line system

 9.4 Electroreception

**Suggested Reading Material**

1. Barrington, E.J.W. The Biology of Hemichordata and Protochordata. Oliver and Boyd, Edinbourgh.

2. Bourne, G.H. The structure and functions of nervous tissue. Academic Press, New York.

3. Carter, G.S. Structure and habit in vertebrate evolution - Sedgwick and Jackson, London.

4. Kingsley, J.S. Outlines of Comparative Autonomy of Vertebrates. Central Book Depot, Allahabad.

5. Kent, C.G. Comparative anatomy of vertebrates.

6. Milton Hilderbrand. Analysis of vertebrate structure. IV. Ed. John Wiley and Sons Inc., New York.

7. Sedgwick, A. A Students Text Book of Zoology, Vol. II.

8. Torrey, T.W. Morphogenesis of vertebrates. John Wiley and Sons Inc., New York and

 London.

9. Walters, H.E. and Sayles, L.D. Biology of vertebrates. MacMillan & Co., New York.

10. Weichert, C.K. and Presch, W. Elements of chordate anatomy, 4th Edn. McGraw Hall

 Book Co., New York.

11. Messers, H.M. An introduction of vertebrates anatomy.

12. Montagna, W. Comparative anatomy. John Wiley and Sons Inc.

13 Andrews, S.M. Problems in vertebrate evolution. Academic Press, New York.

**SEMESTER – II**

**Total Marks: 50**

**Theory Examination: 40**

**Internal Assessment: 10**

**Time: 3 Hours**

**Paper: Z 205 (Open Elective)**

**Economic Zoology**

**Credits: 2**

**Objective:** It is an open elective paper. The aim of this paper is to import basis understanding about the role of animals in human life and their economic value *vis-à-vis* animal health and conservation.

**Outcomes**: Awareness about the strategies used for the culture of economically important animals and their applications for human as well as animal welfare.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Integrated pest management
2. Sericulture : Types of silk, species of silk moth (scientific names), Silkworms and their host plants, mulberry silk worm culture, agricultural aspects of mulberry plant cultivation, extraction and reeling of silk, natural enemies and diseases of silkworm and their control
3. Apiculture : Species of honey bees in India, life history of *Apis cerana* *indica*, agriculture techniques, bee products and their uses, natural enemies and diseases of honey bee and their control.
4. Lac culture: lac insect (Scientific name), composition of lac, strains of lac insect, cultivation of lac host plants (in brief) processing of lac and uses of lac.

**Section –** B

1. Economic status of Vermiculture, Poultry keeping and Dairy industry in Haryana.
2. Carp culture, Prawn culture and Pearl culture.
3. Wool and fur industry, leather industry.
4. Pharmaceuticals from animals: animal oriented medicines

 **Suggested Reading Material:**

1. Insect Pest Management by Dent, D.
2. Agricultural Entomology by Hill, D.S., Timber Press.
3. Entomology and Pest Management by Pedigo L. P. Prentice Hall, India
4. Agricultural Pests: Biology and Control Measures by B. M. Deoray and T. B.

 Nikam, Nirali Publication, Pune.

1. Concepts of Insect Control by Ghosh M. R. Wiley Eastern Ltd. New Delhi.

**SEMESTER – II**

**Paper: Z 206 (Core)**

**Seminar**

**Credits: 1**

**Total Marks: 25**

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 207 (Core)**

**Practical Examination (Based on Papers Z 201 & Z 202)**

**Credits: 4**

**Course Contents:**

1. Study of various components of pond and grassland ecosystem.
2. Determination of Water quality characteristics viz: Dissolved oxygen, pH, free carbon dioxide, salinity, transparency, alkalinity and hardness.
3. Methods of population density measurements.
4. Estimation of biodiversity indices.
5. Histochemistry: Methods of fixation of different tissues.
6. Preparation of tissues for microtomy and cryostat.
7. Histochemical test:

(a) Haemotoxylin-eosin

(b) Toluidine Blue

(c) Sudan Block-B

(d) Mercury bromophenol blue

(e) Methyl green-pyronin-Y

(f) Periodic acid Schiff’s

(g) Acid phosphatase

(h) Alkaline phosphatase

1. Demonstration of live gametes and their staining procedure.
2. Determination of optimum pH, temperature and concentration of amylase, trypsin and Lipase enzyme.
3. Qualitative test of vitamins.
4. Quantification of vitamin A and C.

**SEMESTER – II**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 208 (Core)**

**Practical Examination (Based on Papers Z 203 & Z 204)**

**Credits: 4**

**Course Contents:**

1. Dissections/Demonstration of Digestive, Reproductive, Arterial, Venous systems, Lateral line system, Otolith, Ossicles and Cranial nerves of Rat/ Lab Mice /Fish..
2. Museum specimens and slides :

(i) Protochordates

(ii) Fishes

(iii) Amphibians

(iv) Reptiles

(v) Birds

(vi) Mammals

1. Comparative Osteology

(i) Skull and lower jaw

(ii) Vertebrae

(iii) Girdles

(iv) Limb bones

1. Temporary/Permanent mounts of Hair & Scales
2. Different types of Feathers, Scales & Hair
3. Construction of Phylogenetic tree

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 301**

**Molecular Biology (Core)**

**Credits: 4**

**Objective**: To make students understand the complex molecular mechanisms occurring in cell and the applications of molecular technologies.

**Outcomes**: The study of molecular biology provides the necessary information about the chemistry of life to allow the students to understand the basis of life. The study of molecular biology stands as a tribute to human curiosity for seeking to discover, and to human creative intelligence for devising the complex instruments and elaborate techniques by which these discoveries can be made.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 History and Scope of Molecular Biology

