SIES College of Arts, Science & Commerce (Autonomous)

RISE WITH EDUCATION

NAAC REACCREDITED - 'A' GRADE

(***Affiliated to University of Mumbai***)

Faculty: Science

Program: M.Sc. - I

Subject: ZOOLOGY

Academic Year: 2023 – 2024

Revised Syllabus in Zoology under
Choice Based Credit System (CBCS)
Approved by the Board of Studies in Zoology
Effective from academic year 2023-24 under the aegis of
National Education Policy

Preamble

"Where the mind is without fear and the head is held high ...."

— A poem written by Nobel Laureate Rabindranath Tagore (Nobel Prize in Literature in 1913), the poem represents Tagore's vision of a new and awakened India (it is quoted in this preamble in the context of National Education Policy – New Education Policy).

The implementation of India's National Education Policy 2020, the first education policy of the 21st century, which aims to address the growing developmental imperatives of our country. Universal high-quality education is fundamental for achieving full human potential, besides developing an equitable and just society, and promoting national development. It is the best way forward for developing and maximizing our country's rich talents and resources which eventually will determine the future of our country. Therefore, in this context, our institution's 'Empowered Autonomous Status' becomes all the more relevant, in terms of our contribution as an educational institution to 'Achieving the full potential of every student'.

Under the aegis of academic autonomy, we have the privilege of 'academic freedom' to revise our curriculum, however, we are also aware of the fact that 'academic freedom' needs to be justified with 'academic excellence'. One of the ways to achieve this, is through fine-tuning the curriculum. As students at the postgraduate level would have a foundation of the basics of the subject, this syllabus also focuses on the need to furnish them with skills and understanding essential to make them self-sufficient and build a future. Thus, in addition to enable students to acquire an in depth knowledge of the Core/Mandatory subject, the current syllabus also attempts to integrate a few courses under Department Specific Elective and Research Methodology, which will help students to be equipped with the necessary skills to enhance their core competencies in understanding synergism of pure and applied sciences. Some of the key features of this revised syllabus are as follows:-

- ✓ *Industry Internship / Apprenticeship / On Job Training – A course requiring students to participate in a professional activity or work experience, with an entity external to the educational institution. Internships will involve working with local industry, government or private organizations, etc. to provide opportunities for students to actively engage in on-site experiential learning. Moreover, it will also strengthen academia-industry linkage and increase employability of students.*
- ✓ *Research Methodology – A course requiring students to inculcate research aptitude and to develop an open, inquiring mind that is willing to explore new territories and learn new things. It will also encourage the spirit of curiosity of students, who are not just learners but also potential problem solvers and scientific investigators in their own way. It will not only develop and enhance their research skills in order to make them adapt to the research culture, but also nurture critical thinking and develop analytical reasoning amongst students. Moreover, this course will serve as a stepping stone/foundation for execution of a Research Project in their final year.*
- ✓ *Phylogeny and Systematics, Genetics and Evolution – these concepts have been retained, since it gives the essence of classical zoology which will help students to recognize and appreciate that there are common threads that connect all living organisms.*
- ✓ *Biochemistry & Tools and Techniques in Biology – A course that has been restructured to understand the concepts in biochemistry by integrating it with tools and techniques in biology; it also includes principle, working & applications of instruments used in chromatography, spectroscopy, electrophoresis etc; moreover, it has the concept of Globally Harmonized System, Standard Operating Procedure and Calibration, so as to give the students exposure to Good Laboratory Practices and Hazard Communication, which will inculcate a professional and analytical approach towards Lab safety, Instrumentation and Techniques.*
- ✓ *Department Specific Elective in the form of Biotechnology and Gene manipulation – A course that has been redesigned with emphasis on Medical Biotechnology, Applications of Industrial and Agricultural Biotechnology, which will keep the students abreast with cutting edge technological applications in medicine, healthcare, agriculture, industry etc.*

This syllabus is a collective and constructive effort of the faculty, experts from research institutions, alumni and the board members whose valuable suggestions and expertise were instrumental in materializing this syllabus. The comments and recommendations of the contributors and reviewers have been carefully considered and implemented wherever feasible. For effective teaching-learning, teachers are advised not to follow the syllabus too rigidly, but to exercise their professional discretion and judgement in implementing it. After all teaching is about creating a conducive environment for learners to sustain enthusiasm about the subject. We sincerely hope that all stakeholders from faculty to learners exploring this course will appreciate the importance of a well-designed curricular framework in shaping educational outcomes.

In conclusion, we hope this syllabus will encourage and maximize learning among students to develop open, inquiring minds for holistic development, thereby justifying the essence and spirit of National Education Policy.

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Members of the Board of Studies in the subject of Zoology and Syllabus Committee

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- ✓ *Dr. Sasikumar Menon – Director, Institute for Advanced Training & Research in Interdisciplinary Sciences (IATRIS), (Therapeutic Drug Monitoring Lab), Sion, Mumbai; Faculty, Pharma Analytical Sciences, Ruia College, Mumbai (Subject Expert from outside college/Industry expert)*
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M.Sc. Part I-Zoology – Semester I (Syllabus Grid)

