

Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College of Arts, Science and Commerce

(Autonomous)

Affiliated to University of Mumbai



Syllabus for T.Y.B.Sc.

Semester V & VI

Program: B.Sc.

Course: Zoology

(WEF 2019-20)

T.Y.B.Sc. Zoology Syllabus**Semester V**

Course code	Paper and Title	Unit	Topic	Credits
RJSUZOO501	Paper I: Animal type Study, Comparative anatomy, Developmental biology & Endocrinology	I	Type study-Sepia	2.5
		II	Comparative anatomy of vertebrates–I Skin, Digestive system and circulatory system	
		III	Developmental biology of frog	
		IV	Endocrine glands and their regulation	
RJSUZOO502	Paper II: Haematology, Immunology & Physiology	I	Basic Haematology	2.5
		II	Basic immunology	
		III	Applied haematology & immunology	
		IV	Homeostasis- Feedback mechanism, thermoregulation & ionic regulation	
RJSUZOOP501 &RJSUZOOP5 02			Practicals based on Paper I & II	3
RJSUZOO503	Paper III: Molecular biology, Genetic engineering, Toxicology and Biostatistics	I	Molecular biology	2.5
		II	Genetic engineering	
		III	Toxicology	
		IV	Biostatistics	
RJSUZOO504	Paper IV: Osteology, Ethology, Epidemiology, Wildlife conservation.	I	Human osteology	2.5
		II	Behavioural ethology	
		III	Epidemiology-I	
		IV	National parks and sanctuaries	
RJSUZOOP503 &RJSUZOOP5 04			Practicals based on Paper III & IV	3

Semester VI

Course code	Paper and Title	Unit	Topic	Credits
RJSUZOO601	Paper I: Animal type Study, Comparative anatomy, Developmental biology & Histology	I	Type study-Shark	2.5
		II	Comparative anatomy of vertebrates II- respiratory system,urinogenital system and nervous system	
		III	Developmental biology of chick	
		IV	Mammalian Histology	
RJSUZOO602	Paper II: Enzymology, Physiology and Pathology	I	Enzymology	2.5
		II	Chemical messengers and Cardiac physiology	
		III	Aspects of human reproduction	
		IV	General pathology	
RJSUZOOP601 &RJSUZOOP602			Practicals based on Paper I & II	3
RJSUZOO603	Paper III: Cancer biology, Biotechnology, Genetics, and Bioinformatics	I	Cancer biology	2.5
		II	Animal tissue culture	
		III	Human genetics	
		IV	Bioinformatics	
RJSUZOO604	Paper IV Environmental Biology, Zoopharmacognosy , Epidemiology & Wildlife management	I	Zoogeography	2.5
		II	Bioprospecting and Zoopharmacognosy	
		III	Epidemiology-II	
		IV	Wildlife management	
RJSUZOOP603 &RJSUZOOP604			Practicals based on Paper III & IV	3

T. Y. B. Sc. ZOOLOGY: SEMESTER V (THEORY)

Paper I- Animal type Study, Comparative anatomy, Developmental biology & Endocrinology

Course Code: RJSUZOO501

Total Credits- 2.5

Course Objectives: 1. To acquaint learners with the details of Sepia as a representative of invertebrates.
2. To provide them with general idea of comparative anatomy of vertebrates.
3. To introduce concept of endocrine glands and associated disorders to the learners.

Expected Outcomes: 1. Learner will get an idea of general characters and system details of Sepia.
2. Learner will be familiarized with process of evolution trend which has occurred during vertebrate evolution.
3. The learner will understand concept of hormones and its functions.

Unit I: Type study: *Sepia aculeata*

(15 lectures)

1.1: General characters

- External characters.
- Locomotion.
- Economic importance.

1.2: Organ systems:

- 1.2.1 Digestive system.
- 1.2.2 Respiratory system.
- 1.2.3 Circulatory system.
- 1.2.4 Excretory system.
- 1.2.5 Nervous system and Sense organs.
- 1.2.6 Reproductive system.

Unit II: Comparative anatomy of vertebrates I

(15 Lectures)

2.1: Skin: Functions, anatomy of vertebrate skin, epidermal and dermal derivatives, scales, claws, nails, hoofs, horns, antlers, beaks, feathers, hair and glands.

2.2: Digestive system:

Digestive tube and its evolution.

Tooth structure & position, teeth in lower vertebrates, mammalian dentition.

2.3: Circulatory System:

Aortic arches and venous system in vertebrates.

Unit III: Developmental biology of frog (15 lectures)

Egg, spawn, cleavage, blastula, gastrula, neurula , morphogenesis and metamorphosis.

Unit IV: Endocrine glands and their regulation/ Endocrinology (15 lectures)

4.1: Mammalian Endocrinology

Mammalian Endocrinology: Hormones, functions of hormones and hormonal disorders of the following endocrine glands: pituitary, adrenal, thyroid, parathyroid & pancreas.

Paper II- Haematology, Immunology & Physiology

Course Code: RJSUZOO502

Total credits: 2.5

Course Objectives: 1. To introduce the different aspects of human blood and its clinical significance.
2. To introduce the topic of immunology with emphasis on building strong foundation about the immune system.
3. To acquaint learners with knowledge of diagnostic techniques in haematology as well as immunology.
4. To comprehend the physiological aspects of homeostasis and endocrinology.

Expected Outcomes: 1. Learner will be able to identify various components of blood and their importance.
2. Learner will be familiarized with types of immunity and the significant role of immune system.
3. Learner will be better equipped for further pathological courses or working in a diagnostic laboratory.
4. Learner will be familiarized with adaptations of animals for regulation of heat and ionic balance.

Unit I: Basic Haematology

(15 lectures)

- 1.1: Composition of plasma:** Water, respiratory gases, plasma proteins and other inorganic constituents
- 1.2: Haematopoiesis:** Erythropoiesis, leucopoiesis and Thrombopoiesis
- 1.3: Erythrocytes:** Structure and functions, abnormalities in structure, total count, variation in number; ESR; types of anaemia
- 1.4: Haemoglobin:** Structure, formation and degradation; variants of haemoglobin (foetal, adult).
- 1.5: Leucocytes:** Types and functions, total count and variation in number; leukaemia and its types.
- 1.6: Thrombocytes:** Structure, factors and mechanism of clotting, failure of clotting mechanism.
- 1.7: Blood volume:** Total quantity and regulation; haemorrhage.