2.0 DNA Replication

 2.1 Prokaryotic and Eukaryotic DNA replication

 2.2 Mechanics of DNA replication

 2.3 Enzymes and accessory proteins involved in DNA replication

3.0 Transcription

 3.1 Prokaryotic transcription

 3.2 Eukaryotic transcription

 3.3 RNA polymerases

 3.4 General and specific transcription factors

 3.5 Regulatory elements and mechanisms of transcription regulation

 3.6 Transcriptional and post-transcriptional gene silencing.

4.0 Post-transcriptional Modifications in RNA

 4.1 5'-Cap formation

 4.2 3'-end processing and polyadenylation

 4.3 Splicing, Editing

 4.4 Nuclear export of mRNA

 4.5 mRNA stability

**Section – B**

5.0 Translation

 5.1 Genetic code

 5.2 Prokaryotic and Eukaryotic translation

 5.3 The translational machinery

 5.4 Mechanisms of initiation, elongation and termination

 5.5 Regulation of translation

 5.6 Co- and Post-translational modifications of proteins

6.0 Antisense and Ribozyme technology

 6.1 Molecular mechanisms of antisense molecules

 6.2 Inhibition of splicing, polyadenylation and translation

 6.3 Disruption of RNA structure and capping

 6.4 Biochemistry of ribozyme; hammerhead, hairpin and other ribozymes

 6.5 Strategies for designing ribozymes

 6.6 Application of antisense and ribozyme technologies

7.0 Recombination and Repair

 7.1 Holiday junction, gene targeting, gene disruption

 7.2 Cre/lox recombination

 7.3 RecA and other recombinases

 7.4 DNA repair mechanisms

8.0 Molecular mapping of genome

 8.1 Genetic and physical maps

 8.2 Physical mapping and map-based cloning

 8.3 Southern and fluorescence *in situ* hybridization for genome analysis

 8.4 Chromosome micro-dissection and micro-cloning

 8.5 Molecular markers in genome analysis RFLP, RAPD and AFLP analysis and their applications

 8.6 Molecular markers linked to disease resistance genes

**Suggested Reading Materials**

1. Molecular Biology of the Gene, J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A Steitz and A.M. Weiner. The Benjamin/Cummings Pub. Co., Inc., California.
2. Molecular Cell Biology, J. Darnell, H. Lodish and D. Baltimore Scientific American Books, Inc., USA
3. Molecular Biology of the Cell, B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J,D. Watson. Garland Publishing Inc., New York.
4. Gene VI, Benjamin Lewin, Oxford University Press, U.K.
5. Molecular Biology and Biotechnology. A comprehensive desk reference, R.A Meyers (Ed.), VCH Publishers, Inc., New York.
6. Molecular Cloning: a Laboratory Manual, J. Sambrook, E.F. Fritsch and T. Maniatis, Cold Spring Harbor Laboratory Press, New York.
7. Introduction to Practical Molecular Biology, P.D. Dabre, John Wiley & Sons Ltd., New York.
8. Molecular Biology LabFax, T.A Brown (Ed.), Bios Scientific Publishers Ltd., Oxford.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 302 (Core)**

**Molecular Endocrinology**

**Credits: 4**

**Objective:** To explore the molecular approaches to study the mechanism of action of hormones and related molecules involved in various physiological processes

**Outcomes:**

* It helps in explaining hormonal synergism and antagonism at the molecular level
* Students will be able to identify the organs involved in the endocrine function and an understanding of appropriate key human endocrine disorder will also be developed
* To make student understand the basic structure and chemical organization of hormones and various signaling molecules.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Basic concept of endocrinology, its scope and role in molecular biology.
2. Chemical nature of hormones;

 2.1 Amino-acid derived hormones

 2.2 Peptide hormones

 2.3 Glyco-protein hormones,

 2.4 Steroid hormones and

 2.5 Prostaglandin

1. Biosynthesis of peptide hormones, transcriptional and post-transcriptional modifications
2. Network of extra-cellular and intracellular signals. Role of cell structure in intracellular communication.
3. Prostaglandin structure, type, synthesis and biological activities.
4. Mechanism of action of peptide hormones; concept of second messengers, cAMP, cGMP, Ca++, Calmoduline, IP3, DAG, NO, signal transduction mechanisms.
5. Mechanism of action of steroid hormones; Nuclear receptors, orphan genes and receptors and their role in metabolism and development. Cross talk concept, Heat shock proteins.

## Section – B

1. Hormonal regulation of Metabolism:

 8.1 Role of Insulin & Glucagon in regulation of Carbohydrate metabolism

 8.2 Metabolic regulatory hormones in Lipid & Protein metabolism

1. Role of Parathyroid Hormone in Ca++ & PO4— regulation
2. Genetic basis of hormonal disorders.
3. Sequence-specific DNA binding proteins, DNA binding receptor proteins and their role in gene transcription, cell differentiation and cell proliferation.
4. Gastrointestinal hormones and their role in regulation of metabolic activity.
5. Regulatory substances – Erythropoietin, growth factors, Thymus gland & Kinins.
6. Diabetes & Obesity management vis-à-vis life style & Endocrine factors.

**Suggested Reading Materials**

1. Benjamin Lewin, Genes VII, Oxford University Press.
2. Lodish et al. Molecular Cell Biology.
3. Ethan Bier. The Coiled Spring, Cold Spring Harbor Press.

4. L.P. Freedman. Molecular Biology of Steroid and Nuclear Hormone Receptors, Birkhauser.

5. G. Litwack. Biochemical Actions of Hormones, Academic Press.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 303 (Core)**

**Applied Zoology**

**Credits: 4**

**Objective:** To create acquaintance about economic and therapeutic importance of animals for humans *vis-à-vis* animal welfare.

**Outcomes:** Awareness about use of certain animals and their products for human welfare *vis-à-vis* animal welfare will be created. Information regarding the animals that are responsible for economic losses will also be acquainted.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section- A**

1. Vertebrate and non vertebrate pests, their harmful status and economic importance (Rodents, Birds, Snails and Insects).
2. Pest control practices: Cultural control, Physical control, Mechanical control, Chemical control, Biological control, Herbal control and legal control**.**
3. Integrated pest management and insects of medical and veterinary importance.
4. Pheromones- Production and their use in pest surveillance and management.
5. Zoonosis:
	1. Viral-Rabies,
	2. Japaneses encephalitis;
	3. Bacterial- Brucellosis, Plague;
	4. Ricketsial- Ricketial zoonosis, Q fever, Scrub typhus.
	5. Protozoan, Helminth and Nematode diseases in humans.

**Section-B**

1. Sericulture : Types of silk, species of silk moth (scientific names), Silkworms and their host plants, mulberry silk worm culture, agricultural aspects of mulberry plant cultivation, extraction and reeling of silk, natural enemies and diseases of silkworm and their control.
2. Apiculture : Species of honey bees in India, life history of *Apis cerana indica,* agriculture techniques, bee products and their uses, natural enemies and diseases of honey bee and their control.
3. Lac culture: lac insect (Scientific name), composition of lac, strains of lac insect, cultivation of lac host plants (in brief) processing of lac and uses of lac.
4. Vermiculture, Poultry keeping, piggery and Dairy industry.
5. Prawn culture, Pearl culture.
6. Edible fresh water fishes, Snakes and snake Venom, Economic importance of mammals.
7. Wool and fur industry, leather industry.
8. Pharmaceuticals from animals and stem cell therapy

**Suggested Reading Material:**

1. Insect Pest Management by Dent, D.
2. Agricultural Entomology by Hill, D.S.,Timber Press.
3. General and Applied Entomology by David, B. V. & Ananthakrishnan, T. N., Tata McGraw-Hill Publishing.
4. Entomology and Pest Management by Pedigo L. P. Prentice Hall, India.
5. General and Applied Entomology by Nayar K. K. and T. N. Ananthkrishnan and B. V. Davis, Tata McGrew Hill Publications. New Delhi.
6. Agricultural Pests: Biology and Control Measures by B. M. Deoray and T. B. Nikam, Nirali Publication, Pune.
7. Concepts of Insect Control by Ghosh M. R. Wiley Eastern Ltd. New Delhi.
8. Economic Zoology. Shukla Upadhyay, Rastogi Publication, Meerut, India, 1998.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 304 (Elective)**

**Molecular Cytogenetics – I**

**Credits: 4**

**Objective**: To study the comprehensive biology of the chromosomes and clinical anomalies with their pedigree patterns.

**Outcomes**: Awareness about the molecular composition of the chromosomes and behaviour of the chromosomes during different phases of the cell cycle. Students will be able to understand the various pedigree patterns and their clinical implication.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Biology of Chromosomes:

* 1. Molecular anatomy of eukaryotic chromosomes.
	2. Metaphase chromosomes: Centromere, Kinetochore, Nucleolar organizer regions and rRNA genes.
	3. Telomere: Functions, Telomeric DNA structure, telomere synthesis, telomerase cycle, telomere shortening in cell senescence and immortalization.
	4. Heterochromatin and euchromatin.