THEORY			
Course name and code	**Unit**	**Topic Headings**	**Credits**
SEMESTER I			
A) Major			
a) Mandatory Papers			
Paper I: Phylogeny & Systematics of Non-chordates, Developmental Biology and Genetics			
SIPZOCC111	1	Nonchordates-I	**4**
	2	Nonchordates-II and Hemichordates	
	3	Developmental biology - I	
	4	Genetics	
Paper II: Biochemistry and Tools & techniques in Biology			
SIPZOCC112	1	Biomolecules- A structural and functional approach	**4**
	2	Metabolic pathways and Integration of Metabolism	
	3	Principles and Applications of Microscopy	
	4	Principles and Applications of Spectroscopy	
Paper III: Biostatistics			
SIPZOCC113	1	Biostatistics- I	**2**
	2	Biostatistics- II	
b) Electives			
Paper IV: Biotechnology and Gene Manipulation			
SIPZOEL111	1	Large scale culture and production from recombinant microorganisms	**3**
	2	Medical Biotechnology	
	3	Genome Management and Analysis	
B) Research Methodology			
Paper V: Research Methodology			
SIPZORM111	1	Basic concepts in research, research methods and methodology	**3**
	2	Scientific research writing, research review and research ethics	
	3	Research grants, funding agencies and research projects	
PRACTICAL			
SIPZOCCP111	1	Based on Core course-1 (SIPZOCC111)	**2**
SIPZOCCP112	2	Based on Core course-2 (SIPZOCC112)	**2**
SIPZOELP111	3	Based on DSE (SIPZOEL111)	**1**
SIPZORMP111	4	Based on RM (SIPZORM111)	**1**
		Total	**22**

M.Sc. Part I – Zoology – Semester II (Syllabus Grid)

THEORY			
Course name and code	**Unit**	**Topic Headings**	**Credits**
SEMESTER II			
A) Major			
a) Mandatory Papers			
Paper I: Phylogeny & Systematics of Chordates, Developmental Biology and Evolution			
SIPZOCC121	1	Protochordates and Chordates-I	**4**
	2	Chordates-II	
	3	Developmental Biology- II	
	4	Evolution	
Paper II: Biochemistry and Tools & techniques in Biology			
SIPZOCC122	1	Metabolic pathways and Integration of Metabolism	**4**
	2	Enzyme and Enzyme Kinetics	
	3	Principles and Applications of Chromatography	
	4	Principles and Applications of Electrophoresis	
Paper III: Bioinformatics			
SIPZOCC123	1	Bioinformatics- I	**2**
	2	Bioinformatics- II	
b) Electives			
Paper IV: Biotechnology and Gene manipulation			
SIPZOEL121	1	Microbial synthesis of commercial products	**3**
	2	Enzyme technology in large scale production	
	3	Environmental biotechnology	
B) On Job training or Field project			
Paper V:			
SIPZOOJ121	1	**No Theory Paper**	**-**
PRACTICAL			
SIPZOCCP121	1	Based on Core course-1 (SIPZOCC121)	**2**
SIPZOCCP122	2	Based on Core course-2 (SIPZOCC122)	**2**
SIPZOELP121	3	Based on DSE (SIPZOEL121)	**1**
SIPZOOJP121	4	Based on OJ (SIPZOOJ12)	**4**
		Total	**22**

Semester I – Theory

A) Major

a) Mandatory Papers

Paper Code: SIPZOCC111

Core course-1: Phylogeny of Non-chordates, Developmental Biology and Genetics

Learning objectives:

- *To attempt to gain an insight of the hierarchy of life forms from the simplest to the most complex ones by a study of the levels of organization in animal kingdom. Also, to know the different modifications the animal life has made for its survival, through phylogenetic and taxonomic studies.*
- *To study Developmental Biology to appreciate how embryonic cells interact ultimately to form the entire organism.*
- *To uncover the rules governing the transmission of genetic traits and the relation between genes and chromosomes, through the study of classical genetics and its extension.*

Unit 1: Nonchordates **15 Lectures**

1.1: Principles of Systematics, importance of taxonomic studies in Biology, use of morphometric studies, osteological studies, use of homologous organs

1.2: Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla:

1.2.1: Protista (Protozoa)

1.2.2: Porifera

1.2.3: Coelenterata

1.2.4: Ctenophora

1.2.5: Platyhelminthes and Nemathelminths

1.2.6: Acanthocephala

1.2.7: Annelida

1.2.8: Sipunculoidea

Unit 2: Nonchordates and Hemichordata **15 Lectures**

2.1.: Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla:

2.1.1: Arthropoda

2.1.2: Onychophora: Peripatus, a connecting link between Annelida and Arthropoda

2.1.3: Mollusca

2.1.4: Bryozoa

2.1.5: Brachiopoda

2.1.6: Echinodermata

2.1.7: Chaetognatha

2.2.: Systematic position and affinities of Hemichordata

Unit 3: **Developmental Biology** **15 Lectures**

3.1: Basic concepts in Developmental Biology

3.1.1: Cell fate and commitment

3.1.2: Mechanism of developmental commitment

3.1.3: Mosaic and regulative development

3.1.4: Pattern formation and compartments

3.1.5: Morphogenesis and cell adhesion:

a) Differential cell affinity

b) Cadherins and Catenins

c) Sorting out of embryonic tissues and cell recognition

3.2: Cell differentiation and Totipotency

3.2.1: Nucleocytoplasmic interaction

3.2.2: Mechanism of gene action during cell differentiation

3.2.3: Factors affecting cellular differentiation

3.2.4: Maintenance of differentiation

3.3: Stem cells.

3.3.1: Types of stem cells and their function in development

3.3.2: Stem cells and their role in cancer biology.