Unit II: Basic Immunology

(15 lectures)

2.1: Overview of Immunology

2.1.1: Concept of immunity

2.1.2: Innate immunity - Definition, factors affecting innate immunity, Mechanisms of innate immunity - First line of defence - physical and chemical barriers; Second line of defence - phagocytosis, inflammatory responses and fever

2.1.3: Adaptive or Acquired immunity, Antibody mediated and cell mediated immunity; Active Acquired immunity - Natural and Artificial; Passive Acquired immunity - Natural and Artificial

2.2: Cells and Organs of immune system

2.2.1: Cells of immune system - B cells, T cells and null cells, macrophages, dendritic cells and mast cells

2.2.2: Organs of immune system

Primary: Thymus and bone marrow Secondary: Lymph nodes and spleen

2.3: Antigens: Definition and properties; haptens

2.4: Antibodies: Definition, basic structure, classes of antibodies - IgG, IgA, IgM, IgD and IgE

2.5: Antigen processing and presentation

2.5.1: Endogenous antigens - cytosolic pathways.

2.5.2: Exogenous antigens - endocytic pathways.

Unit III: Applied Haematology & immunology

(15 lectures)

3.1: Applied Haematology: Introduction and scope.

3.2: Clinical significance of Diagnostic Techniques

3.2.1 Haemoglobinopathies (sickle cell anaemia, thalassemia)

3.2.2 Coagulopathies: Haemophilia and purpura

3.3: Biochemical examination of blood:

3.3.1 Liver function tests: Total and direct bilirubin

3.3.2. Kidney function test: Serum creatinine.

3.3.3. Carbohydrate metabolism tests: Blood sugar.

3.3.4 Other biochemical tests: Blood hormones – TSH.

3.4.: Antigen-Antibody interactions and vaccines.

3.4.1 : General features of antigen-antibody interaction

3.4.2 : Precipitation reaction - Definition, characteristics and mechanism. Precipitation in gels (slide test) - Radial immunodiffusion (Mancini method) Double immunodiffusion (Ouchterlony method)

3.4.3: Agglutination reaction definition, characteristics and mechanism. Coomb's test

3.4.4: Immunoassay - ELISA

3.4.5: Principles of vaccines - active and passive immunization, Routes of vaccine administration.

Unit IV: Homeostasis- Feedback mechanism, thermoregulation and ionic regulation (15 lectures)

4.1 Homeostasis: External and internal environment; Control systems in Biology: Feedback mechanism; control of blood glucose level as an example.

4.2 Thermoregulation: Temperature balance; Heat production; Shivering and non-shivering thermogenesis, brown fat- special thermogenic tissues in mammals and heat loss; Acclimation and acclimatization; Adaptive response to temperature: Daily torpor, Hibernation, Aestivation.

4.3 Osmotic and Ionic regulation: Maintaining water and electrolyte balance: ionic regulation in iso-osmotic, hypo-osmotic and hyper-osmotic environment, Problems of living in terrestrial environment: water absorption, salt water ingestion and salt excretion, metabolic water and behavioural adaptations.

Paper III- Molecular biology, Genetic engineering, Toxicology and Biostatistics

Course Code: RJSUZOO503

Total credits: 2.5

- Course Objectives:**
- 1. To introduce Molecular Biology of gene alteration and its effects.*
 - 2. To understand the tools and techniques used in Genetic Engineering.*
 - 3. To introduce the learner basics of Toxicology.*
 - 4. To introduce the learner to the principles of Toxicology, mechanisms of toxicants and regulatory affairs in toxicological studies.*
 - 5. To make learner familiar with Biostatistics as tool for analysis and application.*

- Expected Outcomes:**
- 1. Learner will get an insight in the intricacies of chemical and molecular processes that alter the gene.*
 - 2. Learner will be familiarized with vast arrays of techniques of gene manipulation.*
 - 3. Learner will be familiarized with concepts of toxicology and will be able to apply it in pharmaceutical industry and allied branches.*
 - 4. Learner will be able to develop critical thinking and apply the knowledge in formulating hypothesis and research problems.*

Unit I: Molecular biology

(15 lectures)

1.1: Types of mutation

1.1.1: Point mutations - substitution, deletion and insertion mutations

Types of Substitution mutations - silent, missense and nonsense mutations, transition and transversion. Deletion and Insertion mutations - frameshift mutations .

1.1.2: Trinucleotide repeat expansions - fragile X syndrome, Huntington disease

1.1.3: Spontaneous mutation - tautomeric shifts, spontaneous lesions

1.2: Induced mutations

1.2.1: Physical agents: Ionizing radiation (X-rays, α , β and γ rays) Non-ionizing radiation (UV light)

1.2.2: Chemical agents: Base analogs (5-bromouracil); Intercalating agents (ethidium bromide); Deaminating agents (nitrous acid); Hydroxylating agents (hydroxylamine); Alkylating agents (mustard gas).

1.2.3: Biological mutagenic agents: transposable elements and viruses

1.3: Preventative and repair mechanisms for DNA damage

1.3.1: Mechanisms that prevent DNA damage - superoxide dismutase and catalase

1.3.2: Mechanisms that repair damaged DNA - direct DNA repair (alkyl transferases, photoreactivation, excision repair)

1.3.3: Post replication repair - recombination repair, mismatch repair, SOS repair.

Unit II: Genetic engineering

(15 lectures)

2.1: Tools in Genetic Engineering

2.1.1: Enzymes involved in Genetic Engineering: Introduction, nomenclature and types of restriction enzymes with examples, Ligases - *E. coli* DNA ligase, T4 DNA ligase, polynucleotide kinase, phosphatases, DNA polymerases, reverse transcriptase, terminal transferase.

2.1.2: Vectors for gene cloning: General properties, advantages and disadvantages of cloning vectors - plasmid vectors (pBR322), phage vectors (λ Phage), cosmid vectors (c2XB).

2.1.3: Cloning techniques: Cloning after restriction digestion - blunt and cohesive end ligation, creation of restriction sites using linkers and adapters, cDNA synthesis (Reverse transcription), genomic and cDNA libraries.

2.2: Techniques in Genetic Engineering

2.2.1: PCR techniques: Principle of polymerase chain reaction (PCR), Applications of PCR.

2.2.2: Detection techniques: Blotting techniques and their applications.

Unit III: Toxicology

(15 lectures)

3.1 Introduction to toxicology: definition and scope

3.2 Natural toxins: mycotoxins, microbial toxins, plant toxins (caffeine & nicotine), animal toxins (honey bee sting, venoms of coelenterates, scorpion, snake).

3.3 Dose response relationship: Measurement of dose response relationship, dose response curves, LC50 and LD50, acute and chronic toxicity; margin and safety & therapeutic index; threshold dose and no observed effect level (NOEL).

3.4 Mechanism of absorption through membranes, rates of penetration, routes of absorption in mammals, dermal, gastrointestinal and respiratory.

3.5 Metabolism of toxicants: Phase I reactions, Phase II reactions, metabolism of Paracetamol.

3.6 Target organ toxicity – hepatotoxicity; examples of hepatotoxicants, nephrotoxicity, examples of nephrotoxicants, neurotoxicity, examples of neurotoxicants.