2.0 Giant Chromosomes:

2.1 Polytene Chromosomes

2.2 Lampbrush Chromosomes

3.0 Sex Chromosomes:

* 1. Sex determination and the Y Chromosome
	2. Dosage compensation in *C. elegans, Drosophila* and Humans.
	3. X inactivation in Mice and Mules.
	4. The role of the second X Chromosome
	5. Molecular basis of inactivation.

4.0 Genomic Imprinting:

4.1 Uniparental disomy

4.2 Imprinting disorders

4.3 Ovarian teratomas and hydatiform moles.

4.4 Nature and mechanism of genomic imprinting

4.5 X- inactivation and imprinting

4.6 Sex specific imprinting

**Section – B**

5.0 Somatic Cell Genetics:

5.1 Cell fusion and somatic cell hybrids – agents and mechanism of fusion.

5.2 Gene mapping with somatic cell hybrids

5.3 Applications of somatic cell hybridization

6.0 Genes in Pedigrees:

6.1 Mendelian pedigree pattern.

6.2 Heritable diseases in human.

6.3 Inheritance of mitochondrial diseases

6.4 Complications to the basic pedigree patterns

6.5 Non-Mendelian traits.

7.0 Gene Mutations:

7.1 Spontaneous mutations – Base pair substitution and frame shift mutations

7.2 Induced mutations – Radiation, chemical and environmental

7.3 *In –vitro* site specific mutagenesis.

7.4 Detection of mutagens – The Ames test and sister chromatid exchanges.

8.0 Genetics of Cell Cycle:

8.1 Genetic regulation of cell division in yeast and eukaryotes.

8.2 Molecular basis of cellular check points.

8.3 Molecular basis of neoplasia.

**Suggested Reading Material:**

1. Atherly, A.C., J.R. Girton and J.F. McDonald. The Science of Genetics. Sauders College Publishing, Harcort Brace College Publishers, NY.
2. Brooker, R.J. Genetics : Analysis and Principles. Benjamin/Cummings, Longman Inc.
3. Fairbanks, D.J. and W.R. Anderson. Genetics – The Continuity of Life. Brook/Cole Publishing Company ITP, NY, Toronto.
4. Gardner, E.J., M.J. Simmons and D.P. Snustad. Principles of Genetics. John Wiley and Sons. Inc., NY.
5. Griffiths, A.J.F., J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart. An introduction to genetic analysis. W.H. Freeman and company, NY.
6. Lewin, B. Genes. VI. Oxford University Press, Oxford, New York, Tokyo.
7. Snustad, D.P. and M.J. Simmons. Principles of Genetics. John Wiley and Sons. Inc., NY.
8. Watson, J.D., N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner. Molecular Biology of Genes. The Benjamin/Cummings Publishing Company Inc., Tokyo.
9. Tom Strachan & Read, A.P. Human Molecular Genetics 3rd edition, Garland Publishing 2004, London.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 305 (Elective)**

**Reproduction and Aging – I**

**Credits: 4**

**Objective:** To introduce students to the essential and unifying concepts of physiology, reproduction, neurobiology and development in animals which are central to modern biology.

**Outcomes: Students will be able to understand:**

* the basic and molecular concepts of folliculogenesis, ovulation, follicular atresia and germ line- soma interaction
* the cellular, molecular and biochemical changes in reproductive physiology during ageing
* the importance of diet, exercise, stress and yoga during ageing

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (A & B). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Central nervous system, Hypothalamus-pituitary axis:- Hypothalamus nuclei (anatomy), Vascularity, endocrine functions, Neurosecretions, Neurohormones and Hormones, Pituitary and non-pituitary gonadotrophins and their biological significance.

2.0 Germline-soma interactions during early development.

3.0 Sertoli cell-germ cell interactions and regulation of testicular activity both *in vivo* and *in vitro.*

4.0 Physiology, biochemistry and molecular biology of follicular growth.

5.0 Induced and spontaneous ovulators; Theories of ovulation.

6.0 Follicular atresia; causes, regulation and significance with special reference to fertility regulation.

**Section – B**

7.0 Molecular, cellular and functional changes during ageing, Relationship between reproduction and ageing. Importance of diet, diseases, exercise, stress and yoga.

8.0 Chromatin changes; structural and functional impairment; Acetylatylation, methylation, changes in histones and packing proteins during ageing.

9.0 Enzyme changes during ageing; Isoenzyme patterns, induction of enzymes and molecular properties.

10.0 Collagen changes during ageing; structure, types and cross linking groups and functional changes.

11.0 Hormonal changes during ageing; age-reversal effects of hormones and growth factors.

12.0 Theories of ageing: somatic mutation theory; error theory; codon restriction theory; gene regulation theory; free radical theory ; telomerase theory.

**Suggested Reading Materials:**

1. Guraya S.S. (1998). Cellular and Molecular Biology of General development and Maturation in mammals Narosa Publishing House, New Delhi.
2. Hafez E.S.E.(1994). “Reproduction in farm animals”. Lea Febighiese.
3. Mc Donald L.E. (1988). Veterinary Endocrinology & Reproduction. Varghese Co., Bombay
4. Degrodt L.I.(1995). Endocrinology Vol. I, II, III Saunders.
5. Gurays S.S. (2000). Comparative Cellular and Molecular Biology of Ovary in mammals. I.B.H., New Delhi.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 306 (Elective)**

**Animal Behaviour and Wildlife Conservation – I**

**Credits: 4**

**Objective:** To know the important concept of animal behavior and conservation.

**Outcomes:** It will boost students for betterment of diversified resources and life forms for better conservational measures with keen understanding.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Concept of Animal behaviour; Mile-Stones in the history of animal behaviour and scope.
2. Stereotyped and acquired behaviour patterns : Tropisms, Taxes, Reflexes, Instincts, learning & reasoning; Change in major modes of adaptive behaviour in phylogeny.
3. Perception of the environment : Mechanical, Electrical, chemical, olfactory, auditory, visual
4. Biological rhythms and concept of biological clock.
5. Motivation: Introduction, goal oriented behaviour, biological drives – Primary and Secondary drives.
6. Concept of learning: law of learning, types of learning – Habitation, trial & error learning, latent learning, Insight, Imprinting, Classical conditioning & Instrumental learning.
7. Concept of Migratory behaviour

**Section – B**

1. Wildlife: Definition, significance and Biogeographic/wildlife zones of India.
2. Protected Area Systems: Concept, Historical background, categories and management objectives of protected areas, world growth of protected areas, and Present status of National PA-Systems.
3. Theory and Practice of Biosphere Reserves of the world: Biosphere Reserves of India.
4. Natural Heritage Sites of the world, Natural Heritage sites in India. Important National Park and Wildlife Sanctuaries of India
5. Wildlife and livelihood; Wildlife and illegal trade & control;
6. Wildlife conservation techniques, role of WWF, IUCN, UNEP,
7. Red Data Book; Categories of Endangered Wildlife Species.
8. Avian and Mammalian diversity of the Indian Subcontinent and World.

