

Department of Biological Sciences
Aliah University, Kolkata
Syllabus for 3 Years B.Sc. Zoology Honours (2018-19 onwards)

Semester	Theory			Practical		
	Course Code	Course Title	Marks/ Credits	Course Code	Course Title	Marks/ Credits
I	BZ101	Fundamentals of Biochemistry*	50/4	BZ191	Practical I: Biochemistry and Non Chordates	50/4
	BZ103	Taxonomy & Biology of Non Chordates	50/4			
II	BZ102	Cell and Molecular Biology*	50/4	BZ192	Practical II: Cell-Mol Biology and Chordates	50/4
	BZ104	Biology of Chordates & Animal Distribution	50/4			
III	BZ201	Biochemistry and Endocrinology	50/4			
	BZ203	Ecology & Wild Life Conservation	50/4			
IV	BZ202	Biotechniques and Biostatistics*	50/4	BZ292	Practical III: Ecology, Endocrinology and Biotechniques	50/4
V	BZ301	Human Physiology	50/4	BZ391	Practical IV: Histology and Immunology	50/4
	BZ303	Immunology*	50/4	BZ393	Practical V: Physiology, Micro and Parasitology	50/4
	BZ305	Microbiology and Parasitology	50/4			
VI	BZ302	RDT and Bioinformatics	50/4	BZ392	Practical VI: Genetics, Embryology & Animal Behaviour	50/4
	BZ304	Genetics & Evolutionary Biology	50/4	BZ394	Practical VII: RDT and Bioinformatics plus Project Work/Review	50/4
	BZ306	Embryology & Animal Behaviour	50/4			
	BZ308	Economic Zoology	50/4			
Total			700/56			350/28
Grand Total				1050 Marks / 84 Credits		

* Courses (papers) have the same contents for all the three streams (Botany, Microbiology and Zoology) and will be taught together. Each course (paper) will have 60 Hours of Lecture.

Semester wise distribution of Subjects with Credits/Marks for 3 years**Zoology Honours****Semester I**

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 101	Fundamentals of Biochemistry		50	4
2	Zool (Major)	BZ 103	Taxonomy & Biology of Non chordates		50	4
3	Zool (Major)	BZ 191	Practical- Biochemistry and Non chordates		50	4
4	Botany	BB 131	Theory		50	4
5	Chemistry	CH 131	Theory		50	4
6	Compulsory	EN 131	Communicative English		50	4
					300	24

Semester II

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 102	Cell & Mol. Biology		50	4
2	Zool (Major)	BZ 104	Biology of Chordates & Animal Distribution		50	4
3	Zool (Major)	BZ 192	Practical-Cell Mol. Biology and Chordates		50	4
4	Botany	BB 132	Theory		50	4
5	Chemistry	CH 132	Theory		50	4
6	Compulsory	AI 132	Elementary Arabic & Islamic Studies		50	4
					300	24

Semester III

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 201	Biochemistry and Endocrinology		50	4
2	Zool (Major)	BZ 203	Ecology & Wild Life Conservation		50	4
3	Botany	BB 231	Theory		50	4
4	Botany	BB 261	Practical		50	4
5	Chemistry	CH 231	Theory		50	4
6	Chemistry	CH 261	Practical		50	4
					300	24

Semester IV

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 202	Biotechniques & Biostatistics		50	4
2	Zool (Major)	BZ 292	Practical- Ecology and Biotechniques		50	4
3	Botany	BB 232	Theory		50	4
4	Botany	BB 262	Practical		50	4
5	Chemistry	CH 232	Theory		50	4
6	Compulsory	CH 262	Practical		50	4
					300	24

Semester V

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 301	Human Physiology		50	4
2	Zool (Major)	BZ 303	Immunology		50	4
3	Zool (Major)	BZ 305	Microbiology & Parasitology		50	4
4	Zool (Major)	BZ 391	Practical- Histology and Immunology		50	4
5	Zool (Major)	BZ 393	Practical-Micro, Parasitology and Physiology		50	4
6	Compulsory	EN 331	ENVS		50	4
					300	24

Semester VI

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Major)	BZ 302	RDT and Bioinformatics		50	4
2	Zool (Major)	BZ 304	Genetics & Evolutionary Biology		50	4
3	Zool (Major)	BZ 306	Embryology & Ethology		50	4
4	Zool (Major)	BZ 308	Economic Zoology		50	4
5	Zool (Major)	BZ 392	Practical-Genetics, Embryology & Ethology		50	4
6	Zool (Major)	BZ 394	Practical- RDT and Bioinformatics plus Project/Review		25+25 =50	4
					300	24
Grand Total for 3 Years					1800	144

Draft Syllabus for B.Sc. Zoology Subsidiary Papers (2018 onwards)

Semester-I

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Sub)	BZ 131	Ecology & Evolution		50	4
			Total Marks & Credits =		50	4

Semester-II

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Sub)	BZ 132	Animal Diversity		50	4
			Total Marks & Credits =		50	4

Semester-III

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool (Sub)	BZ 231	Physiology & Embryology		50	4
2	Zool (Sub)	BZ 261	Practical-I (Animal Diversity & Ecology)		50	4
			Total Marks & Credits =		100	8

Semester-IV

Sl. No.	Course Structure	Course Code	Course Title	LTPC	Full Marks	Credit
1	Zool(General)	BZ 232	Economic Zoology and Ethology		50	4
2	Zool(General)	BZ 262	Practical-II (Physiology, Embryology & Histology)		50	4
			Total Marks & Credits =		100	8

Detailed Syllabus

Semester I

BZ 101: Fundamentals of Biochemistry

Total Marks 50, Credits 4

Unit 1: Water and Buffer

No of hours: 6

Physical properties of water, structure of water molecules, Ionization of water
Bronsted – Lowry concept of acid and bases, Concept of pH of weak acids and weak bases, Henderson-Hasselbalch equation
Concept of buffer, strength of buffer, buffer value, important biological buffers (with the help of numerical problems)
Forces involved in biomolecular interactions with examples: Van der Waals interactions, electrostatic interactions, hydrogen bond and hydrophobic interaction

Unit 2: Stereochemistry

No of hours: 4

Plane of symmetry, centre and axis of symmetry; Concepts of chirality; optical isomerism; geometrical isomerism; DL, RS nomenclature
Configuration and Conformation; Projection formula (Fischer & Howarth)
Isomers: anomers, epimers; Stereochemistry of cyclohexane: idea of axial & equatorial bonds (related to chair form conformation).

Unit 3: Carbohydrates

No. of Hours: 12

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses
Stereoisomerism of monosaccharides, Epimers, Mutarotation and anomers of glucose Furanose and Pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose
Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid,
Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose
Polysaccharides, storage polysaccharides, starch and glycogen, Structural Polysaccharides, cellulose, peptidoglycan and chitin

Unit 4: Lipids

No. of Hours: 8

Definition and major classes of storage and structural lipids
Fatty acids structure and functions; Essential fatty acids, Triacyl glycerols structure, functions and properties; Saponification
Structural lipids- Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebrosides and gangliosides
Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers.

Unit 5: Proteins

No. of Hours: 12

Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Titration curve of amino acid and its Significance
Classification, biochemical structure and notation of standard protein amino acids
Ninhydrin reaction. Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D- glutamic acid
Primary and Secondary structure of proteins: Peptide unit and its salient features

The alpha helix, beta pleated sheet and their occurrence in proteins, Tertiary and quaternary structures of proteins; Forces holding the polypeptide together.

