

Hindi Vidya Prachar Samiti's  
**Ramniranjan Jhunjhunwala College of Arts, Science and Commerce**  
**(Autonomous College)**  
**Affiliated to University of Mumbai**



**Syllabus for M.Sc. I**

**Semester I & II**

**Program: M.Sc.**

**Course: Zoology**

**Academic year: 2019-2020**

**SEMESTER –I**

| Theory<br>TOPIC |         |                                |  |   |
|-----------------|---------|--------------------------------|--|---|
| Course          | Credits | Unit                           | Phylogeny, Systematics of non-chordates and assorted topics-I              |   |
| RJSPZOO101      | 4       | I                              |  |   |
|                 |         | II                             |  | Phylogeny, Systematics of non-chordates, Hemichordate & assorted topics |
|                 |         | III                            |  | Phylogeny, Systematics of Chordates & Assorted topics- I                |
|                 |         | IV                             | Comparative Vertebrate Osteology- I  |   |
| RJSPZOO102      | 4       | I                              | Biomolecules- a structural and functional approach-I                       |   |
|                 |         | II                             | Metabolism and Regulation  |   |
|                 |         | III                            | Carbohydrate metabolism and regulation                                     |   |
|                 |         | IV                             | Lipid and mineral metabolism and regulation                                |   |
| RJSPZOO103      | 4       | I                              | Cell cycle and cytoplasmic inheritance.                                    |   |
|                 |         | II                             | Genetics- Extension of Mendelian genetics and non-Mendelian inheritance -I |   |
|                 |         | III                            | Evolution –I   |   |
|                 |         | IV                             | Developmental Biology-I  |   |
| RJSPZOO104      | 4       | I                              | Microtomy, microscopy, centrifugation                                      |   |
|                 |         | II                             | Radioisotopes and extraction techniques                                    |   |
|                 |         | III                            | Principles and application of Spectroscopy                                 |   |
|                 |         | IV                             | Research Methodology   |   |
| Practical       |         |                                |  |   |
| RJSPZOOP101     | 2       | Practicals based on RJSPZOO101 |  |   |
| RJSPZOOP102     | 2       | Practicals based on RJSPZOO102 |  |   |
| RJSPZOOP103     | 2       | Practicals based on RJSPZOO103 |  |   |
| RJSPZOOP104     | 2       | Practicals based on RJSPZOO104 |  |   |

**SEMESTER –II**

| Theory<br>TOPIC |         |                                |   |
|-----------------|---------|--------------------------------|---|
| Course          | Credits | Unit                           | Phylogeny, Systematics of non-chordates and assorted topic-II               |
| RJSPZOO201      | 4       | I                              |   |
|                 |         | II                             | Phylogeny of Protochordates, Agnatha and assorted topics II                 |
|                 |         | III                            | Phylogeny, Systematics of Chordates & Assorted topics- II                   |
|                 |         | IV                             | Comparative Vertebrate Osteology- II  |
| RJSPZOO202      | 4       | I                              | Biomolecules- a structural and functional approach-II                       |
|                 |         | II                             | Enzymes and Enzyme kinetics   |
|                 |         | III                            | Metabolic pathways and Integration of metabolism                            |
|                 |         | IV                             | Regulation of metabolism and inborn errors of metabolism                    |
| RJSPZOO203      | 4       | I                              | Genetics- Chromosome theory of inheritance and Mendelism-II                 |
|                 |         | II                             | Genetics- Extension of Mendelian genetics and non-Mendelian inheritance -II |
|                 |         | III                            | Evolution-II  |
|                 |         | IV                             | Developmental Biology- II   |
| RJSPZOO204      | 4       | I                              | Principles and application of chromatography I                              |
|                 |         | II                             | Principles and application of chromatography II                             |
|                 |         | III                            | Principles and application of chromatography and Electrophoresis            |
|                 |         | IV                             | Good Laboratory Practices and Biosafety                                     |
| Practical       |         |                                |   |
| RJSPZOOP201     | 2       | Practicals based on RJSPZOO201 |   |
| RJSPZOOP202     | 2       | Practicals based on RJSPZOO202 |   |
| RJSPZOOP203     | 2       | Practicals based on RJSPZOO203 |   |
| RJSPZOOP204     | 2       | Practicals based on RJSPZOO204 |   |

**Semester I - THEORY**

**PAPER-I**

**COURSE CODE: RJSPZOO101:Non-chordates, chordates and their phylogeny-I**

**Unit I: Phylogeny, Systematics of non-chordates and assorted topics-I      15 Lectures**

- 1.1. Principles of systematic, importance of taxonomic studies in Biology, use of morphometric studies, Osteological studies, use of homologous organs.
- 1.2. Taxonomic keys: Different kinds of taxonomic keys, their merits and demerits.
- 1.3. Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla-
  - \*1.3.1 Porifera
  - 1.3.2 Coelenterata
  - 1.3.3 Ctenophora

**Unit II: Phylogeny, Systematics of non-chordates, Hemichordate & assorted topics    15 Lectures**

- 2.1. Phylogeny, salient features, classification (wherever applicable) up to classes of the following phyla-
  - 2.1.1 Mollusca
  - 2.1.2 Bryozoa
  - 2.1.3 Brachiopoda
  - 2.1.4 Echinodermata
  - 2.1.5 Chaetognatha
- 2.2 Systematic position and affinities of Hemichordata.
- 2.3 Assorted Topics:
  - \*2.3.1 Economic importance of Protozoa.
  - \*2.3.2. Mesenteries in Coelenterata.
  - \*2.3.3 Economic importance of Arthropoda.
  - 2.3.4 Sense organs in Arthropoda.
  - 2.3.5 Spines and Pedicellariae in Echinodermata.
  - \*2.3.6 Invertebrate larvae- larval forms of free living invertebrates, larval forms of parasites, Strategies and evolutionary significance of larval forms.

