

SYLLABUS FOR
B. SC. ZOOLOGY
(HONOURS & GENERAL) 2016

UNIVERSITY OF CALCUTTA

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DRAFT SYLLABUS FOR B. Sc. ZOOLOGY (HONOURS & GENERAL) 2016

Paper	Unit	No. of Classes	Group	Topic	Marks	
					Gr.	Tot.
PART – I HONOURS						
Paper 1	Unit I	75	Group A	Diversity & Functional Anatomy of Non-chordate Forms	25	50
			Group B	Diversity & Functional Anatomy of Chordate Forms	25	
	Unit II	75	Group A	Cell biology	15	50
			Group B	Genetics	35	
Paper 2	Unit I	75	Developmental Biology			50
	Unit II	75	Practical	Animal forms and Comparative anatomy, Cytological methods and Genetics, Osteology and Embryology	50	
PART – II HONOURS						
Paper 3	Unit I	75	Group A	Systematics	15	50
			Group B	Evolutionary Biology & Adaptation	25	
			Group C	Animal Behaviour	10	
	Unit II	75	Group A	Ecology	25	50
			Group B	Biodiversity and Conservation	25	
Paper 4	Unit I	75	Group A	Animal physiology	25	50
			Group B	Biochemistry	25	
	Unit II	75	Practical	Ecological methods, Systematics and Evolutionary Biology, Animal Physiology and Biochemistry	50	
PART – III HONOURS						
Paper 5	Unit I	75	Molecular Biology			50
	Unit II	75	Group A	Parasitology and Microbiology	25	50
			Group B	Immunology	25	
Paper 6	Unit I	75	Integration Biology and Homeostasis			50
	Unit II	75	Animal Biotechnology & Applied Zoology			50
Paper 7	Practical	75	Molecular biology, Parasitology and Microbiology, Immunology, Histological techniques and staining methods, Adaptation			100
Paper 8	Practical	75	Instrumentation, Report on Environmental audit, Field work assessment, Biostatistics			100

PART - I
(PAPER 1: UNIT I)

(Diversity & Functional Anatomy of Non-chordate & Chordate Forms)

[Note: Classification will be dealt in practical section of the course]

Group A: Non chordate

Marks = 25

1. Animal architecture and Bauplan concept.
2. Classification up to Phylum of Protozoa (according to Levine *et. al.*, 1981); from Phylum to living Subclass with reasons of other non-chordates (according to Ruppert and Barnes, 1994)(Invertebrate chordates excluded)
3. Movement: Ameoboid movement: Mechanism of pseudopodia formation by cytoskeletal proteins. Flagellar movement in *Euglena* – ultra structure of Flagella and mechanism of locomotion
4. Reproduction in *Paramoecium* sp. with **special** reference to conjugation
5. Canal system in Porifera
6. Polymorphism in Siphonophores and its evolutionary significance
7. Coral reef: Types, distribution in India and conservation aspects
8. Metamerism in Annelida and its evolutionary significance
9. Respiration: Terrestrial respiration in *Periplaneta* – Structure of tracheal system and mechanism of respiration. Aquatic respiration in Prawn–structure and types of gills and mechanism of respiration.
10. Nervous system in *Pila* and effect of torsion on it. Nervous system in *Aplysia* and effect of de-torsion on it.
11. Water vascular system in *Asterias* sp.
12. Structural organization of Placozoans

Group B: Chordate

Marks = 25

1. Basic body plan in chordates. Basic concept of chordate classification. Classification up to living Subclass of Fish and Aves; up to living Order of Amphibia and Reptilia; up to Infra-class of Mammals (according to J. Z. Young 1981)
2. Structure of pharynx and feeding mechanism in *Branchiostoma* sp.
3. Metamorphosis in *Ascidia* – justification in the light of survival of the species
4. Comparative anatomy & structural organization of aortic arches in vertebrates.
5. Accessory respiratory structure in teleosts
6. Paedomorphosis with special reference to Axolotl larva
7. Non-poisonous and poisonous snakes; Poison apparatus and biting mechanism of poisonous snake
8. Distinguishing features of Ratites and Carinates
9. Feather of Birds – its type, development, structure, colour variations as adaptive feature and function
10. Exoskeletal structure in Mammals – hair, horns and antlers
11. Distinguishing features of Artiodactyla and Perissodactyla.
12. Functional anatomy of ruminant stomach in cow.

[Note: Eight short questions of 2 marks to be set from both the Groups, of which 5 will be answered. 4 questions from Group A and 4 questions from Group B to be set. Each question will be of 10 marks. Students will answer 2 questions from each group]

PAPER 1, UNIT II
(Cell Biology and Genetics)

Group A: Cell Biology

Marks = 15

1. **Principles of microscopy:** Light Microscopy; Phase contrast microscopy; Electron microscopy (EM) - Scanning EM (SEM) and Transmission EM (TEM)
2. **Cell Membrane:** Chemical composition and properties of membrane components, Fluid mosaic model of membrane structure, membrane fluidity and its experimental demonstration, membrane asymmetry, selective permeability of the membranes, membrane transport, Liposomes, Freeze-etching and freeze fracture technique for membrane study.
3. **Mitochondria-** Marker enzymes distribution, mitochondrial biogenesis, Symbiont hypothesis of mitochondrial origin; mitochondrial DNA.
4. **Endo membrane system of cell:** Signal peptide hypothesis, N-linked & O-linked glycosylation in ER and Golgi body; protein transport and trafficking.

GROUP B: GENETICS

[Marks = 35]

1. **Properties of DNA:** Chargaff's rule, Re-naturation and De-naturation, Hyper-chromic shift, c-value paradox.
2. **Concept of genetic information flow**
 - a. **DNA Replication**
 - i. **In prokaryotes:** Semi-conservative replication; unit of replication, enzymes involved, replication origin replication fork, replication slippage
 - ii. **In eukaryotes:** Origin, polymerase enzymes and telomeric replication
 - b. **Transcription in prokaryotes and eukaryotes:**
 - i. Transcription factors: Transcription activators, Repressors, Motifs (only Basic helix loop helix [BHLH], Leucine zipper – definition and example)
 - ii. Formation of initiation complex (in Prokaryotes and RNA Polymerase II in Eukaryotes)
 - iii. RNA polymerase, chain elongation and termination.
 - c. **RNA processing:** Polyadenylation, methyl capping, splicing.
 - d. **Protein synthesis in prokaryotes:** formation of initiation complex, initiation factors, elongation and elongation factors, termination
3. **Allele concept:** Cis-trans test for allelism, Multiple allele: ABO blood group in human; Isoallele: White eye locus in *Drosophila*; Complex locus: Lozenge locus in *Drosophila*.
4. **Linkage:** Complete and Incomplete linkage; Experiments by Bridges
5. **Crossing over:** Three point mapping method; cytogenetic evidence of crossing over in *Drosophila* by Stern's experiment.
6. **Mutation**
 - a. Types: transition, transversion, frame shift, nonsense, mis-sense, hypomorphic, null, lethal, forward, backward, suppressor, enhancer.
 - b. Mutagens and their effects: UV radiation, ionizing radiation, 5-BU, EMS.
 - c. Mutation detection: X linked mutation detection in *Drosophila* by CIB method, Attached X methods, Autosomal mutation detection by CyLPm (balanced lethal) method, and detection of biochemical mutation in *Neurospora crassa*.