Unit 6: Enzymes

No. of Hours: 10

Structure of enzyme: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme NAD, metal cofactors, Classification of enzymes

Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis

Significance of hyperbolic, double reciprocal plots of enzyme activity, K_m , and allosteric mechanism

Definitions of terms – enzyme unit, specific activity and turnover number, Multienzyme complex; pyruvate dehydrogenase; isozyme: lactate dehydrogenase

Effect of pH and temperature on enzyme activity, Types of enzyme inhibition, competitive- sulfa drugs; non-competitive-heavy metal salts

Unit 7: Nucleic acid

No of Hours: 6

Purine, pyrimidine - definition and structure; Nucleoside, nucleotide: definition and structure

DNA: Double helical structure. A-DNA, B-DNA & Z-DNA (structure and differences)

General structure and types of RNA (tRNA, mRNA, rRNA)

Unit 8: Vitamins

No. of Hours: 2

Classification and characteristics with suitable examples, sources and importance

SUGGESTED READINGS:

1. Berg, J.M., Tymoczko, J.L. and Stryer, L (2007). Biochemistry, VI Edition, W.H. Freeman and Co
2. Campbell and Farrell (2012). Biochemistry. 7th Edn. Brooks and Cole
3. Chatterjee, MN and Shinde, R (2012). A Textbook of Medical Biochemistry. 8th Edn. Jaypee Pub
4. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co. New York
5. Das, D. (200). Biochemistry. Central Book Agency, Kolkata
6. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
7. Jain, J.L., Jain m S and N. Jain. Fundamentals of Biochemistry. S. Chand Pub. N. Delhi
8. Maheswari, N (2008). Clinical Biochemistry. Jaypee Pub., New Delhi
9. Metzler D.E. (2001). The chemical reactions of living cells –2nd edition, 2001, Academic Press.
10. Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill
11. Sathyanarayana U. and Chakrapani, (2002). Biochemistry –Books & Allied (P) Ltd, Kolkata
12. Voet. D & Voet. J.G, (2004). Biochemistry –3rd edition, 2004, John Wiley & Sons, Inc.
13. Zubay G.L, (1998). Biochemistry –4th edition, Mc Graw-Hill

BZ 103: Taxonomy & Biology of Non chordates

Total Marks 50, Credits 4

Unit 1: Taxonomy-General idea of Classification**No. of Hours: 10**

Systematics and Taxonomy; Binomial nomenclature; Hierarchy of categories, Common taxonomic types; General idea of Codes of Zoological Nomenclature; Synonym and Homonym; Basic idea of Cytological and Biochemical taxonomy.

Unit 2: Protista, Parazoa and Metazoa**No. of Hours: 8**

General characteristics and Classification up to classes; Study of *Euglena*, *Amoeba* and *Paramecium* Locomotion and Reproduction in Protista; Evolution of symmetry and segmentation of Metazoa.

Unit 3: Porifera and Cnidaria**No. of Hours: 8**

General characteristics and Classification up to classes; Canal system and spicules in sponges; Metagenesis in *Obelia*, Polymorphism in Cnidaria; Corals and coral reefs

Unit 4: Ctenophora**No. of Hours: 4**

General characteristics and Evolutionary significance

Unit 5: Platyhelminthes and Nematelminthes**No. of Hours: 6**

General characteristics and Classification up to classes; Parasitic adaptations in helminthes

Unit 6: Annelida and Arthropoda**No. of Hours: 8**

General characteristics and Classification up to classes; Excretion in Annelida; Vision and Respiration in Arthropoda; Metamorphosis in Insects, Social life in bees and termites.

Unit 7: Onychophora**No. of Hours: 4**

General characteristics and Evolutionary significance

Unit 8: Mollusca**No. of Hours: 6**

General characteristics and Classification up to classes; Respiration in Mollusca, Torsion and detorsion in Gastropoda; Evolutionary significance of trochophore larva.

Unit 9: Echinodermata**No. of Hours: 6**

General characteristics and Classification up to classes; Water-vascular system in Asteroidea; Larval forms in Echinodermata; Affinities with Chordates.

Suggested Readings:

1. Anderson, D. T. (Ed.) (2001). Invertebrate Zoology. 2nd Ed. Oxford University Press.
2. Barnes, R. D. & Ruppert, E. E., (1994). Invertebrate Zoology. 6thEd. Brooks Cole.
3. Barrington, E. J. W. (1981). Invertebrate Structure and function. 2nd Ed. ELBS & Nelson.
4. Blackwelder, R. E., (1967). Taxonomy- A text and reference book. John Wiley & Sons.
5. Brusca, R. C. & Brusca, G. J. (2002). Invertebrates. 4th Ed. Sinauer Associates
6. Dhami P.S and J.K. Dhami – Invertebrate Zoology – S. Chand and Co
7. Hyman, L. H. (1951). The Invertebrates (Vol-I). Mc.GrawHill Book Company.
8. Jordan, E. L. & Verma, P. S. (2006). Invertebrate Zoology. S. Chand & Company Ltd
9. Kapoor, V. C. (2008). Theory and practice of animal taxonomy. 6th Ed. Oxford & IBH Pub
10. Kotpal, R.L., 1988 – 1992. (All Series) Protozoa, Porifera, Coelentereta, Annelida, Arthropoda, Mollusca, Echinodermata, – Rastogi Publications, Meerut – 250 002.
11. Mayr, E. (1969). Principles of Systematic Zoology. Tata McGraw-Hill.

12. Mayr, E. & Ashlock, P. D. (1991). Principles of Systematic Zoology. 2nd Ed., McGraw-Hill.
13. Meglitsch, P. A. & Schram, F. R. (1991). Invertebrate Zoology. Oxford University Press
14. Parker, T. J. & Haswell, W. (1972). Text Book of Zoology, Volume I. Macmillan Press
15. Pechenik, J. A. (1998). Biology of the Invertebrates, 4th Ed. McGraw Hill
16. Ruppert E. E., Fox, R. & Barnes R. D. (2003). Invertebrate Zoology: a Functional Evolutionary Approach. 7th Ed. Brooks Cole
17. Sinha, K. S., Adhikari, S., & Ganguly, B. B. Biology of Animals. Vol. I. New Central Book Agency

BZ 191: Practical- Biochemistry and Non Chordates

Total Marks 50, Credits 4

Unit I: Biochemistry

1. Concept of molarity, normality, percentage, dilutions, pH and buffers, Preparation of buffers and Numerical problems to explain the concepts.
2. Qualitative tests for the detection of biomolecules: Glucose, Fructose (Benedict's Test); Sucrose (Acid hydrolysis & Benedict's Test); Starch (Iodine Test), Proteins (Biuret method); Amino acids (Ninhydrin); Lipids (Grease Spot Test, Red Test).
3. Study of enzyme kinetics – calculation of V_{max} , K_m , K_{cat} values
4. Estimation of amino acid (glycine) by formol titration
5. Study of protein secondary and tertiary structures with the help of models

Unit II: Biology of Non Chordates

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*
1. Examination of pond water collected from different places for diversity in protista
2. Study of adult *Fasciola hepatica*, *Taenia solium* and their life cycles (Slides/photographs)
3. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
4. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
5. Mount of mouth parts and dissection of digestive system and nervous system of cockroach
6. 4. Study of the following specimens- *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongill*, *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatulula*, *Fungia*, *Meandrina*, *Madrepora*, *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinari*, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Cancer*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx*, *Periplaneta*, *Peripatus*, *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*, *Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
6. Submission of a report/assignment on any related topic on life cycles/coral/ coral reefs or larval forms (crustacean, mollusc and echinoderm)

Suggested Readings:

1. Chatterjee and Chatterjee Practical Zoology
2. Ghosh, K.C. and Manna, B. (2015): Practical Zoology, New Central Book Agency, Kolkata
3. Sinha, J.K., Chatterjee, A.K. and P. Chattopadhyay Advanced Practical Zoology

Semester II**BZ 102: Cell and Molecular Biology**

Total Marks 50, Credits 4

Unit 1: Overview of Cell**No. of Hours 2**

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions

Unit 2: Structure of Cell**No. of Hours 8**

Plasma membrane: Structure and models, Transport of small molecules; Cell Wall- Eukaryotic cell wall, Extracellular matrix, Cell junctions

Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules.

Unit 3: Cell Organelles**No. of Hours 8**

Mitochondria, chloroplasts, lysosomes and peroxisomes, ER and Golgi apparatus

Nucleus: Nuclear envelope, nuclear pore complex, nucleolus and nuclear lamina; Chromatin

Unit 4: Cell Cycle, Cell Death and Cell Renewal**No. of Hours 8**

Cell cycle, Mitosis and Meiosis; Development of cancer, Programmed cell death, Stem cells: Embryonic stem cell, induced pluripotent stem cells

Unit 5: Structures of DNA and RNA / Genetic Material**No. of Hours 4**

DNA structure: Salient features of double helix, Types of DNA, RNA Structure and types

Denaturation and renaturation, cot curves. DNA topology: linking number, twist and writhe

Unit 6: Replication of DNA (Prokaryotes and Eukaryotes)**No. of Hours 8**Bidirectional and unidirectional replication, semi-conservative, semi-discontinuous replication
Mechanism of DNA replication

Enzymes and proteins involved in DNA replication– DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends, and other accessory protein

Various models of DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication

DNA repair- Mismatch and excision repair, Inhibitors of DNA Replication.