3.3.3: Ethical issues related to stem cells**.**

Unit 4: Genetics **15 Lectures**

4.1: Organization of Genetic material

4.1.1: Structure of chromosomes

4.1.2: Chromosome number, shape and types

4.1.3: Variations in chromosome structure and chromosome number

4.2: Principles of Mendelian Genetics

4.2.1: Mendel's laws

4.2.2: Incomplete or partial dominance and co-dominance

4.2.3: Epistasis

4.2.4: Multiple alleles

4.2.5: Lethal alleles (recessive and dominant)

4.2.6: Polygenic inheritance

4.3: Linkage & crossing over

4.3.1: Chromosomal theory of linkage

4.3.2: Mechanism and types of crossing over

4.4: Non-Mendelian Inheritance

4.4.1: Maternal effects; Shell coiling in snails, pigmentation in moths

4.4.2: Cytoplasmic inheritance: Mitochondria, chloroplasts, plasmids, infective particles

Paper Code: SIPZOCC112

Core course-2: Biochemistry and Tools & techniques in Biology

Learning objectives:

- *To go into the details of biomolecules which form the chemical basis of life.*
- *To study in detail the chemical processes that occur in living organisms that maintain life and the modes to regulate them.*
- *To deal with the tools and techniques in Biology that has helped enhance our understanding of the various aspects of Biology.*

Unit 1: Biomolecules - A structural and functional approach **15 Lectures**

1.1: Carbohydrates

1.1.1: Classification: Monosaccharides, oligosaccharides and polysaccharides

a) Monosaccharides: Structure, classification, D- and L-isomers, anomers and mutarotation, pyranose and furanose forms, reactions of monosaccharides, glycosidic bond and nomenclature.

b) Oligosaccharides

c) Polysaccharides: Homopolysaccharides and heteropolysaccharides

1.2.2: Biological functions of carbohydrates

1.2: Lipids

1.2.1: Classification: Simple and complex lipids

1.2.2: Fatty acids: Even and odd carbon fatty acids, numbering the carbon atoms, saturated and unsaturated fatty acids, cis- and trans-configuration, nomenclature.

1.2.3: Acylglycerols: Monoglycerides, diglycerides and triglycerides. Properties of triacylglycerols

1.3.4: Complex lipids: Phospholipids, sphingolipids, sterols and waxes

1.3.5: Biological functions of lipids

1.3: Proteins

1.3.1: Amino acids: Structure, classification

1.3.2: Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure;

1.3.3: Conjugate proteins: Haemoglobin, cytochromes, myoglobin; bonds involved in protein organization

1.3.4: Biological functions of proteins: Biologically important peptides: Glutathione, octa-, nona-, and deca-peptides

1.4: Nucleic acids (RNA and DNA)

1.4.1: Components: Pentose, nitrogenous bases, nucleosides, tautomeric forms of purines and pyrimidines

1.4.2: Structure of DNA: Watson and Crick model; different forms of DNA double helix

1.4.3: Structure, types and functions of RNA

1.5: Complex biomolecules

1.5.1: Glycoproteins: Blood group substances

1.5.2. Glycolipids: Gangliosides

1.5.3: Lipoproteins: Classification and functions – Chylomicrons, VLDL, LDL, HDL and free fatty acid-albumin complex

Unit 2: Metabolic Pathways and Integration of metabolism **15 Lectures**

2.1: Carbohydrate metabolism

2.1.1: Glycolysis: Reaction sequence, aerobic and anaerobic glycolysis, energetics of glycolysis. Regulation of glycolysis

2.1.2: Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids and glycerol. Regulation of gluconeogenesis

2.1.3: Glycogen metabolism: Glycogenesis, Glycogenolysis; regulation of the two pathways

2.1.4: Significance of the following pathways: Hexose monophosphate shunt as a multifunctional pathway

2.1.5: Inborn errors of metabolism in carbohydrate metabolism: Glycogen storage disease, G-6-PD deficiency

2.2: Lipid Metabolism

2.2.1: Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acids, oxidation of unsaturated fatty acids, biosynthesis of fatty acids including desaturation; metabolism of phospholipids, cholesterol and *alcohol

2.2.2: Inborn errors of metabolism in lipid metabolism: Metabolic disorders of cerebrosides

Unit 3: Principles and Applications of Microscopy, Microtomy techniques **15 Lectures**

3.1: Microscopy:

3.1.1: Light microscopy, phase contrast microscopy, fluorescence microscopy, polarization microscopy, confocal scanning microscopy; standard operating procedure and calibration, use, care/maintenance of microscopes

3.1.2: Transmission electron microscopy, scanning electron microscopy, Preparation of standard operating procedure and calibration, use, care/maintenance

3.2: Microtomy: Tissue fixation, dehydration, clearing, infiltration, embedding for paraffin method, sectioning, mounting, and staining: differential and specific; standard operating procedure and calibration, use, care/maintenance of microtome

Unit 4: Principles and Applications of Spectroscopy **15 Lectures**

4.1: Ultraviolet and visible absorption spectroscopy; standard operating procedure and calibration, use, care/maintenance of colorimeter/spectrophotometer

4.2: Fluorescence spectroscopy

4.3: Nuclear magnetic resonance spectroscopy

4.4: Mass spectroscopy

4.5: Atomic absorption spectrophotometer

Paper Code: SIPZOCC113

Core course-3: Biostatistics

Learning objectives:

- *To get acquainted with various statistical techniques applied in biosciences.*
- *To get familiarized with several different tools used to analyse statistical data.*

Unit 1: Biostatistics- I **15 Lectures**

1.1: Basic concepts of sample statistics -Mean, Median, Mode, and Standard Deviation.