7. **Sex determination in *Drosophila* and Human**

8. **Dosage compensation**

a. **In *Drosophila*:** Hyper activation of ♂X by *msl*, *mle* and *roX* RNA followed by *histone Ac16* acetylation

b. **In human:** Inactivation of ♀X by *XIST* RNA followed by DNA methylation

9. **Chromosomal Aberration:** Types and examples from *Drosophila* and human only.

10. **Cytoplasmic inheritance:** Shell coiling in snail, kappa particle in *Paramecium*.

[**Note:** Eight short questions of 2 marks are to be set from both the Groups, of which 5 will be answered. 3 questions from Group A and 5 questions from Group B are to be set. Each question will be of 10 marks. Students will answer 1 question from Group A and 3 questions from Group B]

PAPER 2, UNIT I

DEVELOPMENTAL BIOLOGY

(Marks = 50)

1. **Gametogenesis:** Spermatogenesis & Oogenesis.
2. **Ultra structure:** sperm and ovum in Sea-urchin and mammals.
3. **Egg Membranes**
4. **Fertilization:** In Sea-urchin and mammals
5. **Cleavage:** Cleavage plane, types, role of yolk in cleavage; cleavage process in sea-urchin and mammals.
6. **Blastula formation:** sea urchin and chick
7. **Fate map:** fate mapping methods. Fate map in chick blastula.
8. **Morphogenetic movements:** Types and examples.
9. **Gastrulation:** Frog & chick
10. **Organizer:** Speman-Mangold organiser experiment; concept of induction, determination, and differentiation
11. **Placenta:** Types, examples and functions.
12. **Extra-embryonic membrane:** Formation and function in chick.
13. Concepts of cryopreservation of gametes and embryo of man, IVF and embryo transfer in man
14. **Stem cell:** ES and adult stem cell, characteristic features, definition of potency and niche, markers in human stem cell, potential application of stem cells as regenerative medicine
15. **Organogenesis** – development of eye as an example of reciprocal and repeated inductive events

[**Note:** Eight short questions of 2 marks to be set, of which 5 will be answered. 8 questions of 10 marks to be set. Students will answer 4 questions]

Animal forms & comparative anatomy (10)

1. Study of internal organ systems of one non-chordate (*Periplaneta*) and one chordate (*Oreochromis*) – [*Periplaneta*: Nervous system, Digestive system, Reproductive system. *Oreochromis*: Digestive system, Urinogenital system, Olfactory apparatus.]
2. Anatomical study: kidney, brain, heart, limb bones of different vertebrates using picture/photo or models (clay/plastic/plasticin) or computer generated models.

Cytological methods & Genetics (15)

1. Demonstration and description of compound microscope. Measurement of size (length/breadth) by micrometry of any Cell/organ/protozoa.
2. Pedigree analysis (autosomal, X linked and Y linked traits only).
3. Study of meiotic stages from Grasshopper

Osteology & Embryology (15)

1. Identification of bones with reasons: (a) Skull of *Calotes*, a poisonous snake, *Chelonia*, *Columba*, *Cavia* (b) Vertebrae of *Columba* & *Cavia* (c) Appendicular bones of *Columba* & *Cavia* (d) Girdle bones of *Columba* & *Cavia*
2. Identification of whole mount embryo (24 hrs, 48 hrs, 72 hrs and 96 hrs) of chick;
3. Identification of larval forms: *Nauplius*, *Ephyra*, *Zoea*, *Mysis*, *Megalopa*, *Glochidium*, *Trochophore*, *Veliger*, *Bipinnaria*, tadpole.

Laboratory note Book (5)**Viva Voce (5)****PAPER 3, UNIT I****Systematics, Evolutionary Biology & Animal Behaviour****Group A: Systematics****Marks = 15**

1. Taxonomy – Levels of taxonomy (alpha, beta and gamma taxonomy, micro and macro taxonomy), scope of taxonomy
2. Systematics – Place of Systematics in Biology, contribution of Systematics in Biology
3. Classification (Phenetic and Cladistics)
4. Concept of dendrogram and cladogram
5. Biological Species concept, Subspecies, Polytypic species, Sibling species and Ring species
6. Isolation and its role in speciation (pre mating and post mating)
7. Modes of speciation – Sympatric, Allopatric and Parapatric
8. Type concept – names of primary and secondary types, their definitions and applications
9. Basic principle and use of DNA bar coding in species identification

Group B: EVOLUTION AND ADAPTATION**Marks = 25**

1. RNA world & Origin of life (Chemical origin only)
2. Natural selection, Synthetic theory. Concept of selection: stabilizing, directional and disruptive with example
3. Hardy-Weinberg equilibrium; calculating allele & genotype frequency, mathematical calculation of frequency changes in mutation, migration

4. Genetic drift, founder effect and population bottleneck
5. Bathymetric and discontinuous distribution
6. Barriers and dispersals - types and their impact on animal distribution
7. Zoogeographical realms – names & animal distribution according to Wallace scheme, Avian and Mammalian faunal distribution in different realms
8. Origin of birds
9. Evolution in horse
10. Xeric (camel and lizard); Arboreal (sloth bear) adaptation
11. Adaptive radiation with special reference to Darwin's finches

Group – C: ANIMAL BEHAVIOUR

Marks = 10

1. Instinctive and learning behavior, fixed action pattern
2. Communication in honey bees (dance language and pheromone)
3. Altruism, kinship and selfishness
4. Echolocation in bat
5. Parental investment (fish only); cost and benefit analysis of parental investment; parent-offspring conflict
6. Bird migration

[**Note:** Total 8 short questions of 2 marks are to be set covering all the Groups, of which 5 will be answered. 2 questions from Group A, 4 questions from Group B and 2 questions from Group C are to be set. Each question will be of 10 marks. Students will answer 1 question from Group A, 2 questions from Group B and 1 question from Group C]

PAPER 3, UNIT II

[Ecology, Biodiversity and Conservation]

Group A: ECOLOGY

(Marks = 25)

1. Concept of Ecosystem – structure and function; generalized model of energy flow in ecosystem
2. Wetland as ecosystem service provider
3. Population attributes – dispersal, dispersion, survivorship curves, age distribution
4. Population growth models – natality, mortality exponential and logistic, density dependent and density independent factors
5. Life history analysis, r and k strategies
6. Population interactions – emergence of competition as a central theory experiments of Tansley, Gause and Park, competition exclusion principle, interspecific and intraspecific competitions, Lotka Volterra model
7. Animal's space and resource use. Resource partitioning. Coupled oscillations of predator and prey population – modeling
8. Community and ecosystem – assemblage, guild and community concept, niche concept, edge effect
9. Ecological succession, types of ecological succession with examples, concept of Climax, Connell and Slatyer' model of succession. Tilman's resource-ratio hypothesis
10. Brief idea on El nino, La nina and their consequences

Group B: BIODIVERSITY AND CONSERVATION**(Marks – 25)**

1. Types of biodiversity, biodiversity and human welfare, mega diversity zones and biodiversity hot spots with special reference to India
2. Concept of wildlife, wildlife heritage of India, reasons for wildlife depletion in Indian context
3. Concept of threatened fauna – IUCN categories.
4. Protected area concept – Sanctuary, National Park, Biosphere reserve, Core Zone, Buffer Zone, Corridor concept. Conservation reserves
5. JFM & Arabari model for conservation – key stone, flagship and umbrella species
6. Special management program with special reference to Tiger project
7. Man–animal conflict (man-tiger and man-elephant) – causes and concern
8. Environmental audit and impact assessment
9. Role of NGO's in wildlife conservation in India