**Unit III: Phylogeny, Systematics of Chordates and Assorted topics- I**

**15 Lectures**

- 3.1. Discovery of Coelacanth.
- 3.2. Overview of fish phylogeny.
- 3.3. Primitive tetrapods- Labrynthodonts.
- 3.4. Crossopterigians- A blue print.
- 3.5. Dipnoi- a group that has failed to evolve as Amphibia.
- 3.6. Lissamphibia.
- \*3.7. Sphenodon- a living fossil.
- \*3.8. Extinct reptiles.
- \*3.9. Adaptive radiation in Reptilia.

**Unit IV: Comparative Vertebrate Osteology- I**

**15 Lectures**

- 4.1. Embryonic development of- a) neurocranium, b) splanchnocranium and c) dermatocranium.
- \*4.2. Comparative account of jaw suspension.
- \*4.3. Embryonic development of Vertebra.
- 4.4. Vertebral column of tetrapods- Atlas, Axis, Typical Vertebra, Thoracic vertebra, Trunk vertebra, Caudal vertebra of Dog fish and Bony fish, Frog, Varanus, Pigeon, and Rabbit.

**\* Topics for Assignments & Essays**

**Semester I- PAPER-II**

**COURSE CODE: RJSPZOO102: Biochemistry and metabolism-I**

**Unit I: Biomolecules- a structural and functional approach-I**

**15 Lectures**

**1.1. Concepts:**

- \*1.1.1 Biological Macromolecules.
- \*1.1.2 Polymerization and macromolecules.
- \*1.1.3 Central role of carbon.
- \*1.1.4 Common functional groups.
- \*1.1.5 Common ring structure and isomerization in biological molecules.

**1.2. Carbohydrates:**

- 1.2.1. Classification: mono-, oligo- and poly-saccharides.
  - 1. Monosaccharides- structure, classification, D- and L- isomers, Anomers and mutarotation, open chain and ring forms, pyranose and furanose forms, reactions of monosaccharides, glycosidic bonds and nomenclature.
  - 2. Oligosaccharides.
  - 3. Polysaccharides- homo- and hetero-polysaccharides.
- \*1.2.2. Biological functions of carbohydrates.

**1.3. Lipids:**

- 1.3.1 Classification: simple and complex lipids.
- \*1.3.2. Fatty acids- Even and odd carbon fatty acids, numbering the carbon atoms, saturated and unsaturated fatty acids, cis- and trans-configuration, nomenclature and short hand representation of fatty acids.
- 1.3.3. Acylglycerols- Mono-, di- and tri-glycerides, stereospecific numbering of glycerols in glycerides, properties of triacylglycerol.
- 1.3.4. Complex lipids- Phospholipids, Sphingolipids, Sterols and waxes, Amphipathic lipids: Membrane lipid bilayers.
- 1.3.5. Biological functions of lipids.

## **Unit II: Metabolism and Regulation**

**15 Lectures**

**2.1. Metabolism:** Concept; Catabolism; Anabolism, intermediary metabolism.

### **2.2 Application of Biochemical Thermodynamics to metabolism:**

2.2.1 Laws of thermodynamics, free energy, entropy, enthalpy, exergonic and endergonic reactions.

2.2.2 \*High energy compounds: ATP, ADP, ATP-ADP cycle, ATP-AMP ratio.

2.3 General concepts of metabolic regulation:

2.3.1 Control of metabolic flux, coupled reactions, Allosteric regulation,

2.4 **Biological oxidation:** Electron transport chain and mitochondria; Oxidative Phosphorylation-mechanism, uncoupling of oxidative phosphorylation and its significance.

2.5 Free radicals, antioxidants and antioxidant system.

## **Unit III Carbohydrate metabolism and regulation**

**15 Lectures**

**\*3.1. Glycolysis:** Reaction sequence, flow of carbon, conversion of pyruvate to lactate and Acetylcoenzyme-A, significance of pyruvate-lactate interconversion, aerobic and anaerobic glycolysis and energetic of glycolysis. Regulation of glycolysis.

**3.2. Gluconeogenesis:** Reaction sequence from pyruvate, gluconeogenesis from aminoacids, glycerol, propionate and lactate. Regulation of gluconeogenesis.

**\*3.3. Glycogen metabolism:** Pathway and regulation of Glycogenesis and Glycogenolysis.

**3.4. Significance of following pathways:** Hexose monophosphate shunt as a multifunctional pathway; \*Uronic Acid Pathway; Glyoxalate cycle.

**3.5 Metabolism in starvation.**

## **Unit IV Lipid and mineral metabolism and regulation**

**15 Lectures**

4.1. Dynamics of body lipids, mobilization of fats, regulation of hormone sensitive TG-lipase, fate of glycerol and free fattyacids.

4.2. Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acid, oxidation of unsaturated fattyacids, biosynthesis of fattyacids including desaturation, metabolism of phospholipids, cholesterol and \*alcohol. Formation and significance of Ketone bodies.

4.3 Mineral metabolism and regulation: Calcium metabolism

**\*Topics for Assignments and Essays**

**Semester-I PAPER-III**

**COURSE CODE: RJSPZOO103 : Genetics, Evolution and Developmental Biology-I**

**Unit I: Cell cycle and cytoplasmic inheritance.**

**15 Lectures**

**1.1. Cell cycle and its regulation**

- \*1.1.1. Concept of Cell cycle
- 1.1.2. Checkpoints of cell cycle
- 1.1.3. Regulation of cell cycle in yeast and mammalian cells
- 1.1.4. Disruption of cell-cycle in cancer

**1.2. Cytoplasmic Inheritance / Extra-nuclear Inheritance**

- 1.2.1 Salient feature of Cytoplasmic Inheritance
- \*1.2.2 Cytoplasmic Inheritance in animals.
- 1.2.3 Introduction – Human Mitochondrial Genetics
- 1.2.4 Paternal and Maternal mtDNA Inheritance in Humans
- 1.2.5 mtDNA mutations and Human diseases.

