

RASHTRASANT TUKADOJI MAHARAJ, NAGPUR UNIVERSITY, NAGPUR
SYLLABUS FOR B.Sc. ZOOLOGY (SEMESTER PATTERN)
(With effect from the academic year 2013-2014)

The semester pattern syllabus for B.Sc. Three Year Degree Course in the Subject - Zoology comprises of six semesters. Each semester is based on six theory periods and six practical periods per week. The examination of each semester shall comprise of two theory papers each of three hours duration and carries 50 marks each and a practical of 4 hours duration carries 30 marks. Internal assessment for each semester based on two theory papers of 10 marks each and shall be conducted by university approved teachers. Internal assessment marks should be submitted to the university one month prior to the final examination. Candidates are expected to pass separately in theory, internal assessment and practical examination.

The Structure of Syllabus for B.Sc. Zoology (Semester Pattern) along with distribution of marks is also displayed in the following Table

Semester	Semesterwise Theory Papers and Practicals	Marks			Total Marks
		Theory	Internal Assessment*	Practical	
Semester - I	Theory Paper – I : Life and Diversity of Animals-Nonchordates (Protozoa to Annelida)	50	10		150
	Paper -II : Environment Biology	50	10		
	Practical - I (Based on Paper I & II)			30	
Semester- II	Theory Paper - III : Life and Diversity of Animals- Nonchordates (Arthropoda to Hemichordata)	50	10		150
	Paper - IV : Cell Biology	50	10		
	Practical - II (Based on Paper III & IV)			30	
Semester- III	Theory Paper - V : Life and Diversity of Animals-Chordates (Protochordata to Amphibia)	50	10		150
	Paper - VI : Genetics	50	10		
	Practical - III (Based on Paper V & VI)			30	
Semester - IV	Theory Paper - VII : Life and Diversity of Animals-Chordates (Reptilia, Aves and Mammals)	50	10		150

Contd. on Pg. 2

	Paper - VIII : Molecular Biology and Immunology	50	10		
	Practical - IV (Based on Paper VII & VIII)			30	
Semester - V	Theory Paper - IX :General Mammalian Physiology I	50	10		150
	Paper - X : Applied Zoology I (Aquaculture and Economic Entomology)	50	10		
	Practical - V (Based on Paper IX & X)			30	
Semester - VI	Theory Paper - XI : General Mammalian Physiology II	50	10		150
	Paper - XII : Applied Zoology II (Biotechniques, Microtechnique, Biotechnology, Bioinformatics and Biostatistics)	50	10		
	Practical - VI (Based on Paper XI & XII)			30	
		Grand total			900

*Internal assessment –

- (For Semester I to IV) Based on students attendance and the performance during Unit test exam. and field work
- (For Semester V & VI) Based on students attendance and the performance during Unit test exam., field work and seminar

Semester - I

Paper – I : Life and Diversity of Animals - Nonchordates (Protozoa to Annelida)

Unit – I

(9 Periods)

- 1.1 **Protozoa** : General characters and classification up to classes
- 1.2 **Paramoecium** : Structure and reproduction
- 1.3 **Plasmodium** : Structure and life cycle
- 1.4 **Parasitic Protozoans of Man** : *Entamoeba*, *Trypanosoma*, *Giardia* and *Leishmania* - Mode of infection and its control

Unit – II

(9 Periods)

- 2.1 **Porifera** : General characters and classification up to classes
- 2.2 **Sycon** : Structure, reproduction and development, Canal system in sponges
- 2.3 **Coelenterata** : General characters and classification up to classes
- 2.4 **Obelia** : Structure and life cycle, corals and coral reef formation

Unit – III (9 Periods)

- 3.1 **Helminthes** : General characters and classification up to classes
- 3.2 **Ascaris** : External morphology, reproductive system and life cycle
- 3.3 **Taenia solium** : Structure and life cycle
- 3.4 **Elementary idea of parasitic adaptations in helminthes**

Unit – IV (9 Periods)

- 4.1 **Annelida** : General characters and classification up to classes
- 4.2 **Leech** : Morphology, digestive and urinogenital system
- 4.3 Trochophore larva and its significance
- 4.4 Vermiculture and its importance

Semester – I

Paper – II : Environmental Biology

Unit – I (9 Periods)

- 1.1 Atmosphere: Major zones and its importance, composition of air
- 1.2 Hydrosphere: Global distribution of water, Physico-chemical characteristics of water
- 1.3 Lithosphere: Types of rocks, formation of soil
- 1.4 Renewable and non- renewable energy sources

Unit – II (9 Periods)

- 2.1 Ecosystem - Definition and types
- 2.2 Detailed study of pond ecosystem
- 2.3 Food chain, food web and ecological pyramids
- 2.4 Energy flow in an ecosystem, Single channel, Y – shape and Universal model

Unit – III (9 Periods)

- 3.1 Biodiversity and its conservation
- 3.2 Causes of reduction of biodiversity
- 3.3 Wildlife conservation acts (1972 and 1984), Introductory study of national parks and sanctuaries – Tadoba, Kanha, Bharatpur and Nagzira
- 3.4 Hot spots of biodiversity in India

Unit – IV (9 Periods)

- 4.1 Sources, effect and control measures of air pollution, Acid rain, green house effect, ozone depletion and global warming
- 4.2 Sources, effect and control measures of water pollution
- 4.3 Sources effect and control measures of noise pollution
- 4.4 Toxic effect of heavy metals (lead, cadmium and mercury) – Bioaccumulation and biomagnification

Semester – I

PRACTICAL – I (Based on Paper – I and II)

**Section A : Life and Diversity of Animals – Nonchordates (Protozoa to Annelida)
& Section B : Environmental Biology**

Section A : Life and Diversity of Animals – Nonchordates (Protozoa to Annelida)