**Suggested Reading Materials:**

* 1. Techniques for wildlife Census in India by W.A. Rogers (A field manual); Wildlife Institute of India, Dehradun.
	2. Wildlife Wealth of India by T.C. Majupuria; Tecpress Services, L.P., 487/42-SOL-Wattenslip, Pratunam Bangkok, 10400, Thailand
	3. Ali, S. Ripley S.D. Handbook of Birds of India, Pakistan 10-Vols. Oxford University Press, Bombay.
	4. The Book of Indian Animals by S.H. Prater, BNHS-Publication, Bombay.
	5. Wildlife in India by V.B. Saharia Natraj Publishers, Dehradun.
	6. E.P. Gee, The Wildlife of India.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 307 (Elective)**

**Fish, Fisheries and Aquaculture – I**

**Credits: 4**

**Objective:** To acquaint the students about biology of fish and methods of aquaculture, which are important contributors to food security.

**Outcomes**: It will not only generate knowledge about aquaculture but will also create awareness about food security and its importance and will also be helpful in acquainting with methods of conserving fish diversity.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Definition of Fish, Fisheries and aquaculture.

2.0 Classification of fishes with distinguishing characters and examples of each group.

3.0 Indian fisheries production, utilization and demand.

4.0 Estuarine, Marine, Riverine and wetland fisheries: characteristic species and their exploitation.

* 1. Culture fisheries

5.1 Cultivable organisms for aquaculture.

5.2 Criteria of selection of cultivable fishes

6.0 Design, construction and maintenance of fish culture ponds.

7.0 Ecology of fish pond ecosystem

 7.1 Physico chemical conditions of ponds water and soil

 7.2 Biological conditions of waters

 7.3 Weeds and their control

 7.4 Productivity of fish pond

 7.5 Classification of water bodies on the basis of productivity.

8.0 Water pollution its causes and remedy

9.0 Aquaculture Ranching and Rational fishery.

**Section – B**

10.0 Fish integument: Exoskeleton and colouration

11.0 Fins: origin, types and functions

12.0 Food and feeding habits of fishes, Digestion in fishes

13.0 Respiratory system Gill structure and functions, Accessory respiratory organs swim bladder and webberian ossicles

14.0 Osmoregulation in fishes

15.0 Receptors in fishes

15.1 Chemoreceptors

 15.2 Lateral line organs

 15.3 Eye Ear

 15.4 Pineal organ

16.0 Hormones and reproduction: Induced breeding in carps and catfishes.

17.0 Identification of different maturity stages of fishes.

18.0 Migration in fishes

19.0 Fish diseases and their control

20.0 Age and growth studies

**Suggested Reading Materials:**

1. APHA (1995) *Standard Methods of Examination of Water and Wastewater*. American Public Health Association, AWWA, WCPF, Washington DC.

2. Bardach, JE, Ryther & McLarney, Wo (1972) *Aquaculture*, New York: Wiley-Interscience. 896pp.

3. Boulenger, GA & Bridge, TW (1910) *Fishes* (Vol. VII of the Cambridge Natural History) Cambridge Univ. Press, London.

4. Das, P, Verma, SR, Dhaje, RJ & Malik DS (2002) *Coldwater Fish Genetic Resources and their Conservation*. National Conservators publication, 7, 325pp.

5. Datta Munshi, JS & Srivastava, MP (1998) *Natural History of Fishes and Systematics of Freshwater Fishes of India*. Narendra Publishing house, Delhi, 403pp.

6. Jayram, KC (2013) *The Freshwater Fishes of the Indian Region* (Corrected 2nd Edition) Narendra Publishing house, Delhi, 616pp, XXXIX plates.

7. Lagler, KF, Bardach, JE, Miller, RR & Passino, DRM (1977) *Ichthyology,* 21nd Edition, New York, Wiley, 506 pp.

8. Nikolsky, GV (1963) *The Ecology of Fishes,* Academic Press, London.

9. Pillay, TVR (1990) *Aquaculture, principles and practices*. Fishing New Books. 575pp

10. Tandon, KK & Johal, MS (2006) *Age and Growth in Indian Freshwater Fishes.* Narendra Publishing House Delhi, 232 pp.

11. Jhingran, VG (1983) *Fish and Fisheries of India*. Hindustan Publishing Corporation (India) 954 pp

12. Hoar, WS, Randall, DJ & Donaldson, ME (1983) Fish Physiology. Vol. IXA & IXB. Reproduction. Academic Press, London.

**SEMESTER – III**

**Total Marks: 50**

**Theory Examination: 40**

**Internal Assessment: 10**

**Time: 3 Hours**

**Paper: Z 308 (Open Elective)**

**Animal Diversity & Conservation**

**Credits: 4**

**Objective:** To expose students to the basic understanding of animal diversity, its significance in our life and environment.

**Outcomes:** It will generate initiative among students for conservation of our rich natural resources and diversified life forms.

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section-A**

1. Introduction to Animal Diversity
2. Wildlife zones of the India
3. Techniques of animal counts (Examples of Tiger count)
4. Concept of Protected Area Systems

**Section-B**

1. Concept of Biodiversity Conservation
2. Important Protected Areas of India (Biosphere reserve, National Park & Wildlife sanctuaries), Wildlife Tourism
3. Red Data Book
4. IUCN Categories of wildlife species

**Suggested Reading Materials:**

* 1. Techniques for wildlife Census in India by W.A. Rogers (A field manual); Wildlife Institute of India, Dehradun.
	2. Wildlife Wealth of India by T.C. Majupuria; Tecpress Services, L.P., 487/42-SOL-Wattenslip, Pratunam Bangkok, 10400, Thailand
	3. The Book of Indian Animals by S.H. Prater, BNHS-Publication, Bombay.
	4. Wildlife in India by V.B. Saharia. Natraj Publishers, Dehradun.
	5. E.P. Gee, The Wildlife of India.

**SEMESTER – III**

**Paper: Z 309 (Core)**

**Seminar**

**Credits: 1**

**Total Marks: 25**

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 310 (Core)**

**Practical Examination (Based on Papers Z 301 to Z 303)**

**Credits: 4**

**Course Contents:**

1. Non-protein nitrogenous substances: qualitative estimation of serum Bilirubin serum and urine creatintine.
2. Estimation of Acid and alkaline phosphates.
3. Barr body examination from Buccal smear.
4. Sex chromatin from blood sample.
5. *In-vitro* study of effect of hormones.
6. Study of endocrine glands of vertebrates.
7. Blood groups, hematin crystals, haemoglobin count, DLC, TLC etc.
8. Demonstration of SDS-PAGE and Agarose gel electrophoresis
9. Raising of larval stages-again in respect of mosquitoes:-*Culex*; *Anopheles*; *Aedes*, marking out the basic structural differences at larval level.
10. Preparation of permanent mounts of *Culex* and *Aedes* and *Anopheles* adults- highlight differences, if any, between basic these important vectors.
11. Life cycle study of honey bee, Lac insect, Silk worm, Cabbage butterfly.
12. Study on common household and agriculture pest.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 311 (Elective)**