**Unit II: Genetics- Extension of Mendelian genetics and non-Mendelian inheritance -I**

**15 Lectures**

**2.1. Alleles and phenotypes:**

- 2.1.1. \*Incomplete or partial dominance and co-dominance
- 2.1.2. \*Epistasis
- 2.1.3. Complementation analysis
- 2.1.4. \*Multiple alleles
- 2.1.5. \*Lethal alleles (recessive and dominant lethal alleles)
- 2.1.6. Penetrance and expressivity

**2.2. Quantitative inheritance:**

- 2.2.1. Traits controlled by many loci
- 2.2.2. Location of polygenes
- 2.2.3. Heritability: measurement of heritability

**2.3. Linkage, crossing over and gene mapping:**

- 2.3.1. Chromosomal theory of linkage, lod score for linkage testing.
- 2.3.2. \*Mechanism and types of crossing over
- 2.3.3. Mapping in prokaryotes and bacterial viruses
- 2.3.4. Gene mapping in eukaryotes (three point cross)
- 2.3.5. Genetic mapping in humans-
  - A) Physical chromosome mapping: deletion mapping, somatic cell hybridization mapping, mapping by *in situ* hybridization; correspondence of genetic and physical maps.
  - B) Practical application of chromosome mapping- tracking the inheritance of an allele with coupled DNA markers.



**Unit III Evolution –I**

**15 Lectures**

**3.1 Evolution:**

3.1.1. \*Concept of evolution & theories of organic evolution (Lamarckism, Darwinism, DeVries mutation theory, Neo-Darwinism).

3.1.2 \*Evolution of horse

3.1.3. Human evolution

**3.2. Population and Evolutionary genetics:**

3.2.1 \*Gene pool

3.2.2 Calculating allelic frequencies

3.2.3. The Hardy-Weinberg equilibrium and mating systems (non-random mating, assortative mating, inbreeding, dis-assortative matings).

3.2.4 Adaptive radiation, isolating mechanisms, convergent divergent evolution and co- evolution.

**Unit IV Developmental Biology-I**

**15 Lectures**

4.1 Basic concepts of development, gametogenesis,

4.2 Fertilization: sperm aggregation, activation, chemotaxis, maturation and capacitation in mammals.

4.3 Acrosome reaction, sperm-egg interaction, egg activation and calcium release.

4.4 Electrical events and prevention of polyspermy, cortical reaction.

4.5 Cleavage: types, determinate and regulatory embryos, fate maps.

4.6 Nuclear transplantation experiment

4.7 Gastrulation.

**\*Topics for Assignments and Essays**

**Semester I - PAPER-IV**  
**COURSE CODE: RJSPZOO104-Tools and Techniques in Biology-I**

**Unit I : Microtomy, microscopy, centrifugation** **15Lectures**

- 1.1. Microtomy: Tissue fixation, dehydration, clearing, infiltration, embedding for paraffin method, sectioning, mounting, staining-differential and specific.
- 1.2. Principles and applications of microscopy: \*Light microscopy, phase contrast microscopy, Fluorescence microscopy, polarization microscopy, confocal scanning microscopy, transmission electron microscopy, specimen preparation for electron microscopy, scanning electron microscopy.
- \*1.3. Principles and applications of centrifugation: Basic principles of centrifugation, Low speed and high speed centrifuges, ultracentrifuge, application of centrifugation-preparative techniques, analytical measurements, care of centrifuges and rotors.

**Unit II: Radioisotopes and extraction techniques** **15 lectures**

- 2.1. Principles and applications of radioisotopes: \*Use of isotopes in biological sciences; units of radioactivity, detection and measurement of radioactivity by scintillation counting, autoradiography, preparation for the experiment, performing the experiment.
- 2.2 Principles and application of filtration, distillation and extraction: Ordinary filtration under suction pressure, fractional distillation, steam distillation, technique of extraction with solvents.

**Unit III Principles and application of Spectroscopy** **15 Lectures**

- \*3.1. Ultraviolet and visible absorption spectroscopy
3. 2. Fluorescence spectroscopy
- 3.3. Nuclear magnetic resonance spectroscopy
- 3..4. Mass spectroscopy
- 3..5. Atomic absorption spectrophotometer.

**Unit IV Research Methodology** **15 Lectures**

- 4.1. Research methodology: Meaning of research; objective of research; types of research; Research Process, Criteria for good research.
- 4.2. Research problem: Selecting research problem; necessity of defining a problem; techniques involved in defining the problem.
- 4.3. Research design: Important concepts related to research design.
- 4.4. Interpretation and report writing : Meaning of interpretation, technique of interpretation; layout of research report; types of reports; types of bibliography
- 4.5. Writing research proposal: Characteristics of a proposal; content and organization of a proposal.

**\*Topics for Assignments and Essays**

**Semester I- PRACTICAL RJSPZOO101**

1. **Study of systematic and major features of:**
  - a) Porifera (*Leucosolenia, Grantia, Euplectella, Euspongia*);
  - b) Coelenterata (*Obelia colony, Physalia, Porpita, Sea-anemone, Madrepora, Aurelia*);
  - c) Mollusca (*Chiton, Dentalium, Patella, Aplysia, Limnea/Achatina, Mytilus, Loligo/Octopus, Nautilus*);
  - d) Echinodermata (*Starfish, Brittlestar, Seachurchin, Seacucumber, Featherstar*);
  - e) Minor Phyla (*Comb jelly, Lingula, Sagitta*); Hemichordata (*Balanoglossus*).
2. **Study of accessory respiratory organs in:** *Anabas, Clarius, Sacchobranhus and Boleophthalmus*.
3. **Study of Larval forms:** Echinoderm larvae and Tornaria larva.
4. **Cephalochordata** (*Amphioxus*). Study of systematic and major features of:
  - a) **Agnatha** (*Petromyzon, Myxine*);
  - b) **Pisces** (*Shark, Stingray, Electricray, Hippocampus, Eel and any lung fish*);
  - c) **Amphibia** (*Caecilian, Salamander, Frog, Toad*);
  - d) **Reptilia** (*Turtle/Terrapin, Tortoise, Calotes/Chameleon, Draco, Phrynosoma, Viper, Rattlesnake, Hydrophis, Crocodile/Alligator/Gharial*)
5. Comparative Osteology: **Types of vertebrae** (Procoelous, Opisthocoelous, Amphicoelous, Heterocoelous)

