

**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	<b>Theory</b> <b>Paper – I :</b> Life and Diversity of Animals-Nonchordates (Protozoa to Annelida)	50	10		150
	<b>Paper -II :</b> Environment Biology	50	10		
	<b>Practical - I</b> (Based on Paper I & II)			30	
Semester- II	<b>Theory</b> <b>Paper - III :</b> Life and Diversity of Animals- Nonchordates (Arthropoda to Hemichordata)	50	10		150
	<b>Paper - IV :</b> Cell Biology	50	10		
	<b>Practical - II</b> (Based on Paper III & IV)			30	
Semester- III	<b>Theory</b> <b>Paper - V :</b> Life and Diversity of Animals-Chordates (Protochordata to Amphibia)	50	10		150
	<b>Paper - VI :</b> Genetics	50	10		
	<b>Practical - III</b> (Based on Paper V & VI)			30	
Semester - IV	<b>Theory</b> <b>Paper - VII :</b> Life and Diversity of Animals-Chordates (Reptilia, Aves and Mammals)	50	10		150
	<b>Paper - VIII :</b> Molecular Biology and Immunology	50	10		
Semester - V	<b>Practical - IV</b> (Based on Paper VII & VIII)			30	150
	<b>Theory</b> <b>Paper - IX :</b> General Mammalian Physiology I	50	10		
	<b>Paper - X :</b> Applied Zoology I (Aquaculture and Economic Entomology)	50	10		
Semester - VI	<b>Practical - V</b> (Based on Paper IX & X)			30	150
	<b>Theory</b> <b>Paper - XI :</b> General Mammalian Physiology II	50	10		
	<b>Paper - XII :</b> Applied Zoology II (Biotechniques, Microtechnique, Biotechnology, Bioinformatics and Biostatistics)	50	10		
	<b>Practical - VI</b> (Based on Paper XI & XII)			30	
		<b>Grand total</b>			<b>900</b>

\*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 3

**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 4

**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) : *Paramoecium*, *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*, *Drancunculus*, *Ancylostoma*, *Wuchereria*

VI. Annelida : *Aphrodite*, *Nereis*, *Chaetopteurs*, *Tubifix*, *Hirudinaria*

**2. Study of permanent slides**

*Enatmoeba*, *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 CO<sub>2</sub> 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 08

(4 Museum specimens + 1 Env. bio. spot + 3 slides)

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' 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

**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 08

(5 Museum specimens + 3 slides)

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. Subrahmyam 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*, CO<sub>2</sub> 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 11

**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 08

(4 Museum specimens, 4 slides – 2 from frog embryology and 2 from histology)

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 premitive 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- 10

(3 Museum specimens, 5 slides – 2 from chick embryology;  
from histology and 1 from immunology, 2 bones)

- 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- Veerballa 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 Laodish 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 Upadhay A and Upadhay K. Himalaya publication
12. Molecular cell Biology by Bamrach
13. Cell and Molecular Biology by P.K. Gupta

### **Immunology**

1. Immunology – R. C. Kuby et al.
2. Immunology - Tizzard
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 O<sub>2</sub> and CO<sub>2</sub>
- 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, carbamate 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 nebulosa*
  - 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*, *Clariaus*, *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 08

(2 from Mammalian histology, 3 from Aquaculture and 3 from Economic Entomology)

- 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 03

H-E staining of given slide

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 Editon CBS Pub. New Delhi.
2. Bergman, N. H. Comparative Genomics. Humana Press Inc. Part of Springer Science+Business Media, 2007.
3. Baxevanis, A. D. Ouellate, 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 Publishersand Distributors Pvt. Ltd. (O'Reilly), Mumbai.