Unit 7: Transcription in Prokaryotes and Eukaryotes**No. of Hours 10**

Concept of Operon (lac and trp), Promoter and Operator

Mechanism of Transcription; RNA polymerase, transcription unit; Transcription in Eukaryotes: RNA polymerases, general Transcription factors, Inhibitors of Transcription Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from lac operon and trp operon

Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, Genetic imprinting

Unit 8: Post-Transcriptional Processing**No. of Hours: 4**

Concept of introns and exons, RNA splicing, spliceosome machinery

Concept of alternative splicing, Polyadenylation and capping

Unit 9: Translation (Prokaryotes and Eukaryotes)**No. of Hours 8**

Genetic code, Degeneracy of the genetic code and Wobble Hypothesis; Translational machinery, charging of tRNA, aminoacyl tRNA synthetases; Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation; Inhibitors of protein synthesis in prokaryotes and eukaryotes.

Suggested Readings:

1. Albert Bruce, Bray Dennis, Levis Julian ,Raff Martin, Roberts Keith and Watson James (2008).Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.
2. Cooper, G.M. and Hausman, R.E. (2009). The Cell: AMolecularApproach.5thEdition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
3. Hardin, J. Bertoni, G and Klein smith, J. L. (2012). Becker's World of the Cell. 8th Edn, Pearson Benjamin Cummings, San Francisco.
4. Harvey, L. (2004). Molecular Cell Biology. 5th Edn. W.H. Freeman
5. Karp, G. (2008). Cell and Molecular biology: Concepts and Application. 5th Edn, John Wiley
6. Lewin, B. (2008). Gene IX. Joned and Barlett.
7. Lodish, Berk, Matsudaira, Kaiser, Bretscher, Ploegh, Amon, and Martin (2016) Molecular Cell Biology. 8th Edn. W.H. Freeman
8. Pal, A. (2011). Textbook of Cell and Molecular Biology 3rd Edn, Bokks and Allied, Kolkata.
9. Plopper, G, D. Sharp, Siroski, E (2015) Lewin's Cell 3rdEdition—Johns & Bartlett Publishers
10. Pollard and Earnshaw (2007). Cell Biology. 2nd. Edn Saunders.
11. Reed, J.C. and Green, D.R. (2011). Apoptosis: Physiology and Pathology. Cambridge Univ. Press
12. Russel, P.J. (2010). i-Genetics: A Molecular Approach 3rd edition. Pearson Benjamin
13. Verma and Agarwal. Cell Biology, Genetics, Mol Biology, Evolution and Ecology. S. Chand Pub
14. Watson, Baker, Bell, Gann, Lewin, Losick (2014). Molecular Biology of the Gene, Pearson

BZ 104: Biology of Chordates & Distribution

Total Marks 50, Credits 4

Unit 1: Introduction to Chordates**No. of Hours: 2**

General characteristics and outline classification

Unit 2: Protochordata**No. of Hours: 6**

General characteristics of Hemichordata, Urochordata and Cephalochordata; Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordata

Unit 3: Origin of Chordata**No. of Hours: 4**

Dipleurula concept and the Echinoderm theory of origin of chordates. Advanced features of vertebrates over Protochordata

Unit 4: Agnatha**No. of Hours: 4**

General characteristics and classification of cyclostomes up to class

Unit 5: Pisces**No. of Hours: 6**

General characteristics and classification of Chondrichthyes and Osteichthyes up to order. Swim bladder and accessory respiratory organs (lateral sense organ) in fishes. Migration, Osmoregulation and Parental care in fishes.

Unit 6: Amphibia**No. of Hours: 4**

General characteristics and classification up to order. Neoteny / Paedogenesis in Amphibia; Parental care in Amphibians.

Unit 7: Reptilia**No. of Hours: 4**General characteristics and classification up to order; Affinities of *Sphenodon*. Poison apparatus and Biting mechanism in snakes.**Unit 8: Aves****No. of Hours: 6**General characteristics and classification up to order; *Archaeopteryx*- a connecting link. Principles and aerodynamics of flight, Flight adaptations and Migration in birds.**Unit 9: Mammals****No. of Hours: 4**

General characters and classification up to order; Affinities of Prototheria. Adaptive radiation with reference to locomotory appendages.

Unit 10: Zoogeography**No. of Hours: 4**

Zoogeographical realms, Theories pertaining to distribution of animals. Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

Unit 11: Comparative anatomy of vertebrates**No. of Hours: 6**

Structure, functions and derivatives of integument. Overview of axial and appendicular skeleton, Jaw suspension; Visceral arches; Comparison of anatomy of stomach and dentition.

Unit 12: Comparative physiology of vertebrates**No. of Hours: 10**

Respiratory organs in fish, amphibian, birds and mammals; General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts; Comparative account of brain in vertebrates; Brief account of visual and auditory receptors in man.

Suggested Readings:

1. Arora, M.P. *Chordata I. Himalaya Pub House*
2. Darlington P.J. *The Geographical Distribution of Animals*, R.E. Krieger Pub Co.
3. Hall B.K. and Hallgrimsson B. (2008). *Strickberger's Evolution*. IV Edition. Jones and Bartlett
4. Jordan, E.L. & Verma, P.S. (2003). *Chordate Zoology*. S. Chand & Company Ltd. New Delhi.
5. Kardong, K.V. (2002). *Vertebrates: Comparative anatomy, function evolution*. Tata McGraw Hill.
6. Kent, G. C. & Carr, R.K. (2001). *Comparative anatomy of the Vertebrates*. 9th Ed. McGraw Hill.
7. Nelson, J.S. (2006): *Fishes of the World*, 4th Edn. Wiley.
8. Parker, T.J. & Haswell, W. (1972). *Text Book of Zoology*, Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press, London.
9. Pough H. Christine M. J. and B. Haiser (2002). *Vertebrate life*, VIII Edition, Pearson Internatl.
10. Rastogi, V.B. *Ecology and Animal Distribution*. Rastogi Publication.
11. Romer, A. S. & Parsons, T.S. (1986). *The vertebrate body*. 6th Ed. Saunders College Pub.
12. Sinha, K. S, Adhikari, S. Ganguly B.B. & Bharati Goswami, B.D. (2001). *Biology of Animals*. Vol. II. New Central Book Agency
13. Saxena, R.K. & Saxena, S.C. (2008): *Comparative Anatomy of Vertebrates*, Viva Books Pvt. Ltd.
14. Young, J. Z. (2004). *The Life of Vertebrates*. III Edition. Oxford University Press.

BZ 192: Practical- Cell Mol Biology & Chordates
Total Marks 50, Credits 4

Unit I: Cell & Molecular Biology

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs.
3. Cytochemical staining of DNA – Feulgen.
4. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Study of different stages of Mitosis & Meiosis by permanent slides.
7. Study of different types of DNA and RNA using micrographs and model/schematic representations.
8. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent)
9. Estimation of RNA using colorimeter (orcinol reagent)
10. Resolution and visualization of DNA by Agarose Gel Electrophoresis.

Unit II: Biology of Chordates

1. Spot identification of
 - a. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*
 - b. Agnatha: *Petromyzon*, *Myxine*
 - c. Fishes: *Scoliodon*, *Sphyrna*, *Pristis*, *Torpedo*, *Chimaera*, *Mystus*, *Heteropneustes*, *Labeo*, *Catla*, *Cirrhinus*, *Hypophthalmichthys*, *Cyprinus*, *Exocoetus*, *Anguilla*, *Hippocampus*, *Tetrodon*, *Anabas*, *Clarias*
 - d. Amphibia: *Necturus*, *Bufo*, *Hyla*, *Alytes*, *Axolotl* larva, *Tylotriton*
 - e. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Mabuya*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*
 - f. Mammalia: Bat (Insectivorous and Frugivorous), *Funambulus*
2. Key for Identification of poisonous and non-poisonous snake
3. Mounting of cycloid and ctenoid scales
4. Study of disarticulated skeleton of Toad, Pigeon and Guinea pig
Identification of mammalian skulls: One herbivorous (Guinea pig) and one carnivorous animal (Dog)
5. Study and Dissection of Afferent arterial system, brain, pituitary in Carp

Suggested Readings:

1. Chatterjee and Chatterjee Practical Zoology
2. Ghosh, K.C. and Manna, B. (2015): Practical Zoology, New Central Book Agency, Kolkata
3. Sinha, J.K., Chatterjee, A.K. and P. Chattopadhyay Advanced Practical Zoology

Semester III**BZ 201: Biochemistry and Endocrinology**

Total Marks 50, Credits 4

Unit 1: Overview of Metabolism**No. of Hours: 8**

Catabolism vs Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways; Shuttle systems and membrane transporters; ATP as "Energy Currency of cell"; Coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

Unit 2: Carbohydrate Metabolism**No. of Hours: 6**

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

Unit 3: Lipid Metabolism**No. of Hours: 8**

β -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms, Biosynthesis of palmitic acid; Ketogenesis; Fatty Acid Biosynthesis; Metabolism of Triglycerides And Phospholipids.