**RJSPZOO102**

1. **Qualitative tests for carbohydrates** and identification of the nature of carbohydrates in the given sample:
  - i. Molisch's test;
  - ii. Anthrone test;
  - iii. Iodine test;
  - iv. Barfoed's test;
  - v. Seliwanoff's test;
  - vi. Fehling's test;
  - vii. Benedict's test;
  - viii. Picric acid test;
  - ix. Mucic acid test; and
  - x. Bial's test.
2. Determination of **glucose by Benedict's method** (volumetric).
3. Determination of **reducing sugars by 3,5-dinitrosalicylic acid** (colorimetric) method.
4. Determination of **glycogen** in the given tissue (liver/skeletal muscle/kidney/brain).
5. Acid and enzyme hydrolysis of **glycogen** and colorimetric estimation of the products by 3,5-DNSA method.
6. Isolation of starch from potato.
7. Determination of acid value of fats/oils.
8. Determination of saponification value of fats/oils.

**RJSPZOO103**

1. Temporary squash preparation of onion/garlic root tip cells to study stages of mitosis.
2. Temporary squash preparation of testis of cockroach/ grasshopper/ Tradescantia pollen to study stages of meiosis.
3. Demonstration of inter-chromosomal connections in the cells of Tradescantia buds.
4. Temporary preparation of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus.
5. Study of chromosome structures in human karyotype.
6. Study of different types of chromosome banding techniques.
7. Temporary preparation of buccal smear to study sex chromatin in human

**RJSPZOO104**

1. Identification of pictograms, symbols and signs of safety in laboratory practice.
2. Microtomy: Tissue preservation and fixation, dehydration, infiltration, paraffin embedding and block preparation, sectioning, staining.
3. Solutions and Buffers: Mode of expressing concentration of solutions- Molarity (M), Molality (M), normality (N), Mass concentration, mass fraction, mass percentage or % (w/w), % by volume (v/v), parts per million (ppm) with practical exercises. Types of solutions- Stock solutions practical exercises
4. Preparation of buffers of different pH using Henderson-Hasselbalch equation and its verification using pH meter.
5. Determination of pKa of weak acid.
6. Colorimeter: Selection of filter and determination of unknown concentration of solute.

**Semester II - THEORY**

**PAPER-I**

**COURSE CODE: RJSPZOO201: Non-chordates, chordates and their phylogeny - II**

**Unit I: Phylogeny, Systematics of non-chordates and assorted topic-II      15 Lectures**

- 1.1. Platyhelminthes and Nematelminthes
- 1.2. Acanthocephala
- \*1.3. Annelida
- \*1.4. Sipunculoidea
- 1.5. Arthropoda
- 1.6 Onychophora – Peripatus, A connecting link between Annelida and Arthropoda.

**Unit II: Phylogeny of Protochordates, Agnatha and assorted topics II      15 Lectures**

- \*2.1. Urochordata and its affinities.
- \*2.2. Cephalochordata and its affinities
- 2.3. Vertebrate ancestry and origin of Vertebrates.
- 2.4. Changes leading to first vertebrates.
- 2.5. Salient features and phylogeny of Ostracoderms.
- \*2.6. Affinities of Cyclostomes- a) resemblance with Cephalochordates.  
b) differences from fishes. c) vertebrate characters. d) specialized characters.

**Unit III: Phylogeny, Systematics of Chordates and Assorted topics- II**

- 3.1. Warm blooded reptiles.  
Archaeopteryx- a connecting link between Reptiles and Aves.
- 3.2. Affinities of Aves and classification up to subclass.
- 3.3. Origin of flight (theory of cursorial & arboreal origin).
- \*3.4. Birds as glorified reptiles.
- \*3.5. Egg laying mammals- connecting link between reptiles and mammals.
- \*3.6. Classification of mammals up to orders.
- \*3.7. Dentition in mammals.
- 3.8. Walking gait (Plantigrade, Digitigrade, and Unguligrade)

**Unit IV: Comparative Vertebrate Osteology- II**

- 4.1. Pectoral & Pelvic girdles of Dog fish, Bony fish, Frog, Varanus, Pigeon and Rabbit
- 4.2. Comparative anatomy of limbs of tetrapods.
- \*4.3. Mechanism of support and movements- Running, Jumping and Digging.

**PAPER-II**

**COURSE CODE: RJSPZOO202 : Biochemistry and Metabolism- II**

**Unit I: Biomolecules- a structural and functional approach-II**

**15 Lectures**

**1.1. Proteins as polymers of amino acids**

\*1.1.1. Amino acids: structure, classification based on structure, polarity, nutritional requirement and metabolic fate; properties of amino acids; derivatives of amino acids, non-transcribed amino acids as protein constituents, D-amino acids.

1.1.2. Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate proteins- haemoglobin, cytochromes, myoglobin; bonds involved in protein organization, Ramchandran plot.

1.1.3. Properties of proteins: classification, denaturation and protein folding.

**1.2. Nucleic acids: Types- RNA and DNA.**

1.2.1. Components: Pentose, Nitrogenous bases, Nucleosides.

1.2.2. Structure of DNA: \*Watson and Crick model; different forms of DNA double helix.

\*1.2.3. Structure, types and functions of RNA.