1.2: Concept of sample size and power

1.3: Concept of randomization and sampling techniques

1.4: Concept of significance and confidence limits

1.5: Introduction to Various statistical tests - parametric and non-parametric

1.6: Use of Statistical Packages for Data evaluation

1.7: Concept of level of significance, power of test and confidence limits

1.8: Application of normal distribution

Unit 2: Biostatistics- II **15 Lectures**

2.1: Statistical approach to biological samples

2.2: Introduction to Data collection techniques

2.3: Design of experiments, for e.g. Block designs, Latin square

2.4: COV and ANOVA (one way ANOVA and two way ANOVA)

2.5: Concept of correlation, coefficient of correlation and its calculation by using Pearson's coefficient of correlation

2.6: Regression analysis with application to Standard Graph

2.7: Student's t test, chi square test, z test and f test

a) Electives

Paper Code: SIPZOEL111

DSE: Biotechnology and Gene manipulation- I

Learning objectives:

- *To keep abreast with the current trends in this fast-moving field of Biotechnology, that is an intersection of technology and Biology.*
- *To gain an in-depth knowledge of the application of recombinant DNA technology in food, microbial technology and for the production of genetically engineered animal cells to obtain commercial products for human use.*
- *To emphasize the significance of Biotechnology in the field of medicine for production of therapeutic agents viz., vaccines and monoclonal antibodies that have revolutionized medical science.*

Unit 1: Large scale culture and production from recombinant microorganisms **15 Lectures**

1.1: Batch fermentation

1.2: Fed batch fermentation

1.3: Continuous fermentation

1.4: Maximizing the efficiency of fermentation process

1.5: Harvesting, disrupting and downstream processing

1.6: Basic Design of bioreactors and its types

1.7: Mammalian cell lines and their characteristics

1.8: Media for the cultivation of mammalian cells

1.9: Commercial products produced with mammalian cell culture

Unit 2: Medical Biotechnology **15 Lectures**

2.1: Subunit vaccines:

2.1.1: Subunit vaccine production against viruses: Herpes simplex, Bovine foot and mouth disease virus

2.1.2: Peptide vaccines: Synthetic drugs (engineered proteins)

2.1.3: Genetic immunization: DNA vaccines, Antisense DNA, Therapeutic ribozymes

2.1.4: Live recombinant vaccines

2.1.5: Attenuated vaccines against Cholera, Salmonella sp.

2.1.6: Vector vaccines: Vaccine directed against viruses – Rabies virus G-protein, Hepatitis B surface antigen.

2.1.7: Anti-idiotypic vaccine for cancer treatment.

2.1.8: Recent development in vaccine development w.r.t. Covid19

2.2: Monoclonal antibodies (mAbs) and therapeutic applications:

2.2.1: mAbs for prevention of rejection of transplanted organs

2.2.2: Treatment of bacterial blood infection

2.2.3: Human monoclonal antibodies

2.2.4: Hybrid human-mouse monoclonal antibodies

2.2.5: HIV therapeutic agents

2.2.6: Anti-tumour antibodies

Unit 3: Genome Management and Analysis **15 Lectures**

3.1: The basic tools of genetic engineering:

3.1.1: Cloning vectors: General purpose plasmid vectors: pUC19, pBR322, Bacteriophage and cosmid vectors.

3.1.2: Yeast artificial chromosomes (YACs) as vectors

3.2: Gene transfer techniques:

3.2.1: Calcium phosphate co-precipitation, electroporation.

3.2.2: Liposome mediated, crispr- cas9

3.2.3: Gene gun or Biolistic approach, Protoplast fusion, viral mediated gene transfer techniques.

3.3: Analysis of Genome:

3.3.1 DNA fingerprinting

3.3.2: Immunological assays: Western blot, ELISA

3.3.3: Polymerase chain reaction and its Variants (RT-PCR, qPCR)

3.3.4: Chemical synthesis of DNA: Oligonucleotide synthesis by Phosphoramidite method.

A) Research Methodology

Paper Code: SIPZORM111

RM: Research Methodology

Learning objectives:

- *To inculcate in students research aptitude and to develop an open, inquiring mind that is willing to explore new territories and learn new things.*
- *To encourage the spirit of curiosity of students, in order to develop the potential to be problem solvers and scientific investigators in their own way.*
- *To develop and enhance their research skills in order to make them adapt to the research culture*
- *To nurture critical thinking and develop analytical reasoning amongst students*
- *To equip students with essential concepts and necessary skills for execution of a research project in eir final year.*

Unit 1: Basic concepts in research, research methods and methodology **15 Lectures**

Basic concepts in research - meaning of research, objectives of research, characteristics and purposes of research, significance and relevance of research

Research process or the process of Science – Scientific inquiry, Steps of scientific inquiry or flow diagram for the scientific method, Observation, Developing and Testing Hypothesis, Inductive reasoning, Predictions & Experiments, Deductive reasoning, Presenting & Analyzing the data, Scientific theory, Example / Case study of the Scientific method, Example / Case study of Hypothesis testing.

Types of research – fundamental research, applied research, translational research, etc and comparison of types of research – descriptive versus analytical, fundamental versus applied, qualitative versus quantitative, conceptual versus empirical; research methods versus research methodology.

Research problem – meaning and statement of research problem, formulating research problem, identification and selection of research problem, techniques involved in defining a research problem, types of variables (experimental and control groups etc)

Research design – meaning of research design, nature and importance of research design, concepts related to research design, types of research design, experimental designs for examples – informal experimental design, formal experimental design etc.