Unit 4: Protein Metabolism**No. of Hours: 6**

Biosynthesis of amino acids, Catabolism of amino acids: Transamination, Deamination; Fate of C-skeleton of Glucogenic and Ketogenic amino acids, Urea cycle.

Unit 5: Oxidative Phosphorylation**No. of Hours: 6**

Redox systems; Review of mitochondrial respiratory chain; Inhibitors and un-couplers of Electron Transport System.

Unit 6: Introduction to Endocrinology**No. of Hours: 4**

History of endocrinology, Classification, Characteristic and Transport of Hormones; Neurosecretions, Neurohormones, Homeostasis.

Unit 7: Epiphysis, Hypothalamo-hypophyseal Axis**No. of Hours: 8**

Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms; Structure of pituitary gland, Hormones and their functions, Hypothalamohypophyseal portal system, Disorders of pituitary gland.

Unit 8: Peripheral Endocrine Glands**No. of Hours: 8**

Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis; Hormones in homeostasis, Disorders of endocrine glands.

Unit 9: Regulation of Hormone Action**No. of Hours: 6**

Hormone action at Cellular level: Hormone receptors, transduction and regulation; Hormone action at Molecular level: Molecular mediators

Suggested Readings:

1. Campbell and Farrell (2012). Biochemistry. 7th Edn. Brooks and Cole
2. Chatterjee, MN and Shinde, R (2012). A Textbook of Medical Biochemistry. 8th Edn. Jaypee Pub
3. Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition, W.H. Freeman and Co. New York
4. Jain, J.L., Jain m S and N. Jain. Fundamentals of Biochemistry. S. Chand Pub. N. Delhi
5. Metzler D.E. (2001). The chemical reactions of living cells –2nd edition, 2001, Academic Press.
6. Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill

7. Sathyanarayana U and Chakrapani, (2002). Biochemistry –Books & Allied (P) Ltd, Kolkata
8. Voet. D & Voet. J.G, (2004). Biochemistry –3rd edition, 2004, John Wiley & Sons, Inc.
9. Fox, T. Brooks, A. And Baidya, B. (2015). Endocrinology. JP Medical, London.
10. Gardner And Shoback, Greenspan's Basic and Clinical Endocrinology, McGraw Hill Lange.
11. Goodman, H.M. (2000). Basic Medical Endocrinology. 4th Edn. Academic Press.
12. Hadley and Levine 2007, Endocrinology, Pearson Prentice-Hall, Pearson Education Inc
13. Jameson, J.L. (2010). Harrison's Endocrinology. 2nd Edn. McGraw Hill
14. Melmed, Polonsky, Larsen and Kronenberg -William's Text Book of Endocrinology, Elsevier
15. Neal, J.M. (2000). Basic Endocrinology; An Interactive Approach. Blackwell Science.
16. Norris, D.O. (2007). Vertebrate Endocrinology. 4th Edn. Elsevier Academic Press

BZ 203: Ecology & Wildlife Conservation
Total Marks 50, Credits 4

Unit 1: Introduction to Ecology**No. of Hours: 8**

History of ecology, Autecology and synecology, Levels of organization; Laws of limiting factors, Study of physical factors, Biosphere.

Unit 2: Population**No. of Hours: 12**

Unitary and Modular populations; Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion; Exponential and logistic growth, equation and patterns, r and K strategies; Population regulation - density-dependent and independent factors; Population interactions, Gause's Principle with laboratory and field examples; Lotka-Volterra equation for competition and Predation, functional and numerical responses.

Unit 3: Community**No. of Hours: 8**

Community characteristics: species richness, dominance, diversity, abundance; Ecotone and edge effect; Ecological succession with one example; Theories pertaining to climax community.

Unit 4: Ecosystem**No. of Hours: 8**

Types of ecosystems with one example in detail; Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web; Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies; Nutrient and biogeochemical cycle with one example of Nitrogen cycle; Human modified ecosystem

Unit 5: Population interactions:**No. of Hours: 6**

Intraspecific and interspecific associations- positive and negative interactions; Mutualism, Commensalism, Parasitism, Predation and Competition.

Unit 6: Introduction to Wild life**No. of Hours: 8**

Concept of wildlife and wildlife heritage, Importance of conservation; Causes of depletion of wildlife in Indian context; Concept of threatened fauna – IUCN categories, Hotspots and Megadiversity.

Unit 7: Wildlife conservation strategies**No. of Hours: 10**

In-situ and Ex-situ conservation, Wild life protection act (1972); Wild life Sanctuary, national park, biosphere reserve-objectives and process of creation; Different Wild life conservation strategies and projects in India (Tiger, Rhino).

Suggested Readings:

1. Basu, R.N. (2004). A Compendium of Terms in Ecology and Environment. Naya Udyog.
2. Begon, Harper & Townsend-Ecology: Individuals, Populations & communities. Blackwell science.
3. Chapman and Reiss, Ecology - Principles & Application. Cambridge University Press.
4. Colinvax, P. (1993). Ecology 2. John Wiley & Sons, Inc. New York.
5. Dash, M. C., (2001). Fundamental of Ecology. 2nd Ed. Tata McGraw-Hill Company.
6. Freedman, B. (1989). Environmental Ecology. Academic press, Inc.
7. Joshi & Joshi (2009)- A Text Book of Ecology and Environment. Himalaya Publishing House.
8. Kormondy, E. J. (2002). Concepts of Ecology. 4th Indian Reprint, Pearson Education.
9. Krebs, C. J. (2001). Ecology. Benjamin Cummings.
10. Molles, Jr. M.C. (2005). Ecology: Concepts and Applications. 3rd Ed. McGraw- Hill.
11. Odum, E. P. & Barret, G. W. (2005). Fundamentals of Ecology. 5th Ed. Thompson Brooks/Cole.

12. Ricklefs, R. E. & Miller, G. L. (2000). Ecology. 4th Ed. W. H. Freeman & Company.
13. Brooks/Cole. Saharia, V. B. (1998). Wildlife in India. Natraj Publishers.
14. Smith, T. M & Smith, R. L. (2006). Elements of Ecology. 6th Ed. Pearson Education.
15. Stiling, P. (2009). Ecology- Theories and Applications. 4th Ed. Prentice Hall of India.
16. Van Dyke, F. (2008). Conservation Biology: Foundations, Concepts, Application, Springer

Semester IV**BZ 202: Biotechniques and Biostatistics**

Total Marks 50, Credits 4

Unit 1: Bioenergetics**No of Hours 6**

First and Second Laws of Thermodynamics; Definition of Gibb's Free Energy Enthalpy, and Entropy; Mathematical Relationships; Standard Free Energy Change and Equilibrium Constant; Coupled Reactions, Additive Nature of Standard Free Energy Change
Energy Rich Compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP.

Unit 2: Microscopy: Principles and applications**No of Hours 8**

Principles and applications of - Light microscopy: brightfield and darkfield, Phase contrast microscopy, Fluorescence Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy); Micrometry.

Unit 3: Electromagnetic radiation and Spectrophotometry**No of Hours 8**

Basic principles of electromagnetic radiation: Energy, wavelength, wave numbers and frequency, review of electronic structure of molecules.

UV-visible spectrophotometry: Beer Lambert law, light absorption and its transmittance, factors affecting absorption properties of a chromophore, Principle and use of study of absorption spectra of biomolecules; structural analyses of DNA/ protein using absorption of UV light. Colorimetry and turbidometry

Fluorescence spectroscopy: Theory of fluorescence, static and dynamic quenching, resonance energy transfer, fluorescent probes in the study of protein and nucleic acids.

Mass spectrometry (MALDI-TOF): Physical basis and uses of MS in the analysis of proteins/ nucleic acids.