1. Study of museum specimens (Classification of animals up to orders)

- I. Protozoa (Slides) : *Paramecium*, *Euglena*, *Amoeba*, *Plasmodium vivax*
- II. Porifera: *Sycon*, *Leucosolenia*, *Hyalonema*, *Euplectella*, *Spongilla*
- III. Coelenterata : *Obelia*, *Aurelia*, *Tubipora*, *Fungia*, *Adamsia*
- IV. Platyhelminthes : *Planaria*, *Fasciola*, *Taenia*
- V. Aschelminthes : *Ascaris*, *Dracunculus*, *Ancylostoma*, *Wuchereria*
- VI. Annelida : *Aphrodite*, *Nereis*, *Chaetopteurs*, *Tubifix*, *Hirudinaria*

2. Study of permanent slides

Entamoeba, *Giardia*, Sponge gemmules, Sponge spicules, V.S. *Sycon*, T.S. *Sycon*, *Obelia* medusa, *Miracidium*, *Redia* and *Cercaria* larvae of *Fasciola*, T.S. male and female *Ascaris*, Scolex of *Taenia*, Mature and gravid proglottids of *Taenia solium*, T.S. of Leech through crop pockets, Trochophore larva

3. Dissection

Digestive, nervous and reproductive system of Earthworm

4. Mounting

Spicules and gemmules of Sponge, *Obelia* colony, *Nereis* parapodia, Jaws of Leech, Nephridia of Leech.

Section B: Environmental Biology

1. Estimation of dissolved oxygen of water
2. Estimation of free CO₂ of water
3. Estimation of pH of water sample
4. Estimation of total hardness of water
5. Study of pond ecosystem - Producers, consumers and decomposers
6. Quantitative analysis of plankton

Visit to a National park and Sanctuary

Distribution of Marks –	Total Marks 30
i. Identification and Comment on Spots (4 Museum specimens + 1 Env. bio. spot + 3 slides)	08
ii. Dissection -	08
iii. Environmental biology experiment	04
iv. Permanent stained preparation	03
v. Submission of certified practical record	03
vi. Submission of Slides & tour diary	02
vii. Viva voce	02

Semester – II
Paper – III : Life and Diversity of Animals – Nonchordates
(Arthropoda to Hemichordata)

Unit – I **(9 Periods)**

- 1.1. **Arthropoda** : General characters and classification up to classes
- 1.2. **Cockroach** : Mouth parts, digestive system and reproductive system
- 1.3. **Insects as Vectors** : Mosquito, Housefly, Sandfly, Tse-Tse fly
- 1.4. **Study of crustacean larvae** : Nauplius, Zoea and Megalopa; Social behavior in honey bees

Unit – II **(9 Periods)**

- 2.1 **Mollusca** : General characters and classification up to classes
- 2.2 **Pila** : Morphology, digestive, respiratory and reproductive system
- 2.3 **Pearl formation in Mollusca**
- 2.4 **Molluscan larvae** : Glochidium and Veliger

Unit – III **(9 Periods)**

- 3.1 **Echinodermata** : General characters and classification up to classes
- 3.2 **Asterias** : External features and digestive system
- 3.3 Water vascular system and locomotion in Starfish
- 3.4 **Echinoderm larvae** : Bipinnaria and Auricularia

Unit – IV **(9 Periods)**

- 4.1 **Hemichordata** : General characters and phylogeny
- 4.2 **Balanoglossus** : External features and digestive system
- 4.3 Reproduction in *Balanoglossus* , Tornaria larva
- 4.4 Affinities of *Balanoglossus*

Semester – II
Paper – IV: Cell Biology

Unit – I **(9 Periods)**

- 1.1 Ultrastructure of prokaryotic and eukaryotic cell
- 1.2 Plasma membrane: Structure- Fluid Mosaic Model and functions
- 1.3 Endoplasmic reticulum: Types, ultrastructure and functions
- 1.4 Golgi complex: Ultrastructure and functions

Unit – II **(9 Periods)**

- 2.1 Ultrastructure of mitochondria
- 2.2 Oxidative phosphorylation – Glycolysis and Krebs's cycle
- 2.3 Electron Transport Chain and terminal oxidation
- 2.4 Lysosome: Structure, polymorphism and functions

Unit – III **(9 Periods)**

- 3.1 Nucleus: Ultrastructure of nuclear membrane
- 3.2 Structure and functions of nucleolus
- 3.3 Chromosome: Structure and types, structure of nucleosome
- 3.4 Giant chromosomes: Lamp-brush and polytene chromosome

Unit - IV **(9 Periods)**

- 4.1 Ribosome: Structure, types, Lake's model and functions
- 4.2 Somatic cell division: Cell cycle and Mitosis
- 4.3 Meiosis (different phases and significance), synaptonemal complex
- 4.4 Cellular ageing and cell death, Elementary idea of cancer and its causative agents

Semester – II

PRACTICAL – II (Based on Paper – III and IV)

Section A : Life and Diversity of Animals – Nonchordates (Arthropoda to Hemichordata) & Section B: Cell Biology

Section – A : Life and Diversity of Animals – Nonchordates (Arthropoda to Hemichordata)

1. Study of museum specimens (Classification of animals up to orders)

- I. Arthropoda : *Peripatus, Cyclops, Daphnia, Lepas, Sacculina, Limulus, Crab, Scolopendra, Julus, Dragonfly, Grasshopper, Moth*
- II. Mollusca : *Chiton, Dentalium, Aplysia, Pila, Mytilus, Loligo, Sepia, Octopus*
- III. Echinodermata : *Asterias, Ophiothrix, Holothuria, Antedon, Echinus*
- IV. Hemichordata : *Balanoglossus, Saccoglossus*

2. Study of permanent slides-

Nauplius, Zoea and Megalopa larva of Arthropoda, Veliger and Glochidium larva of Mollusca, T.S. of arm of star fish, Bipinnaria and Auricularia larva, T.S. *Balanoglossus* through collar and proboscis, Tornaria larva

3. Dissection -

- I. Digestive system of Cockroach
- II. Reproductive system of Cockroach
- III. Nervous system of *Pila*