**1.3. Complex biomolecules**

1.3.1 \*Glycoproteins: Blood group substances

1.3.2 Glycolipids: Gangliosides.

1.3.3 Lipoproteins: Classification and functions- chilomicrons, VLDL, LDL, HDL, and free fatty acid-albumin complex.

**1.4. DNA & Protein sequencing techniques:**

1.4.1: DNA sequencing: Maxam-Gilbert method, Sanger's method.

Protein sequencing: Sanger's method.

1.4.2: Introduction to CRISPR , NGS sequencing techniques.

**Unit II: Enzymes and Enzyme kinetics**

**15 Lectures**

**2.1. Enzymes and Enzyme kinetics.**

\*2.1.1. Enzymes: Nomenclature and classification with numerical code; chemical nature of enzymes.

\*2.1.2. Mechanism of enzyme action: Fischer's Lock and Key Theory, Koshland's Induced fit model; Mechanism of enzyme catalysis.

2.1.3. Enzyme kinetics: Michaelis Menton equation; Lineweaver-Burk plot; significance of Vmax and Km; factors affecting enzyme activity; enzyme activation and inhibition.

2.1.4. Regulatory enzymes: a) covalently modulated, b) allosteric regulation, c) Isoenzymes (LDH, CK, ALP, ADH)

2.1.5. Non-protein enzymes- Ribozymes.

2.1.6. Advanced enzymes in human healthcare (e.g. fungal lactase, Hemicellulase, Trypsin chymotrypsin mix)

**Unit III: Metabolic pathways and Integration of metabolism**

**15 Lectures**

**3.1. Protein Metabolism:**

3.1.1. Metabolism of amino acids: Amino acid pool, transamination; oxidative and non-oxidative deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids.

\*3.1.2. Metabolism of ammonia: Urea cycle.

**3.2. Metabolism of nucleic acids:**

3.2.1 Synthesis of ribonucleotides- a brief idea of *de novo* pathway and salvation pathway.

\*3.2.2. Conversion of ribonucleotides to deoxyribonucleotides.

3.2.3. Degradation of nucleotides.

3.3. Integration of Metabolism, Energy demand and supply; Integration of major metabolic pathways of energy metabolism; intermediary metabolism; organ specialization and metabolic integration.

**Unit IV: Cell signalling and pathways**

**15 Lectures**

**4.1. Cell signalling**

Cell signaling Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, second messengers.

**4.2 Cell signalling pathways**

4.2.1 Signal transduction pathways,

4.2.2 Regulation of signaling pathways,

4.2.3 Bacterial and plant two-component systems,

4.2.4 Bacterial chemotaxis and quorum sensing.

**PAPER-III**

**COURSE CODE: RJSPZOO203: Genetics, Evolution and Developmental Biology -II**

**Unit I: Genetics- Chromosome theory of inheritance and Mendelism-II      15 Lectures**

**1.1. Mendelian genetics, probability and statistics**

1.1.1 Combining probabilities (sum rule and product rule)

1.1.2. Chi square test

**1.2. Modern concept of gene**

1.2.1. \* Difference between prokaryotic and eukaryotic gene structure

1.2.2. Properties of genes, gene-enzyme relationship

1.2.3. One gene-one enzyme hypothesis, one gene-one polypeptide concept.

1.2.4. Fine structure of gene, cistron, recon and muton

1.2.5. Split gene- exon and intron

1.2.6. Mobile genes and transposons

1.2.7. Pseudoalleles

**Unit II: Genetics- Extension of Mendelian genetics and non-Mendelian inheritance -II**

**15 Lectures**

**2.1. Determination of sex**

\*2.1.1. Environmental control of sex (*Bonellia*, *Crepidula*); temperature dependent sex determination (TSD) in reptiles.

2.1.2. Genic control of sex determination in Maize, *Caenorhabditis elegans*

\*2.1.3. XX-XO, XX-XY and ZZ-ZW method of sex determination

2.1.4. Genic balance theory of sex determination in *Drosophila*

2.1.5. Gynandromorphs in *Drosophila*

2.1.6. Haplodiploidy in honeybees

2.1.7. Sex chromatin, Lyon hypothesis, X inactivation

2.1.8. SRY and Dax genes

\*2.1.9. XX males and XY females in human.

**2.2. Non-Mendelian Inheritance:**

\*2.2.1. Maternal effects; Shell coiling in snails, pigmentation in moths

2.2.2. Cytoplasmic inheritance: Mitochondria, chloroplasts, plasmids, infective particles.

2.2.3. Microbial genetics: Transformation, conjugation, Transduction.



- \*3.1. Additive gene action and continuous variation
- 3.2. Heterosis and inbreeding depression: measuring inbreeding, the effects of inbreeding
- 3.3. Processes that change allelic frequencies: mutation, migration, natural selection, directional selection, stabilizing and disruptive selection, heterozygote advantage, balance between selection and mutation; genetic drift- random genetic drift.
- 3.4. Environmental variation: causes of environmental variation; genotype by environmental interaction
- 3.5. Broad sense heritability: a) Effect of dominance, epistasis and environmental variations on selection;  
b) Quantitative trait loci and DNA markers;  
c) Realized heritability.
- 3.6. Limits on selection

#### **Unit IV: Developmental Biology- II**

**15 Lectures**

- 4.1. Morphogenesis and organogenesis
- 4.2. Pattern formation in drosophila, amphibian and chick.
- 4.3. Organogenesis:
  - a. Vulva formation in C.elegans
  - b. Eye lens (any suitable example)
  - c. Limb development in chick.
- 4.4 Morphogenesis in insect and amphibians.
- 4.5 Regeneration in planaria, hydra and Urodels.

**Unit I Principles and application of chromatography I**

**15 Lectures**

- \*1.1 Planar chromatography (Paper and Thin layer): Preparation of stationary support, solvent, detection and measurement of components, applications.
- 1.2 Column chromatography: Packing and operation of column, loading the column, eluting the column, collection of effluent, detection of effluent, application.
- 1.3 Ion exchange chromatography: Ion exchange resins, selection of ion-exchanger, choice of buffers, preparation and use of ion-exchangers, storage of resins.