3.7 Regulatory Toxicology: CPCSEA guidelines for animal testing centre, ethical issues in animal studies, Alternative methods in toxicology (*in vitro* tests)

Unit IV: Biostatistics

(15 lectures)

4.1: Measures of Variation: Variance, standard deviation, standard error.

4.2: Probability Distributions: Normal, Binomial, p- value, Probability - Addition and multiplication rules and their applications.

4.3: Testing of Hypothesis: Basic concepts, types of hypothesis: Null hypothesis and Alternate hypothesis, Levels of significance and testing of hypothesis

4.4: Parametric and non-parametric test: Parametric tests: two-tailed Z-test and t-test Non-parametric test: Chi-square test and its applications

4.5: Correlation: Correlation coefficient and its significance

Paper IV- Osteology, Ethology, Epidemiology, Wildlife conservation

Course Code: RJSUZOO504

Total credits: 2.5

- Course Objectives:**
- 1. To introduce the structure and function of human bones and muscles.*
 - 2. To acquaint the learner with sociobiological behaviour and interaction of animals within population.*
 - 3. To study the course, or natural history, of disease, determine the frequency of disease in populations.*
 - 4. To introduce learner to the various national parks, sanctuaries and ecotourism.*

- Expected Outcomes:**
- 1. Learner will be familiarized with the arrangement of bones in the human body. Also it will help in understanding nature of anatomical injuries.*
 - 2. Learner will be able to understand different aspects of social, reproductive and chronobiological behaviour in animals.*
 - 3. Learners will get an idea of scope and dynamics of epidemiology.*
 - 4. The learner will understand importance of national parks, sanctuaries and need of ecotourism.*

Unit I: Human Osteology

(15 lectures)

1.1: Introduction: Bone structure (Histology) and general functions of bones.

Cartilage: General structure, functions

1.2: Axial skeleton

1.2.1: Skull: General characteristics of skull bones - Cranial and facial bones

1.2.2: Vertebral column: General characteristics of a vertebra, structure of different types of vertebrae (cervical, thoracic, lumbar, sacrum and coccyx)

1.2.3: Ribs and sternum: General skeleton of ribs and sternum

1.2.4: Hyoid bone: Structure and function.

1.3: Appendicular skeleton

1.3.1: Pectoral girdle and bones of forelimbs

1.3.2: Pelvic girdle and bones of hind limbs

1.4: Sexual dimorphism of human skeleton.

Unit II: Behavioural ethology

(15 lectures)

2.1: Social behaviour:

2.1.1: Territoriality, Schooling in fishes, Herd migration,

2.1.2: Kin selection, Altruism, reciprocal altruism,

2.1.3: Social organization in insects and primates.

2.2: Reproductive Behaviour patterns:

2.2.1: Mating systems in animals,

2.2.2: Courtship behaviour- characteristics of courtship, Examples of courtship- Invertebrate (Spider) and Vertebrate (Bower bird), Nest building- Baya weaver bird.

2.2.3: Parental care-Factors affecting parental care, Parental care in fishes and amphibians.

2.3: Biological clocks: Circadian, Circalunar and Circannual rhythms.

Unit III: Epidemiology-I

(15 lectures)

3.1: Scope of epidemiology: Perspective of epidemiology; descriptive and analytical epidemiology; epidemiological triad; stages of diseases, screening for diseases.

3.2: Epidemiology of communicable diseases : definition of common terms.

3.3: Dynamics of disease transmission : Reservoir, route of transmission, incubation.

Unit IV: National parks and sanctuaries.

(15 lectures)

4.1: India biodiversity; rare and endangered animals of India: wildlife conservation projects; important national parks, sanctuaries (Sanjay Gandhi, Tadoba, Jim Corbett, Kaziranga, Nagarhole, Kanha, Bhitarkanika, Periyar).

PRACTICAL SYLLABUS FOR SEMESTER V

Practical I & II

Total credits: 3

- Course objectives:** 1. To acquaint learners with the details of Sepia as a representative of invertebrates & to familiarize them with histological structure of some important endocrine glands of human body.
2. Introduction to study of laboratory techniques and diagnostic tools in haematology and immunology.

- Expected outcome:** 1. The learner will be able to understand about invertebrate organ systems and histology of endocrine glands.
2. The learner will be able to use instruments and kits for clinical diagnostics in pathology laboratory

Course Code: RJSUZOO501

Practical I (Based on theory Paper I)

1. Study of Sepia with the help of diagram / Photograph / Simulation whichever possible. No animal shall be dissected.
 - a) Digestive system,
 - b) Reproductive system
 - c) Nervous system
 - d) Jaws
 - e) Radula
 - f) Chromatophores
 - g) Spermatophores
 - h) One demonstration of Sepia systems.
2. Mounting of fish scales- Placoid, cycloid and ctenoid.
3. Frog embryology- Egg spawn, cleavage, blastula, gastrula, tadpole stages.
4. Study of slides of pituitary, adrenal, thyroid, parathyroid & pancreas.

Course Code: RJSUZOO502

Practical II (Based on theory Paper II)

1. Enumeration of Erythrocytes - Total Count.
2. Enumeration of Leucocytes - Total Count.
3. Differential count of Leucocytes.
4. Erythrocyte Sedimentation Rate by suitable method - Westergren or Wintrobe method.
5. Estimation of haemoglobin by Sahli's acid haematin method.
6. Estimation of total serum/ plasma proteins by Folin's method.
7. Separation of plasma proteins by PAGE.
8. Estimation of blood glucose by o-toluidine method.
9. Estimation of serum/ plasma total triglycerides by Phosphovanillin method.
10. Latex agglutination test - Rheumatoid Arthritis.
11. Vidal Test- Typhoid detection.

Practical III & IV

Total credits: 3

Course objectives: 1. To introduce molecular biology of DNA and RNA and to understand the tools and techniques used in Genetic Engineering.
2. To introduce the learner to the world of practical approach in Toxicology and Biostatistics.
3. To introduce the concepts of Osteology, Ethology and Conservation of biodiversity.

Expected outcome: 1. The learner will be able to isolate nucleic acids from biological samples. They will also get basic idea about restriction mapping.
2. The learner will be able to perform toxicological studies using enzymes and can further extrapolate the data using tools of biostatistics.
3. The learner will get better insight on human skeleton, animal behaviour and biodiversity conservation.

