## SYLLABUS FOR CBCS MODE SEMESTER BASED 2-YEARS M.SC. IN ZOOLOGY

**\*\*Effective from Session 2021-22 onwards**\*\*



# Department of Biological Sciences **ALIAH UNIVERSITY**

II-A/27, Action Area II, New Town Kolkata 700160

## The Postgraduate Degree Programme namely 'Master of Science in Zoology' of Aliah University will be offered with the following POs and PSOs:

## PROGRAMME OUTCOMES (POS):

**PO-1: Core competency-** Students will acquire core competency in the subject, and in allied subject areas and enable the learners to take certification of Master's degree in Zoology.

**PO-2: Analytical ability-** The students will be able to demonstrate the knowledge in understanding research and addressing practical problems; and will be equipped with recent advances in Zoology from organismic to reductionist biology

**PO-3: Communication skills-** Students will gain a standard communication skill and will be able to read and understand documents with in-depth analyses and logical arguments. Students will be well-versed in speaking and communicating their ideas or findings to a wider audience.

**PO-4: Society challenges-** It also aims to empower students to understand the challenges of society and the country that falls into the realms of Zoology, such as Aquaculture, Reproductive health, Behavior and Biological timekeeping, Cancer Biology, Microbiome and their roles in health and diseases, Bioremediation of pollutants and pesticides, etc

**PO-5: Critical Thinking, Problem-solving & Research-** This course is designed to ignite the inquisitive mind. An increased understanding of fundamental concepts and their applications of scientific principles is expected at the end of the program. Students will become critical thinker and acquire problem solving capabilities and address different questions by formulating the hypothesis, data collection and critically analyse the data to decipher the degree to which their scientific work supports their hypothesis for research

**PO-6:** Digitally equipped- With the use of computers and softwares for computational biology and few other topics, Students will acquire digital skills and integrate the fundamental concepts with modern tools.

**PO-7: Ethical and Psychological strengthening-** Students will also strengthen their ethical and moral values and shall be able to deal with psychological weaknesses.

**PO-8: Team Player & Nation Building-** Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations. Students will learn team workmanship in order to efficiently serve institutions, industry and society; and help in the development of the country.

**PO-9: Independent Learner-** Apart from the subject specific skills, generic skills, especially in programs of biological sciences, the program outcome would lead to gain knowledge and skills for further higher studies, competitive examinations and employment.

**PO-10: Career Development-** Widen the scope of the learners for careers in different sectors of employment. Enable the students to avail career opportunities in teaching, industry and research.

## **PROGRAMME SPECIFIC OUTCOMES (PSOS)**

**PSO-1:** Students will be able to demonstrate a broad understanding of animal diversity, including knowledge of the scientific classification and evolutionary relationships of major groups of animals.

**PSO-2:** Students will be able to recognize the relationships between structure and functions at different levels of biological organization (e.g., molecules, cells, organs, organisms, populations, and species) for the major groups of animals.

**PSO-3:** Students will be able to characterize the biological, chemical, and physical features of environments (e.g., terrestrial, freshwater, marine, host) that animals inhabit.

**PSO-4:** Students will be able to explain how animals' function and interact with respect to biological, chemical and physical processes in natural and impacted environments.

**PSO-5:** Students will be able to explain how organisms' function at the level of the gene, genome, cell, tissue, organ and organ-system. Drawing upon this knowledge, they will be able to give specific examples of the physiological adaptations, development, reproduction and behaviour of different forms of life.

**PSO-6:** Students will be able to understand the applied biological sciences or economic Zoology such as sericulture, apiculture, aquaculture, industrial microbiology, rDNA technology and medicine for their career opportunities.

**PSO-7:** The broad skills and the deeper knowledge in the field would make them highly successful and excellent academician, researcher, entrepreneur and contribute to Nation building.

Department of Biological Sciences Aliah University, Kolkata

## SYLLABUS FOR 2-YEARS MSC IN ZOOLOGY (CBCS)

The postgraduate Degree Programme namely 'Master of Science in Zoology' of Aliah University will be consist of:

## 1. Core Course (CCT and CCP): [Total Paper: 13; Total Credit: 13x4=52]

Discipline specific compulsory basic course. Minimum 10 *theory* papers (each of 4 credits i.e. totalling minimum 10x4 = 40 credit points) and 3 *practical* papers (each of 4 credits i.e. totalling minimum 3x4 = 12 credit points) based on the 10 theory core course papers are mandatory.