Methods of data collection, data presentation and data analysis – types of data (primary and secondary data), data collection methods (primary and secondary), tabulation and presentation of data, Hypothesis testing – overview of parametric test, non-parametric tests (chi-square test, analysis of variance, non-parametric tests), overview of multivariate analysis techniques (correlation analysis, regression analysis).

Unit 2: Scientific research writing, research review and research ethics **15 Lectures**

Report writing – meaning of report, meaning of research report and report writing, different steps in report writing, characteristic of report, significance of report

Scientific research writing – writing a research article/paper/manuscript, types of research articles, writing an abstract, types of abstracts, selection of key words, citing references/bibliography (Harvard style, Numeric style, APA style, end note/foot note), overview of science communication organisations/companies or forums, opportunities as professional writers (examples such as Cactus

Communications, India BioScience Newsletter etc).

Literature review – Introduction to literature review, steps in writing a literature review, relevance of literature review, primary research article/original research article, secondary research article/review article.

Research review and journals – critique and review of research paper/manuscript, overview of types of research journals and publications (examples of peer-reviewed, open access journals) relevance of impact factor, h-index, citations, overview of ResearchGate (professional network for researchers and scientists)

Model organisms in research and guidelines – Concept of model organisms, recommended laboratory animal models, Purpose bred species, Animal study design/preclinical trials, Organization for Economic Cooperation and Development (OECD) guidelines, Committee for Control and Supervision of Experiments on Animals (CCSEA) guidelines, Alternative to animal models.

Research ethics – Avoiding plagiarism, Awareness of misconduct or fraud, Acknowledgement / Declaration of conflict of interest; Plagiarism checker software (Examples – Turnitin, Urkund etc); Overview of composition and responsibilities of Institutional Animal Ethics Committee (IAEC), Overview of composition and responsibilities of Institutional Ethics Committee (IEC), Overview of Indian Council of Medical Research guidelines (ICMR) for Biomedical research, Overview of International Conference on Harmonization – Good Clinical Practices (ICH-GCP) guidelines.

Unit 3: Research grants, funding agencies and research projects **15 Lectures**

Research grants/funds – concept of getting research grants or funds or research projects.

Research projects – writing a research proposal / project; components of research proposal/project; major/minor research projects (University Grants Commission, University of Mumbai etc), components of research grants (for example - consumables, contingency grants, utilization certificate etc)

Funding agencies in India – overview of government and nongovernment funding agencies in India (Examples such as Department of Science & Technology; Department of Biotechnology; Indian Council of Medical Research; Council of Scientific & Industrial Research; Department of Ayurveda, Yoga & Naturopathy, Unani, Siddha & Homeopathy; Indian National Science Association; etc);

Research fellowships in India – concept of research fellowship, research fellows – junior research fellow, senior research fellow, research associate etc; Examples of fellowships – Prime Ministers Research Fellowship, ICMR JRF, CSIR-UGC JRF, DBT-JRF, TATA Innovation Fellowships, DST- INSPIRE, DBT- Ramanjugan fellowships etc.

Global funding agencies/Research fellowships worldwide – overview of international funding agencies, how to apply to global funding agencies, examples such as Fulbright Program, United States India Educational Foundation (USIEF), British Council Fellowship, Humbolt Research Fellowship etc.

Semester I

Practical – I (SIPZOCCP111)

Based on Core course-1 (SIPZOCC111)

1**.** Study of Animal type**:**

Earthworm: Morphology, Digestive system, nervous system; mounting of setae, spermatheca, ovaries & nephridia

2. Study of Systematics and major features of:

a) Protozoa: *Amoeba, Euglena, Paramoecium, Plasmodium*

b) Porifera: *Leucosolenia, Euplectella, Euspongia*

c) Coelenterata/ Cnidaria: Sea anemone, Madrepora, *Aurelia*

a) Helminthes: *Planaria*, Liverfluke, Tapeworm, *Ascaris*.

b) Annelida: Nereis, Earthworm, Leech

c) Arthropoda: Crab, Scorpion, Limulus, Centipede, Millipede, Beetle

d) Mollusca: *Chiton*, *Dentalium*, *Patella*, *Achatina*, *Mytilus*, Octopus,

e) Echinodermata: Starfish, Brittle star, Sea urchin, Sea cucumber, Feather star

f) Hemichordata: *Balanoglossus*

g) Study of larval forms:

Larvae of Helminthes (Miracidium, Redia, Cercaria, Metacercaria); Trochophore larva; Crustacean larvae; Ascidian tadpole, Echinoderm larvae and Tornaria larva

3. Temporary preparation of onion/ garlic root tip cells to study stages of mitosis and calculate mitotic index

4. Study of mouth parts of cockroach and study of salivary glands of cockroach

5. Study of polytene chromosomes from salivary gland cells of Drosophila/ Chironomus larva

6. Temporary preparation of buccal smear to study sex chromatin in human

7. Culture and maintenance of Fruit fly

8. Determination of sex in drosophila (morphological examination)

Practical – II (SIPZOCCP112)
Based on Core course-2 (SIPZOCC112)

1) Qualitative tests for carbohydrates and identification of the nature of carbohydrates in the given sample: Molisch's test, Anthrone test, Iodine test, Barfoed's test, Seliwanoff's test, Fehling's test,

Benedict's test, Picric acid test, Mucic acid test, and Bial's test

2) Determination of reducing sugars by 3,5-dinitrosalicylic acid (colorimetric) method

3) Estimation of glycogen in the given tissue (liver/ skeletal muscle/ kidney/ brain)

4) Acid and enzyme hydrolysis of glycogen and colorimetric estimation of the products by 3,5-DNSA method

5) Determination of acid value of fats/ oils

6) Determination of saponification value of fats/ oils

7) Reichert-Meissl (RM) number of fat

8) Study of Good Laboratory Practices (GLP): Globally Harmonized System (GHS), Application and relevance of GHS (Physical Hazards, GHS Health and Environmental Hazards); GHS for classification and labelling of chemicals, chemical hazards/pictograms, symbols, signal words, hazard statements; GHS Safety Data Sheet (SDS)/Material Safety Data Sheet (MSDS); Chemical spillage/disposal, Fire safety and extinguishers.