**Practical Examination (Based on Papers Z 304)**

**Credits: 4**

**Course Contents:**

1. Making karyological preparations from testicular material of suitable insects by squash and air drying techniques to study the structure and behaviour of chromosomes during mitosis and meiosis.
2. Study of chiasma frequency and terminalisation co-efficient.
3. Study of meiosis from Datura and *Tradescantia* for meiotic configuration and chromosomal abberations.
4. Demonstration of banding techniques (C, G and T).
5. Study of NORs in insect chromosomes.
6. Making preparations from salivary glands of *Chironomus* larvae / D*rosophila* larvae to study polytene chromosomes.
7. Preparation of human buccal smear to study sex chromatin.
8. Nuclear sexing from polymorphonuclear leucocytes.
9. Identification of meiotic and mitotic stages from permanent slides.
10. Gel electrophoresis: Practical demonstration.
11. Isolation of genomic DNA.
12. PCR : Introduction and practical demonstration.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 311 (Elective)**

**Practical Examination (Based on Papers Z 305)**

**Credits: 4**

**Course Contents:**

1. Demonstration of brain, spinal cord and associated nerves and male and female reproductive systems of earthworm, cockroach, grass hopper, and rat.
2. Perfusion techniques and fixation method for histological studies.
3. Processing of nervous and reproductive tissues for microanatomy and histochemistry.
4. Study of permanent slides on mammalian reproductive and nervous tissues.
5. Study of folliculogenesis and atresia in rat ovary.
6. Study of apoptosis in nervous tissues and gonads.
7. Extraction and estimation of macromolecules such as proteins, carbohydrates, lipids, and nucleic acids.
8. Histochemical and biochemical analysis of age pigments.
9. Study of vitellogensis in different animals.
10. Oocyte collection; aspiration and slicing method.
11. Oocyte maturation *in vitro*.
12. Sperm morphology, capacitation, sperm count, and sperm motility.
13. *In vitro* fertilization.

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 311 (Elective)**

**Practical Examination (Based on Papers Z 306)**

**Credits: 4**

**Course Contents:**

1. Designing of experiments, observations, techniques of data analysis, presentation of results and writing of laboratory report.

1. To demonstrate locomotive, explorative withdrawal and habituation behaviours in animals.
2. To demonstrate response of animals to light.
3. To demonstrate antennal grooming behaviour in cockroach.
4. Demonstration of food preferences in insects/pests
5. Investigation of habituation of diving response of mosquito larvae.
6. To study the effect of temperature on heartbeat of cockroach/ Gill movements in Fishes.
7. Field study of nesting behaviour of common available avian fauna of the region.
8. Study of Migratory Birds
9. To study mobbing response of birds.
10. Study of animal behavior patterns using repertoire sheets.
11. To prepare charts of wildlife zones of India and the world.
12. Field visits to local areas/Project Report

**SEMESTER – III**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 311 (Elective)**

**Practical Examination (Based on Papers Z 307)**

**Credits: 4**

**Course Contents:**

1. Study of Anatomy and Morphology of important group of fishes.

2. Taxonomic study of common families, genera and species of fishes

3. Collection of fishes of Haryana

4. Survey of fish fauna of a specific fishing spot by each student

5. Examination of skeleton of cartilaginous and bony fishes

6. Study of histological and microscopic structure in fishes

7. Analysis of physical and chemical properties of water

8. Qualitative and quantitative examination of macrozoobenthos and planktons in a water body.

9. Study of Aquatic weeds and aquatic insects

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 401 (Core)**

**Developmental Biology**

**Credits: 4**

**Objective:** To explain how a variety of interacting processes generate an organism’s heterogeneous shapes, size and structural features that arise on the trajectory from embryo to adult, or more generally throughout a life cycle.

**Outcomes:**

* Based on learning contents of embryology, students can have a systematic and organised learning about the knowledge and concepts of growth and development.
* Developmental biology displays a rich array of material and conceptual practices that can be analysed to better understand the scientific reasoning exhibited in experimental life sciences

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type coverng the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Introduction to animal development

 1.1 Problems of developmental biology

 1.2 Developmental patterns in metazoans

 1.3 Development in unicellular eukaryotes

2.0 Creating multicellularity

 2.3 Cleavage types

 2.4 Comparative account of gastrulation

3.0 Early vertebrate development

 3.1 Neurulation and ectoderm

 3.2 Mesoderm and endoderm

4.0 Cytoplasmic determinants and autonomous cell specification

 4.1 Cell commitment and differentiation

 4.2 Cell specification in nematodes

 4.3 Germ cell determinants

 4.4 Germ cell migration

 4.5 Progressive cell - Cell interaction and cell specification fate

5.0 Body Axis

 5.1 Establishment of Body axis in mammals and birds

 5.2 Proximate tissue interactions

 5.3 Genetics of axis specification in *Drosophila*

6.0 Homeobox concept in different phylogenetic groups

**Section – B**

7.0 Tetrapod limb development

8.0 Hormones as mediators of development

 8.1 Amphibian metamorphosis

 8.2 Insect metamorphosis

 8.3 Ovarian luteinization and mammary gland differentiation.

9.0 Environmental evolution and animal development

 9.1 Environmental cues and effects

 9.2 Malformations and disruptions

 9.3 Changing evolution through development modularity

 9.4 Developmental constraints

10.0 Biology of sex determination

 10.1 Chromosomal sex determination - mammals and *Drosophila*

 10.2 Testis determining genes

 10.3 Ovarian development

 10.4 Secondary sex determination in mammals

 10.5 Environmental sex determination.

11.0 Cell diversification in early animal embryo

 11.1 *Xenopus* blastomeres

 11.2 Morphogen gradients

 11.3 Skeletal muscle regeneration

 11.4 Connective tissue cell family

 11.5 Blood cells formation

12.0 The Stem cells concept

 12.1 Embryonic stem cells

 12.2 Renewal by stem cell-epidermis

 12.3 Bone marrow transplant

 12.4 Stem cell therapy

**Suggested Reading Material**

1. S.F. Gilbert. Developmental Biology. Sinauer Associates Inc., Massachusetts.
2. Ethan Bier. ‘The Cold Spring'. Cold Spring Harbor Laboratory Press, New York.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 402 (Core)**

**Vertebrate Immunology**

**Credits: 4**

**Objective:** To provide an understanding of fundamental immunology and the immunological basis of treatment of some common diseases.