Course code: RJSUZOOP503 Practical III (Based on theory Paper III)

1. Quantitative estimation of RNA by Orcinol method.
2. Quantitative estimation of DNA by Diphenylamine method.
3. Separation of Genomic DNA by Agarose gel electrophoresis.
4. Problems based on Restriction endonucleases.
5. To study the effect of CCl₄ on the level of enzyme activity in liver on Aspartate and Alanine amino transferase, Alkaline phosphatase (*in vitro* approach).
6. Following biostatistics practicals will be done manually:
 - a. Problems based on Z-test
 - b. Problems based on t-test
 - c. Problems based on Chi-square test
 - d. Correlation

(Learner is expected to identify appropriate test for the given problem)

Course code: RJSUZOOP504 Practical IV (Based on theory Paper IV)

1. Study of Human Axial Skeleton - Skull (whole) and Vertebral column (axis, atlas, typical cervical, typical thoracic, typical lumbar, sacrum, coccyx).
2. Study of Human Appendicular Skeleton - Pectoral and pelvic girdle with limb bones.
3. Disorders associated with skeletal system-Tendonitis, foot rot.
4. Study of social organization in termites, honey bee, elephants and hanuman langur.
5. Study of parental care in Sea horse, Gourami, Tilapia, Caecilian, Mid-wife toad.
6. To mark national parks and sanctuaries on map of India.
7. To identify brand animals of various national parks, sanctuaries and comment on its IUCN status.
8. Project or assignment on epidemiology (Group study on disease).

T. Y. B. Sc. ZOOLOGY: SEMESTER VI (THEORY)
Paper I- Taxonomy - Chordates and Type Study

Course Code:RJSUZOO601

Total credits: 2.5

Course Objectives: 1. To acquaint learners with the details of Shark as a representative of vertebrates.
2. To provide them with general idea of comparative anatomy of vertebrates.
3. To acquaint learners with knowledge of developmental biology with chick as a model.
4. To make understand learner concept of histology.

Expected Outcomes: 1. Learner will get an idea of general characters and system details of Shark.
2. Learner will be familiarized with process of evolution trend which has occurred during vertebrate evolution.
3. Learner will understand the basics of chick embryo development and the practical applications of studying Chick Embryology.
4. Learner will understand Histology of various mammalian tissues.

Unit I: Type study: Shark

(15 lectures)

1.1: Habit, habitat, distribution, external characters including sexual dimorphism, classification and economic importance.

1.2: Skin, exoskeleton, endoskeleton and systems:

- a) Digestive system.
- b) Respiratory system.
- c) Blood vascular system.
- d) Nervous system and receptor organs.
- e) Urinogenital system, copulation, fertilization and development.

Unit II: Comparative anatomy of vertebrates II- Respiratory system, Urinogenital system and Nervous system.

(15 lectures)

2.1: Nervous system:

Development and differentiation of primary brain vesicles and their cavities, flexures of brain, evolution of cerebral hemispheres & cerebellum with reference to shark, frog, lizard, pigeon & rabbit.

2.2: Urinogenital System:

Archinephros, pronephros, mesonephros, metanephros, structure of nephron, urinogenital ducts, urinary bladder in vertebrates.

Unit III: Developmental biology of chick

(15 lectures)

3.1.1: Structure of Hen's egg, physico-chemical nature and forms of yolk - granular, platelets and spheres; fertilization, cleavage, blastulation, gastrulation

3.1.2: Structure of chick embryo - 18hours, 24 hours, 33 hours, 48 hours and 72 hours

3.1.3: Extra embryonic membranes

Unit IV: Mammalian histology

(15 lectures)

4.1: Histology

Histological structures of the following mammalian organs: stomach, intestine, liver, kidney, testes and ovary.

Paper II- Enzymology, Physiology and Pathology

Course Code: RJSUZOO602

Total credits: 2.5

Course Objectives: 1. To introduce concepts of enzyme Biochemistry and applications of enzymes.
2. To understand the working of neurotransmitters and basics of cardiac physiology.
3. To comprehend the physiological aspects of homeostasis and Endocrinology.
4. To acquaint learner with the concept and details of tissue culture.

Expected Outcomes: 1. Learner will understand enzyme kinetics and therapeutic role of enzymes.
2. The student will identify the role of neurotransmitters and appreciate the working of human heart.
3. Learner will be familiarized with adaptations of animals for regulation of heat and ionic balance. Also they will understand the structure, function and disorders of endocrine glands.
4. Learner will get an idea of tissue culture practices and its wide range of scope in allied industries.

Unit I: Enzymology

(15 lectures)

- 1.1: Introduction and Nomenclature:** Definition; concept of activation energy; nomenclature and classification (based on IUB - Enzyme Commission) of enzymes; chemical nature of enzyme, co-factors and co-enzymes
- 1.2: Enzyme Action and Kinetics:** Mechanism; Factors affecting enzyme activity - substrate, pH and temperature. Derivation of Michaelis-Menten equation and Lineweaver-Burk plot; Concept and significance of K_m , V_{max}
- 1.3: Enzyme Inhibition:** Competitive and non-competitive inhibitors and their kinetics; therapeutic applications of enzyme inhibitors
- 1.4: Regulation of Enzyme Activity:** Allosteric regulation and regulation by covalent modification of enzymes; Isozymes (LDH)
- 1.5: Industrial applications of enzymes:** Food and detergents

Unit II: Chemical messengers and Cardiac physiology

(15 lectures)

2.1 Chemical Messengers: Introduction, concept and classification; Neurotransmitters and Neurosecretory substance, Acetyl catecholamine, Gama-amino butyric acid (GABA), Aspartic acid, Purine ATP, Mode of working of transmitters; X and Y organ of crustaceans.

2.2 Cardiac Physiology: Vascular pumps: Suction pump in open circulation and pressure pump in closed circulation; Cardiac output, Venous return, Pace maker, Electrical activity in heart muscles: Electrocardiogram; Chemical and nervous regulation of heart

Unit III- Aspects of human reproduction

(15 lectures)

3.1 Human Reproductive system and Hormonal regulation

Anatomy of human male and female reproductive system, Hormonal regulation of Reproduction
Impact of age on reproduction-Menopause and Andropause

3.2 Contraception & birth control

Methods of Contraception- Natural Methods and Artificial methods,
Sterilization, Termination, Abortion

3.3 Infertility- Causes and treatment in females and males.

3.4 Infertility associated disorders- Endometriosis, Polycystic Ovarian syndrome (PCOS), POF
(Primary ovarian failure)

3.5 Assisted Reproductive Technology

Sperm banks, cryopreservation of gametes and embryos, Surrogacy,
Techniques of ART - In vitro fertilization (IVF), Embryo transfer (ET), Gamete intra-fallopian transfer
(GIFT), intra-zygote transfer (ZIFT), Intracytoplasmic sperm injection (ICSI) with ejaculated sperm and
with sperm retrieved from testicular biopsies- Testicular sperm extraction (TESE) , Ethical
Considerations of ART

Unit IV: General Pathology

(15 lectures)