9) Microtomy: Tissue preservation and fixation, dehydration, infiltration, paraffin embedding and block preparation, sectioning, staining

10) Determination of pKa of a weak acid

11) Colorimeter: Selection of filter and determination of unknown concentration of solute

Note: There are no practical's based on Paper 3 (Biostatistics)

Practical – IV (SIPZOELP111)
Based on DSE (SIPZOEL111)

1) Demonstration of aseptic technique: Work place for aseptic handling; packing glassware (flasks, test tubes, pipettes, petri dishes) for sterilization; aseptic transfer of liquids (Pipetting from flask to test tube).

2) Preparation of LB agar plate, slant, butt and demonstration of streaking technique using bacterial culture to obtain isolated colonies.

3) Determination of viable cell count in the given culture of bacteria by dilution and spreading technique.

4) Isolation of genomic DNA from the given strain of bacteria/ tissue and show the purity of the isolate by performing agarose gel electrophoresis.

5) To estimate the number of bacteria in the given culture by Nephelometry

Practical – V (SIPZORMP111)
Based on RM (SIPZORM111)

Practical's based on Research Methodology

1) Student will be provided with a sample research paper, whereby, the title, abstract, key words will be masked, and the student will be required to frame a title for that research paper, choose key words and write an abstract for the sample research paper.
2) Then, the student will be given the same sample research paper, however, now it will be unmasked and the student will be asked to compare the accuracy of their title, key words, and abstract with the sample research paper.
3) Students will be provided with a sample research paper, and the students will prepare a poster on a chart paper, for poster presentation of that research work. The poster must include the following: introduction, objectives, materials and methods, observation, results, conclusion and discussion, relevance/impact, bibliography.
4) Students will be provided with a sample research paper, and the students will prepare a power point presentation, for presentation of that research work. The presentation must include the following: introduction, objectives, materials and methods, observation, results, conclusion and discussion, relevance/impact bibliography.
5) Students will be provided with a sample research paper, and the students will write a review for that research paper. The review must include the following: overview of the research paper, advantages or impact of research paper, limitations or shortcomings of the research paper, future plan or extension of the research work.
6) Students will be given a research topic, and the students will write a research proposal, giving outline/scheme for execution of the proposed research work. The outline/scheme of the proposed research work must include: literature review, objectives, purpose and rationale, materials and methodology, results, conclusion and discussion, bibliography.

Semester II – Theory

A) Major

a) Mandatory Papers

Paper Code: SIPZOCC121

Core course-1: Phylogeny & Systematics of Chordates, Developmental Biology and Evolution

Learning objectives:

- *To attempt to gain an insight of the hierarchy of life forms from the simplest to the most complex ones by a study of the levels of organization in animal kingdom. Also, to know the different modifications the animal life has made for its survival, through phylogenetic and taxonomic studies.*
- *To understand the evolutionary processes that have helped shape life on earth through a study of organic evolution; also, to understand the evolutionary path our ancestors walked to attain to this present-day Homo sapiens species.*

Unit 1: Protochordates and Chordates-I **15 Lectures**

1.1: Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla

1.1.1: Urochordata and its affinities

1.1.2: Cephalochordata and its affinities

1.1.3: Salient features and phylogeny of Ostracoderms

1.1.4: Affinities of Cyclostomes:

1.1.5: Overview of fish phylogeny

1.1.6: Primitive tetrapods: Labyrinthodonts

1.1.7: Crossopterigians: A blue print

1.1.8: Dipnoi: A group that has failed to evolve as Amphibia

1.1.9: Lissamphibia

Unit 2: Chordates-II **15 Lectures**

2.1: Phylogeny, salient features, classification up to classes (wherever applicable) of the following phyla

2.1.1: *Sphenodon*: a living fossil

2.1.2: Extinct reptiles

2.1.3: Adaptive radiation in Reptilia

2.1.4: Warm blooded reptiles; Archaeopteryx: A connecting link between Reptiles and Aves

2.1.5: Affinities of Aves and classification up to subclass

2.1.6: Birds as glorified reptiles

2.1.7: Egg laying mammals: A connecting link between reptiles and mammals

2.1.8: Classification of mammals up to orders

2.1.9: Walking gait: Plantigrade, Digitigrade and Unguligrade

Unit 3: Developmental Biology **15 Lectures**

3.1: Cell specialization: RBC, secretory cell, retinal rod cell

3.2: Organizer and its role in embryonic development

3.3: Primary embryonic induction

3.4: Metamorphosis, Regeneration and Aging:

3.4.1: Metamorphosis:

a) Progressive metamorphosis: Amphibian metamorphosis

b) Metamorphosis in insects – Types of insect metamorphosis; eversion and differentiation of imaginal discs; hormonal control of insect metamorphosis.

c) Retrogressive metamorphosis: Ascidian.

d) Programmed cell death

3.4.2: Regeneration: Regeneration in Hydra; regeneration of salamander limbs

3.4.3: Aging: Senescence, life span and causes of aging

Unit 4: Evolution **15 Lectures**

4.1: Concept of evolution and theories of evolution: Lamarckism, Darwinism, De Vries Mutation theory, Neo-Darwinism and other significant theories.