**Outcomes: The students will have understanding about**

* How the immune system can fight infection and other diseases
* The strategies to improve existing vaccines and how to approach these
* Cellular and molecular basis of inflammatory response
* Mechanisms involved in control of immune response
* The dynamic nature of the immune system and the need for extensive redundancy in the face of pressure from external infectious diseases and malignancies and auto-immune diseases which arise internally

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Innate and Acquired Immunity

2.0 Phylogeny and Ontogeny of immune system

 2.1 Organization and structure of lymphoid organs

 2.2 Cells of the immune system and their differentiation

 2.3 Lymphocyte traffic

3.0 Nature of immune response

4.0 Nature of antigens and superantigens

 4.1 Antigenicity and immunogenicity

 4.2 Factors influencing immunogenicity

 4.3 Epitopes and haptens

5.0 Structure and Functions of Antibodies

 5.1 Classes and subclasses

 5.2 Gross and Fine structure

 5.3 Antibody mediated effector functions

6.0 Antigen-Ab interactions *in vitro* and *in vivo.*

7.0 Complement System

8.0 Major Histocompatibility Complex in mouse and HLA system in human

 8.1 MHC haplotypes

 8.2 Class I and class II molecules

 8.3 Cellular distribution

 8.4 Peptide binding

 8.5 Expression and diversity

 8.6 Disease susceptibility and MHC/HLA

**Section – B**

9.0 Organization and expression of Ig genes

 9.1 Models for Ig gene structure

 9.2 Multigene organization of Ig genes

 9.3 DNA rearrangements and mechanisms

 9.4 Generation of antibody diversity

 9.5 Differential expression of Ig genes.

10.0 T-cell receptors

 10.1 Isolation, molecular components and structure

 10.2 T-cell maturation and thymus

 10.3 T H-cell activation mechanism 10.4 T-cell differentiation

 10.4 Cell death and T-cell population

11.0 B-cell generation, activation and differentiation

 11.1 B-cell receptors

 11.2 Selection of immature self-reactive B-cells

 11.3 B-cell activation and proliferation

 11.4 T H-B-Cell interactions

 11.5 Humoral immune response-kinetics

12.0 Cytokines

 12.1 Structures and functions

 12.2 Cytokine receptors

 12.3 Cytokines and Immune response

13.0 Cell-mediated effector functions

 13.1 Cell adhesion molecules

 13.2 Effector cells and molecules

 13.3 CTL and NK cells-mechanisms of action

14.0 Hyper sensitivity and auto-immunity

15.0 Immunological tolerance and vaccines.

**Suggested Reading Material**

1. Kuby. Immunology, W.H. Freeman, USA.

2. W. Paul. Fundamentals of Immunology.

3. I.M. Roitt. Essential Immunology, ELBS Edition.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 403 (Core)**

**Environmental Toxicology**

**Credits: 4**

**Objectives:** To apprise the students about the toxicants and their effects on human health

**Outcomes:** The awareness about toxic agents, their effects and knowledge about mode of

 transformation of toxicants will help in creating skilled personnel in the field of

 environment protection and research

**Note:**

1. Nine questions will be set in all.
2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.
3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section- A**

1. Environmental Toxicology:
	1. Historical background, Classical toxicology, ecotoxicology and environmental toxicology.
	2. Classification of toxicants.
2. Toxic agents: Pesticides, metals, solvents radiation, carcinogens, poisons, bio-toxins, petrochemicals.
3. Toxicant uptake:
	1. Route of toxicant uptake/Absorption of toxicant
	2. Uptake at tissue and cellular level/Distribution and storage of toxicant.
	3. Biotransformation and elimination of toxicant.
4. Xenobiotics: Definition, types and significance Target organ toxicity:
	1. Hematotoxicity
	2. Hepatotoxicity
	3. Nephrotoxicity
	4. Neurotoxicity
	5. Dermotoxicity

**Section- B**

1. Environmental Toxicology: Food additives, air, water and soil pollutants.
2. Effect of pollutant on ecosystem with case study of important Organo-phosphorous and Organo-chlorine pesticides, Nitrates, Polychlorinated biphenyls, Clenbutarol.
3. Solid waste management: Primary waste products-Solid waste, toxic biological and hospital landfills, incineration, source reduction and recycling.
4. Bioremediation, its role and significance.
5. Toxicological risk assessment and management with reference to relevant case study.
6. Principles and significance of systematic toxicology.
	1. Definition, introduction and discussion of Genotoxicology.
	2. Applications of toxicology anthropogenic activities and environment.
7. Human toxicology and medicinal ethics.

**Suggested Reading Material**

1. Handbook of Solid Waste Management by Wilson, Van Nostrand, Reinhold.
2. Environmental Studies by D.B. Botkin, & E.A. Keller, Martill Publising Co., Columbs, Toronto, London.
3. Bioremediation Technology by Fulekar, M.H.
4. Biotranformation: Bioremediation Technology for Health & Environmental Protection by R. D. Stapleton Jr. and V.P. Singh (Ed), Elsevier.
5. Casarett & Doull's Toxicology: The Basic Science of Poisons by Curtis Klaassen.
6. Ecotoxicology: The study of pollutants in ecosystems. 3rd Ed. Elsevier by Moriarty, F.
7. Environment concerns and strategies. Ashish Pub. House, NDL by T.N. Khushoo.
8. Environmental biology. Akashdeep Pub. House by R.R. Trevedi Gurdeep Raj.
9. Textbook: A Textbook of Modern Toxicology. Third Edition by E. Hodgson (Ed.). John Wiley & Sons, Inc. (Posted on the D2L content page.)
10. Environmental Health by Monroe T. Morgan
11. Handbook of Environmental Health and Safety – principle and practices by H. Koren; Lewis Publishers
12. Principles of Environmental Toxicology by I. C. Shaw and J. Chadwick; Taylor & Francis ltd.
13. Introduction to Toxicology, 3rd Ed. Taylor & Francis, London by Timbrell, J.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 404 (Elective)**

**Molecular Cytogenetics – II**

**Credits: 4**

**Objectives:** To apprise the students about chromosomal anomalies and the techniques to

 detect them clinically in different pathological conditions

**Outcomes:** Awareness about the structural and numerical chromosomal anomalies by using

 banding techniques and the methods used for the diagnosis of the chromosomal

 aberrations in pathological conditions will be generated. Students will get

 acquainted about human genome project and its applications

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Human Cytogenetics:

* 1. Human karyotype.
	2. Nomenclature for normal chromosomes (ISCN)
	3. Variable chromosome features
	4. Nomenclature for acquired chromosome aberrations
	5. Nomenclature for meiotic chromosomes
	6. Species codes.

2.0 Chromosome Banding Techniques and their Applications:

* 1. Q-banding
	2. C-banding
	3. G-banding and R-banding
	4. T-banding
	5. High-Resolution and Replication banding
	6. Nuclease banding
	7. Molecular correlates of chromosome bands.
	8. Functional significance of chromosome bands.

3.0 Numerical and Structural Abnormalities of Human Chromosomes –Syndromes:

3.1 Autosomal syndromes – cat-cry syndrome, Wolf-Hirchhorn syndrome, Trisomy 13, Trisomy 18, Trisomy 21.

3.2 Sex chromosomal syndromes – Turner syndrome, Klinefelter syndrome, XYY, True and Pseudohermaphroditism.

3.3 Chromosomal abnormalities and dermatoglyphics.

3.4 Fragile sites and fragile X syndrome.

4.0 Cytogenetic Implications and Consequences of Structural Changes and Numerical Alterations of Chromosomes:

* 1. Aberrations of chromosome number – Polyploidy, aneuploidy
	2. Aberrations of chromosome structures – Duplications, deletions, inversions, translocations.

**Section – B**

5.0 rDNA Technology:

5.1 Gene-cloning

5.2 Vectors

5.3 cDNA and genomic liberaries

5.4 Blotting techniques

5.5 Chromosome walking

5.6 Application of rDNA technology

6.0 Molecular Cytogenetic Techniques:

6.1 FISH

* 1. Chromosome painting
	2. Automated karyotyping
	3. Flow cytometery
	4. DNA fingerprinting

7.0 Molecular Markers in Genome Analysis:

* 1. RFLP
	2. RAPD
	3. AFLP
	4. PCR and its applications in genome analysis
	5. Microarrays – bases expression analysis.