4. Mounting-

Crustacean larvae and plankton; Mouth parts, trachea and salivary gland of Cockroach; Gill lamella, osphradium and radulla of *Pila*

Section B: Cell Biology

1. Study of pictures of ultra structure of prokaryotic cell & eukaryotic cell
2. Study of osmosis in human RBCs (hypotonic, hypertonic and isotonic medium)
3. Demonstration of mitotic cell division in onion root tips by squash method
4. Demonstration of meiosis in *Tradescantia* bud/ Grasshopper testis by squash method
5. Demonstration of salivary gland chromosome in Chironomous larva
6. Demonstration of mitochondria in buccal epithelium/ lip mucosa by Janus Green-B method
7. Use of ocular micrometer and measurement of micro objects
8. Demonstration of Barr body in blood smear

Distribution of Marks –	Total Marks	30
i. Identification and Comment on Spots (5 Museum specimens + 3 slides)	08	
ii. Dissection -	08	
iii. Cell biology experiment	04	
iv. Permanent stained preparation	03	
v. Submission of certified practical record	03	
vi. Submission of Slides	02	
vii. Viva voce	02	

List of Recommended Books : (For Semester – I & II)

Life and Diversity of Animals – Non Chordates

1. Barnes – **Invertebrate Zoology (Holt-Saunders international)** Philadelphia, USA
2. Barradaile L.A. & Potts F.A. – **The Invertebrate**
3. Nigam – **Biology of Nonchordates**
4. Kotpal, Agrawal & Khetrpal – **Modern Text Book of Zoology - Invertebrates**, Rastogi Publication, Meerut
5. Puranik P.G. & Thakur R.S. – **Invertebrate Zoology**
6. Majupuria T.C. – **Invertebrate Zoology**
7. Dhami & Dhami – **Invertebrate Zoology**
8. Parker & Hashwell, **Textbook of Zoology Vol. I (Invertebrates)** A.Z.T.B.S. Publishers & Distributors, New Delhi
9. Dr. S.S. Lal **Practical Zoology Invertebrates 9th edition**, Rastogi Publication Meerut
10. EJW Barrington– **Invertebrate Structure and Function** ELBS III Edition

11. R.L. Kotpal – **Phylum Protozoa to Echinodermata (series)**, Rastogi and Publication, Meerut
12. Parker J. and Haswell W. – **Text Book of Zoology**, ELBS Edition
13. Vidyarthi – **Text Book of Zoology**, Agrasia Publishers, Agra
14. Jordan E.L. and Verma P.S. – **Chordate Zoology**, S. Chand and Co., New Delhi
15. Ayer E. – **Manual of Zoology**
16. M.D. Bhatia – **The Indian Zoological Memories – Leech**
17. Beni Prasad – **The Indian Zoological Memories – Pila**
18. P. K. Gupta – **Vermicomposting for Sustainable Agriculture**, Agrobios India Ltd
19. A manual of Practical Zoology Invertebrates – P. S. Verma

Environmental Biology

1. Ashthana D.K. – **Environmental Problem & Solution**
2. Agrawal K.C. – **Environmental Biology**
3. Agrawal K.C. - **Biodiversity**
4. Mukharjee – **Environmental Biology**
5. S. Arora – **Fundamentals of Environmental Biology**
6. Sharma – **Ecology & Environmental Biology**
7. Verma P.S. & Agrawal V.K. – **Environmental Biology, S. Chand.**
8. Trivedi & Rao – **Air Pollution**
9. Chapman & Reiss – **Ecology-Principles and Applications**, Cambridge
10. Chatterjee B – **Environmental Laws-Implementation and Problems**
11. Sharma P.D. – **Environmental Biology**, Rastogi Publication, Meerut
12. Trivedi R.K. – **Hand Book of Environmental Laws, Rules, Guidelines, Compliances and Standards, Enviromedia**
13. Odum E.P. and Barret – **Fundamentals of Ecology**, Thomson
14. Smith R.L. – **Ecology and Field Biology**, Harper Collins
15. D.N. Saxena – **Environmental Biology**, Studium Press (India)
16. Davis – **Behavioral Ecology**
17. Kumar and Asija – **Biodiversity – Principle of Conservation**
18. Rao and Rao – **Air Pollution**
19. S. Satyanarayan, S. B. Zade, S.R. Sitre and P.U. Meshram – **A Text Book of Environmental Studies**, Allied publisher (India)
20. Smitz – **Introduction to Water Pollution**
21. N.S. Subrahmanyam A V.S.S. Sambamurthy – **Ecology**

Cell Biology

1. C.B. Powar, **Cell Biology** – Himalaya Publication, New Delhi
2. Dr. S.P. Singh, Dr. B.S. Tomar – **Cell Biology** 9th revised edition, Rastogi Publication, Meerut
3. Gupta P.K. – **Cell and Molecular Biology**, Rastogi Publication, Meerut

4. Veer Bala Rastogi – **Introduction to Cell Biology**, Rastogi Publication, Meerut
5. Gerald Karp – **Cell and Molecular Biology-Concepts and Experiments**, John Wiley, 2007
6. De-Robertis – **Cell Biology**
7. Verma and Agrawal – **Concepts of Cell Biology**
8. Dowben – **Cell Biology**
9. Witt – **Biology of Cell**
10. Ambrose and Eastyr – **Cell Biology**

Semester – III

Paper – V : Life and Diversity of Animals - Chordates (Protochordata to Amphibia)

Unit – I (9 Periods)

- 1.1 **Protochordata** : General characters and classification up to order
- 1.2 **Herdmania** : Structure, digestive system, ascidian tadpole and retrogressive metamorphosis
- 1.3 **Amphioxus** : Structure, digestive system, circulatory system, sense organs and protonephridia
- 1.4 **Agnatha** : General characters of Cyclostomata (*Petromyzon* and *Myxine*)

Unit – II (9 Periods)