Unit 4: Radiation Biology**No of Hours 6**

Concept of radioisotopes, types of radioactive decay (gamma and beta emitter), half-life, detection and measurement of radioactivity: methods based upon ionization (GM counter), methods based upon excitation (scintillation counter)

Autoradiography, radioisotopes in diagnosis and radiotherapy. Effect of radiations (ionizing and non-ionizing) on living systems, precautions and safety measures in handling radioisotopes

Unit 5: Chromatography**No of Hours: 10**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography, Column chromatography: packing and fraction collection. Gel filtration chromatography, ionexchange chromatography and affinity chromatography; GLC, HPLC.

Unit 6: Electrophoresis**No of Hours: 6**

Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, Isoelectric focusing, 2D gel electrophoresis; Zymogram preparation; Principle and applications of Agarose gel electrophoresis.

Unit 6: Hydrodynamic methods**No of Hours: 8**

Viscosity: Methods of measurement of viscosity, specific and intrinsic viscosity, relationship between viscosity and molecular weight, measurement of viscoelasticity of DNA.

Sedimentation: Principle of centrifugation; Svedberg equation, RCF and sedimentation coefficient; relationship between RPM and RCF; differential and density gradient centrifugation, preparative and analytical ultracentrifugation techniques, fractionation of cellular components using centrifugation with examples.

Flow Cytometry: Basic principle of flow cytometry and cell sorting, detection strategies in flow cytometry.

Unit 8: Biostatistics**No of Hours 8**

Introduction to biostatistics & its use; Idea on variables, frequency distribution and sampling; Measures of central tendency: mean, median, mode. Measures of distributions: variance, range, quartile deviation; Standard deviation and standard error - problems and application; Students t-test and Chi square test- problems and application; Correlation and Regression.

Suggested Readings:

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
2. David Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd Ed., W.H. Freeman and Company.
3. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
4. Willey MJ, Sherwood LM & Woolverton C J.(2013). Prescott, Harley and Klein's Microbiology. 9th Ed., McGraw Hill.
5. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
6. De Robertis EDP and De Robertis EMF.(2006). Cell and Molecular Biology. 8th edition. Lipincott Williams and Wilkins, Philadelphia.
7. Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
8. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology. Tata McGraw Hill.
9. A. Edmondson and D. Druce : Advanced Biology Statistics, Oxford University Press; 1996.
10. W. Danial : Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons
11. PK Bannerje-Introduction to Biostatistics, S Chand Publications
12. Zar, Jerrold H. (1999). *Biostatistical Analysis*, IV Edition, Pearson Education Inc and Dorling Kindersley Publishing Inc. USA

BZ 292: Practical: Ecology, Endocrinology and Biotechniques
Total Marks 50, Credits 4

Unit 1: Ecology & Endocrinology

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, determination of pH and free CO₂, Quantitative estimation of Dissolved O₂ and CO₂ (APHA method) of water by titrimetric methods.
4. Demonstration and display of Endocrine glands in laboratory bred rat/photograph
5. Study of the permanent slides of all the endocrine glands (Thyroid, Adrenal, Pancreas, Testis and Ovary)
6. Demonstration of hormone assay through ELISA from available teaching kit

Unit 2: Biotechniques

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Study of structural changes of proteins at different pH/Temperature using UV spectrophotometry.
4. Determination of melting temperature of DNA.
5. Separation of mixtures by paper / thin layer chromatography.
6. Demonstration of column packing in any form of column chromatography.
7. Separation of protein mixtures by any form of chromatography.
8. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
9. Preparation of agarose gel and loading of sample.
10. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
11. Study the effect of temperature on the viscosity of a macromolecule (Protein/DNA).
12. Separation of components of a given mixture using a laboratory scale centrifuge.

Semester V

BZ 301: Human Physiology

Total Marks 50, Credits 4

Unit 1: Tissues

No. of Hours: 6

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue; Structure and types of bones and cartilages, Ossification, bone growth and resorption.

Unit 2: Blood

No. of Hours: 6

Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Complement system & Fibrinolytic system, Haemopoiesis; Blood groups: Rh factor, ABO and MN.

Unit 3: Muscle

No. of Hours: 6

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch; Motor unit, summation and tetanus.

Unit 4: Nervous System

No. of Hours: 8

Structure of neuron, resting membrane potential, Origin of action potential and its propagation across the myelinated and unmyelinated nerve fibers; Types of synapse, Synaptic transmission and, Neuromuscular junction; Reflex action and its types - reflex arc; Physiology of hearing and vision.

Unit 5: Reproductive System

No. of Hours: 2

Histology of testis and ovary; Physiology of male and female reproduction

Unit 6: Physiology of Digestion

No. of Hours: 8

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

Unit 7: Physiology of Respiration

No. of Hours: 8

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

Unit 8: Renal Physiology

No. of Hours: 6

Structure of kidney and its functional unit; Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance.

Unit 9: Physiology of Heart

No. of Hours: 10

Structure of mammalian heart, Coronary circulation; Structure and working of conducting myocardial fibre; Origin and conduction of cardiac impulses; Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.

Suggested Readings:

1. Barrets, Brooks, et al- Ganong review of Medical Physiology, McGraw Hill
2. CC Chatterjee- Human Physiology Part I & II, CBS Publishers
3. Fox, S.I. (2011). Human Physiology. 12th Edn. Mc Graw Hill.
4. Guyton and Hall, *Textbook of Medical Physiology*, Harcourt Asia / WB Saunders Company
5. Sembulingam and Sembulingam (2012) Essentials of Medical Physiology. 6th Edn. Jaypee Pub

6. Sherwood, L. (2013). Human Physiology from cells to systems. 8th Edn., Brooks & Cole
7. Tortora and Derrickson, (2009). *Principles of Anatomy and Physiology*, John Wiley & Sons
8. Widmaier, Raff and Strang (2008) *Vander's Human Physiology*, XI Edition., McGraw Hill

BZ 303: Immunology
Total Marks 50, Credits 4

Unit 1: Introduction**No. of Hours: 4**

Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.

Unit 2: Immune Cells and Organs**No. of Hours: 8**

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT.

Unit 3: Antigens**No. of Hours: 4**

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants.

Unit 4: Antibodies**No. of Hours: 6**

Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies.

Unit 5: Major Histocompatibility Complex**No. of Hours: 4**

Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways).

Unit 6: Complement System**No. of Hours: 4**

Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement Activation

Unit 7: Generation of Immune Response**No. of Hours: 10**

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance.

Unit 8 Immunological Disorders and Tumor Immunity**No. of Hours: 10**

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, CGD; Types of tumors, tumor Antigens, causes and therapy for cancers.

Unit 9: Immunological Techniques**No. of Hours: 10**

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, RIA, ELISA, ELISPOT, Western blotting, Immunofluorescence, Flow cytometry, Immunoelectron microscopy.

Suggested Readings:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition WileyBlackwell Scientific Publication, Oxford.

3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Khan F, The Elements of Immunology, Pearson Publication
5. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
6. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinburgh.
7. Richard C and Geoffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

BZ 305: Microbiology & Parasitology
Total Marks 50, Credits 4

Unit 1: Introduction to Microbiology**No. of Hours: 8**

Concept of microorganisms (prokaryotic microbes and eukaryotic microbes); Bacterial classification- Whittaker's Five Kingdom and Carl Woese three domain concept of living organisms, General features of Eubacteria and Archaeobacteria.

Unit 2: Morphology of Bacteria and Virus**No. of Hours: 10**

Cell wall (Structure of peptidoglycan), Cell membrane; Differences between gram- positive and gram-negative species; External capsule and glycocalyx, Plasmids and episomes; Nuclear material, Bacterial Chromosome (differences with eukaryotic chromosome); Cytoplasmic inclusions, Ribosomes; Structural organization of viruses, Prions and viroids; Bacteriophages-Life cycles of T4 and lambda phages (Lytic and Lysogeny).

Unit 3: Infection of pathogens to human populations**No. of Hours: 4**

Communicable and Non-communicable disease; Endemic, Epidemic, Pandemic and Sporadic concept.

Unit 4: Diagnostic Microbiology and Bacteria culture**No. of Hours: 8**

Koch's postulates, Sensitivity and specificity of test results; Principles and applications: Simple staining, Gram-staining, Acid-fast staining; Microbial nutrition and types; Phases of Bacterial growth and factors affecting growth; Culture Media: Simple media, Complex media, Differential, Selective and Enriched media.