4.1: General Pathology: Introduction and scope

4.2: Cell injury: Mechanisms of cell injury: ischemic, hypoxic, free radical mediated and
chemical

4.3: Retrogressive changes: Definition, types of degeneration(causes and effects): cellular
swelling, fatty, mucoid and amyloid

4.4: Disorders of pigmentation: Endogenous: Brief ideas about normal process of
pigmentation, melanosis, jaundice (causes and effects)

4.5: Necrosis: Definition and causes; nuclear and cytoplasmic changes; types: coagulative,
liquefactive, caseous, fat and fibroid

4.6: Gangrene: Definition and types - dry, moist and gas gangrene

Paper III-Cancer biology, Biotechnology, Genetics and Bioinformatics

Course Code: RJSUZOO603

Total credits: 2.5

Course Objectives: 1. To impart the knowledge of cellular and molecular biology of cancer.
2. To introduce molecular biology of gene alteration and its effects.
3. To understand the tools and techniques used in genetic engineering.
4. To acquaint learners with the fascinating world of human genetics and bioinformatics.

Expected Outcomes: 1. The student will understand at the cellular level the causes, preventive measures and treatment for cancer.
2. Learner will get an insight in the intricacies of chemical and molecular processes that alter the gene.
3. Learner will be familiarized with vast arrays of techniques of gene manipulation.
4. Learner will get an idea on the significance of genetic health and the role of computational biology in present time.

Unit I: Cancer biology

(15 lectures)

1.1: Biology of cancer: Introduction, general properties of cancer cells.

1.2: Cell Cycle : Eukaryotic cell cycle, Regulation of cell cycle progression.

1.3: Cell Signaling: Signaling molecules and their receptor; functions of cell surface receptors; Intracellular signal transduction pathway. Programmed cell death.

1.4: Causes of Cancer: carcinogens – radiation, chemical and viral , Oncogenes, Tumor suppressor genes.

1.5: Prevention and treatment: Prevention and regulation; Chemotherapy, Radiation therapy, Immuno therapy and Gene therapy.

1.6: Tumor immunology : Antitumor effector cells and Regulation of tumor immunity, Tumor-associated Antigens, Mechanisms of tumor rejection.

Unit II: Animal tissue culture

(15 lectures)

2.1: Aseptic techniques

2.1.1: Sterilization - basic principles of sterilization, importance of sterility in cell culture

2.1.2: Sterile handling - swabbing, capping, flaming, handling bottles and flasks, pipetting, pouring.

2.2: Culture media

2.2.1: Types of media - Natural and Artificial media

2.2.2: Balanced Salt Solutions

2.2.3: Complete Media - amino acids, vitamins, salts, glucose, oxygen supplements, hormones and growth factors, antibiotics

2.2.4: Factors influencing cell culture - surface tension and foaming, viscosity, temperature, osmolality, pH, CO₂, bicarbonate and O₂

2.3: Advantages of tissue culture –concept of HeLa cells and stem cells, control of the environment, *in vitro* modelling of *in vivo* conditions in tissue culture.

2.4: Limitations of tissue culture.

2.5: Culture techniques

2.5.1: Preparation of cells / organs for culture

2.5.2: Cover slip, Flask and Tube culture

2.5.3: Primary and established cell lines

2.5.4: Hybridoma technology

Unit III: Human Genetics

(15 lectures)

3.1: Chromosomal Aberrations:

Numerical: Aneuploid and Polyploidy (Autopolyploidy and Allopolyploidy); Non-disjunction during mitosis and meiosis.

Structural: Deletion: types, effects and disorders; Translocation: types: Robertsonian and non-Robertsonian disorders; Inversion: types, effects and significance; Duplication and their evolutionary significance (multigene families).

3.2: Genetic Disorders: Inborn Errors of Metabolism: Phenylketonuria, G-6-PD deficiency, Alkaptonuria, Albinism ;Single gene mutation: Cystic fibrosis ;Multifactorial: Breast Cancer ;Uniparental Disomy: Angelman Syndrome and Prader-Willi Syndrome

3.3: Diagnosis: Prenatal Diagnosis: Amniocentesis and Chorionic villus sampling, Banding techniques (G, C, Q), FISH, Protein truncation test (PTT).

Unit IV: Bioinformatics

(15 lectures)

4.1: Introduction

4.1.1: Introduction to Bioinformatics and Bioinformatics web resource (NCBI, EBI, OMIM, PubMed)

4.1.2: Applications of Bioinformatics

4.2: Databases - Tools and their uses

4.2.1: Biological databases;

Primary sequence databases: Nucleic acid sequence databases (GenBank, EMBL-EBI, DDBJ) Protein sequence databases (UniProtKB, PIR) Secondary sequence databases OR Derived databases - PROSITE, BLOCKS

Structure databases and bibliographic databases

4.3: Sequence alignment methods

4.3.1: BLAST, FASTA

4.3.2: Types of sequence alignment (Pairwise & Multiple sequence alignment)

4.3.3: Significance of sequence alignment

4.4: Predictive applications using DNA and protein sequences

4.4.1: Evolutionary studies: Concept of phylogenetic tree, convergent and parallel evolution

4.4.2: Pharmacogenomics: Concept and applications

4.4.3: Metabolomics: Concept and applications

4.5: Bioinformatics programme in India.

**Paper IV- Environmental Biology, Zoopharmacognosy,
Epidemiology & Wildlife management.**

Course Code: RJSUZOO604

Total credits: 2.5

Course Objectives: 1. Learner should understand the different factors affecting the environment and wildlife.
2. To introduce the learner to concepts of Bioprospecting and Zoopharmacognosy.
3. To acquaint learner with the distribution on animals around the world.

Expected Outcomes: 1. Learner will get sensitized to the issues concerning with environment, threats to wildlife and the different methods of conservation.
2. Learner will become aware about commercialization of biological discoveries as well as ethological aspect of non-human self medication.
3. Learner will get an idea about how and why animals got distributed on the earth.

Unit I: Zoogeography

(15 lectures)

1.1: Introduction: Plate tectonics and continental drift theory

1.2: Animal Distribution and Barriers

1.2.1: Isolating mechanisms

1.2.2: Patterns of animal distribution - continuous, discontinuous and bipolar

1.2.3: Barriers of distribution - Topographic, climatic, vegetative, large water masses, land mass, lack of salinity and special characteristic habit (homing instinct).

1.2.4: Means of dispersal - land bridges, natural rafts and drift wood, favouring gales, migration by host, accidental transportation and by human agencies

1.3: Zoogeographical Realms: Palearctic, Ethiopian, Oriental, Australian, Neotropical, Nearctic and Antarctic.