- 2.1 **Pisces** : Salient features of Chondrichthyes and Osteichthyes, Origin of paired fins in fishes
- 2.2 Migration and Accessory respiratory organs in fishes
- 2.3 **Amphibia** : General characters and classification up to order
- 2.4 Parental care and Neotony in Amphibia

Unit – III (9 Periods)

- 3.1 Gametogenesis and type of eggs
- 3.2 Fertilization of egg
- 3.3 Post fertilization development of fish
- 3.4 Types of scales of fishes, Development of placoid scales

Unit – IV (9 Periods)

- 4.1 Frog Embryology - Cleavage , blastulation and gastrulation
- 4.2 Fate map, Morphogenetic movements in gastrula of frog
- 4.3 Development of respiratory organs in frog
- 4.4 Development of Aortic arches of frog

Semester – III
Paper – VI : Genetics

Unit – I **(9 Periods)**

- 1.1 Mendelian Principles- Dominant recessive relationships, Mendelian laws
- 1.2 Interaction of genes- Epistasis - dominant and recessive, codominance, incomplete dominance
- 1.3 Quantitative genetics – Polygenic traits, inbreeding and outbreeding, hybrid vigor
- 1.4 Extracellular genome – Presence and functions of mitochondrial DNA, plasmids

Unit – II **(9 Periods)**

- 2.1 Cytoplasmic inheritance- *Kappa* particles in *Paramecium*, CO₂ sensitivity in *Drosophila*, milk factor in mice
- 2.2 Linkage and crossing over – Basic concepts of linkage, types and theories
- 2.3 Concepts of genes – Cistron , muton and recon
- 2.4 Genetic disorders in human beings – Haemoglobin disorders – Thalassemia and Sickle cell anemia. Metabolic disorder: Phenylketonurea

Unit – III **(9 Periods)**

- 3.1 Sex determination – ZZ, XY, XO, ZW pattern, Sex determination in *Drosiphila* – Genic balance theory, Environmental sex determination in *Bonellia*
- 3.2 Chromosomal aberrations: addition, deletion, duplication and inversion
- 3.3 Gene mutations- Spontaneous and induced mutations, mutagenic agents
- 3.4 Disorders related to chromosomal number- Turner syndrome, Klinefelter syndrome and Down syndrome

Unit – IV **(9 Periods)**

- 4.1 Lethal genes – Concepts and consequences
- 4.2 Population genetics: Basic concepts in population genetics, Hardy Weinberg equilibrium and its significance
- 4.3 Genetic counseling – Introduction , purpose, hereditary diseases and disorders
- 4.4 Applied genetics - DNA fingerprinting , amniocentesis, sperm banks, karyotyping

Semester – III

PRACTICAL – III (Based on Paper – V and VI)

**Section A : Life and Diversity of Animals – Chordates (Protochordata to Amphibia)
& Section B : Genetics**

Section A : Life and Diversity of Animals – Chordates (Protochordata to Amphibia)

1. Identification, classification , distinguishing characters and adaptive features of

- I. **Urochordata** : *Herdmania, Salpa, Doliolum*
- II. **Cephalochordata** : *Amphioxus*
- III. **Cyclostomata** : *Petromyzon, Myxine*
- IV. **Pisces** : *Pristis, Torpedo, Notopterus, Exocoetus, Clarius, Ophiocephalus, Catla, Rohu, Mrigal*
- V. **Amphibia** : *Ichthyophis ,Bufo, Salamander*

2. Dissection of the locally available culturable fish-

- i. Digestive system
- ii. Reproductive system
- iii. Brain

3. Developmental Biology –

Study of permanent slides of Frog embryology: T.S. Blastula, T.S. Gastrula, T.S. Neurula, T.S. tadpole passing through internal and external gill stage

4. Study of permanent slides-

Amphioxus through Pharynx, Intestine, Gonad and Caudal region; V.S. skin, T.S. Testis, T.S. Ovary of Frog; T.S. Stomach, T.S. Intestine, T.S. Liver of fish

5. Permanent stained preparation:

Fish scales – Placoid, cycloid, ctenoid; Hyaline cartilage and striated muscle

Section B : Genetics –

1. Study of monohybrid and dihybrid ratio
2. Study of normal human karyotype (Normal male and female)
3. Study of characters and karyotypes of Syndrome like Down, Klinefelter & Turner
4. Study of the genetic traits (Hardy Weinberg law) in human being (Tongue rolling, ear lobe, PTC taster/ non taster)

Distribution of Marks –	Total Marks 30
i. Dissection	06
ii. Identification and comment on spots (4 Museum specimens, 4 slides – 2 from frog embryology and 2 from histology)	08
iii. Genetics experiment	03
iv. Genetics study – Karyotypes , syndromes, genetic traits in man	03
v. Permanent stained preparation	03
vi. Submission of certified practical record	03
vii. Submission of slides	02
viii. Viva voce	02

Semester – IV

Paper - VII : Life and Diversity of Animals – Chordates (Reptilia, Aves and Mammals)

Unit – I (9 Periods)

- 1.1 **Reptilia**- Classification based on temporal vacuities
- 1.2 Poison apparatus, biting mechanism , snake venom and its importance
- 1.3 **Aves** – Comparison of Ratitae and Caranitae, Flight adaptations and migration
- 1.4 **Mammals** – General characters of Prototheria, Metatheria and Eutheria

Unit –II (9 Periods)

- 2.1 Modern theories of evolution : Darwinism and Neo-Darwinism
- 2.2 Adaptations – Cursorial, Aquatic, Terrestrial, Fossorial and Volant
- 2.3 Introduction to genetic basis of evolution – Species Deme, Variation
- 2.4 Races in Man (Caucasoid, Negroid, Mongoloid and Australoid)

Unit –III (9 Periods)

- 3.1 Comparative account of aortic arches and heart in Reptiles, Birds and Mammals
- 3.2 Structure of hen's egg
- 3.3 Development of chick up to primitive streak stage
- 3.4 Development of extra embryonic membranes in chick and functions