[**Note:** Eight short questions of 2 marks are to be set from both the Groups, of which 5 will be answered. 4 questions from Group A and 4 questions from Group B are to be set. Each question will be of 10 marks. Students will answer 2 question from Group A and 2 questions from Group B]

PAPER 4, UNIT I**Animal physiology and Biochemistry****Group A: ANIMAL PHYSIOLOGY****Marks = 25**

1. Structure & function of haemoglobin, transport of O₂ and CO₂ in mammals, Bohr and Haldane effect, Chloride shift.
2. Physiology of excretion – physiology of urine formation, urea cycle, nitrogenous wastes- ammonia, urea, uric acid, creatinine.
3. Physiology of osmo-regulation in vertebrates
4. Origin and propagation of nerve impulse through nerves, synaptic and neuro-muscular junctions, functional significance of Giant nerve fibers in mollusks
5. Physiology of skeletal muscle contraction
6. Temperature regulation in cold desert
7. Physiology of vision in human, compound eyes and image formation in insects
8. Physiology of hibernation and aestivation with reference to amphibians, reptilians and gastropods

Group B: BIOCHEMISTRY**Marks = 25**

1. Carbohydrate metabolism – Glycogenesis, Glycogenolysis, Neoglucogenesis
2. Metabolism of amino acids; transamination and oxidative and non-oxidative deamination
3. Nucleic acid metabolism – Purine salvage pathway
4. Beta-oxidation of fatty acids –
 - a. Palmitic acid {saturated (C 16:0)}
 - b. Linoleic acid {unsaturated (C 18:2)}
5. Integration: Krebs cycle, Oxidative phosphorylation and Electron transport chain
6. Enzymes - Classes; kinetics and factors affecting enzyme action, enzyme inhibition
7. Structure and function of neuro-transmitter: **glutamate**, γ -aminobutyric acid (**GABA**), **dopamine** (DA), **norepinephrine** (**noradrenaline**; NE, NA), epinephrine (adrenaline)

[**Note:** Eight short questions of 2 marks are to be set from both the Groups, of which 5 will be answered. 4 questions from Group A and 4 questions from Group B are to be set. Each question will be of 10 marks. Students will answer 2 question from Group A and 2 questions from Group B]

PAPER 4, UNIT II

(PRACTICAL)

Marks = 50

Ecological methods: (10)

1. Use of pH meter for estimation of pH in water and soil samples
2. Study of micro arthropods of water and soil samples
3. Determination of dissolved O₂, free CO₂ of water
4. Zoo-plankton count by standard methods

Systematic & Evolutionary Biology: (10+10)

- General discussion, distinguishing characters and classification of respective Phylum should be taken into consideration. In Laboratory Note Book scheme of classification of all Phylum should be written before identification
- Key making with the specimens both from non-chordate (e.g., insects) and chordates (e.g., fishes)
- Identification with reasons of the following Museum specimens should be done

Non-chordates: *Elphidium, Scypha (Syn, Sycon), Neptune's cup, Aurelia, Pennatula, Sea anemone, Fasciola, Chaetopterus, Beroe, Madrepora, Nereis, Aphrodite, Squilla, Hippa, Eupagurus, King crab, Peripatus, Belostoma, Achatina, Chiton, Patella, Aplysia, Mytilus, Sepia, Loligo, Nautilus, Asterias, Sea-urchin, Sea-lily, Balanoglossus*

Chordates: *Branchiostoma, Ascidia, Petromyzon, Myxine, Torpedo, Sphyrna, Hippocampus, Mystus, Necturus, Ichthyophis, Tylostotriton, Cryptobranchus, Hyla, Chameleon, Gekko, Vipera, Calotes, Mabuya, Varanus, Naja, Hydrophis, Mega Chiroptera*

Animal Physiology and Biochemistry (10)

1. Quantitative estimation of protein by modified Lowry's colorimetric method
2. Qualitative tests for Carbohydrate (Starch, Sucrose, Maltose Fructose, Glucose), Protein (Albumin, Gelatin, Peptone), fat, uric acid (in Alkaline solution) and urea (Tests to be performed – Red Litmus Test, Hypobromite test, Biuret test, Millon's test, Iodine test, Benedict's test, Barfoed test, Seliwanof's test)
3. Counting of cockroach haemocytes using haemocytometer
4. Preparation of Normal, molar and standard solutions, phosphate buffers, serial dilutions

Submission of Laboratory note Book (5)

Viva Voce (5)

PART III
(PAPER 5, UNIT I – THEORY)
Molecular Biology (Marks = 50)

1. **Genome analysis**
 - a. DNA sequencing: Principle of Dideoxy sequencing
 - b. Restriction enzyme: Types and use in gene cloning
 - c. Cloning vectors: Characteristic features, Plasmid vector (pBR322, pUC19), Cosmid, phage vector, Concept of expression and Shuttle vector
 - d. Construction of genomic DNA and cDNA libraries
 - e. PCR: Basic Principle. Use of Allele specific RT-PCR
 - f. DNA fingerprinting: Principle of RFLP, mini-satellites, microsatellites, RAPD and its uses
 - g. Blot Technique: Southern Blot and Northern Blot
2. **Proteome Analysis:** Principle and use of SDS PAGE, affinity chromatography and Gel Filtration chromatography, immuno-electrophoresis, Western blot (excluding methodology)
3. **Regulation of gene expression:** Operon concept (inducible and repressible viz. Lac and Tryptophan operon)
4. **Epigenetic regulation of gene expression:** DNA methylation (CpG) and histone acetylation.
5. **Recombination:** Homologous recombination, Holliday Model of recombination, definition and example of site specific and transpositional recombination; Gene conversion
6. **DNA repair mechanism:** Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair
7. **Apoptosis:** concept, molecular signaling (extrinsic and intrinsic) and significance
8. **Cell cycle & cancer genetics:** Concept of cell cycle check points and molecular regulation, concept of normal and transformed cell, role of proto-oncogene, tumour suppressor genes. Molecular mechanism of proto-oncogene activation
9. **Molecular basis and detection technique for human genetic disorders:** Sickle cell Anemia, Thalassemia, Hemophilia
10. **Transposable Genetic Element:** Concept of transposon and retrotransposon, Characteristic features of IS element in bacteria SINE and LINE element in mammals and their role in chromosomal aberration

[**Note:** Eight short questions of 2 marks are to be set from the Group, of which 5 will be answered. 7 questions of 10 marks each from the Group are to be set. Students will answer 4 questions]

PAPER 5, UNIT II
Parasitology, Microbiology and Immunology

Group A: PARASITOLOGY and MICROBIOLOGY

Marks = 25

1. Inter-specific associations
2. Origin and evolution of parasitism with special reference to nematodes
3. Host-parasite interaction, parasitic adaptations in internal parasites with special reference to protozoa and helminths
4. Life cycle of important parasites; Mechanism of host-finding; establishment in host; growth; reproduction and modes of transmission of a) *Plasmodium vivax*, b) *Entamoeba histolytica*, c)

Leishmania donovani, d) *Wuchereria bancrofti*, e) *Fasciola hepatica*, and f) *Ascaris lumbricoides*