Unit II: Bioprospecting and Zoopharmacognosy

(15 lectures)

1.1: Bioprospecting

1.1.1: Traditional and modern bioprospecting, economic value of bioprospecting

1.1.2: Bioprospecting and conservation, advantages and disadvantages

1.2: Zoopharmacognosy

1.2.1: Definition and types

1.2.2: Self-medication and its mechanism

1.2.3: Methods of self-medication through:

a) Ingestion - ants and mammals

b) Geophagy - invertebrates and birds

c) Absorption and adsorption

1.2.4: Applications - Social and trans-generational aspects of insects, birds and mammals

1.2.5: Contribution to human medicines

Unit III: Epidemiology-II

(15 lectures)

3.1: Prevention and control of communicable diseases- Notification, isolation, quarantine, disinfection; concurrent, terminal, precurrent/ prophylactic methods of disinfection: natural, physical, chemical, immunization; general measures.

3.2: Epidemiology of communicable diseases: Diagnosis, transmission, prevention, control measures and treatment of-

- a) Diseases of viral origin- dengue, swine flue
- b) Diseases of bacterial origin- TB, leprosy, leptospirosis
- c) Diseases of protozoan origin- Malaria
- d) Diseases of helminthes origin- Ascariasis, Dracunculosis, Filariasis

3.3 WHO and its programme: Malaria, TB ,Polio control programme, outcome with respect to India.

Unit IV: Wildlife management

(15 lectures)

4.1: Habit, Habitat, Territory of Wild Animals: Herbivores, carnivores, solitary, social, types of habitats and territories.

4.2: Threats to Wildlife

4.2.1: Poaching and hunting, deforestation, encroachment, competition (intra-specific and inter-specific), overgrazing and climate change, diseases (zoonosis and reverse zoonosis)

4.2.2: Tourism and human animal conflict

4.3: Wildlife Conservation

4.3.1: Techniques and methods used for wildlife census: Aerial counts, camera trap, line transect census and track surveys, capture mark recapture method, wildlife radio telemetry

4.3.2: Forest management, policies and Acts:

Management- Prescribed burning, reforestation

Forest policy 1988; The Indian Forest Act, 1927

Indian Wildlife (Protection) Act, 1972 and Convention for International Trade of endangered species (CITES).

4.4 Case studies Community based conservation and management in Namibia, Wolf reintroduction in Yellow Stone National Park, Silent Valley conservation- people's movement, Diclofenac and vulture population decline

PRACTICAL SYLLABUS FOR SEMESTER VI

Practical I & II

Total credits: 3

- Course objectives:**
1. To acquaint learners with the details of Shark as a representative of vertebrates & to familiarize them with histological structure of some mammalian organs.
 2. To familiarize them with different stages of chick embryo development.
 3. To make the learner understand enzyme kinetics and other physiological aspects practically.

- Expected outcome:**
1. The learner will be able to understand about vertebrate organ systems and histology of mammalian organs.
 2. Students would be able to understand changes which occur in the chick embryo during development.
 3. The learner will be able to comprehend the kinetics of enzyme activity in a better way and they would understand how different factors can affect enzymatic reactions.

Course Code: RJSUZOO601 Practical I (Based on theory Paper I)

1. Study of Shark with the help of diagram / photograph / simulation whichever possible.
No animal shall be dissected.
 - a) Digestive system
 - b) Heart and Aortic arches
 - c) Urinogenital System
 - d) Endoskeleton of shark:
 - i. Axial - Skull and vertebral column
 - ii. Appendicular - Pelvic and pectoral fins, pelvic and pectoral girdle
2. Brain: Comparative study of brains of shark, frog, lizard, bird (pigeon /fowl) & rat.
3. Study of ontogeny of chick embryo using permanent slides - 18 hours, 24 hours, 33 hours, 48 hours and 72 hours.
4. Preparation of temporary mounting of chick embryo up to 48 hours of incubation.
5. Observation of Permanent slides: Mammalian Tissues- liver, kidney, testis, ovary, stomach and intestine.

Course Code: RJSUZOO602 Practical II (Based on theory Practical II)

1. Effect of varying pH on activity of enzyme Acid Phosphatase.
2. Effect of varying enzyme concentration on activity of enzyme Acid Phosphatase.
3. Effect of varying substrate concentration on activity of enzyme Acid Phosphatase.
4. Effect of inhibitor on the activity of enzyme Acid Phosphatase.
5. Separation of LDH isozymes by agarose / polyacrylamide gel electrophoresis.
6. Study of stages of estrous cycle in mice by vaginal cytology.
7. Mounting of nerve cells and neurosecretory cells from cockroach brain.
8. Study of ECG and disorders of heart function.
9. Study of contraceptive devices- condom, diaphragm, contraceptive pills, copper-T.
10. Study of pregnancy detection kit.

Practical III & IV

Total credits: 3

Course objectives: 1. To provide opportunity to learner to deal with some basic aspects of tissue culture. Also to introduce karyotype analysis and use of bioinformatics tool.
2. To make them aware about Zoogeographical distribution of animals on earth. To familiarize them with some basic techniques of population analysis .

Expected outcome: 1. The learner will be able to understand importance of aseptic techniques in tissue culture and would get hands on experience of using computer for obtaining gene or protein sequences through bioinformatics tools.
2. The learner will understand the different factors which affect Zoogeographical distribution of animals. After learning some basic population analysis techniques learner would be able to extend this knowledge to environmental research projects.

Course Code: RJSUZOOP603 Practical III (Based on theory Paper III)

1. Study of slides and photographs: leukemia/ sarcoma/lymphoma/carcinoma
2. Calculation of mitotic index from the photograph or stained preparation of onion root tip or cancer cells.
3. Instruments for tissue culture – Autoclave, Millipore filter, CO₂ incubator, Laminar air-flow. (Principle and use).
4. Packaging of glassware for tissue culture.
5. Aseptic transfer techniques(demonstration only)
6. Trypsinization and vital staining using Trypan blue stain (demonstration only)
7. Karyotype (Idiogram) analysis for the following syndromes with comments on numerical and / or structural variations in chromosomes .
 - a. Turner's syndrome
 - b. Klinefelter's syndrome
 - c. Down's syndrome
 - d. Cri-du-chat syndrome
 - e. D-G translocation
 - f. Edward's syndrome
 - g. Patau's syndrome
8. Interpretation of genetic formulae: Deletion, duplication, inversion and translocation.
9. Explore BLAST for nucleotide sequence comparison.
10. Explore the databases (Nucleotide, Protein) at NCBI for querying a nucleotide or protein sequence.
11. Exploring bibliographic database PubMed for downloading a research paper on subject of interest with the use of operators.