Unit –IV (9 Periods)

- 4.1 Blastocyst and implantation in Mammals; Types of placenta on the basis of morphological and histological structure; functions of placenta
- 4.2 Stem cells : Sources, types and their use in human welfare
- 4.3 Biological clock : Diurnal and rhythmic behavior in birds and mammals
- 4.4 Role of pheromones in reproductive behavior

Semester – IV

Paper - VIII : Molecular Biology and Immunology

Unit - I (9 Periods)

- 1.1 DNA: Structure of DNA, forms of DNA, properties of DNA, DNA as a genetic material
- 1.2 RNA: Structure of RNA, types of RNA, RNA as a genetic material
- 1.3 Prokaryotic and eukaryotic gene structure
- 1.4 **Recombination in Bacteria:** Bacterial transformation – Griffith’s experiment, Conjugation in bacteria, transduction

Unit - II (9 Periods)

- 2.1 **DNA replication:** Semiconservative model, Meselson Stahl experiments. Process of replication – origin of replication, concept of replication, directionality of replication
- 2.2 **Genetic code:** Characteristics of genetic code, Wobble hypothesis
- 2.3 **Protein synthesis:** Transcription mechanism – Initiation , elongation and termination of transcription. Translation – activation of amino acids, transfer of activated amino acids to tRNA, Initiation, elongation and termination of polypeptide chain; inhibitors of protein synthesis
- 2.4 **Gene regulation models** - Lac operon and tryptophan operon

Unit - III (9 Periods)

- 3.1 **Concepts of immunity** – Innate and acquired immunity, organs of the immune system
- 3.2 **Antigen** - Structure, diversity, functions and types of antigen
- 3.3 **Antibody**- Structure, types and functions
- 3.4 **Antigen-antibody interaction** – Precipitation and agglutination

Unit - IV (9 Periods)

- 4.1 **Types of immune response:** B cell response (antibody mediated), T cell response (cell mediated)

- 4.2 **Complement system:** Basic concepts of complement cascades, classical, alternative and MBL pathways, implications of complement system in immune defense
- 4.3 **Cytokines-** General account on cytokines, Cytokine related diseases
- 4.4 **Autoimmunity and immunodeficiencies-** Autoimmune diseases and their treatment, AIDS and other immunodeficiencies

Semester – IV

PRACTICAL – IV (Based on Paper – VII and VIII)

Section A : Life and Diversity of Animals – Chordates (Reptilia, Aves and Mammals) & Section B: (Molecular Biology and Immunology)

Section A : Life and Diversity of Animals – Chordates (Reptilia, Aves, Mammals, Embryology)

1. **Identification, classification , distinguishing characters and adaptive features of –**
 - i. **Reptilia :** *Chameleon, Varanus, Pharynosoma, Draco, Tortoise, Cobra, Krait, Russel’s viper, Sea snake*
 - ii. **Birds :** Owl, Woodpecker, Kingfisher, Kite, Duck, Parrot
 - iii. **Mammals :** Squirrel, Mongoose, Bat, Loris, Rabbit
2. **Study of skeleton of Rabbit and Fowl**
3. **Developmental Biology –**
Study of permanent slides of chick embryology W.M.: 18 hrs, 24 hrs, 30 hrs, 36 hrs, 72hrs
4. **Study of permanent slides-** V.S. skin of Bird, Filoplume of bird, V.S. Skin of Mammal

Section B: Molecular Biology and Immunology

Molecular Biology :

1. Staining of DNA and RNA in blood smear of fish/human by methyl green pyronin technique
2. Introduction to basic laboratory instruments and equipments- Autoclave, Centrifuge, pH meter, Micropipettes, Digital balance, Homogenizer, Electrophoresis apparatus; Molar and normal solutions calculations
3. Isolation of DNA (Genomic DNA from any available source) by phenol extraction method

Immunology :

1. Determination of blood groups (ABO and Rh) in humans
2. Antigen – Antibody interaction by double diffusion method (Ouchterlony)
3. Study of histological slides of organs of immune system – Thymus, Lymph nodes and Spleen

Distribution of Marks –**Total Marks 30**

i.	Identification and comment on spots- (3 Museum specimens, 5 slides – 2 from chick embryology; from histology and 1 from immunology, 2 bones)	10
ii.	Molecular biology experiment	08
iii.	Immunology experiment	07
iv.	Submission of certified practical record	03
v.	Viva voce	02

List of Recommended Books: (For Semester - III and IV)**Life and Diversity of Animals -Chordates**

1. T. B. of Zoology vol II – Parker & Haswell
2. T. B. of Vertebrate Zoology -S. N. Prasad
3. Chordate Zoology –E. L. Jordan and P. S. Verma
4. Vertebrate Zoology – Vishwanath
5. Zoology of Chordates – Nigam H. C.
6. Phylum: Chordata – Newman H.H.
7. Biology of Vertebrates –Walter & Sayles
8. The Vertebrate Body – Romer A. S.
9. Comparative Anatomy of the Vertebrates – Kingslay J. D.
10. The Biology of Amphibia – Noble G. K.
11. Snakes of India – Gharpura K. G.
12. Life of Mammals – Young J.Z.
13. Vertebrates – Kotpal R. L.
14. Introduction to Chordates – Majupuria T.C.
15. Vertebrate Zoology – Dhami & Dhami
16. T. B. Vertebrate Zoology – Agrawal
17. Protochordates – Chatterjee & Pandey
18. Protochordates – Bhatia
19. T. B. of Chordates – Bhamrah and Juneja
20. Chordate Anatomy – Arora M.P.
21. The Chordates – Alexander.
22. T. B. of Animal Embryology – Puranik
23. T. B. of Chordate Embryology – Dalella & Verma
24. T. B. of Embryology – Sandhu
25. T. B. of Embryology – Armugam