**Unit II: Principles and application of chromatography II**

**15 Lectures**

- 2.1. Gel chromatography: \*Theory of gel filtration; physical characteristics of gel chromatography, chemical properties of gel, selection of gel, gel preparation and storage, operation of gel column, application
- 2.2 Affinity chromatography: Chromatography media, immobilized ligands, attachment of ligands to the matrix, experimental procedures and application.

**Unit III Principles and application of GC,HPLC and Electrophoresis**

**15 Lectures**

**3.1. Gas and Liquid chromatography**

3.1.1 Gas chromatography(GC): Instrumentation, selection of operating conditions, analysis of data and application.

3.1.2 HPLC.

**3.2. Electrophoresis**

- \*3.2.1. Theory of electrophoresis
- \*3.2.2. Horizontal agarose gel electrophoresis
- \*3.2.3. Vertical polyacrylamide gel electrophoresis
- 3.2.4. Pulse field electrophoresis
- 3.2.5. Capillary electrophoresis
- 3.2.6. Isoelectric focusing of proteins
- 3.2.7. Two dimensional electrophoresis.

**Unit IV: Good Laboratory Practices and Biosafety**

**15 Lectures**

**4.1** Safety in laboratories, Use, care and maintenance of common laboratory equipments: Microscope , pH meter, Colorimeter/Spectrophotometer, analytical balance, centrifuge, electrophoresis apparatus, glassware.

**4.2** Biosafety: General safety measures, Personal protection, chemical hazards, spillage and waste disposal, first aid.

**4.3** Risk assessment.

**4.4** Biosafety levels 1-4

**\* Topics for Assignments & Essays**

**RJSPZOOP201**

1. Study of animal type\*: *Periplanata americana*: Morphology, digestive system, nervous system, reproductive system and life history. Mountings of- cornea, salivary glands, gonapophyses, spermatheca
3. Study of systematics and major features of: Helminthes (*Planaria*, Liverfluke, Tapeworm, *Ascaris*, *Trichinella*); Annelida (*Nereis*, Earthworm, Leech); Sipunculoidea: (*Sipunculus*), Arthropoda (Lobster, *Balanus*, Crab, *Lepas*, Scorpion, Spider, *Limulus*, Centipede, Millipede, Beetle). Urochordata (Simple Ascidian, *Salpa/ Doliolum*); Cephalochordata (*Amphioxus*).
4. Study of Larval forms: Larvae of Helminthes- Miracidium, Redia, Cercaria, Metacercaria; Trochophore, Crustacean larvae, Ascidian tadpole.
5. Study of systematics and major features of: Aves (Ostrich, Kiwi, Kite, Owl, and Duck); Mammals (Duck billed platypus, Echidna, Kangaroo, Shrew, Bat, Loris, Seal/ Walrus, Dolphin, Sea Cow, Tiger, Giant panda, Tapir, Camel, Striped squirrel, Guinea pig, Porcupine, Rabbit)
6. Comparative Osteology: Study of pectoral and pelvic girdles (Shark, Bony fish, Frog, Varanus, Pigeon, Rabbit); Study of comparative anatomy of tetrapod limbs (Frog, Varanus, Pigeon and Rabbit).

\*Demonstration practical/ Dissection/Virtual dissection/Model (2D or 3D)/Chart of animal system as per UGC guidelines.

**RJSPZOOP202**

1. Determination of total cholesterol and HDL cholesterol from serum.
2. Qualitative tests for amino acids and Proteins: Ninhydrin test; Xanthoproteic test; Millon's test; Biuret test.
3. Colorimetric estimation of protein by Peterson-Lowry method.
4. Quantitative estimation of amino acids using ninhydrin reagent.
5. Isolation of casein from milk.
6. Detection of conformation of BSA by viscosity measurement and effect of varying concentration of urea on viscosity of BSA.
7. Determination of creatinine in serum and urea.
8. SDH specific activity.

1. Problems in genetics.
2. Pedigree analysis.
3. Quantitative estimation of DNA in a suitable tissue by diphenyl amine method.
4. Quantitative estimation of RNA in a suitable tissue by orcinol method.
5. Observation of morphogenetic movements in chick embryo.
6. Isolation of limb bud and its chorioallantoic grafting.

**RJSPZOOP204**

1. Identification of lipids in a given sample by TLC.
2. Separation of pigments from leaves or flowers by adsorption column chromatography.
3. Separation of amino acids by ion exchange chromatography using cation exchanger.
4. Separation and identification of amino acids by 2D paper chromatography
5. SDS-polyacrylamide slab gel electrophoresis of proteins.

**RJSPZOO101 and RJSPZOO201**

- Vertebrate comparative anatomy, Function, Evolution, K.V. Kardong, 3<sup>rd</sup> Ed. Tata McGraw Hill Publication.
- Vertebrate Life: F.H.Pough, C.M.Janis, J.B.Heiser, 6<sup>th</sup> Ed. Pearson Education.
- Functional Anatomy of Vertebrates. An evolutionary perspective. K.F.Liem, W.E.Bemis, W, F.Walker, L.Grande, 3<sup>rd</sup> Ed. Harcourt College Publishers.
- The Life of Vertebrates: J.Z.Young, ELBS-Oxford Univ. Press.
- A Text Book of Zoology; T.J.Parkar and W.A.Haswell, McMillan.
- Chordate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company.
  - Biology of Invertebrates; J.A.Pechenik, 4<sup>th</sup> Ed, Tata McGraw Hill Publication.
  - Invertebrate Zoology; E.L.Jordan and P.S.Verma, S. Chand & Company.
  - Analysis of Vertebrate Structure: Milton Hildebrand, Wiley International
  - Life of Invertebrates; Russell, W.D. Hunter, McMillan
  - Invertebrate Zoology: Bares, R.D., Saunders Publication.