5. Concept of Vector with special reference to resurgence of malaria (bio-ecology, vector potentiality, present susceptibility status to commonly used insecticide of important rural malaria vectors of India - *Anopheles culicifacies*)
6. Characterization and classification of bacteria (on the basis of staining methods)
7. Techniques of microorganism culture (sterilization reproduction and growth, maintenance and preservation of pure cultures), Control of micro-organisms
8. Microbes in relation to common diseases of man and control (Cholera and Shigella)

Group B: IMMUNOLOGY

Marks = 25

1. Cells and organs associated with immune system; Innate and adaptive immunity
2. Antigens – characteristics, antigenic determinants, antigen processing and presentation
3. Antibody – structure, types, binding sites and binding mechanisms
4. Cytokines, adjuvants – complete and incomplete
5. Complement proteins – pathways and activation (classical, alternative and lectin mediated pathway, MAC formation)
6. Humoral and cell mediated immunity in man, mollusks and insects
7. T-cell – structure, receptor and maturation (signal hypothesis excluded); B-cell – activation and differentiation (signal hypothesis excluded); Macrophage – types, generation and function
8. **MHC**: Structure and Function.
9. Monoclonal antibody production strategy and use of monoclonal antibody

[**Note:** Eight short questions of 2 marks are to be set from both the Groups, of which 5 will be answered. 4 questions from Group A and 4 questions from Group B are to be set. Each question will be of 10 marks. Students will answer 2 question from Group A and 2 questions from Group B]

PAPER 6, UNIT I

INTEGRATION BIOLOGY & HOMEOSTASIS

Marks = 50

1. Neuro-endocrine integration
 - a. General concept of hormone action and receptors
 - b. Chemical messengers – kiromones, synomones, info-chemicals, semio-chemicals – their types, mode of action and behavior modulation
 - c. Homeostasis of Ca^{++} regulation and Blood glucose regulation
 - d. Mechanism of hormone action (cAMP, ip3, DAG, TRK), neuro-hypophysis, adeno-hypophysis, hypothalamic regulatory peptides, endocrine tissues of the gastrointestinal endoderm
 - e. Biosynthesis, secretion, mode of action, functional significance and regulation of T_3 , T_4 , Adrenalin, Nor-adrenalin, Insulin and Glucagon
 - f. Insect hormones – neuro-endocrine regulation of diapauses and metamorphosis
 - g. Environmental signaling in sex reversals in fish and mollusks – role of endocrine disruption and signals

- h. Endocrine regulation of estrous and menstrual cycle.
- 2. Biological light production in animals
 - a. Chemistry of bioluminescence in insect and its significance
 - b. Electric organs in electric rays
- 3. Biological rhythm – concept, types and its control by pineal and SCN

[**Note:** Eight short questions of 2 marks are to be set from the Group, of which 5 will be answered. 7 questions of 10 marks each from the Group are to be set. Students will answer 4 questions]

PAPER 6, UNIT II

ANIMAL BIOTECHNOLOGY & APPLIED ZOOLOGY

Marks = 50

1. Transgenic animals

- (i) Production of transgenic animals: cloning (methodology and application)
- (ii) Contribution of transgenic animals to human welfare (Poultry and Dairy)

2. Biotechnology and Applied Zoology

- (i) Modern techniques of fish hybridization and induced breeding in carps.
- (ii) Application of biotechnology in – (a) Sericulture, (b) Lac culture, (c) Api culture, (d) Pearl culture practice, (e) Prawn culture
- (iii) Integrated pest management and biological control of pests: principles and significance.
- (iv) Principle of LD₅₀ and LC₅₀ and their application in applied Zoology

3. Animal cell culture

- (i) Cell culture types
- (ii) Cell culture technology (suspended and adherent culture)
- (iii) Cell culture media (RPMI-1640, M-199 and its components)

4. Gene therapy: Principle: Ex-vivo & In-vivo gene therapy. Strategies, Viral and non-viral vectors, antisense therapy.

[**Note:** Eight short questions of 2 marks are to be set from the Group, of which 5 will be answered. 7 questions of 10 marks each from the Group are to be set. Students will answer 4 questions]

PAPER 7

PRACTICAL

Marks = 100

Molecular Biology: (15)

- (a) Paper Chromatography for amino acid separation,
- (b) Slide TLC for oil separation,
- (c) Quantitative estimation of DNA in solution by Diphenyl method (at 595 nm).

Parasitology & Microbiology: (20)

- (a) Study of gut contents of cockroach (fixation, staining & identification)
- (b) Identification, systematic position, characters & clinical importance of the following parasites – *Entamoeba*, *Giardia*, *Trypanosoma*, *Plasmodium spp.*, *Leishmania*, *Wuchereria bancrofti*, *Ascaris* (male & female)
- (c) Gram staining of bacteria

Immunology: (5)

- (a) Determination of human blood group
- (b) Histology of primary and secondary lymphoid organs – thymus and spleen only

Histological techniques and staining methods: (15+10)

- (a) Tissue fixation, embedding, microtomy, staining and mounting of histological tissues (liver, pancreas, thyroid, kidney, ovary and testis) of white rat
- (b) Identification of mammalian histological tissue sections: liver, pancreas, thyroid, kidney, adrenal, ovary, testis, stomach and lung
- (c) Identification of stages of estrous cycle in white rat

Adaptations: (15)

Study of animals from museum specimens to analyze adaptive features for cursorial, aquatic, desert, volant and deep sea adaptations; features for parasitic mode of life.

Laboratory note Book: (10)**Viva Voce: (10)****PAPER 8****PRACTICAL****Marks = 100****Instrumentation (20)**

Principle/function and laboratory use of micropipette, pH meter, colorimeter, centrifuge, digital balance, autoclave

Report on Environmental audit (20)

Local Biodiversity Record (in group/individual of a particular area) – at least two records of faunal diversity along with ecological notes and photographic documentations in two seasons should be done. For example: butterfly community or bird community of a particular area.

Field work assessment (20)

Submission of field study report on any two of the following

- a. Ecosystem and its biodiversity assessment. (Any suitable ecosystem) (various diversity indices with explanation must be presented)
- b. Estuarine bheri/freshwater fish farm (species cultured/reared, whether exotic/ornamental fishes are cultured, viability of the farm, cost benefit accounts, impact on local people and prospect in the specific area)
- c. Poultry farm (species/breed cultured/reared, homeland of the breed, viability of the farm, cost benefit accounts, impact on local people and prospect in the specific area)
- d. Apiary (species cultured, types of bees cultured, fixed/mobile, viability of the farm, cost benefit accounts, impact on local people and prospect in the specific area)
- e. Sericulture center (species cultured/reared, description of moth and its host plant cultured, viability of the farm, cost benefit accounts, impact on local people and prospect in the specific area)
- f. Visit a place of wild life interest (Sanctuary, National Park, Biosphere Reserve etc.) {Man-wildlife conflict, eco-tone, edge effect, eco-sensitivity, economics of the native inhabitants, logging and lopping effect, conservation process practiced etc.}
- g. Agriculture farms for pest study & idea of IPM practices (type of farm, season visited, status of the farm at the time of visit, observed practices, reported practice, viability of

the farm, cost benefit accounts, impact on farmers and impact on the specific beneficiaries)

- h. Visit to an institution of zoological importance – its documentation. For example: Zoo Garden, ZSI, Zoological Gallery of the Indian Museum, etc.