26. Early Embryology of Chick – Pattern
27. Chordate Embryology – Verma & Agrawal
28. Chordate Embryology – Tomar
29. The Frog – Rugh
30. An Introduction to Embryology – Balinsky
31. Comparative Vertebrate Embryology – Mcwen
32. Developmental Biology – S. C. Goel
33. Introduction to Embryology – Berry
34. Organic Evolution – N. Armugam
35. Evolution – M. P. Arora
36. Animal Behavior – Smith and Hill
37. Animal Behavior – Arora
38. Animal Behavior – Gundevia and Singh
39. Practical Zoology Vertebrates – Dr. S. S. Lal, Rastogi Publication, Meerut
40. A manual of Practical Zoology Vertebrates – P. S. Verma

Genetics

1. Genetics & Genetic Engineering – Joshi
2. Genetic Engineering & its applications – Joshi
3. Genetics – Gardener
4. Genetics – Winchester
5. Genetics – Gupta
6. Principles of Genetics – Sinnot Dunn, Dobzansy
7. Genetics – Ahluwalia
8. Genetics – Sarin
9. Elementary Genetics – Singleton
10. General Genetics – SRb, Owen & Edger
11. Genetics – Alenberg
12. Foundation of Genetics – Pai
13. Genetics - Stickberger
14. T. B. of Genetics- Veerbala Rastogi
15. Gene VI by Benjamin Lewis, Oxford press
16. Gene VIII by Benjamin Lewis, Oxford press
17. Genetics Vol. I and II by Pawar C. B., Himalaya publication

Molecular Biology

1. Cell and Molecular Biology by De Robertis- E. D. P., I. S. E. publication
2. Molecular Biology by Turner P. C. and Mc Lennan , Viva Books Pvt. Ltd
3. Advanced Molecular Biology by Twyman R. M., Viva Books Pvt. Ltd
4. Molecular Biology by Freifelder D., narosa publication House

5. Molecular Biology of Gene by Watson J. D. et. al., Benjamin publication
6. Molecular Cell Biology by Darnell J. Scientific American Books USA
7. Molecular Biology of the Cell by Alberts B., Bray D. Lewis J., Garland Publishing Inc
8. Essentials of Molecular Biology by Freifelder D., Narosa Publication House
9. Molecular Cell Biology by Lodish H., Berk A., Zipursky S. L., Matsudaira P. Baltimore D. and Darnell J., W. H. Freeman and Co.
10. The Cell: Molecular Approach by Cooper G. M.
11. Molecular Biology by Upadhyay A and Upadhyay K. Himalaya Publication
12. Molecular Cell Biology by Bamrath
13. Cell and Molecular Biology by P.K. Gupta

Immunology

1. Immunology – R. C. Kubly et al.
2. Immunology - Tizard
3. Immunology - Roitt, Brostoff and D. Male
4. Immunology - Abbas

Semester – V

Paper - IX : General Mammalian Physiology –I

Unit – I : Enzymes

(9 Periods)

- 1.1 Enzymes – Distribution and chemical nature of enzymes
- 1.2 General properties of enzymes
- 1.3 Classification of enzymes
- 1.4 Factors affecting enzyme activity

Unit-II : Nutrition and Digestion

(9 Periods)

- 2.1 Structure and functions of digestive glands - (Salivary, Gastric, Intestinal, Liver and Pancreas)
- 2.2 Gastrointestinal hormones
- 2.3 Digestion and absorption of proteins, carbohydrates and lipids.
- 2.4 Vitamins- Fat soluble and water soluble vitamins; Sources, deficiency and diseases

Unit-III :Respiration

(9 Periods)

- 3.1 Respiratory pigments - Types , distribution and properties
- 3.2 Mechanism of Respiration
- 3.3 Transport of O₂ and CO₂
- 3.4 Respiratory disorders and effects of smoking

Unit-IV : Circulation**(9 Periods)**

- 4.1 Composition and functions of blood
- 4.2 Blood clotting – Intrinsic and extrinsic factors, blood groups and Rh factor
- 4.3 Cardiac cycle
- 4.4 E.C.G. and Blood pressure

Semester – V**Paper –X : Applied Zoology-I
(Aquaculture and Economic Entomology)****Unit –I : Aquaculture****(9 Periods)**

- 1.1 Site selection and construction ,Pre stocking and post stocking management of nursery, rearing and stocking ponds
- 1.2 Breeding of fishes by bund and Chinese hatcheries. Induced breeding by hypophysetion. New generation drugs in induced breeding
- 1.3 Brief study of freshwater aquaculture system – Polyculture, cage culture, sewage fed fish culture, integrated fish farming
- 1.4 Fish products and byproducts, Fish preservation

Unit-II**(9 Periods)**

- 2.1 Prawn culture and Pearl culture
- 2.2 Fabrication and setting up of aquarium and its maintenance
- 2.3 Breeding of aquarium fishes – Live bearers and egg layers
- 2.4 Diseases caused by fungi, bacteria, protozoa and helminthes

Unit-III : Economic Entomology (Methods of pest control)**(9 Periods)**

- 3.1 Chemical control : Insecticides - Pyrethroids, carbomate and HCN – mode of action, merits and demerits
- 3.2 Biological control – Biological agents – predators and parasites; merits and demerits
- 3.3 Crop pest: Life cycle, damage and control of
 - I. Cotton spotted boll worm -*Earias vitella*
 - II. Stored grain pest- Rice Weevil, *Sitophilus oryzae*
- 3.4 Animal pest: Life cycle, damage and control of –
 - I. House fly – *Musca nebulo*
 - II. Stable fly – *Stomoxys calcitrans*

Unit-IV : Economic Entomology (Industrial entomology)

(9 Periods)

- 4.1 Sericulture- Types of Silkworm. Life cycle and rearing of mulberry silkworm, *Bombyx mori*
- 4.2 Life cycle and rearing of non mulberry silkworm (Tasar), *Antheraea mylitta* ; Brief idea of cocoon processing for silk fabric - cocoon boiling, reeling, rereeling, winding, doubling, twisting and weaving
- 4.3 Apiculture – Types of honey bees. Life cycle, culture, movable frame hive, bee product and its economic importance
- 4.4 Lac culture – Lac insect, *Laccifer lacca* - Life cycle, Lac processing, Lac products and Economic Importance