Course Code: RJSUZOO604 Practical IV (Based on theory Paper IV)

1. Indicate the distribution of fauna in the world map with respect to its realm and comment on the pattern of distribution.
 - a. Palearctic: Giant Panda and Japanese Macaque
 - b. Ethiopian: Common ostrich and African bush elephant
 - c. Oriental: Indian one-horned Rhinoceros and Gharial
 - d. Australian: Platypus and Red Kangaroo
 - e. Neotropical: Guanaco and South American Tapir
 - f. Nearctic: Virginia opossum and Sea otter , Raccoon
 - g. Antarctic: Emperor Penguin and Antarctic Minke Whale

2. Excursion (Study tour / Visit to Zoo / Sanctuary / National park / Research institute, etc. and submit a report. College may conduct more than one field visit for wide exposure, if feasible. However, at least one field visit should be such that it is affordable to every student.

3. Study of bioprospecting:
 - a. Tumour suppression compounds e.g. Sponge.
 - b. Skin erythema treatment from gel - Aloe vera, Aloe ferox.

4. Study of Zoopharmacognosy in ants, cats, elephants and dogs.

5. Temporary preparation of head and mouth parts of mosquito.

6. Identification of diseases with the help of Photograph/ specimen
 - a)TB
 - b) Leprosy
 - c)Ascariasis
 - d)Dracunculosis
 - e)Filariasis

7. Study of population density by line transect & quadrat method and calculate different diversity indices.

8. Identification of animals with the help of pug marks.

SCHEME OF EXAMINATION (FOR BOTH SEMESTERS)

Internal examination

There would be one internal class test comprising of 20 marks each (total 40 marks). Each class test shall consist of 20 multiple choice questions with equal weightage.

The second class test will comprise of 10 questions of ½ M, 5 questions of 1M and 2 out of 4 questions to be attempted of 5 mark each.

Question paper pattern for external theory

Total: 60 marks

Q.1 Based on Unit I..... 12 M

a,b,c- Attempt any two questions out of three

Q.2 Based on Unit II.....12M

a,b,c- Attempt any two questions out of three

Q.3 Based on Unit III.....12M

a,b,c- Attempt any two questions out of three

Q.4 Based on Unit IV.....12M

a,b,c- Attempt any two questions out of three

Q.5 Short notes (Mixed from all Units)..... 12M (3M each)

a or a- Unit I

b or b- Unit II

c or c- Unit III

d or d- Unit IV

Practical examination

One Practical at the end of each Semester consisting of

Practical I-50 marks and Practical II-50 marks but passing combined out of 100.

Practical III-50 marks and Practical IV-50 marks but passing combined out of 100.

A candidate will be allowed to appear for the practical examinations if he/she submits a certified journal of T.Y.B.Sc. Zoology or a certificate from the Head of the department / Institute to the effect that the candidate has completed the practical course of T.Y.B.Sc.Zoology as per the minimum requirements.

In case of loss of journal, a candidate must produce a certificate from the Head of the department /Institute that the practicals for the academic year were completed by the student. However, such a candidate will be allowed to appear for the practical examination, but the marks allotted for the journal will not be granted.

HOD's decision, in consultation with the Principal, shall remain final and abiding to all.

T. Y. B. Sc. Zoology: Semester V (Practical)

Skeleton of Practical Examination Question Paper- Practical I

Total Marks: 50

- Q1. Sketch, label and describe Digestive/ Nervous / Reproductive System of Sepia. 10
- Q2. Sketch and label jaws/ radula/ chromatophores/ spermatophores of Sepia. 05
- Q3. Mountings of scales (any two)– placoid/cycloid/ctenoid 10
- Q3. Identify and describe. (a,b,c based on frog embryology and d,e based on endocrinology) 15
- Q4. Viva 05
- Q5. Journal 05

Skeleton of Practical Examination Question Paper- Practical II

Total Marks: 50

- Q.1 Estimate total plasma proteins by Folin's method. 15
- OR**
- Estimate serum/plasma total triglycerides by Phosphovanillin method.
- OR**
- Estimation of glucose by O-toluidine method.
- Q.2. Enumerate erythrocytes in the given sample and comment on clinical condition. 10
- OR**
- Enumerate leucocytes in the given sample and comment on clinical condition.
- OR**
- Present a report on differential count of leucocytes and comment on clinical condition.
- Q.3. Estimate haemoglobin by Sahli's acid haematin method. 10
- OR**
- Record Erythrocyte Sedimentation Rate by Westergren / Wintrobe method.
- OR**
- Perform separation of plasma proteins by PAGE.
- Q.4. Perform Latex agglutination test - Rheumatoid Arthritis. 05
- OR**
- Perform Vidal test.
- Q.5. Viva voce 05
- Q.6. Journal 05

Skeleton of Practical Examination Question Paper-Practical III

	Total Marks: 50
Q.1 Demonstrate the effect of CCl ₄ on the level of enzyme activity of aspartate/alanine amino transferase / alkaline phosphatase in liver (<i>in vitro</i> approach)	12
Q.2 Estimate the amount of RNA by Orcinol method from the given sample.	10
or	
Estimate the amount of DNA by Diphenylamine method from the given sample.	
or	
Separation of Genomic DNA by Agarose gel electrophoresis.	
Q.3 Problems based on Restriction endonucleases.	08
Q.4 Problems based on Biostatistics.	10
Q.5 Viva voce	05
Q.6 Journal	05

Skeleton Question Paper for Practical Examination- Practical IV

	Total Marks: 50
Q.1 Identification	24
Spot a) and b) Based on osteology – (human axial skeletonSkull (whole) and Vertebral column (axis, atlas, typical cervical, typical thoracic, typical lumbar, sacrum, coccyx). (any two)	
Spot c) and d) Based on osteology - human Appendicular skeleton(Pectoral and pelvic girdle with limb bones.) (any two)	
Spot e) Based on social organization (termites, honey bee, elephants and hanuman langur.) (any one)	
Spot f) Based on parental care (sea horse, Gourami, Tilapia, Caecilian, Mid-wife toad.) (any one)	
Q.2 To mark national parks and sanctuaries on map of India and describe about the identified National Park or Sanctuary. (Sanjay Gandhi, Tadoba, Gir, Jim Corbett, Bharatpur, Kaziranga, Bandipur-Mudumalai) (any one)	10
Q. 3 To identify brand animals of national parks/sanctuaries & comment on its IUCN status.	06
Q.4 Viva Voce	05
Q.5. Journal	05

T. Y. B. Sc. Zoology: Semester VI (Practical)

Skeleton of Practical Examination Question Paper-Practical I

Total Marks: 50

- Q1. Sketch and label and describe Digestive system, Heart and aortic arches, Urinogenital system, Cranial nerves of Shark. 10
- Q2. Sketch and label endoskeleton of Shark (Any one skull/ vertebra / pelvic fin/ pectoral fin/ pelvic girdle/ pectoral girdle) 05
- Q3. Preparations of temporary mounting of chick embryo upto 48 hours of incubation. 10
- Q3. Identify and describe.
a,b, based on brains
c, d based on chick embryology and
e,f on mammalian histology 15
- Q4. Viva 05
- Q5. Journal 05