## 2. Discipline Specific Elective Course (DET and DEP): [Total Paper: 4; Total Credit: 4x4=16]

Discipline specific elective courses (choice based) which are more advanced or specialized would be offered in the Semester- III and IV. 4 papers (2 theory and 2 practical) each of 4 credits totalling 4x4 = 16 credit points have to be chosen out of the 6 papers offered.

## 3. Generic Elective Course (GEC): [Total Paper: 2; Total Credit: 2x4=8]

Interdisciplinary elective course (choice based) to be opted from a discipline other than one's main discipline (s) of choice in the Semester-III and IV. Two papers each of 4 credits totalling 2x4 = 8 credit points have to be chosen out of the 4 papers offered.

## 4. Aliah University Compulsory Course (AUC): [Non-credit]

There will be a Compulsory Course on "Elementary Arabic and Islamic Studies" having no credit points in Semester-I.

## 5. Ability Enhancement Compulsory Course (AEC): [Non-credit]

There will be a Compulsory Course on Disaster management/ Human Rights/ Value Education/ Yoga/ Soft Skills having no credit points in Semester-II.

## 6. Project and Dissertation (PRJ): [Total Paper: 1; Total Credit: 1x4=4]

Students have to work on a specific project and will write a dissertation on it followed by a presentation in Semester IV. (1 paper of 4 credit totalling 1x4 = 4 credit points).

## LIST OF CORE COURSE THEORY (CCT) PAPERS

- 1. ZOOPGCCT01 : Non-Chordates and Taxonomy
- 2. ZOOPGCCT02 : Ecology and Conservation
- 3. ZOOPGCCT03 : Cell Biology
- 4. ZOOPGCCT04 : Principles of Biochemistry
- 5. ZOOPGCCT05 : Chordates and Animal Physiology
- 6. ZOOPGCCT06 : Endocrinology
- 7. ZOOPGCCT07 : Biostatistics and Bioinformatics
- 8. ZOOPGCCT08 : Immunology and Parasitology
- 9. ZOOPGCCT09 : Molecular Biology
- 10. ZOOPGCCT10 : Evolution and Animal Behaviour

### List Core Course Practical (CCP) Papers

ZOOPGCCP01 : Core Course Practical I
 ZOOPGCCP02 : Core Course Practical II
 ZOOPGCCP03 : Core Course Practical III

## List of Discipline Specific Elective Course (DET and DEP) Papers

1.	ZOOPGDET01	:	Genetics
2.	ZOOPGDET02	:	Aquatic Biology and Fisheries
3.	ZOOPGDET03	:	Entomology
4.	ZOOPGDEP01	:	Discipline Elective Practical I
5.	ZOOPGDEP02	:	Discipline Elective Practical II
6.	ZOOPGDEP03	:	Discipline Elective Practical III

## List of Generic Elective Course (GEC) Papers

(To be opted by the students of other disciplines)

1.	ZOOPGGEC01	:	Genetic Engineering
2.	ZOOPGGEC02	:	Biotechniques and Bioethics
3.	ZOOPGGEC03	:	Entrepreneurship in Biology
4.	ZOOPGGEC04	:	Disease Biology

S1. No.	Course Title	Course Code	Credit s	Mark s		
	Semester I					
1	Non-Chordates and Taxonomy	ZOOPGCCT01	4	50		
2	Ecology and Conservation	ZOOPGCCT02	4	50		
3	Cell Biology	ZOOPGCCT03	4	50		
4	Principles of Biochemistry	ZOOPGCCT04	4	50		
5	Core Course Practical I	ZOOPGCCP01	4	50		
6	Elementary Arabic and Islamic Studies	PGAUC01	0	0		
* PGAUC01: Aliah University Compulsory Course- Non-Credit Paper						

## SEMESTER-WISE CURRICULUM PLAN

Semester II					
7	Chordates and Animal Physiology	ZOOPGCCT05	4	50	
8	Endocrinology	ZOOPGCCT06	4	50	
9	Biostatistics and Bioinformatics	ZOOPGCCT07	4	50	
10	Immunology and Parasitology	ZOOPGCCT08	4	50	
11	Core Course Practical II	ZOOPGCCP02	4	50	
12	Disaster Management/ Human Rights & Value Education/ Yoga & Life Skills (Any one)	PGAEC01	0	0	
* PGAEC01: Ability Enhancement Compulsory Course- Non-Credit Paper					

Semester III					
13	Molecular Biology	ZOOPGCCT09	4	50	
14	Core Course Practical III	ZOOPGCCP03	4	50	