Unit 5: Microbes in health and disease:**No. of Hours: 8**

Beneficial and harmful microbial interactions with humans, Host-parasite interactions; Brief account of microbial diseases- Bacterial (Typhoid, Staphylococcal Food Poisoning, TB), Viral (Dengue, AIDS); Antibiotic resistance.

Unit 6: Introduction to parasitism**No. of Hours: 2**

Brief introduction of Parasitism; Parasites and Hosts: types and examples; Parasitoid.

Unit 7: Host parasite relationship**No. of Hours: 4**

Morphological and Physiological changes in host and parasite; Phoresis, Commensalisms, Parasitism and Mutualism.

Unit 8: Life-cycle, Pathogenecity and Control of-**No. of Hours: 10**

- a) *Entamoeba histolytica*, *Plasmodium vivax* and *Giardia intestinalis*
- b) *Fasciolopsis buski*, *Schistosoma haematobium*, *Taenia solium* and *Hymenolepis nana*
- c) *Ascaris lumbricoides*, *Wuchereria bancrofti* and *Trichinella spiralis*
- d) *Pediculus humanus* (head and body louse), *Xenopsylla cheopis* and *Cimex lectularius*

Unit 9: Biology of Vectors**No. of Hours: 6**

- a) Vectors- Different types
- b) Details and Control measures of: *Anopheles*, *Culex* and *Phlebotomus*

Suggested Readings:

1. Alexander, M. (1977). Introduction to Soil Microbiology. John Wiley and Sons, New York.
2. Atlas, R. M. and Bartha, R. (1997). Microbial Ecology: Fundamentals and Applications, 4th ed.
3. Benjamin/Cummings. Black, Microbiology: Principles and Explorations, John Wiley and Sons
4. Campbell, R. (1983). Microbial Ecology. 2nd ed. Oxford, Blackwell.
5. Pinehuk, G. (2003). Schaum's outline Series: Theory and Problems of Immunology. McGraw-Hill.

6. Prescott, L.M., Harley, J. P. and Klein, D.A. (2011). Microbiology, McGraw Hill
7. Schlegel, H.G. (1993). General Microbiology. 7th ed. Cambridge University Press
8. Stanier, R.Y., Adelberg, E.A. and Ingraham, J. L. (1986). General Microbiology. 5th ed. Macmillan
9. Tortora, Funke and Case. C.L. (2008). Microbiology: An Introduction, Cummings Publishing H
10. Voyleys, B.A. (2002). The Biology of Viruses. 2nd Edn. McGraw Hill
11. Arora, D. and Arora, B. (2001). Medical Parasitology. II Edition. CBS Publications and Distributors
12. Bogitsch, B.J., Carter, C. E. and Oeltmann T.N. (2013). Human Parasitology. 4th Edn. Elsevier.
13. Bose M (2017). Parasitoses and zoonoses. New Central Book Agency. 1:3-808
14. Chakraborty P (2016). Textbook of Medical parasitology, 3rd edition. New Central Book Agency
15. Gunn, A. and Pitt, S.J. (2012). Parasitology: an Integrated Approach. Wiley Blackwell.
16. John, D.T. and W.A. Petri (2006). Markell and Voge's Medical Parasitology. 9th Edn. Elsevier.
17. Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers
18. Muller, R. and Wakelin, D. (2002). Worms and Human Disease, CAB International Pub.
19. Noble and Noble (1982) Parasitology: The biology of animal parasites, Lea & Febiger
20. Ratan Lal and Rajesh Bhatia-Medical Parasitology, III Edition, Jaypee B Publishers (P) Ltd
21. Roberts, L.S and Janovy, J. (2009). Smith & Robert's Foundation of Parasitology, McGraw Hill

BZ 391: Practical- Histology & Physiology
Total Marks 50, Credits 4

Unit 1: Histology

1. Tissues- Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue.
2. Fixatives and fixation: Principle, types and procedure
3. Dyes and Stains used in histology (classification, composition and properties)
4. Principle of staining: Double and Triple staining methods of histological tissue sections
5. Histological and functional aspects of lung, liver, Kidney, pituitary, thyroid, adrenal, testis and ovary in mammals.
6. Histological organization of different parts of mammalian alimentary canal.
7. Tissue structure and function: brain, skin, blood, lymph node, bone and muscles

Unit 2: Physiology

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Preparation of haemin and haemochromogen crystals.
4. Recording of blood pressure using a sphygmomanometer.
5. Examination of sections of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.
6. Demonstration of the unconditioned reflex action (Deep tendon reflex as knee jerk reflex).
7. Preparation of temporary mounts: Squamous epithelium, Striated muscle fibres

BZ 393: Practical- Immunology, Microbiology & Parasitology

Total Marks 50, Credits 4

Unit I. Immunology

1. Identification of human blood groups.
2. Perform Agglutination test.
3. Perform Total Leukocyte Count of the given blood sample.
4. Perform Differential Leukocyte Count of the given blood sample.
5. Separate serum from the blood sample (demonstration).
6. Perform immunodiffusion by Ouchterlony method / Radial Immunodiffusion method.
7. Perform DOT ELISA/Indirect ELISA.
8. Perform immunoelectrophoresis.

Unit II. Microbiology and Parasitology

1. Simple staining and Gram's staining of bacteria.
2. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria.
3. Preparation of slant and stab; Culture techniques: Spread plate, Pour plate and Streak plate
4. Biochemical test for characterization:
 1. Catalase, Nitrate-reduction, Indole production, Methyl Red and Voges-Proskauer Test.
5. Microbiological examination of milk (Methylene blue reductase test), Sugar fermentation test
6. Identification of life stages of *Giardia lamblia* and *Leishmania donovani* through permanent slides/microphotographs
7. Identification of adult and life stages of *Schistosoma haematobium*, *Taeniasolium* through permanent slides/microphotographs
8. Identification of adult and life stages of *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis* through permanent slides/microphotographs
9. Identification of plant parasitic root knot nematode, *Meloidogyne* from the soil sample
10. Identification of *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/photographs.

Semester VI**BZ 302: RDT and Bioinformatics**

Total Marks 50, Credits 4

Unit 1: Introduction to Genetic Engineering**No. of Hours: 2**

Milestones in genetic engineering and biotechnology.

Unit 2: Molecular Cloning- Tools and Strategies**No. of Hours: 6**

Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering, DNA modifying enzymes and their applications; Cloning and expression Vectors; preparation of insert, linkers & adapters

Unit 3: Methods in Molecular Cloning**No. of Hours: 10**

Transformation of DNA: Chemical method, Electroporation. Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viralmediated delivery, *Agrobacterium* - mediated delivery. DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern – blotting techniques, SDS-PAGE, Western blotting.

Unit 4: DNA Amplification and DNA sequencing**No. of Hours: 6**

Principle and Applications of PCR, RT-PCR, Real-Time PCR; Sanger's method of DNA Sequencing: traditional and automated sequencing.

Unit 5: Construction and Screening of Genomic and cDNA libraries**No. of Hours: 8**

Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping, DNA microarray analysis.

Unit 6: Applications of Recombinant DNA Technology**No. of Hours: 8**

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, Ethical aspects of Biotechnology.

Unit 7: Introduction to Bioinformatics and Biological Databases**No. of Hours: 8**

Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB. Human Genome Project.

Unit 8: Sequence Alignments, Phylogeny and Phylogenetic trees**No. of Hours: 8**

Local and Global Sequence alignment, pairwise and multiple sequence alignment; Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices; Types of phylogenetic trees, Different approaches of phylogenetic tree construction-UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood.

Unit 9: Protein Structure Predictions**No. of Hours: 4**

Hierarchy of protein structure - primary, secondary and tertiary structures, modeling; Structural Classes, Motifs, Folds and Domains; Protein structure prediction in presence and absence of structure template; Protein structure and rational drug design.

Suggested Readings:

1. Brown, TA- Molecular Biology Lab fax II: Gene Cloning and DNA Analysis, Academic Press
2. Butler, J.M. (2010). Fundamentals of Forensic DNA Typing. Academic Press.
3. Ghosh Z and Mallick B. Bioinformatics: *Principles and Applications*, Oxford University Press.
4. Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA
5. Harisha, S- Biotechnology Procedures and Experiments Handbook. Infinity Science Press
6. Mosier, N.S. And Ladisch, M.R. (2009). Modern Biotechnology. John Wiley.
7. Pevsner J- *Bioinformatics and Functional Genomics*, II Edition, Wiley Blackwell
8. Primrose, and Twyman. Principles of Gene Manipulation and Genomics. 7th Edn.
9. Singh, B.D. Biotechnology. Kalyani Pub. New Delhi.
10. Weaver. Molecular Biology. 5th edition.
11. Zvelebil, Marketa and Baum O. Jeremy (2008). *Understanding Bioinformatics*, Garland Science, Taylor and Francis Group, USA

BZ 304: Genetics & Evolutionary Biology
Total Marks 50, Credits 4

Unit 1: Mendelian Genetics and its extension**No. of Hours: 8**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy; Sex-linked, sex-influenced and sex-limited inheritance and Polygenic Inheritance.