4.2: Geological time scale

4.3: Human evolution

4.4: Population and Evolutionary genetics

4.4.1: Gene pool, speciation

4.4.2: Calculating allelic frequencies

4.4.3: The Hardy-Weinberg equilibrium and mating systems (non-random mating, assortative mating, inbreeding, dis-assortative mating)

4.4.4: 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

Paper Code: SIPZOCC122

Core course-2: Biochemistry and Tools & techniques in Biology

Learning objectives:

- *To study in detail the chemical processes that occur in living organisms that maintain life and the modes to regulate them.*
- *To study enzymes, the catalysts found in living organisms.*
- *To learn about the inadequacies of the metabolic machinery due to defects at the genetic level.*

Unit 1: Metabolic pathways and integration of metabolism **15 lectures**

1.1: Protein Metabolism

1.1.1: 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

1.1.2: Metabolism of ammonia: Urea cycle

1.2: Metabolism of Nucleic acids

1.2.1: Synthesis of ribonucleotides: A brief idea of de novo pathway and salvation pathway

1.2.2. Conversion of ribonucleotides to deoxyribonucleotides

1.2.3: Degradation of nucleotides

1.3: Integration of Metabolism

1.3.1: Energy demand and supply; integration of major metabolic pathways of energy metabolism

1.3.2: Intermediary metabolism; organ specialization and metabolic integration

1.3.3: Metabolism in starvation

Unit 2: Enzymes and Enzyme Kinetics **15 Lectures**

2.1: Enzymes: Nomenclature and classification with numerical code; chemical nature of enzymes

2.2: Mechanism of enzyme action: Fischer's Lock and Key Theory, Koshland's Induced fit model; Mechanism of enzyme catalysis

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

2.4: Regulatory enzymes: Covalently modulated; allosteric regulation; Isoenzymes (LDH, CK, ALP, ADH)

2.5: Non-protein enzymes: Ribozymes

2.6: Advanced enzymes in human healthcare, e.g., fungal lactase, hemicellulase, trypsin chymotrypsin mix

Unit 3: Principles and Applications of Chromatography **15 lectures**

3.1: Planar chromatography (Paper chromatography and Thin layer chromatography):

Preparation of stationary support, solvent, detection and measurement of components, applications; concept of method development and method validation in chromatography

High Performance Thin Layer Chromatography (HPTLC): Instrumentation, selection of operating conditions, analysis of data and application; standard operating procedure and calibration, use, care/maintenance of HPTLC

3.2: Column chromatography:

Packing and operation of column, loading the column, eluting the column, collection of eluents, detection of eluent, applications

High Performance Liquid Chromatography (HPLC): Instrumentation, selection of operating conditions, analysis of data and application; standard operating procedure and calibration, use, care/maintenance of HPLC

3.3: Ion exchange chromatography:

Ion exchange resins, selection of ion exchanger, choice of buffers, preparation and use of ion exchangers, storage of resins

3.4: 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, applications

3.5: Affinity chromatography:

Chromatography media, immobilized ligands, attachment of ligands to the matrix, experimental procedures and applications

3.6: Gas chromatography:

Gas chromatography (GC): Instrumentation, selection of operating conditions, analysis of data and applications; standard operating procedure and calibration, use, care/maintenance of GC

Unit 4: **Principles and Applications of Electrophoresis** **15 Lectures**

4.1: Electrophoresis:

4.2: Theory and principle of electrophoresis

4.3: Horizontal agarose gel electrophoresis

4.4: Vertical polyacrylamide gel electrophoresis; standard operating procedure and calibration, use, care/maintenance of electrophoretic units

4.5: Pulse field electrophoresis

4.6: Capillary electrophoresis

4.7: Isoelectric focusing of proteins

4.8: Two-dimensional electrophoresis

Paper Code: SIPZOCC123

Core course-3: Bioinformatics

Learning objectives:

- *To gain insight of the potential of Bioinformatics – a field applying computer knowledge to study genomes.*

Unit 1: Bioinformatics- I **15 lectures**

1.1: Gene experience, DNA microarray and Proteomics.

1.2: Primary databases, Secondary databases.

1.3: Gene experience: Introduction, Basic steps for gene expression.

1.4: Microarray: - Concept of microarrays; spotted arrays, oligonucleotide arrays, designing the experiment, Two-colour microarray experiments.

1.5: Tools for microarray analysis

1.6: Microarray design, microarray experimentation, fabrication computational analysis of Microarray data, Applications of microarray technology

1.7: Proteomics:-Protein sequence information, composition and properties, physicochemical properties based on sequence, sequence comparison

Unit 2: Bioinformatics- II **15 Lectures**

2.1: Protein Microarray and Phylogenetic analysis

2.2: Proteomics classification; Tools and techniques in proteomics;

2.3: 2-D gel electrophoresis, PAGE, isoelectric focusing, affinity chromatography, Mass spectroscopy for protein analysis, MALDI-TOF, Electrospray ionization (EST), Tandem mass spectroscopy (MS/MS) analysis; tryptic digestion and peptide fingerprinting (PMF)

2.4: Protein Micro array in protein expression, profiling and diagnostics, drug target discovery.