15	*Discipline Elective Paper I	ZOOPGDET01	4	50
16	*Discipline Elective Practical I	ZOOPGDEP01	4	50
17	#Generic Elective Paper I	ZOOPGGEC01	4	50
* Discipline Elective- 1 Theory (ZOOPGDET01) and 1 Practical (ZOOPGDEP01) to be chosen out of 6 options # Generic Elective- 1 Paper (ZOOPGGEC1) to be chosen out of 4 options by the students of other disciplines				

Semester IV					
18	Evolution and Animal Behaviour	ZOOPGCCT10	4	50	
19	**Discipline Elective Paper II	ZOOPGDET02	4	50	
20	**Discipline Elective Practical II	ZOOPGDEP02	4	50	
21	##Generic Elective Paper II	ZOOPGGEC02	4	50	
22	Project and Dissertation	ZOOPGPRJ01	4	50	
** Discipline Elective- 1 Theory (ZOOPGDET02) and 1 Practical (ZOOPGDEP02) to be chosen out of 6 options ## Generic Elective- 1 Paper (ZOOPGGEC02) to be chosen out of 4 options by the students of other disciplines					

Total Credits / Total Marks	80	1000

## CORE COURSE THEORY (CCT) PAPERS CONTENT

## Paper Code: ZOOPGCCT01 Paper Title: Non-Chordates and Taxonomy

#### **Course Objective:**

- To provide an insight to the learner about the existence of different life forms on the Earth and appreciate the diversity of animal life.
- To help the student to understand the features of Kingdom Animalia and systematic organisation of the animals based on their evolutionary relationships, and structural and functional affinities.
- To make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life.
- To understand the basic concept of taxonomy and its relevance. Species concepts and the various schools of biological classification.
- To introduce the procedures and tools of taxonomic collection and identification.
- To create interest among them to explore the animal diversity in nature.

#### Learning Outcomes:

Upon completion of the course, students should be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- The students will well be versed with the collection and identification techniques and the use of various tools in taxonomy.
- Appreciate the diversity of non-chordates living in varied habits and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

#### Section A: Lower Non-Chordates

**Unit I:** Nutrition in Protozoa; Reproduction in Protozoa; Origin of Metazoa; Organization and affinities of Porifera

**Unit II:** Polymorphism in Coelenterata; Colony formation in Coelenterata; Coral Reefs-Definition, Formation, Types and Distribution

**Unit III**: Salient features of parasitism in Helminthes; Outlines of the ecology of soil nematodes; Adaptive radiation in Polychaeta

#### Section B: Higher Non-Chordata

**Unit IV:** Organization, affinities, and evolutionary significance of Onychophora; Parasitism in Crustacea; Larval forms in Crustacea

**Unit V:** Mouth parts of insects; Nutrition in Insects, Excretory mechanism of insects with special reference to Cryptonephridial mechanism; Tracheal and plastron respiration of insects. Insect Immune system, metamorphosis, diapauses and their interrelationship and regulation; Atypical modes of reproduction Bioluminescence and its biological significance in Insects; Basic concept of insect pest management

**Unit VI:** Adaptive radiation in Mollusca; Larval forms in Echinodermata; Affinities of Echinodermata; Brief outlines of the structure and affinities of minor phyla with special reference to Ctenophora and Rotifera.

#### Section C: Systematics

**Unit VII:** Fundamental of Systematics Biological classification, Hierarchy of categories and higher taxa, Taxonomic characters: procedures and keys, Species concepts: varieties, subspecies, sibling species, race etc. International code of Zoological nomenclature.

**Unit VIII:** Kingdoms General outline of kingdoms including Monera & Protista; Broad outline & Diversity in kingdom Animalia

**Unit IX:** Methodologies in systematics Morphology based taxonomy, Numerical taxonomy, Cyto-taxonomy and chemotaxonomy, Molecular systematics, DNS fingerprinting & Molecular markers for detection/evaluation of polymorphism, RFLP, RAPD etc.

#### Suggested Readings

- 1. This is Biology: The Science of Living World, Mayr, M. (1997), Universities Press Ltd.
- 2. J.R.B. Alfred and Ramakrishna (2004) Collection, Preservation and Identification of animals. Zoological Survey of India Publications.
- 3. N.A. Campbell and J.B. Reece (2004) Biology, 7th edition, Benjamin Cummings Publ.
- 4. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International.
- 5. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002).
- 6. The Invertebrates: A New Synthesis, III Edition, Blackwell Science.
- 7. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson.
- 8. A general textbook of entomology, Imms. A. D., Chapman & Hall, UK.
- 9. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M Saunders College Publication, USA.