[**Note:** Field study may be made in any time of the three year course]

Biostatistics (20)

Experimental project work and Data Analysis – Mean, Mode, Median, Probability, Hypothesis testing (Chi-square, t-test. Correlation test, Work shop for advanced biological methods (to be organized once in two years during Part II and Part III)

Laboratory note Book (10)

Viva Voce (10)

**Draft Syllabus for three years B.Sc. (General Course), Zoology,
University of Calcutta, 2016**

PART – I		
PAPER – I		Marks
Group A	Non-Chordate	35
Group B	Cell Biology and Genetics, Molecular Biology	35
Group C	Developmental Biology	30
Total		100
PART – II		
PAPER II		Marks
Group A	Chordate	35
Group B	Ecology, Animal Behavior, Biodiversity and Wildlife	35
Group C	Histology, Endocrinology, Animal Physiology & Biochemistry	30
Total		100
PAPER – III		
Laboratory Course (all Groups)		100
PART – III		
PAPER – IV		Marks
Group A	Applied Zoology	30
Group B	Evolutionary Biology	20
Group C	Parasitology & Immunology	20
Group D	Laboratory course	30
Total		100
Total = 400		

Zoology General

Part –I

(100 Marks)

Paper I: Theory (Full Marks –100)

Group-A: (Course No ZG-01) Functional Anatomy of Non-Chordates (Full marks –35)

(Lectures: 35)

1. Classification with distinctive features and suitable examples of sub-kingdom Protozoa (up to Phylum) (Levine *et al*, 1980) and Phylum Porifera, Cnidaria, Platyhelminthis, Annelida, Arthropoda, Mollusca and Echinodermata (up to Class)
2. General structure & function of the following with reference to the specimens mentioned:
 - (a) **Locomotion** – Microfibrils (*Amoeba*), Cilia (*Paramoecium*)
 - (b) **Feeding & digestion** – Microphagy (*Amoeba*), Macrophagy (*Periplanata*)
 - (c) **Respiration** – Ctenidium & pulmonary sac (*Pila*), gills (prawn), Trachea (cockroach)
 - (d) **Excretion** – Nephridia (Earthworm)
 - (e) **Circulation** – Open circulation (Cockroach), Closed circulation (Earth worm)
 - (f) **Nervous system** – Cockroach, Apple snail
 - (g) **Reproduction** : (a) Fission (*Amoeba*); (b) Budding (*Hydra*) (c) Conjugation (*Paramoecium*), (d) Metagenesis in *Obelia*

[**Note:** Scheme of classification other than Protozoa as per Ruppert and Barnes (1994), 6th Ed., Invertebrate Zoology.]

Group – B: (Course No ZG-02) Cell Biology, Genetics and Molecular Biology

(Full marks –35)

(Lectures: 35)

1. Fluid mosaic model of plasma membrane
2. Cell cycle check points
3. Physio chemical properties, types, structures and functions of DNA and RNA.
4. DNA as a genetic material explanation with experiment
5. Mechanisms of replication, transcription and translation in *E. coli*
6. Linkage and recombination
7. Modes of inheritance of autosomal and sex linked genes in man (Thalassemia & Haemophilia, colour blindness)
8. Sex determination in *Drosophila* (Genic Balance Theory only)

Group – C (Course No. ZG-03) Developmental Biology

(Full Marks –30)

(Lecture: 30)

1. Spermatogenesis and Oogenesis
2. Fertilization in sea urchin
3. Types of eggs and cleavages; process of cleavage in *Amphioxus*
4. Gastrulation in *Amphioxus*
5. Extra-embryonic membranes in chick
6. Placenta types and function

PART –II

Paper II Theory (Full Marks –100)

Group A: (Course No.ZG-04) Functional Anatomy of Chordates

(Full Marks –35)

(Lectures: 35)

1. Classification of Phylum Chordata with distinctive features and suitable examples – up to living subclass (Amphibia, Reptilia and Mammalia); up to subclass (Fishes and Aves) (Scheme of classification as per J.Z. Young 1980, Life of vertebrates)
2. Functional anatomy – digestive system in *Oreochromis*; Circulatory system in *Columba*
3. Structure & function of the followings:
 - a. Integument – general structure & function; integumentary derivatives (scales in fishes, feathers of *Columba*)
 - b. Pharynx (*Branchiostoma*); stomach (*Bos*)
 - c. Respiratory structures and Respiration : Gill (Fish); lung and Air sac (*Columba*)
 - d. Circulatory structure and circulation: Single circuit heart (fish); double circuit heart (Amphibia and Mammals)
 - e. Nervous system – Brain in *Oreochromis*
 - f. Origin and distribution of cranial nerves in fish.

Group B. (Course No ZG-05) Ecology, Animal Behavior, Biodiversity and Wildlife

(Full Marks 35)

(Lectures 35)

1. Population – definition and growth
2. Community – definition and types
3. Basic concept of Biodiversity, Biodiversity hotspots.
4. Honey bee – Hive, castes and their roles
5. Conservation of wild life – purpose & methods, concept of Biosphere Reserve, importance & strategies of wildlife conservation; National park & Wildlife Sanctuary.
6. Basic idea of ecotoxicology and xenobiotics
7. Climate change – Global warming, acid rain, ozone depletion (cause and effect)

Gr. C (Course No ZG-06) Histology, Endocrinology, Animal Physiology & Biochemistry

(Full marks- 30)

(Lectures: 30)

1. General characters of hormones: Naming and function of hormones secreted from Pituitary
2. Histology of pancreas (theory)
3. Enzyme – classification & characteristics; mechanism of enzyme action; effects of pH and temperature on enzymatic action
4. Nerve impulse propagation & synaptic transmission
5. Osmoconformers and Osmoregulators – definition and example; Osmoregulation in fishes

Paper III. PRACTICAL**(Course No. ZG 07)****(Full marks 100)**

- | | |
|---|------------|
| 1. Demonstration | (15+15=30) |
| i) Cockroach: digestive, nervous and female reproductive system | |
| ii) <i>Oreochromis</i> : digestive and urino-genital system | |
| 2. Mounting and preparation | (7½+7½=15) |
| (i) Mouth parts of cockroach | |
| (ii) Cycloid and Ctenoid scale of fin fish | |
| (iii) Haemolymph of cockroach (Leishman/Giemsa stain) | |
| (iv) Gut contents of cockroach for protozoa (Fixation, staining and identification) | |
| (v) Whole mount of aquatic and soil micro-arthropods | |
| (vi) Epithelial cells from buccal smears with staining | |
| 3. Identification with reasons: 1 from bones, 1 from histological slides, 2 from non-chordates and 2 from chordate specimens; systematic position up to taxon as mentioned in the theory. | (30) |
| (i) Bones: Skull, vertebrae, limb and girdle bones of <i>Columba</i> | |
| (ii) Histological slides: Sections of mammalian liver, pancreas, testis, ovary, and thyroid. | |
| (iii) Non-chordate specimens: <i>Paramoecium</i> , Scypha, <i>Sea-anaemone</i> , <i>Ascaris</i> (male & female), <i>Hirudinaria</i> , Scorpion, <i>Bombyx mori</i> (adult male & female), <i>Lamellidens</i> , <i>Pila</i> , <i>Loligo</i> , Starfish, <i>Balanoglossus</i> . | |
| (iv) Chordate specimens: <i>Amphioxus</i> , <i>Petromyzon</i> , <i>Scolidon</i> , <i>Lates</i> , <i>Rhacophorus</i> , Axolotl larva, <i>Tylotriton</i> , <i>Gekko</i> ; <i>Hemidactylus</i> , Turtle, <i>Naja</i> , Chiroptera | |
| 4. Report on field study tours: | 10 marks |
| Zoological importance: Zoological garden or Museum | |
| 5. Viva | 10 |
| 6. Laboratory Note Book | 5 |