Semester – V

PRACTICAL – V (Based on Paper IX and X)

Section A: General Mammalian Physiology - I and Section B : Applied Zoology –I (Aquaculture and Economic Entomology)

Section A: General Mammalian Physiology – I

1. Detection of action of salivary amylase on starch
2. Detection of carbohydrates, proteins and Lipids
3. Detection of Vitamin A and Vitamin C
4. Measurement of lung capacity
5. Preparation Haemin crystal
6. Total count of WBC and RBC
7. **Study of histological slides of Mammal** – T.S. salivary gland, T.S. stomach, T.S. intestine, T.S. pancreas, T.S. liver and T.S. lung

Section B : Applied Zoology –I (Aquaculture and Economic Entomology)

Aquaculture:

1. **Collection and identification of fishes**
 - a. Freshwater edible fishes – catla, rohu, mrigal, grass carp, silver carp, *Cyprinus carpio* , *Ophiocephalous*, *Clarius*, *Heteropneustes*, *Wallago*, *Mystus*,
 - b. Aquarium fishes – Gold fish, Molly, Sword tail, Kissing *Gourami*
2. **Dissection:**
 - a. Digestive, reproductive and brain with pituitary of culturable fishes
 - b. Gonosomatic index
3. **Fabrication and setting up of aquarium**
4. **Mounting:** Scales of fishes, zooplankton

Economic Entomology:

1. Study of Insect Pest

- a. Agriculture pest – Grasshopper , Red Cotton bug, Gram pod borer, Cotton pink bollworm, Cotton spotted bollworm
- b. Medical pest – House fly, Mosquito , *Pediculus humanus*
- c. Veterinary pest – Stable fly , Dog tick, Bird lice
- d. Stored grain pest – Stored grain weevil, Flour moth
- e. Useful Insects – Honeybee, Silk moth, Lac insect, Dragon fly, Lady bird beetle

2. **Mounting** : Mouth parts, Legs, wings of any insects and sting of Honeybee

3. **Visit** to – Fish farm, Apiculture, Sericulture, Agricultural educational centre, Sea shore and Lake

Distribution of Marks

Total Marks 30

i. Physiology experiment	05
ii. Identification and comment on spots (2 from Mammalian histology, 3 from Aquaculture and 3 from Economic Entomology)	08
iii. Dissection of fish / Gonosomatic index	05
iv. Permanent stained preparation	02
v. Submission ,collection and study tour report	02
vi. Submission of certified practical record	03
vii. Viva voce	05

Semester – VI

Paper -XI : General Mammalian Physiology - II

Unit –I : Nerve and Muscle Physiology

(9 Periods)

- 1.1 Types of neurons, E.M. structure of neuron
- 1.2 Conduction of nerve impulse
- 1.3 Ultrastructure of striated muscle, Sliding filament theory of muscle contraction
- 1.4 Properties of muscles (Twitch, Tetanus, Tonus, Summation, All or None Principle, Muscle fatigue)

Unit-II : Excretion (9 Periods)

- 2.1 Structure of uriniferous tubule
- 2.2 Mechanism of urine formation
- 2.3 Counter – current mechanism
- 2.4 Normal and abnormal constituents of urine; Elementary idea of dialysis

Unit-III : Endocrinology (9 Periods)

- 3.1 Structure and functions of pituitary gland
- 3.2 Structure and functions of thyroid and parathyroid gland
- 3.3 Structure and functions of adrenal gland
- 3.4 Structure and functions of pineal gland

Unit-IV : Reproduction (9 Periods)

- 4.1 Oestrous and menstrual cycle
- 4.2 Male and female sex hormones
- 4.3 Causes of infertility in male and female
- 4.4 Contraceptives – Mechanical and hormonal ; *In-vitro* fertilization

Semester - VI

Paper - XII : Applied Zoology –II

(Biotechniques, Microtechnique, Biotechnology, Bioinformatics and Biostatistics)

Unit –I : Biotechniques (9 Periods)

- 1.1 **Concepts of sterilization:** Filtration, autoclaving, dry heat sterilization, wet sterilization and radiation
- 1.2 **Separation of biomolecules:** Centrifugation (Sedimentation, density gradient); Chromatography (Elementary idea of thin layer, gel filtration and ion exchange - Principles and applications)
- 1.3 **Electrophoresis:** Agarose gel electrophoresis, SDS-PAGE
- 1.4 Principles of colorimeter and spectrophotometers

Unit-II : Microtechnique (9 Periods)

- 2.1 Fixation, dehydration, clearing, embedding & section cutting
- 2.2 Difficulties encountered during section cutting (causes and remedies)
- 2.3 Double staining with Haematoxylin and Eosin
- 2.4 Histochemical staining techniques for carbohydrates (Periodic acid schiff), proteins (Mercury-bromophenol blue) and lipids (Sudan black-B)

Unit-III : Biotechnology**(9 Periods)**

- 3.1 Basic concepts in recombinant DNA technology, Gene isolation method- Shotgun cloning
- 3.2 Isolation of gene- DNA manipulation enzymes: Nucleases, ligases, polymerases
- 3.3 Basic concepts of cloning vectors and splicing : Insertion of DNA and ligation using blunt ends, cohesive ends, Cloning vectors
- 3.4 Application of biotechnology: Insulin and vaccine production

Unit-IV : Bioinformatics and Biostatistics**(9 Periods)**

- 4.1 Bioinformatics: Definition, Basic concepts in bioinformatics, importance and role of bioinformatics in life sciences
- 4.2 Bioinformatics databases- introduction, types of databases
- 4.3 Nucleotide sequence databases, Elementary idea of protein databases
- 4.4 Biostatistics – Tabulation of data, presentation of data, sampling errors, mean, mode, median, probability, standard error and standard deviation