## Paper Code: ZOOPGCCT02 Paper Title: Ecology and Conservation

#### **Course Objective:**

- Understand the Structure and Functions of the ecosystem and sensitize the students about the paramount role and importance of Nature.
- Knowledge of environmental pollution in relation to air, water and soil.
- To understand climate change: Greenhouse gases, their sources, trends and role, Ozone layer and its depletion (Global warming, Sea level rise, UV radiation) acid rain, Bioindicator and biomarkers of environmental change.
- To know the Biodiversity Concept, types and situation in India. IUCN categories. Strategies of conservation: In situ conservation & Ex situ conservation measures.
- Knowledge of various acts related to Biodiversity conservation and protection and international conventions.
- Enables students to understand practical aspects of ecology and helps them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc.

#### Learning Outcomes:

On completion of this course the students will be able to:

- Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- Analyse various types of ecosystems, correlate different ecosystems.
- Comprehend the population characteristics, dynamics, growth models and interactions.
- Understand the community characteristics, ecosystem development and climax theories.
- Analyse the threat and suggest conservative measures.
- Analyse environmental impact and monitor various physical, chemical and biological properties of

soil water and air.

• Apply the basic principles of ecology in wildlife conservation and management.

#### **Unit I: Concept of Ecology**

Introduction to ecology: level of organization, environmental concepts: Soil, atmosphere, light temperature, laws and limiting factors; adaptation and acclimatization: plants and animals; ecological amplitude; ecological species concept, ecotype, ecads, ecological equivalents & guilds; edges and ecotones.

#### **Unit II: Ecosystem Ecology**

Concept of ecosystem, production, food webs, energy flow through ecosystem; Transfer efficiencies: consumption, assimilation, production; Ecological pyramid: number, biomass, energy; mineral cycling (C, N, P); Controls on ecosystem function: bottom-up and top-down control; Types of ecosystems: freshwater and marine, estuary; Biomes: species, distribution, precipitation, temperature; Habitat and Niche: Concept; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.

#### **Unit III: Population Ecology**

Characteristics of population: density, dispersion, demographics, survivorship curve; Population growth: exponential and logistic growth; Population regulation: density dependent and independent; concept of metapopulation; r and k strategies; population dynamics; estimation of population size; age structure; trade off; grime's triangle; Species Interactions: Types of intraspecific and interspecific interactions, mutualism, ammensalism, commensalism; Connell's experiment, Lotka Volterra model, Gause principle; Prey and Predation interaction: Defence-Mechanical & chemical; Avoiding predation- aposematic & cryptic coloration; Mimicry: Batesian and Mullerian.

#### Unit IV: Community & Behavioural Ecology

Species richness & evenness; relative abundance; Simpson's and Shannon index; Species area and intermediate disturbance hypothesis; Succession: Type and mechanism; hydrarch and xerarch succession; model of succession; concept of climax; theory of island biogeography; Behavioural ecology: Altruism, inclusive fitness, reciprocal altruism, Hamilton's rule and kin selection; mating behaviour: sexual selection; optimal foraging theory; imprinting.

#### **Unit V: Biodiversity**

Concept, levels, importance of biodiversity, Global diversity hotspots, IUCN red list categories, General idea about Red Data Book, Megadiversity centres of world; Conservation: Objective, strategies & type of conservation, management, keystone species, indicator species, umbrella species, flagship species; Sustainable development, natural resource management in changing environment; Biodiversity protected areas in India; Biosphere reserves, resources and management, Effect of manmade alteration of environment on Biospheres; Molecular ecology, genetic analysis of single and multiple population, phylo-geography, conservation genetics, Modern tools and techniques to assess biodiversity.

#### Unit VI: Climate change

Environmental stresses and their management, greenhouse effect, stratospheric ozone, effect of ozone depletion, Kyoto protocol, Montreal protocol, acid and nitrogen deposition, coping with climatic variations, BOD, COD, biomagnification, eutrophication, threats to biodiversity.

#### **Unit VII: Bioremediation**

Bioremediation strategies; Major classes of contaminants; Uptake, biotransformation, detoxification, elimination and accumulation of toxicants. Factors influencing bioaccumulation from food and trophic transfer. Pesticides and other chemicals in agriculture, industry and hygiene and their disposal. Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health, biodegradation.