**RJSPZOO102 and RJSPZOO202**

- Biochemistry- 2<sup>nd</sup> Ed. 2002 by U. Satyanarayan, Books and Allied Publ.
- Biochemistry- 2<sup>nd</sup> Ed. S.C. Rastogi, Tata McGraw Hill.
- Fundamentals of Biochemistry- 3<sup>rd</sup> Ed. 1988; J.I.Jain, S. Chand and Co. Publ.
- Biochemistry- a Functional Approach; MacGuilver
- [www.enzymesIndia.com](http://www.enzymesIndia.com)

**RJSPZOO103 and RJSPZOO203**

- Genetics; Daniel J. Fairbanks and W.R. Anderson. Wadsworth Publ.
- Prin. Of Genetics; Robert H. Tamarin; 7<sup>th</sup> Ed. Tata McGraw Hill
- Basic Human Genetics; Elaine Johansen Mange and Arthur Mange; Indian Reprint; 1997; Rastogi Publ.
- Genes and Evolution: A.P. Jha; MacMillon India
- Concepts of Genetics; William S. Kluge;, M.R.Cummings, Pearson Edu.
- Developmental Biology; Scott F. Gilbert, Sinauer Associates Inc.
- Developmental Biology; T. Subramanian, Narosa Publ.

- 
- Biology of Developing System; Philip Grant; Holt Saunders International Ed.
  - Evolution; M. W. Strikberger, CBS Publ.
  - Cytology and Genetics; Sumitra Sen and Dipak Kumar Kar, Narosa Publ.
  - Instant Notes- Developmental Biology; R.M. Twyman, Bios. Scientific Pub. Ltd.

**RJSPZOO104 and RJSPZOO204**

- Modern Experimental Biochemistry; 3<sup>rd</sup> Ed. Rodney Boyer, Pearson Education.
- Principles and Techniques of Practical Biochemistry. Wilson and Walker, Cambridge Univ.Press.
- Biological Science; 3<sup>rd</sup> Ed. D.J.Taylor, N.P.O.Green, G.W.Stou, Cambridge Univ. Press
- Cell and Molecular Biology- Concepts and Experiments, Gerald Karp. John Wiley & Co.
- Introductory Practical Biochemistry; S.K.Swahney, Randhir Sing. Narosa Publ.
- An Introduction to Practical Biochemistry; 3<sup>rd</sup> Ed. David Plummer. Tata McGraw Hill
- Practical Research Planning and Design; 2<sup>nd</sup> Ed. Paul D. Leedy. Macmillan Publ.
- Elementary Practical Organic Chemistry Part I: Small Scale Preparations. 2<sup>nd</sup> Ed. Arthur I. Vogel. CBS Publ. and Distributors.
- Research Methodology. Methods and Techniques; C.R.Kothari. Wiley Eastern Ltd. Mumbai.
- Biosafety: WHO manual

**A) Internal Assessment- 40%**

**a) Theory**

| Sr. No. | Evaluation type          | Marks |
|---------|--------------------------|-------|
| 1.      | One Assignments/ Project | 20    |
| 2.      | Seminar & Presentation   | 20    |

**B) External examination- 60%**

**a) Semester End Theory Assessment- 60%**

**60 Marks**

- i) Duration – These examinations shall be of two hours duration for each paper.
- ii) Theory Question Paper Pattern:-
  - There shall be five questions each of 12 marks. On each unit there will be one question and the first one will be based on entire syllabus.
  - All questions shall be compulsory with internal choice within the questions. Each question will be of 18 to 20 marks with options.
- Question may be subdivided into sub-questions a, b, c... and the allocation of marks depend on the weightage of the topic.



**Semester I/Semester II EXAMINATION**

Maximum Marks: 60

Duration: 2 Hours

Marks Option: 90

Question 1: Unit I

Question 2: Unit II

Question 3: Unit III

Question 4: Unit IV

Question 5: Unit I to Unit IV (Mixed Questions)

Instructions:

- i. All questions are compulsory.
- ii. All questions carry equal marks.
- iii. Draw neat and labeled diagrams wherever necessary.

1. Answer any **two questions** from the following (Based on Unit I)
  - a. 06
  - b. 06
  - c. 06
2. Answer any **two questions** from the following (Based on Unit II)
  - a. 06
  - b. 06
  - c. 06
3. Answer any **two questions** from the following (Based on Unit III)
  - a. 06
  - b. 06
  - c. 06
4. Answer any **two questions** from the following (Based on Unit IV)
  - a. 06
  - b. 06
  - c. 06
5. Answer any **four questions** from the following (Based on entire syllabus)
  - a. 03
  - b. 03
  - c. 03
  - d. 03
  - e. 03
  - f. 03

**PRACTICAL EXAMINATION RJSPZOO101**

Total Marks: 50

- |  |           |    |
|--|-----------|----|
| 1. Identify, classify with reasons and describe the specimen/slide | A,B,C,D,E | 20 |
| 2. Identify and describe   | F,G,H.    | 12 |
| 3. Identify, sketch & label and describe the osteology specimen    | I,J .     | 08 |
| 4. Viva.   |           | 05 |
| 5. Journal.  |           | 05 |

- Candidates are required to present certified journal on the day of practical examination.

**PRACTICAL EXAMINATION RJSPZOOP102**

Total Marks: 50

1. Estimate the yield of glycogen from skeletal muscles / liver. Show the results to the examiners and submit a report. 20

Or

Demonstrate the enzymatic / acid hydrolysis of glycogen from the given sample. Show the results to the examiners and submit a report. 20

Or

Identify the nature of carbohydrates in the given sample using qualitative tests (6 tests). 20

2. From the given material isolate Starch and estimate the yield. Show the results to the examiners and submit a report. 20

Or

Estimate the amount of Glucose by Benedict's volumetric method. Show the results to the Examiners and submit a report. 20

Or

Determine the amount of reducing sugars from the given sample by DNSA method. Show the results to the examiners and submit a report. 20

Or

Determine the Saponification Value / Acid Value / Reichert-Meissl (RM) number of the given sample of lipid. Show the results to the examiners and submit a report. 20

3. Viva 05
4. Journal 05

- Candidates are required to present certified journal on the day of practical examination.