Unit 2: Linkage, crossing over, recombination and mutation**No. of Hours: 12**

Linkage and Crossing Over, molecular basis of crossing over; Models of Recombination (Holliday model); Measuring Recombination frequency and linkage intensity using three factor crosses; Interference and coincidence, Somatic cell hybridization; Mutation- Types with examples, Mutagens; Chromosomal aberration, Non-disjunction; Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached *X* method.

Unit 3: Sex determination and Dosage compensation**No. of Hours: 6**

Mechanisms of sex determination in *Drosophila* and man; Sex determination in mammals; Dosage compensation in *Drosophila* & Human.

Unit 4: Extra chromosomal inheritance and Transposable elements**No. of Hours: 8**

Criteria for extra chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Kappa particle in Paramecium and Shell spiralling in snail; Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, LINE, SINE, Alu elements in humans.

Unit 5: Genetic recombination in bacteria**No. of Hours: 4**

Transformation, Conjugation-F⁺, F⁻, Hfr & F' strain; Transduction-Generalized & specialized types.

Unit 6: Origin of Life & Evolutionary concepts**No. of Hours: 8**

Chemogeny, RNA world, Biogeny; Origin of photosynthesis, Evolution of eukaryotes; Lamarckism, Darwinism and Neo Darwinism; Geological time scale- Neutral theory of molecular evolution, Molecular clock; Phylogenetic trees, Convergent & Divergent evolution.

Unit 7: Species concept**No. of Hours: 4**

Biological and Evolutionary species; Isolating mechanisms and modes of speciation; Sympatric, Allopatric and Parapatric speciation.

Unit 8: Hardy-Weinberg equilibrium and factors affecting it**No. of Hours: 4**

Genetic Drift, Founder effect and Bottle Neck effect; Role of Migration and Mutation in changing allele frequencies.

Unit 9: Evolution of horse and man**No. of Hours: 4****Unit 10: Mass extinction-Causes and five major extinctions****No. of Hours:****Suggested Readings:**

1. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). *Evolution*. Cold Spring, Harbour Laboratory Press
2. Brooker, R.J. (2012). *Genetics Analysis and Principles*. 4th Edn. McGraw Hill.
3. Chattopadhyay, S. (2012). *Life: Evolution, Adaptation, Ethology*. 3rd Edn. Books and Allied,
4. Futuyma, D. J. (1997). *Evolutionary Biology*. Sinauer Associates.

5. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Ed. Wiley India.
6. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. (2010). *Introduction to Genetics Analysis* WH Freeman.
7. Hall, B. K. and Hallgrimsson, B. (2008). *Evolution*. IV Edition. Jones and Bartlett Publishers
8. Hyde, D. (2009). *Introduction to Genetic Principle*. McGraw Hill.
9. Kardong, K. (2004). *An Introduction to Biological Evolution*. McGraw Hill.
10. Klug, Cummings and Spencer, *Concepts of Genetics*. X Edition. Benjamin Cummings.
11. Pierce, B.A. (2013). *Genetics Essentials: Concepts and Connections*. 2nd Edn. Freeman W.H.
12. Ridley, M. (2004). *Evolution*. III Edition. Blackwell Publishing
13. Russel, P. J. (2009). *Genetics- A Molecular Approach*. III Edition. Benjamin Cummings.
14. Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wiley and Sons Inc.

BZ 306: Embryology and Ethology

Total Marks 50, Credits 4

Unit 1: Introduction**No. of Hours: 4**

Basic concepts: Phases of Development, Cell-cell interaction; Differentiation and growth, Differential gene expression.

Unit 2: Early embryonic development-**No. of Hours: 8**

Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal); Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

Unit 3: Late embryonic development**No. of Hours: 4**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

Unit 4: Post embryonic development**No. of Hours: 6**

Metamorphosis: Changes, hormonal regulations in amphibians and insects; Development of heart, brain and Eye in chick and vertebrate; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration; Ageing: Concepts and Theories.

Unit 5: Implications of Developmental Biology**No. of Hours: 4**

Teratogenesis- Teratogenic agents and their effects on embryonic development; In vitro fertilization; Stem cell (ESC) and Amniocentesis.

Unit 6: Basic concepts of Ethology**No. of Hours: 6**

Origin and history of Ethology; Brief profiles of Von Frish, Ivan Pavlov, K Lorenz, N Tinbergen; Proximate and ultimate causes of behaviour, Methods and recording of a behaviour.

Unit 7: Patterns of Behaviour**No. of Hours: 8**

Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting.

Unit 8: Social and Sexual Behaviour**No. of Hours: 10**

Social Behaviour: Concept of Society; Communication and the senses; Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance; Sexual Behaviour: Asymmetry of sex, Sexual dimorphism, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice); Role of male and female in parental investment, parent-offspring conflict; Effect, cost and benefit of parental investment.

Unit 9: Biological rhythm**No. of Hours: 8**

Chronobiology and Biological oscillation; Types and characteristics of biological rhythms: Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Circannual rhythms Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin.

Unit 10: Biological rhythm**No. of Hours: 2**

Relevance of biological clocks; Chronopharmacology, Chronomedicine, Chronotherapy; Role in Migration in birds and fishes.

Suggested Readings:

1. Balinsky and Fabian- An Introduction to Embryology, International Thompson Computer Press
2. Carlson, B.M. Human Embryology and Developmental Biology, Elsevier
3. De Jonge and Barratt-The Sperma cell, Cambridge Univ Press
4. Gilbert SF. Developmental Biology, Sinauer Associates, Inc., Publishers
5. Slack JMW-Essential Developmental Biology, Blackwell Pub
6. Verma and Agarwal-Developmental Biology, S. Chand Pub. New Delhi
8. Wolpert, L- Principles of Development. 2nd Edn. Oxford Univ. Press
9. Alcock, J. (2001). Animal Behaviour: An Evolutionary Approach. , Sinauer Associate
10. Chattopadhyay, S-Life: Evolution, Adaptation, Ethology, Books and Allied
11. Dujatkin, L.A.-Principles of Animal Behaviour, W.W.Norton and Co
12. Kumar, V- Biological Rhythms, Narosa Publishing House
13. Mathur, R- Animal Behaviour. Rastogi Pub
14. Ruhela, A. and Sinha, M-Recent Trends in Animal Behaviour. Oxford Book Co

BZ 308: Economic Zoology

Total Marks 50, Credits 4

Unit 1: Introduction to Economic Zoology**No. of Hours: 2****Unit 2: Pest and Pest Management****No. of Hours: 12**

Definition and types of Pest, Insect pest of economically important crops; Insects affecting human health, Non insect pests, Insect-host plant interaction; Integrated Pest management, Insecticides-Types, use and side effects, Biopesticides; Life history, damage and control measures of the some important pests like- *Leptocorisaacuta*, *Sitophilusoryzae*, *Anomissabolifera*, *Leucinodesorbinalis*, Mango pest, *Bandicota bengalensis* and some others.

Unit 3: Aquaculture**No. of Hours: 8**

- a) Induced breeding of carps, Fish diseases – their symptoms and remedies.
- b) Composite fish culture, Air breathing fishes, Exotic fishes & their role.
- c) Freshwater & brackish water prawn culture.
- d) Pearl culture – Pearl producing oysters and their distribution, Composition of pearl.

Unit 4: Sericulture and Apiculture**No. of Hours: 12**

Silk worm species and their host plants; Brief idea of silk worm rearing; extraction and reeling of silk; Diseases and enemies of silk moths; concept on non-mulberry sericulture; Types of honey bees, Composition of honey and its uses; Modern methods of apiary management; Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis), Pollen, etc.

Unit 5: Animal husbandry**No. of Hours: 12**

Dairy farming and cattle management, Techniques of dairy management; Common dairy breeds (cow), Diseases of cattle's, Zoonosis; Poultry farming, Common poultry breeds (fowl), rearing methods, diseases & control.