Part III**Full marks –100****Paper IV Group A. (Course No ZG-8): Applied Zoology****(Full Marks 30)****(Class 30)**

1. Sericulture: Life history and rearing of *Bombyx mori*, harvesting & processing of cocoon, reeling and extraction of silk, diseases of worms of *Bombyx mori* and control measures.
2. Aquaculture: Principles, definition and scope. Exotic fishes- their merits and demerits. Basic principles of different aquaculture system (Polyculture and integrated farming); culture of prawn
3. Pest and Management: a) Definition and types of pests with examples. Life history, behaviour, ecology, damage and control of the following pests: i) Paddy *Scirpophaga* (Syn. *Tryporyza incertulas*, ii) Stores grain-*Sitophilus oryzae*, iii) Mammalian pest (*Bandicota bengalensis*).
4. Apiculture: Development of Apiary in India. Types of honey bees, modern methods of apiary management, products and its uses. Problems and prospects.
5. Poultry: fowl - Types of breeds, rearing and disease management.

Gr. B. (Course No ZG-09) Parasitology & Immunology

(Full Marks: 20)

(Lectures-20)

1. Parasitism (definition and types) and other inter-specific interactions (symbiosis, commensalism and mutualism).
2. Life history, Pathogenecity and clinical features of (i) *Entamoeba histolytica*, (ii) *Plasmodium vivax*, (iii) *Ascaris*
3. Outline structure and classification of immunoglobulin, antigen-antibody reaction

Group – C. Evolutionary Biology

Course No **ZG-10**

(Full marks: 20)

(Lectures-20)

1. Definition of systematics & taxonomy
2. Species as a unit of evolution (definition and types: biological, sibling and polytypic species)
3. Chemical basis of origin of life
5. Anatomical and Physiological adaptations: Aquatic (fish), Desert (Camel) and Volant (Pigeon) animals.
6. Zoogeographical realms (Wallace scheme) with characteristic mammalian fauna.

Group – D. Laboratory course

(Course No. **ZG-11**)

(Full marks –30)

1. Experimental works
 - a. Estimation of dissolved O₂ content of water **or** Estimation of free CO₂ content of water 8
 - b. Pedigree analysis: sex linked recessive, autosomal recessive and dominant 4
 - c. Determinant of ABO blood group & Rh factor in man **or** Measurement of water pH and handling of pH meter 4
2. Field training – Submission of report on **any one** place from the following: 8
 - a. Freshwater fish farm
 - b. Poultry farm
 - c. Apiary
 - d. Sericulture center
 - e. Place of wild life interest (Sanctuary, National Park)
 - f. Species diversity studies in local area.

[**Note:** Field report = 5 and Viva on Field report = 3; Students will not be allowed to sit in the examination without valid Field Report]

3. Identification: (Write specimen characters and applied importance) **any three** $3 \times 2 = 6$
Taenia solium, *Scirpophaga* (Syn. *Tryporyza*) *incertulas*, *Sitophilus oryzae*, *Epilachna*, *Lepisma*, Termite queen, *Bandicota bengalensis*, *Labeo rohita*, *Catla catla*, *Cyprinus carpio*, *Tenuulosa* (*Hilsa*) *ilisha*, *Penaeus sp*, *Macrobrachium rosenbergi*.

SUGGESTED READINGS WITH REGARD TO B. Sc. COURSE IN ZOOLOGY

Animal Diversity – I: Non-chordate

1. Text book of Zoology, Volume–I: Invertebrates – Parker & Haswell (Eds. A. J. Marshall & W. D. Williams) {ELBS Macmillan}
2. Invertebrate Zoology – E. E. Ruppert and R. D. Barnes (Harcourt Asia)
3. Invertebrate – R. C. Brusca & G. J. Brusca (Sinauer Assoc. Inc.)
4. Invertebrate – J. A. Pechenick (TATA McGraw Hill)
5. Invertebrate structure and function – E. J. W. Barrington (ELBS Nelson)
6. IMM's General Text Book of Entomology – (Chapman & Hall)
7. Reef evolution – R. Wood (Oxford Univ. Pr.)
8. The Diversity of Living Organisms – R. S. K. Barnes (Blackwell Science)
9. An introduction to the Invertebrates – J. Moore (Cambridge Univ. Pr.)
10. Introduction to General Zoology, Volume I – K. K. Chaki, G. Kundu, S. Sarkar (NCBA)
11. Biology of non-chordates – H.C. Nigam (Vishal Pub.)
12. General Zoology – C. A. Villee, W. F. Walker and R. D. Barnes (Saunders College Pub.)
13. Invertebrate Zoology – P. A. Meglisch and F. R. Schram (Oxford Univ Pr.)
14. Invertebrate inter relationship – P. Wilmer (Cambridge Univ. Pr.)
15. Modern Text Book of Invertebrates – R. L. Kotpal (Rastogi)

Animal diversity – II: Chordate

1. Text book of Zoology, Volume II, Vertebrates – Parker & Haswell (Ed. A. J. Marshall){ELBS Macmillan}
2. Vertebrate life – F. H. Pough & W. N. McFarland (Prentice Hall)
3. The Life of Vertebrates – J. Z. Yong (ELBS Oxford)
4. Vertebrates : Comparative anatomy, function, Evolution – K. V. Kardong (WCB McGraw Hill)
5. Comparative Anatomy of Vertebrates – G.C. Kent & L. Miller (WCB Pub)
6. The Vertebrate body – A. S. Romer & T. S. Parsons (Saunders)
7. Biology of Vertebrates – H. E. Walter & L. P. Sayles (Macmillan)
8. Elements of Chordate Anatomy – C. K. Weichert & W. Presch (TATA McGraw Hill)
9. Analysis of Vertebrate Structure – M. Hildebrand & G. Goslow (Wiley)
10. An introduction to Ornithology & biology of the blue rock pigeon – B. N. Bhattacharyya (NCBA)
11. Introduction to General Zoology, Volume II – K. K. Chaki, G. Kundu, S. Sarkar (NCBA)
12. Biology of Amphibians – W. E. Duellman & L. Trueb (McGraw Hill)
13. Vertebrate Zoology – F. B. Mondal (Oxford IBH)
14. Modern Text Book of Vertebrates – R. L. Kotpal (Rastogi)

Cell Biology, Genetics, Molecular Biology and Biotechnology

1. Principles of Genetics – R. H. Tamarin (McGraw Hill)
2. The World of Cell – W. M. Becker, L. J. Kleinsmith, J. Hardin
3. Genetics – M. W. Strickberger (Macmillam)
4. Genetics – S. Elrod and W. Stansfield (Schaum)