2.5: Phylogenetic analysis:-

2.5.1: Evolution, elements of phylogeny, methods of phylogenetic analysis

2.5.2: Phylogenetic tree of life, comparison of genetic sequence of organisms, phylogenetic analysis tools-Phylip, ClustalW.

2.6: Applications of Bioinformatics in various fields

Environment, biotechnology, molecular biology, neurobiology, agriculture, drug designing, biomedical genome medicines, medical microbiology.

a) Electives

Paper Code: SIPZOEL121

DSE: Biotechnology and Gene manipulation- II

Learning objectives:

- *To familiarize with the basic tools of genetic engineering involved in tailoring genetic information to delve into the genomes of organisms; designing cloning vectors and using DNA fragments as research tools.*
- *To procure knowledge of the biotechnological aspects dealing with degradation of xenobiotics that is foreign to our environment, and the effective utilization of biomass.*
- *To deal with the tools and techniques in Biology that has helped enhance our understanding of the various aspects of Biology.*

Unit 1: Microbial synthesis of commercial products **15 Lectures**

1.1: Organic acids and their commercial applications: Citric acid, gluconic acid, lactic acid

1.2: Antibiotics: Cloning antibiotic biosynthetic gene by complementation and other methods; synthesis of novel antibiotics and improving antibiotic production; Aminoglycosides and their uses

1.3: Polysaccharides:

1.3.1: Bacterial polysaccharides: General properties and their commercial applications – Dextran, xanthan, alginate; genetic engineering for large scale production of xanthan gum and its modification

1.3.2: Marine polysaccharides: General properties and their commercial application – Agar and agarose, Chitosan

1.4: Polyesters: Polyhydroxyalkanoates (PHA) – Biosynthesis of PHA; Biopol, a commercial biodegradable plastic

Unit 2: Enzyme technology in large scale production **15 Lectures**

2.1: Biotransformations

2.1.1: Biocatalyst immobilization:

Methods of immobilization – Cross linking, supported immobilization, adsorption and ionic binding, covalent coupling, lattice entrapment

2.1.2: Immobilized enzyme reactors: Batch reactors, Continuous reactors.

2.1.3: Enzymes in diagnostic assays – Test strip systems; Biosensors**:** Principle, Working and types.

Unit 3: Environmental Biotechnology **15 Lectures**

3.1: Biomass utilization:

3.1.1: Production of single cell proteins by using biomass as raw material

3.1.2: Commercial production of fructose and alcohol from biomass

3.2: Bioremediation of xenobiotic compounds:

3.2.1: Characteristics of xenobiotics in the environment

3.2.2: Genetic engineering of biodegradative pathways: Manipulation by transfer of plasmid.

3.3: Bioleaching of metals

3.3.1: Biochemical mechanism of bioleaching.

3.3.2: Types of bioleaching

3.3.3: Methods for bioleaching: Tank and heap bioleaching

3.3.4: Microorganisms used for bioleaching

Semester II

Practical – I (SIPZOCCP121)

Based on Core course-1 (SIPZOCC121)

1. Study of Animal type:

Fish (*Sciaena* – Dhoma or *Shark* – Mori): Morphology, Digestive system, Heart & Aortic arches, Urino-genital system, mountings of gills, scales.

2. Study of Systematics and major features of:

a) Cephalochordata: *Amphioxus*

b) Urochordata: *Ascidian*

c) Agnatha: *Petromyzon*, *Myxine*

d) Pisces: Shark, Sting ray, Mackerel, Hippocampus, Eel.

e) Amphibia: *Caecilian*, Salamander, Frog, Toad, *Amphiuma*

f) Reptilia: Turtle, Tortoise, Chameleon, *Phrynosoma*, *Hydrophis*, Crocodile, Gharial.

g) Aves: Kingfisher, Kite, Vulture, Duck

h) Mammals: Duck-billed platypus, Kangaroo, Shrew, Bat, Loris, Dolphin, Sea Cow (Dugong).

3. Determination of effect of stressors on heart rate of Daphnia.

4. Demonstration of isolation of limb bud and its Chorio-allantoic grafting.

Practical – II (SIPZOCCP122)

Based on Core course-2 (SIPZOCC122)

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 proteins by Peterson-Lowry method

4. Quantitative estimation of amino acids using Ninhydrin reagent

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. Determination of SDH specific activity

9. Identification of lipids in a given sample by TLC

10. Separation of pigments from leaves or flowers by adsorption column chromatography 3.

11. Separation of amino acids by ion exchange chromatography using cation exchanger

12. Separation and identification of amino acids by two-dimensional paper chromatography

13. SDS-polyacrylamide slab gel electrophoresis of plasma proteins

Practical – IV (SIPZOELP121)

Based on DSE (SIPZOEL121)

1. Immobilize yeast cells in calcium alginate and prepare a bioreactor column to demonstrate invertase activity in the bioreactor column

2. To plot a growth curve for the microorganisms provided

3. Demonstrate the effect of media on growth curves of given microorganism, using two different media (minimal and enriched)

4. Quantitative estimation of DNA from a suitable tissue by Diphenylamine method

5. Quantitative estimation of RNA from a suitable tissue by Orcinol method

6. Molecular phylogeny: Construction of phylogenetic trees (using amino acid and nucleotide

Based on On-job training/Field Project (SIPZOOJ12)

Practical based on Internship Report / On Job Training

Learning objectives:

- *To understand the inner workings of industries or research institutes in the field of animal sciences.*
- *To gain experience of hands-on work in a structured organization.*

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