8.0 Genome Projects:

* 1. Human genome project – history, organization, goals and value of the project.
	2. Genetic mapping of the human genome
	3. Physical mapping of the human genome
	4. Human genome diversity project
	5. Model organisms and other genome projects.
	6. Life in the post genomic era.

**Suggested Reading Material**

1. Atherly, A.C., J.R. Girton and J.F. McDonald. The Science of Genetics. Sauders College Publishing, Harcort Brace College Publishers, NY.
2. Brooker, R.J. Genetics : Analysis and Principles. Benjamin/Cummings, Longman Inc.
3. Fairbanks, D.J. and W.R. Anderson. Genetics – The Continuity of Life. Brook/Cole Publishing Company ITP, NY, Toronto.
4. Gardner, E.J., M.J. Simmons and D.P. Snustad. Principles of Genetics. John Wiley and Sons. Inc., NY.
5. Griffiths, A.J.F., J.H. Miller, D.T. Suzuki, R.C. Lewontin and W.M. Gelbart. An introduction to genetic analysis. W.H. Freeman and company, NY.
6. Lewin, B. Genes. VI. Oxford University Press, Oxford, New York, Tokyo.
7. Snustad, D.P. and M.J. Simmons. Principles of Genetics. John Wiley and Sons. Inc., NY.
8. Watson, J.D., N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner. Molecular Biology of Genes. The Benjamin/Cummings Publishing Company Inc., Tokyo.
9. Tom Strachan & Read, A.P. Human Molecular Genetics 3rd edition, Garland Publishing 2004, London

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 405 (Elective)**

**Reproduction and Aging – II**

**Credits: 4**

**Objectives:** To introduce students to the essential and unifying concepts of physiology,

 reproduction, neurobiology and development in animals which are central to

 modern biology to specify the targets for fertility regulation

**Outcomes:** The students will have knowledge about the:

* Basic and molecular concepts of reproductive and neurophysiology
* Cellular and molecular mechanisms of fertilization, implantation, pregnancy and lactation
* Basic concepts of nervous system and mechanism of action and various neuropsychiatric disorders.

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Biology of oocyte maturation and its regulations.
2. Molecular basis of fertilization; Capacitation, Acrosome reaction, Cortical granules exocytosis & egg activation. *In vitro* and *in vivo* fertilization, sexing, stem cells, cloning and future prospectives.
3. Corpus luteum, structure and functions. Control of luteal functions including luteolytic & luteotrophic factors, Pseudopregnancy and gestation periods.
4. Hormonal regulation of implantation, pregnancy, parturition, placenta and its hormones. Artificial wombs, Immunocontraception; Mammary glands and physiology of lactation.
5. In vitro fertilization and embryo transfer technology with special reference to wildlife conservation.
6. Environmental factors influencing Reproduction; Pheromones and Reproduction.

**Section – B**

1. Structure and classification of neurons and glial cells. synaptic action, dendritic properties and functional operation of spinal cord, Brain stem, Autonomic nervous system.

8.0 Principles of synaptic transmission; Ca2+ and transmitter release; post synaptic transmission mechanism; diversity of neurotransmitters: acetylcholine, catecholamine, serotonin, GABA, glycine, histamine, peptides, NO, and opiods.

9.0 Apoptosis its molecular mechanism regulation, and significance.

10.0 Neurophychiatric disorders; Diseases involving myelin; Ischemia and hypoxia; Epileptic seizers; Alzheimer disease; Prion disease; Progeria, Parkinson’s disease.

11.0 Dietary requirements of the aged, psychological and social problems of the aged.

**Suggested Reading Materials:**

1. Guraya S.S. (1998). Cellular and Molecular Biology of General development and Maturation in mammals Narosa Publishing House, New Delhi.
2. Hafez E.S.E.(1994).”Reproduction in farm animals”. Lea Febighiese.
3. Mc Donald L.E. (1988). Veterinary Endocrinology & Reproduction. Varghese Co., Bombay
4. Degrodt L.I.(1995). Endocrinology Vol. I,II,III Saunders.
5. Gurays S.S. (2000). Comparative Cellular and Molecular Biology of Ovary in mammals. I.B.H., New Delhi.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 406 (Elective)**

**Animal Behaviour and Wildlife Conservation – II**

**Credits: 4**

**Objectives:** To explore the important concept of animal behavior and conservation.

**Outcomes:** It will enhance students understanding for betterment of diversified resources and

life forms for the sustainable natural resource utilization and better conservational

 measures with keen understanding and new approaches.

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1.0 Social behaviour:

1.1 Aggregations and society;

1.2 Advantages of group living;

1.3 Types of social organization in animals

1.4 Group selection, kin selection, altruism, reciprocal altruism.

1.5 Territoriality and parental care

1.6 Behaviour Ecology: Habitat selection

2.0 Social behaviour of termites, ants and primates.

3.0 Various means of communication in animals: Chemical, Visual, auditory, touch etc.

4.0 Hormones and animal Behaviour: Hormones important to behavioural regulation;

 Genetic basis of behaviour

* 1. Aggressive behaviour; sexual attraction and sexual behaviour.

6.0 Pheromones and animal behaviour: types of pheromones, role of pheromones in

 animal behaviour; pheromones of social insects.

7.0 Human Ethology

**Section – B**

8.0 Wildlife Census: Planning a wildlife census, understanding sample counts, Block

 counts, Road side counts, Dung counts, Pugmark census, Water-hole census,

 Presentation of India. Key industrial animals.

1. Study of signs and symptoms: A practice of recording field observations

10.0 Bio-telemetry, Ageing and Sexing techniques.

11.0 Wildlife Tourism: Definition scope and range; Popular Wildlife Tourist Sports of the

 world, Popular Wildlife spots in India, Sustainable use of wildlife spots.

12.0 Wildlife Damage, its nature and definition, electric fences for wildlife damage control, Basic electric fence design, Trench design, line trapping, Mist netting, Rocket netting Chemical capture: Equipment, Drugs, Plan of operation.

13.0 Poaching: Its definition and implications, conducting anti-poaching operations,

 evidence in poaching cases.

14.0 National Projects: Project Tiger, Project elephant, Project Rhinoceros, Project

 Crocodiles, Project Hangul, Manipur Brow Antlered Deer.

**Suggested Reading Materials:**

1. Techniques for wildlife Census in India by W.A. Rogers (A field mannual); Wildlife Institute of India, Dehradun.
2. Wildlife Wealth of India by T.C. Majupuria; Tecpress Services, L.P., 487/42-SOL-Wattenslip, Pratunam Bangkok, 10400, Thailand
3. Ali, S. Ripley S.D. Handbook of Birds of India, Pakistan 10-Vols. Oxford University Press, Bombay.
4. The Book of Indian Animals by S.H. Prater, BNHS-Publication, Bombay.
5. Wildlife in India by V.B. Saharia Natraj Publishers, Dehradun.
6. E.P. Gee, The Wildlife of India.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 3 Hours**

**Paper: Z 407 (Elective)**

**Fish, Fisheries and Aquaculture – II**

**Credits: 4**

**Objectives:** To generate knowledge about the recent methods of fish stock improvement and

 intensive culture of important fin-fish and shell-fish species.