Unit 6: Lac Culture and Vermiculture**No. of Hours: 12**

History of lac culture, Types of of lac insect and their host plants, Biology of lac insect; Lac cultivation, Properties and uses of lac, Prospects and problems of lac culture; Vermiculture, Vermicomposting and vermibed, History and vermibreeds; Ecology of earthworms, vermiculture process, advantages and disadvantages.

Unit 7: Production of transgenics and their uses in health and agriculture**No. of Hours: 2****Suggested Readings:**

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)

BZ 392: Practical- RDT, Bioinformatics and Genetics
Total Marks 50, Credits 4

Unit 1: RDT and Bioinformatics

1. Preparation of competent cells for transformation.
2. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
3. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
4. Ligation of DNA fragments, DNA Sequencing (Sanger's Method)
5. Cloning of DNA insert and Blue white screening of recombinants.
6. Interpretation of sequencing gel electropherograms.
7. Designing of primers for DNA amplification.
8. Amplification of DNA by PCR; Demonstration of Southern blotting.
9. Introduction to different operating systems - UNIX, LINUX and Windows
10. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB
11. Sequence retrieval using BLAST; alignment & phylogenetic analysis using clustalW & phylip
12. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool
13. Protein structure prediction: primary structure analysis, secondary structure prediction using psipred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK)

Unit 2: Genetics

1. To study the Mendelian laws and gene interactions using Chi-square tests
2. Study of Linkage, recombination, gene mapping using the data
3. Study of Human Karyotypes; normal and abnormal (Turner's, Down's and Klinefelter syndrome) from photographs
4. Pedigree analysis of some human inherited traits.
5. Study of homology and analogy from suitable specimens/ pictures

BZ 392: Practical- Embryology, Ethology & Project/Review work
Total Marks 50, Credits 4

Unit 1: Practical- Embryology, Ethology**Total marks 25, Credits 2**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides or photographs: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 24, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of different sections of placenta (photomicrograph/ slides)
4. To study nests and nesting habits of the birds and social insects.
5. To study geotaxis behaviour in earthworm.
6. To study the phototaxis behaviour in insect larvae.
7. Study and actogram construction of locomotor activity of suitable animal models.
8. Study of circadian functions in humans (daily eating, sleep and temperature patterns)

Unit 1: Project/Review work**Total marks 25, Credits 2**

A student has to do a project work / review work in a topic given by his/her supervisor (to be decided by lottery amongst all the teachers present for that Semester) and submit the report/review within a stipulated time. During examination the work has to be presented before an evaluation team (one external member may be invited) and the student will be credited based on the quality of the report and presentation.

Zoology Subsidiary Papers

BZ 131: Ecology and Evolution

Unit 1: Ecology

Definition and Components of Ecosystem, Food chain, Food web, Ecological pyramid

Energy flow through trophic levels;

Unique and group attributes of population: Demographic factors, life tables, fecundity tables, survivorship curves, dispersal and dispersion, Growth curves, K strategies. Population regulation, density dependent and independent factors

Population Interactions, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition.

Community characteristics: species diversity, abundance, , dominance, richness, Vertical stratification, Ecotone and edge effect, Succession with one example

Unit 2: Biodiversity and Conservation

Biodiversity, causes of depletion and control measures; Conservation of Wildlife: Purpose & Methods; Concept of National Park, Sanctuary & Biosphere Reserve

Management strategies for tiger conservation; Wild life protection act (1972)

Unit 3: Evolution and Adaptation

Chemical basis of Origin of Life, Outline idea about different Evolutionary theories

Biological species concept; Modes of speciation (Allopatric, Sympatric)

Macro and micro evolution, Extinction, Geological Time Scale

Secondary aquatic adaptation (Whale), Volant adaptation in Bird

BZ 132: Animal Diversity

Unit 1. Phylum Protista

General characters and classification up to classes; Locomotory Organelles and locomotion in Protozoa; Life cycle of Plasmodium

Unit 2. Phylum Porifera

General characters and classification up to classes; Canal System in *Sycon*

Unit 3. Phylum Cnidaria

General characters and classification up to classes; Polymorphism in Hydrozoa

Unit 4. Phylum Platyhelminthes

General characters and classification up to classes; Life history of *Taenia solium*

Unit 5. Phylum Phylum Nematoda

General characters and classification up to classes; Life history of *Ascaris lumbricoides* and its parasitic adaptations

Unit 6. Phylum Annelida

General characters and classification up to classes; Nephridia in Annelida

Unit 7. Phylum Arthropoda

General characters and classification up to classes; Vision in Arthropoda, Metamorphosis in Insects , Social life in insects.

Unit 8. Phylum Mollusca

General characters and classification up to classes; Respiration in *Pila*; Pearl Formation

Unit 9. Phylum Echinodermata

General characters and classification up to classes; Water-vascular system in *Asterias*

Unit 10. Protochordata

General features; Feeding in *Branchiostoma*

Unit 11. Agnatha

General features of Agnatha and classification of cyclostomes up to classes

Unit 12. Pisces

General features and Classification up to orders; Osmoregulation in Fishes

Unit 13. Amphibia

General features and Classification up to orders; Metamorphosis in Toad

Unit 14. Reptiles

General features and Classification up to orders; Poisonous and non-poisonous snakes, Biting mechanism in snakes

Unit 15. Aves

General features and Classification up to orders; Flight adaptations in birds

Unit 16. Mammalia

Classification up to orders; Cranial nerves in *Cavia*

BZ 231: Physiology and Embryology

Unit 1. Nerve and muscle

1. Structure of a neuron, Resting membrane potential, Graded potential, Origin of Action potential and its propagation in myelinated and non-myelinated nerve fibres.
2. Ultra-structure of skeletal muscle, Molecular and chemical basis of muscle contraction.

Unit 2. Digestion

Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids

Unit 3. Respiration

Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood

Unit 4. Excretion

Structure of nephron, Mechanism of Urine formation, Counter-current Mechanism

Unit 5. Cardiovascular system

Composition of blood, Homeostasis, Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle

Unit 6. Reproduction and Endocrine Glands

Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle
Structure and function of pituitary, thyroid, pancreas and adrenal

Unit 7. Early Embryonic Development

Gametogenesis: Spermatogenesis and oogenesis with reference to mammals, vitellogenesis in birds; Fertilization: external (amphibians), internal (mammals), blocks to polyspermy; Early development of frog and chick (structure of mature egg and its membranes, patterns of cleavage, fate map, up to formation of gastrula); types of morphogenetic movements; Fate of germ layers; Neurulation in frog embryo

Unit 8. Late Embryonic Development

Implantation of embryo in humans, Formation of human placenta and functions, other types of placenta on the basis of histology; Metamorphic events in frog life cycle and its hormonal regulation.

Unit 9. Control of Development

Fundamental processes in development (in brief) – Gene activation, determination, induction, differentiation, morphogenesis, intercellular communication, cell movements and cell death

BZ 232: Ecology and Animal Behavior

Unit 1: Economic Zoology

- i) Sericulture : Types of silk moths and their host plants. Life history and Life history and rearing of *Bombyx mori*, harvesting and processing of cocoon.
- ii) Aquaculture : Induced breeding and Composite fish culture. Exotic fishes, Pearl culture
- iii) Apiculture : Types of Indian Honey bees, Methods of Rearing, Methods of Extraction and preservation of Honey.
- iv) Lac culture : Lac insect and lac host plants, Strains of lac insects, Cultivation of lac insect, Composition of Lac. Processing of lac and uses.
- v) Poultry: Types of fowl breeds, Deep litter system of rearing.
- vi) Pest, types, Bionomics and control of *Scirpophaga incertulas*, *Sitophilus oryzae* and *Bandicoota bengalensis*, Integrated Pest Management

Unit 1: Ethology

Introduction to Ethology; Orientation, Reflexes; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting
 Social Behaviour: Concept of Society; Communication and the senses;
 Altruism; Insects' society with Honey bee as example; Foraging in honey bee and advantages of the waggle dance
 Sexual Behaviour, Role of male and female in parental investment
 Types and characteristics of biological rhythms: Short- and Long- term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms
 Circannual rhythms Photoperiod and regulation seasonal reproduction of vertebrates; Role of melatonin; Relevance of biological clocks; Role in Migration in birds and fishes

BZ 261: Practical- Animal Diversity and Ecology

BZ 262: Practical- Physiology, Embryology and Histology