**PRACTICAL EXAMINATION RJSPZOOP103**

Total Marks: 50

1. Make a temporary squash preparation of testis of cockroach/ grasshopper/  
Tradescantia young anther to study stages of meiosis. 15  

Or

Make a temporary preparation of polytene chromosomes from salivary gland cells  
Of Drosophila/ Chironomus larva. 15
2. Make a temporary squash preparation of onion/garlic root tip cells to study stages  
of mitosis. 09  

Or

Make a temporary preparation of buccal smear to study sex chromatin in human. 09
3. a. Make a karyotype analysis from the given printed material and comment on the  
numerical or/and structural variations in the chromosomes. 08  
b. Identify and describe different types of chromosome banding techniques. 08
4. Viva 05
5. Journal 05

- Candidates are required to present certified journal on the day of practical examination.

**PRACTICAL EXAMINATION RJSPZOOP104**

Total Marks: 50

1. **Major Experiment:** 15
- Demonstrate the relationship between absorbance of light and the conc. of the dye in the solution using different wavelengths for five dilutions. Tabulate the readings. Plot the absorbance curves on the same graph paper and explain the choice of ideal filter from your results.
- Or**
- Determine the pKa of the given weak acid.
2. **Minor Experiment:** 13
- Using Henderson Hasselbalch equation calculate the  $p^H$  of buffer prepared by mixing known volume of either acid and or salt solutions. Check  $p^H$  using  $p^H$  meter.
- Or**
2. (a) Identify the pictograms/ signs/symbols 'a' and 'b' and comment on their significance in a scientific laboratory. 06
- And**
- (b) Prepare a solution of a given molarity/Normality 07
3. **Minor Experiment:** 12
- From the infiltrated tissue prepare blocks, trim and mount it on the holder for section cutting.
- Or**
- Trim the given block, mount it on the block holder, cut the sections and from ribbons prepare slides
- Or**
- Dewax the mounted ribbons and stain the sections with Hematoxylin/Eosin.
4. Viva 05
5. Journal 05
- ☛ Candidates are required to present certified journal on the day of practical examination.

**PRACTICAL EXAMINATION RJSPZOOP201**

Total Marks: 50

**M.Sc. ZOOLOGY Semester I**

**PRACTICAL EXAMINATION RJSPZOOP101**

Total Marks: 50

- |  |           |    |
|--|-----------|----|
| 1. Identify, classify with reasons and describe the specimen/slide | A,B,C,D,E | 20 |
| 2. Identify and describe   | F,G,H.    | 12 |
| 3. Identify, sketch & label and describe the osteology specimen    | I,J .     | 08 |
| 4. Viva.   |           | 05 |
| 5. Journal.  |           | 05 |

- Candidates are required to present certified journal on the day of practical examination.

**Semester II**

**PRACTICAL EXAMINATION RJSPZOO202**

Total Marks: 50

1. Estimate the protein content of the given tissue homogenate by Peterson-Lowry method  
Show the results to the examiners and submit the report. 20

**Or**

Estimate the amino acid content of the given sample by Ninhydrin reagent. Prepare a Standard graph.

**Or**

Demonstrate the effect of inhibitor on Succinic Dehydrogenase activity. Show the results to the examiners and submit a report.

**Or**

Demonstrate the effect of variation in Urea concentration on the conformation of Protein by viscosity measurements. Show the results to the examiners and submit a report.

**Or**

Estimate the concentration of Creatinine in the given serum / urine sample. Show the results to the examiners and submit a report.

2. Isolate Casein from the given sample of milk and determine its yield. Show the results to the examiners and submit a report. 20

**Or**

Determine Total / HDL Cholesterol from the given serum sample. Show the results to the examiners and submit a report. 20

**Or**

Detect the protein / amino acids in the given sample using qualitative tests (4 tests) 20

3. Viva 05

4. Journal 05

- Candidates are required to present certified journal on the day of practical examination.

**M.Sc. ZOOLOGY**

**Semester II**

**PRACTICAL EXAMINATION RJSPZOO203**

Total Marks: 50

- |  |    |
|--|----|
| 1. Extract and quantitatively estimate the amount of DNA/RNA from the given tissue homogenate.                     | 15 |
| 2. Demonstrate the morphogenetic movements in chick embryo and isolate Limb bud from the given chick embryo.       | 09 |
| Or   |    |
| Isolate limb bud from the given chick embryo and demonstrate chorioallantoic grafting from the given chick embryo. |    |
| 3. (i) Solve the given problem in Genetics.  | 08 |
| (ii) Solve the given problem related to Pedigree analysis.   | 08 |
| 4. Viva  | 05 |
| 5. Journal   | 05 |

\* Candidates are required to present certified journal on the day of practical examination.



**PRACTICAL EXAMINATION RJSPZOO204**

Total Marks: 50

1. Demonstrate the technique of two-dimensional paper chromatography to separate the amino acids. Calculate R<sub>f</sub> value. 20

**Or**

Demonstrate the use of adsorption column chromatography to separate the pigments from leaves or flowers.

**Or**

Demonstrate the technique of ion exchange column chromatography in the separation of amino acids using two buffers.

- 2 Identification of lipids in a given sample by TLC. 10

**and**

Demonstrate SDS-PAGE under reducing conditions for separation of Plasma/Proteins. 10

3. Viva 05  
4. Journal 05

- Candidates are required to present certified journal on the day of practical examination.