Skeleton of Practical Examination Question Paper- Practical II

Total Marks: 50

- Q.1 Demonstrate the effect of _____ on the activity of acid phosphatase (Substrate concentration / pH variation / Enzyme concentration / Inhibitor concentration) 15
- Q.2 Separate LDH isozymes from the given sample by agarose / polyacrylamide gel electrophoresis 10
- OR**
- Q.2 Mounting of nerve cells and neurosecretory cells from cockroach.
- OR**
- Q.2 Pregnancy detection using kit.
- Q.3 Identify and describe a, b, c, d, e 15
- a Any one stage of Estrous cycle of mice
b and c: ECG
d and e: Contraceptive device.
- Q.4 Viva voce 05
- Q.5 Journal 05

Skeleton of Practical Examination Question Paper- Practical III

Total Marks: 50

Q.1 Arrange the chromosomes from the given karyotype and identify and describe the syndrome.	12
Q.2 Prepare the given glassware for sterilization.	08
Q.3 Identify and describe A and B A: slides or photographs: leukemia / sarcoma/lymphoma/carcinoma B: Autoclave, Millipore filter, CO ₂ incubator, Laminar air-flow. (Principle and use).	04
Q.4. a) Interpret the of genetic formula	03
b) Calculation of mitotic index from the photograph.	05
Q.5 Project based on Bioinformatics	08
Q.6 Viva voce	05
Q.7 Journal	05

Skeleton Question Paper for Practical Examination-Paper IV

Total Marks: 50

Q1. Identify the given animals with respect to their realms and comment. (any two)	06
Q2. Identification with the help of Photograph/ specimen based on a) Bioprospecting: (Sponge, Aloe vera, Aloe ferox.) (any one) b) Zoo Pharmacognosy: (ants, cats, elephants and dogs) (any one) c) Epidemiology: (TB , Leprosy, Ascariasis, Dracunculosis, Filariasis) (any one)	09
Q3. Temporary preparation of head and mouth parts of mosquito	05
Q4. Study of population density by line transect Or quadrat method and calculate different diversity indices.	10
Q5 Identification of animals with the help of pug marks.	02
Q6. Study tour or field report submission and discussion	08
Q7. Viva Voce	05
Q8 Journal	05

Paper I

- A manual of Zoology - Part I, Invertebrata; Ayyar, M. Ekambaranath
- Instant Notes in Animal Biology by Richard D. Jurd.
- Introduction to Zoology - Vol I: K. K. Chaki, G. Kundu and S. Sarkar, New Crystal Book Agency.
- Modern text book of Zoology - Invertebrates; Eleventh; Edition Professor R.L. Kotpal; Rastogi publication
- Invertebrate Zoology by FatikBaran 2012, PHI Learning
- A Textbook of Invertebrates by N.C. Nair et al. 2010 Saras publications
- Practical Zoology: Invertebrate, by S. S. Lal, 2016
- Invertebrate Zoology by Ruppert, Fox, Barnes, 7th edition, 2003 publications Cengage Learning
- Invertebrate Zoology by D.T. Anderson 2nd edition 2002, publications Oxford
- Invertebrates by Richard C. Brusca et al, 3rd edition 2016, publications Oxford
- Biology of the invertebrates by Jan A. Pechenik, 7th edition, 2014 publications McGraw Hill
- An introduction to the invertebrates by Janet Moore, 2nd edition 2006, publications Cambridge
- Zoology for Degree Students-I; Dr. V. K. Agarwal. S. Chand
- Invertebrate Zoology; E.L. Jordan and P.S. Verma
- Vertebrate comparative anatomy, Function, Evolution: K. V. Kardong, 3rd Ed. Tata McGraw Hill publication.
- The life of Vertebrates: J. Z. Young, ELBS-Oxford Univ. Press.
- A Text Book of Zoology: T. J. Parker and W. A. Haswell, McMillan.
- Chordate zoology: E. L. Jordan and P. S. Verma, S. Chand & Co.
- Developmental Biology: 5th Ed, Scott F. Gilbert, Sinauer Associates Inc.
- Developmental Biology: T. Subramoniam, Narosa Publishers.
- Bailey's Text Book of Histology, 6th Ed: Scientific book Agency
- General Endocrinology 3rd Ed,: Turner and Bagnara, Saunders.

Paper II

- Human Physiology - Volume 1; C.C. Chatterjee.
- Essentials of Haematology; Shirish M. Kawthalkar; Jaypee Brothers.
- Williams Hematology; Kenneth Kaushansky, Marshall A. Lichtman, E. Beutler, Thomas J. Kipps, Josef Prchal, Uri Seligsohn.
- Essential Haematology; Victor Hoffbrand, Paul Moss, John Pettit.
- Short Textbook of Haematology; Shah B.S.; C.B.S. Publisher and Distributor.
- Mechanisms of Body Functions; Second Edition; Dexter M. Easton; Prentice-Hall of India Pvt. Ltd., New Delhi; 1978.
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- Principles of Anatomy & Physiology; Thirteenth Edition; Gerard J. Tortora & Bryan Derrickson; Biological Science Textbooks, Inc.; 2012.
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 - Immunology: A textbook; Rao C. V.; Alpha Science Int'l Ltd.; 2005.
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 - Prescott's Microbiology; Ninth Edition; Joanne M. Willey, Linda M. Sherwood & Christopher J. Woolverton; McGraw-Hill Education; 2014.
 - Immunology; Third Edition; Janis Kuby; W.H. Freeman; 1997.
 - Kuby Immunology; Sixth Edition; Thomas J. Kindt, Richard A. Goldsby, Barbara Osborne & Janis Kuby; W.H. Freeman; 2007.
 - Cellular and Molecular immunology; Abbas A. K., Lichtman A. H. & Pillai S.; Elsevier Health Sciences; 2014.
 - Roitt's Essential Immunology - Vol. 20; Delves P. J., Martin S. J., Burton D. R., & Roitt I. M.; John Wiley & Sons; 2011.
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 - Text book of Comparative Physiology; R Nagabhushanam, Ms Kodarkar, Sarojini R. India Book House Pvt. Ltd.
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Paper III

- Introduction to Molecular Biology; Peter Paoella; Tata McGraw Hill; 2010.
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Paper IV

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- A Guide of Osteology (for medical students); Prakash Kendra, Lucknow.
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- Public Health & Sanitation Part I &II: The All India Institute of Local Self Government. SthanikrajBhavan, C.D.BarfiwalaMarg, Andheri (W), 400058,
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