5. Concepts of Genetics – W. S. Klug and M. K. Cummings (Pearson)
6. Cell Biology – G. M. Cooper (Sinauer)
7. Cell Structure, Function and Metabolism – N. Cohen (Hodder & Stoughton)
8. Cell and Molecular Biology – Concepts and Experiments – G. Karp (Wiley)
9. I-Genetics – P. J. Russel (Pearson, Benjamin Cummings)
10. Genetics – P. C. Winter, G. I. Hickey & H. L. Fletcher (Viva)
11. Molecular Biology of the Cell – B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts & P. Walter (Garland Science)
12. Molecular and cell biology – W. D. Stansfield, J. S. Colome and R. J. Cano (Schams)
13. Human Molecular Genetics – T. Strachan & A. Read (BIOS Scientific)
14. Cell cycle control – C. Hutchison & D.M. Glover (IRL Oxford Univ.)
15. A Text Book of Genetics & Molecular Biology – S. Roychoudhuri (NCBA)
16. Problems on Genetics, Molecular Genetics and evolutionary genetics – P. K. Banerjee (NCBS)
17. Animal Cell Culture – a practical approach – J. R. W. Masters (Oxford Univ. Pr.)
18. Genetic Engineering – P. S. Verma & V. K. Agarwal (S. Chand)
19. Introduction to Biotechnology- W. J. Thieman and M.A. Palladino (Pearson)
20. Molecular Biology of the gene – J. D. Watson (Pearson)
21. Advanced Molecular Biology – Twyman (Springer)
22. Genes IX – B. Lewin (Oxford)
23. Molecular Biology and Biotechnology – R. A. Meyers (VCH Pub.)
24. Animal cell culture – S. J. Morgan & D. C. Darling (Oxford)
25. Genetics – V. B. Rastogi (Kedarnath Ramnath)

Animal Physiology & Biochemistry

1. Lehninger Principle of Biochemistry – D. L. Nelson & M. M. Cox (Maxmillan)
2. Harper's Illustrated Biochemistry – (McGraw Hill)
3. Fundamentals of Biochemistry – A. C. Deb (NCBA)
4. A Clinical Companion to Accompany Biochemistry – J. Berg & G. Tomaselli (Freeman & Co)
5. Outlines of Biochemistry – E. E. Conn & P. K. Stumpf (Wiley Eastern)
6. Biochemistry – B. D. Hames, N. M. Hooper & J. D. Houghton (Viva)
7. Aestivation: Molecular and Physiological Aspects – A. Navas, C. Carvalho, J. Eduardo (Springer)
8. Comparative Physiology of Fasting, Starvation, and Food Limitation – Mc Cue, D. Marshall (Springer)
9. Physiological Studies on Aestivation in Pomacea Urceus – M. A. Thomas (University of the West Indies Pr., Trinidad)
10. Comparative Animal Physiology – C. L. Prosser and F. A. Brown (Saunders)
11. Animal Physiology – Adaptation & Environment – K. Schmidt-Neilson (Cambridge University Press)
12. General and Comparative Physiology – W. S. Hoar (PHI)
13. Text Book of Medical Physiology – A. C. Guyton (Holt Saunders)
14. Ganong's Review of Medical Physiology – (McGraw Hill)
15. Biochemistry – D. Das (Academic Publishers)
16. A clinical companion to accompany biochemistry – K. Saltsman, J. Berg & G. Tomaselli (Freeman & Co.)

Histology, Endocrinology & Reproductive Biology

1. Endocrinology – M. E. Hadley and J. E. Levine (Prentice Hall)
2. Endocrinology – G. J. Goldsworthy, J. Robinson & W. Mordue (Blackie)
3. General Endocrinology – C. D. Turner & J. T. Bagnara (Saunders)
4. Comparative Vertebrate Endocrinology – P. J. Bentley (Cambridge Univ. Pr.)
5. Text book of Comparative Endocrinology – A. Gorbman & H. W. Bern (Wiley)
6. Introduction to Endocrinology – C. S. Negi (PHI)
7. Mammalian Endocrinology – A. K. Boral (NCBA)
8. Essential Endocrinology – C. G. D. Brook & N. J. Marshall (Wiley)
9. Vertebrate Endocrinology – D. Norris (Elsevier)
10. Histology: A text and atlas – M. H. Ross & E. J. Reith (Williams & Wilkins)
11. Bloom & Fawcett: Concise Histology – D. W. Fawcett (Arnold)
12. Basic Histology – L. C. Janqueira, J. Carneiro & R. O. Kelly (Appleton & Lange)
13. Histology and Histological techniques – Bankroft (Elsevier)
14. Review of Histology – M. B. Ganz, D. L. Levick & J. W. Lash (J.B. Lippincott Co.)
15. Endocrinology and Reproductive Biology – K. V. Shastry (Rastogi)

Developmental Biology

1. An introduction of Embryology – B. I. Balinsky (Sunders Int.)
2. Foundations of Embryology – B. M. Carlson (McGraw Hill)
3. Comparative Embryology of the Vertebrates – O. E. Nelson (McGraw Hill)
4. Developmental Biology – S. Gilbert (Sinauer)
5. Principles of Development – L. Wolpert (Oxford Univ. Pr.)
6. Developmental Biology – R. M. Twyman (Viva)
7. Essential Reproduction – M. H. Johnson & B. J. Everitt (Blackwell Science)
8. Essential Developmental Biology – J. M. W. Slack (Blackwell)
9. Principles of Developmental Biology – F. H. Wilt and S. C. Hake (Norton & Co.)

Microbiology, Parasitology & Immunology

1. Microbiology : An Introduction – G. J. Tortora, B. R. Funke and C. L. Case (Pearson)
2. Principles of Microbiology – G. Sumbali and R. S. Mehrotra (TATA McGraw Hill)
3. Microbiology – M. J. Pelczar Jr., E. C. S. Chan & N.R. Krieg (TATA McGraw Hill)
4. Medical microbiology – S. Baron (Addison Wesley Pub. Co.)
5. Animal Parasitology – J. D. Smyth (Cambridge Uni. Pr.)
6. General Parasitology – T. C. Cheng (Academic Pr.)
7. Parasitology – Protozoology and Helminthology – K. D. Chatterjee (Chatterjee Medical Pub.)
8. Text book of Medical Parasitology – P. Chakraborty (NCBA)
9. Foundation of Parasitology – L. S. Schmidt, G. D. Roberts & J. Janovy (McGraw Hill Int.)
10. Parasitism – The diversity and ecology of animal parasites- A. O. Bush, J. C. Fernandez, G. W. Esch and J. R. Seed (Cambridge Univ. Pr.)
11. Simplified course on Parasitology and Immunology – S. K. Rej & R. Roy (NCBA)
12. Invertebrate Immunity – K. Söderhäll (Springer)

13. Insect infection and immunity – evolution, ecology and mechanism – J. Rolff & S. E. Reynolds (Oxford Univ. Pr.)
14. The elements of Immunology – F. H. Khan (Pearson)
15. Text book of Basic and Clinical Immunology – S. Gangal & S. Sontakke (University Pr.)
16. Immunology – D. Male, J. Brostoff, D. B. Roth & I. Roitt (Mosby Elsevier)
17. Kubly Immunology – T. J. Kindt, R. A. Goldsby & B. A. Osborne (Freeman)
18. Immunology and immunotechnology – A. K. Chakraborty (Oxford Univ. Pr.)
19. Principles of Cellular and Molecular immunology – J. M. Austyn & K. J. Wood (Oxford Univ. Pr.)