Semester – VI**PRACTICAL – VI (Based on Paper XI and XII)**

**(Section A: General Mammalian Physiology – II and Section B: Applied Zoology – II ,
Biotechniques, Microtechnique, Biotechnology, Bioinformatics and Biostatistics)**

Section A : General Mammalian Physiology – II

1. Detection of urea, albumin, sugar and creatin in urine
2. Sperm count in a given semen sample
3. **Dissection:** Endocrine glands of Culturable fishes
4. **Study of histological slides of Mammal** – T.S. kidney, pituitary, thyroid, adrenal, testis, ovary; uterus, placenta, medulated and non medulated nerve fibre, smooth and striated muscle

Section B : Applied Zoology – II (Biotechniques, Microtechnique, Biotechnology, Bioinformatics and Biostatistics)

1. Separation of amino acids by paper chromatography
2. Separation of proteins by electrophoresis technique
3. Block preparation and section cutting
4. Double staining method (H-E)
5. Demonstration of carbohydrates, proteins and lipids by histochemical methods
6. Determination of mean, mode, median from a given biostatistical data and/or graphical representation of the data using computers

7. Use of internet for survey of literature using protein and nucleotide databases(NCBI)
8. Use of softwares like Microsoft offices
9. **Visit to Biotechnology centre to study working principles of different instruments**

Distribution of Marks	Total Marks 30
I. Physiology experiment	05
II. Identification and comments on spots (Mammalian histology 3 spots)	03
III. Microtechnique - Section cutting, spreading and H-E staining of given slide	03
IV. Dissection of fish	05
V. Analysis of given biostatistical data	02
VI. Retrieval of specific literature from given information	02
VII. Submission of slides and study tour report	02
VIII. Submission of certified practical record	03
IX. Viva voce	05

List of Recommended Books: (For Semester V and VI)

Physiology

1. Human Physiology – Chatterjee A. G. vol. I & II
2. Medical Physiology – Gyton
3. T. B. of Animal Physiology – Berry
4. Introduction to Animal Physiology and Related Biotechnology – H. R. Singh
5. Animal Physiology – Arora M.P.
6. General and Comparative Physiology – Hoar W. S.
7. T. B. of Animal Physiology – Hurkat and Mathur
8. Animal Physiology – Nahbhushan and kodarkar
9. T. B. of Animal Physiology & General Biology – Thakur & Puranik
10. General Endocrinology – Turner Bagnaro
11. Reproduction and Human welfare – Greep and koblinsky
12. Animal Physiology – Shashtri & Goel
13. Animal Physiology – Verma & Tyagi
14. Human Physiology - Vander and sheman
15. Applied Physiology – Keels, Neils and Joels
16. Animal Physiology – Rastogi S. C.
17. Animal Physiology – Veerbala Rastogi

18. Comparative Vertebrate Endocrinology – Beutley

Aquaculture

1. Wealth of India, Raw Material, Vol. IV – ICAR
2. Fishes of India vol I & II- Day
3. Fish & Fisheries of India – Jhingran
4. Hatchery Manual for Common Indian & Chinese carps – Jhivgan & Pallin
5. Fish Pathology – Roberts
6. Introduction of Fishes – Khanna
7. Fishery Science & Indian Fishes – Khanna
8. Fishery Science & Indian Fisheries – Shrivastava
9. A Manual of F. W. Aquaculture – Santhanam
10. An Aid to Identification of Commercial Fishes of India & Pakistan- Mishra
11. Standard Methods for Examination of Water & Waste Water - APHA
12. Hand Book of Breeding of Major Carps by Pituitary Hormones – S. L. Chonder
13. Principles of Aquaculture – Zade S. B., Khune C. J., Sitre S.R. and Tijare R.V.

Entomology

1. T. B. of Applied Entomology – K. P. Shrivastava
2. T. B. of Agricultural Entomology - II S Pruthi
3. Modern Entomology – D. B. Tembhare (2nd Edition)
4. A Hand Book of Practical Sericulture – Ullar S. R. & Narsimhanna M.N.
5. Destructive and Useful Insects – Metcalf C.L. & Flint W.P.
6. General Text Book of Entomology – Richards O. W. & Davis R. G.
7. Agricultural Pests of India & South East Asia – Atawal A.S.
8. Hand Book of Economic Entomology for South Asia – Ayyar & Ram Krishna.
9. Medical Entomology – Hati A. K.
10. Bee-Keeping in India – Singh S

Biotechnique and Microtechnique

1. Animal Tissue Technique – Humason
2. Histological Technique – Devaenport
3. Microtechnique – Jiwaji & Patki
4. Microtechnique – Wankhede
5. Biophysical Chemistry – Upadhyay, Upadhyay and Nath
6. Techniques in Life Sciences – D. B. Tembhare

Biotechnology

1. Elements of Biotechnology – Gupta
2. T. B. of Biotechnology – Dubey
3. Modern Concept of Biotechnology – Kumar H. D
4. Advances in Biotechnology – Jogdand

5. T. B. of Biotechnology – Chatwal
6. Molecular Biotechnology – Primrose

Bioinformatics and Biostatistics

1. Mount W. 2004. Bioinformatics and Sequence Genome Analysis 2nd Edition CBS Pub. New Delhi.
2. Bergman, N. H. Comparative Genomics. Humana Press Inc. Part of Springer Science+Business Media, 2007.
3. Baxevanis, A. D. Ouellette, B. F. F. 2009. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John-Wiley and Sons Publications, New York.
4. Campbell A. M. and Heyer, L. J. 2007. Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings.
5. Des Higgins and Willie Taylor 2000. Bioinformatics: Sequence, Structure and Databanks. Oxford University Press.
6. Rashidi H. H. and Buehler 2002. Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London.
7. Gibas Cynthia and Jambeck P. 2001. Developing Bioinformatics Computer Skills: Shroff Publishers and Distributors Pvt. Ltd. (O'Reilly), Mumbai.