**Outcome**: This will help in developing skilled personnel in techniques of improving the fish

 Stock and yield of aquaculturally important aquatic organisms.

**Note:**

1. Nine questions will be set in all.

2. Question No. 1, which will be objective/short answer type covering the entire syllabus, will be compulsory. The remaining eight questions will be set section wise selecting four questions from each section (I & II). The candidate will be required to attempt question No. 1 and four more selecting two questions from each section.

3. As far as possible the questions should be divided into sub-parts and marks indicated part wise.

**Section – A**

1. Introduction to fish biotechnology
2. Selection and hybridization
3. Androgenesis and Gynogenesis – natural and induced
4. Polyploidy induced
5. Sex reversal and sterility
6. Transgenesis, transgenes and application
7. Cryopreservation of gametes and embryo
8. Fish-by products
9. Fish preservation process
10. Nutritive aspect of fish meat and oil.

**Section – B**

1. Different systems for aquaculture: pond culture, cage culture, raceway culture.
2. Culture of important fish species (Major carps, common carps, Chinese carps, cat fish culture and Tilapia culture).
3. Integrated Aquaculture and waste water aquaculture
4. Pearl Culture
5. Frog culture
6. Prawn culture-Fresh and brackish water
7. Impact of Aquaculture on Environment
8. Methods of Fishing : Crafts and gear technology
9. Nutrition in Aquaculture
	1. Nutrient and non-nutrient diet components
	2. Preparation and processing of feed, feed formulae,
	3. Natural and supplementary feed and their utilization

**Suggested Reading Materials:**

1. Ponniah, AG, Das, P & Verma SR (Ed.) (1998) Fish Genetics and Biodiversity Conservation. Nature Conservators, Muzaffarnagar, India 474pp.

2. Bardach, JE, Ryther, JH & Mclarnely, OW (1972) Aquaculture. Wiley Interscience.

3. Boyd, CE (1988) Water quality management for pond fish culture. Developments in Aquaculture and Fisheries Sciences. I. Elsevier Scientific Publishing Company, Amsterdam.

4. Delince, G (1992) The Ecology of the fish pond system. Kluwer Academic Publishers, Netherlands, 230 pp.

5. Hepher, B (1975) Supplementary feeding in fish culture. In: Nutrition and Production of Fishes. Vol. 3 S. Karger, Basel : 183-198

6. Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research, New Delhi. 755 pp.  **SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 408 (Core)**

**Practical Examination (Based on Papers Z 401 to Z 403)**

**Credits: 4**

**Course Contents:**

* + - 1. Studies of normal development with reference to normal tables of developmental stages of frog/toad chick.
			2. Preparation of whole mounts of embryo and larvae when present
			3. Studies of different types of eggs with reference to their yolk contents
			4. Morphology of chick egg
			5. Determination of volume and density of yolk and albumin
			6. Antigen-antibody interaction in vitro.
			7. ELISA.
			8. Phagocytosis *in vitro*.
			9. Immunological diagnosis of pregnancy/infection/cancer.
			10. Histology of lymphoid organs
			11. Studies on vaginal smears during different stages of estrous cycle.
			12. Bioassay to demonstrate toxicological effect : Micronuclei Assay and demonstration of Single Cell Gel electrophoresis to elucidate toxicological effect
			13. Qualitative test of pesticides exposed fruits and vegetables
			14. Determination of sediment chemistry
1. Moisture
2. Carbonate
3. Nitrate
4. pH
5. Phosphate
6. Texture
7. Organic Carbon

.**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 409 (Elective)**

**Practical Examination (Based on Papers Z 404)**

**Credits: 4**

**Course Contents:**

1. Making karyological preparations from bone marrow of a rodent for making somatic karyotypes.
2. Making karyological preparations from differen tissues of fishes/amphibians/birds for making karyotypes.
3. Study of meiosis in testicular material of suitable vertebrates.
4. Banding techniques in the chromosomes of vertebrates/human.
5. Nucleolus organizer regions in the chromosomes of Human/Rat/Mice/Bird/Fish.
6. Study of Micronuclei and other nuclear anomalies in exfoliated epithelial buccal cells
7. Single Cell Gel Electrophoresis: Practical demonstration
8. To perform short term lymphocyte culture from the blood sample.
9. A survey for the study of :
	1. ABO and Rh blood groups
	2. Some morphogenetic and behavioural traits.
	3. Some biochemical traits.
10. Preparation of pedigrees and pedigree analysis.
11. Submission of a Survey/Project report.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 409 (Elective)**

**Practical Examination (Based on Papers Z 405)**

**Credits: 4**

**Course Contents:**

1. Effects of pesticides, drugs, and xenobiotics on granulosa cells *in vitro*.
2. Effects of pesticides, oxidants, and free radicals on testicular tissue *in vitro*.
3. Morphological charges during spermeogensis.
4. Localization of steroidogenic enzymes.
5. Estimation of catalase from nervous and reproductive tissue
6. Determination of Glutathione peroxides, glutathione reductase during aging.
7. Lipid peroxidation by MDA method.
8. Impact of Vitamin C & F on lipid peroxidation *in vitro.*
9. Fluorescence studies on age pigment.
10. Age related changes in sperm characteristics.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 409 (Elective)**

**Practical Examination (Based on Papers Z 406)**

**Credits; 4**

**Course Contents:**

1. To study the effect of temperature on gill movement in fishes.
2. To study nesting behaviour of squirrels in different habitats vis., urban environment, grain-market-area, roadside plantations, orchards gardens etc.
3. Field study of burrowing behaviour of common available rodent fauna of the region.
4. Study of morphological changes in common avian species during breeding season.
5. Preparation of charts of endangered amphibians, reptiles and mammals with ecological remarks.
6. Animal behaviour patterns using Photostat sheets/ repertoire sheets
7. Analysis of standard pug marks of large sized wild mammals.
8. Study of Migratory Birds
9. Study of Diversity indices : use of software in calculating diversity indices
10. Study of beaks and claws of different bird species.
11. Field visit to a zoo or wildlife part/sanctuary and preparation of field report
12. Preparation of field diary on the basis of observations regarding habitat, habits of common available avian and rodent fauna of the region.

**SEMESTER – IV**

**Total Marks: 100**

**Theory Examination: 80**

**Internal Assessment: 20**

**Time: 4 Hours**

**Paper: Z 409 (Elective)**

**Practical Examination (Based on Papers Z 407)**

**Credits: 4**

**Course Contents:**

1. Fish Feed formulation and processing.

2. Proximate analysis of fish feed (Determination of moisture, protein, fat, ash carbohydrate, fiber and energy).

3. Taking out of pituitary gland, preservation and preparation of extract.

4. Determination of length weight relationship.

5. Determination of age of fish using hard parts

6. Analysis of fecundity, Gonado somatic index (GSI), Hepatosomatic index (HIS) in

 some fishes.

7. Study of crafts and gear and method of operation

8. Visit to fish farm and fish market

9. Histopathological effect of commonly used pesticides on fish tissue