Evolution, Systematics and Animal Behaviour

1. Evolutionary Biology – D. J. Futuyama (Sinauer Associates Inc.)
2. Evolution – M. W. Strickberger (CBS Pub.)
3. Evolution of the Vertebrates – E. H. Colbert, M. Morales & E. I. Minkoff (Science)
4. Introduction to Evolution – P. A. Moody (Kalyani Pub.)
5. Evolution – T. Dobzhansky, F. J. Ayala, G. L. Stebbins & J. W. Valentine (Surjeet Pub.)
6. Understanding Evolution – E. D. Hanson (Oxford Univ. Pr.)
7. Life: Origin, Evolution and Adaptation – S. Chattopadhyay (Books & Allied Pub.)
8. Organic Evolution – V. B. Rastogi (Kedarnath Ramnath)
9. Principles of Systematic Zoology – E. Mayr & P. D. Ashlock (McGraw Hill Int.)
10. Principle of Systematic Zoology – E. Mayr (TATA McGraw Hill)
11. Principles of Animal Taxonomy – G. G. Simpson (Oxford IBH)
12. Zoogeography – P. J. Darlington (John Wiley)
13. Animal Behaviour – D. McFarland (Longman)
14. An introduction to Animal Behaviour – A. Manning & M. S. Dawkins (Science)
15. Animal Behaviour – L. Drickamar & S. H. Vessey (McGraw Hill)
16. Animal Behaviour – R. Mathur (Rastogi)

Ecology, Biodiversity and Conservation

1. Elements of Ecology – T. H. Smith and R. L. Smith
2. Microbial Ecology : Fundamentals and Applications – R. M. Atlas and R. Bartha
3. Essentials of Ecology – C. Townsend, J. L. Harper, M. Bagon
4. Fundamentals of Ecology – E. P. Odum (Saunders)
5. Ecology: Principles and Applications – J. L. Chapman & M. J. Reiss (Cambridge Univ. Pr.)
6. Ecology – the experimental analysis distribution and disturbance – C. J. Krebs (Benjami Cummings)
7. Ecology: Science and Practice – C. Faurie, C. Ferra, P. Medori & J. Devaux (Oxford IBH)
8. Ecology – A. Mackenzie, A. S. Ball & S. R. Virdee (Viva)
9. Principles of Ecotoxicology – C. H. Walker, S. P. Hopkin, R. M. Sibley & D. B. Peakall (Taylor & Francis)
10. Wetland: Crisis and options – G. K. Saha (Astral)
11. Animal Ecology and distribution of animals – V. B. Rastogi & M. S. Jayaraj (KNRN, N Delhi)
12. Biodiversity – E. O. Wilson (National Academic Press)

13. Fundamentals of Conservation Biology – M. L. Hunter, J. James & P. Gibbs (John Willey & Sons)
14. Loss of biodiversity and its ethical implications – A. Ghosh, S. P. Agarwala & B. Sau (Sadash)
15. An introduction to Behavioural Ecology – J. R. Krebs & N. B. Davies (Blackwell Scientific)
16. Environmental Science – G. T. Miller (Brookes Kole)
17. Environmental Biology – Park
18. Wildlife of India – T. C. Majupuria (Techpress, Bangkok)
19. An introduction to Wildlife Biology: Indian perspective – G. K. Saha & S. Majumder (PHI)
20. Endangered animals of India – A. K. Mukherjee (Z.S.I)
21. Ecology – R. E. Ricklefs & G. L. Miller (McMillan)
22. Invertebrate Surveys for Conservation – T. R. New (Oxford Univ. Pr.)
23. Threatened Mammals of India – G. K. Saha & S. Majumdar (Daya Publication House)
24. Wild life (Protection) Act 1972 – Wild life Society of India (Nataraj Publication)

Applied Zoology

1. Pest Control – H. F. Van Emden (Cambridge Univ. Pr.)
2. Applied Entomology – P. G. Fenemore, A Prakash (Wiley Eastern Ltd.)
3. A manual of Freshwater Aquaculture – E. Santhanam, N. Sukumaran & P. Natarajan (Oxford IBH)
4. Aquaculture: Principle and practice – T. V. R. Pillay (Wiley Int)
5. Fish and Fisheries – S. Kumar & M. Tembhre (NCBS)
6. Fish and Fisheries – K. Pandey & J. P. Shukla (Rastogi)
7. Animal Husbandry – G. C. Banerjee (ICAR)
8. Hand Book of Animal Husbandry – ICAR
9. Sericulture & Silk Industry – D. C. Sarkar (NBT)
10. An introduction to Sericulture – G. Ganga & J. S. Chetty (Oxford IBH)
11. Lac Culture – N. Ghorai (International Books & Periodicals Supply Service)
12. Bee keeping in India – ICAR
13. Introduction to Economic Zoology – S. Sarkar, G. Kundu, K. K. Chaki (NCBS)
14. Economic Zoology – G. S. Shukla & V. B. Upadhyay (Rastogi)
15. Livestock & Poultry Production – E. N. Moore & H. Singh (PHI)
16. Insect Pest of crop – S. Pradhan (PHI)
17. অর্থনৈতিক প্রাণিবিদ্যা – শঙ্কর প্রসাদ মাইতি, প্রদীপ দাশগুপ্ত ও ত্রিলোচন মিত্র (NCBS)

Biostatistics

1. Biostatistics: Principles and Practice – B. Antonisamy, S. Christopher, and P. P. Samuel (Kugler Pub.)
2. Statistics – Concepts and Controversies – D. S. Moore (Freeman & Co.)
3. Statistics – F. McGill, S. McLennan & J. Migliorini (Stanley Thornes)
4. Experimental design and data analysis for Biologists – G. P. Quinn & M. J. Keough (Cambridge Univ. Pr.)
5. Statistics – N. G. Das (Central)
6. Basic Statistics – A. M. Goon, M. K. Gupta & B. Dasgupta (World Pr.)
7. Problems on Biomathematics – P. K. Banerjee (NCBA)

8. Elements of Biostatistics – S. Prasad (Rastogi)

Text Books covering various aspects of the syllabus

1. Introduction to General Zoology, Volume I – K. K. Chaki, G. Kundu, S. Sarkar (NCBA)
2. Introduction to General Zoology, Volume II – K. K. Chaki, G. Kundu, S. Sarkar (NCBA)
3. Biology of Animals, Volume I – B. B. Ganguli, A. K. Sinha & S. Adhikary (NCBS)
4. Biology of Animals, Volume II – A. K. Sinha, S. Adhikary, B. B. Ganguli & B. C. B. Goswami (NCBS)
5. Fundamental of Biology of Animals – S. Adhikary & A. K. Sinha (NCBS)
6. Text Book of Zoology – A. Chatterjee & C. Chakraborty (Nirmala Library)
7. স্নাতক প্রাণিবিদ্যা – ১ম, ২য়, ৩য় খণ্ড – দেবপ্রসাদ চট্টোপাধ্যায় (Book Syndicate)
8. স্নাতক প্রাণিবিদ্যা – কেদারনাথ ভট্টাচার্য (Books & Allied Pub)
9. সমকালীন প্রাণিবিদ্যা (পার্ট ১,২) – শঙ্কর প্রসাদ মাইতি, ত্রিলোচন মিত্র (NCBA)
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