#### Suggested Readings

- 1. Ecology-Peter Stiling, Second Edition-2015
- 2. Elements of Ecology-T. M. Smith and R.L. Smith-Eighth edition-2011
- 3. Campbell Biology-Urry et.al-Eleventh Edition-2016
- 4. Concepts of Ecology, Kormondy, E. J. 4th Edition. Prentice-Hall,
- 5. Ecological Modelling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
- 6. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
- 7. Principles of Terrestrial Ecosystem Ecology. 2011. Chaplin, F.S., Matson, P.A. and Virtuosic, P.M. Springer.
- 8. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.
- 9. Freshwater Ecology: A Scientific Introduction. Closs G., Downes B. and Boulton A. Wiley- Blackwell Publisher
- 10. Basic Ecology, Odum, E. P., 1983. Saunders College Publishing

## Paper Code: ZOOPGCCT03 Paper Title: Cell Biology

#### **Course Objective:**

This course is designed to give the students

- Basic idea of cell structure including macromolecules, membranes, and organelles.
- Cell signalling, communication and cell transport
- Cell division: process and regulation; and cell culture- types and methods
- Cell culture: basic concepts and applications

#### Learning Outcomes:

On completion of this course the students will be able to:

- Students will understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles.
- Students will understand different cellular components in cell signalling, communication and transport.
- They will know the different types of cell culture and methods involved in it
- Students will apply their knowledge of cell biology to selected examples of changes or losses in cell function. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation.

#### Unit I: Structure of Cell

Plasma membrane: Structure and transport of small molecules; Protein and Small Molecule Trafficking: Receptor-mediated endocytosis; intra-cellular transport, lysosomes, organelle biogenesis; extra-cellular transport: biogenesis of membrane proteins, protein modification, glycosylation; pumps, channels, and transporters; Extracellular matrix; Structure and organization of Microtubules, Intermediate filaments and Microfilaments

#### Unit II: Cell signalling

Hormones and their receptors, cell surface receptors, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways, bacterial and plant two-component systems, light signalling in plants, bacterial chemotaxis and quorum sensing.

#### Unit III: Cell cycle and cancer

Cell cycle and its regulation, Genetic rearrangements in progenitor cells, oncogenes, tumour suppressor

genes, cancer and the cell cycle, virus-induced cancer, metastasis, angiogenesis, interaction of cancer cells with normal cells, apoptosis, autophagy, anoikis; therapeutic interventions of uncontrolled cell growth. Stem cell: Embryonic stem cells (ESC) and Adult stem cells (ASC).

#### Unit IV: Cell culture & Cell Biology Techniques

Introduction and historical background of animal cell culture. Types of cell culture. Basic characteristics of tissue culture media. Basic equipment and facilities in animal cell culture. Types of culture media and culture wares. Sterilization methods for culture wares and culture media. Maintenance of a cell line and storage of cells; Microscopy- Brightfield, Phase Contrast, Confocal & Electron Microscopy; Immunofluorescence, and Cell fractionation, FACS

#### Suggested Readings

- 1. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley. ISBN- 978-0470483374.
- 2. The World of the Cell, 7th edition (2008), Becker, Kleinsmith, Hardin and Bertoni. Benjamin Cummings, ISBN-13: 978-0805393934.
- 3. The Cell: A Molecular Approach, 6th edition (2013), Cooper and Hausman; Sinauer Associates, Inc. ISBN-13:978-1605351551.
- 4. Essential Cell Biology, 7th edition (2009), Alberts, Bray, Hopkin, Johnson, Lewis, Raff, Roberts and Walter. Garland Science. ISBN-13:978-0815341291.
- Molecular Cell Biology, 7th edition (2012), Lodish, Berk, Kaiser, Krieger, Bretscher, Ploegh, Amon and Scott. W. H. Freeman. ISBN-13: 978-1429234139.

## Paper Code: ZOOPGCCT04 Paper Title: Principles of Biochemistry

#### **Course Objective:**

This course is designed to give the students

- The understanding of acids, bases and buffers and their relevance in living systems.
- The information about the structure and function of various biomolecules such as carbohydrate, protein (including their role as biocatalysts) and nucleic acids.
- The knowledge about enzymes and catalysis.
- Use of various techniques involved in biochemical analysis.

#### **Learning Outcomes:**

After completion of the course, a student will be able to achieve these outcomes:

- The students will learn about the chemical structures of carbohydrates, and their structural and metabolic role in cellular systems.
- The students will learn about structure and function of lipids, circulating lipids and inflammatory lipid mediators etc.
- They will also learn about primary, secondary, tertiary, quaternary structure of proteins.
- The students will understand about the structure and function of nucleosides and nucleotides.
- The students will learn about the enzymes and various enzymatic mechanisms in the biological system.
- Students will learn the application of various techniques used in biochemical analysis.

#### **Unit I: Introduction**

Chemical basis of life; water; concepts of acid and base, reaction kinetics, pH, buffer; Biomolecular hierarchy; Macromolecules; Molecular assemblies: Stabilizing interactions.

#### Unit II: Carbohydrates

Definition, classification and structure of carbohydrates; Isomers; Sugar derivatives; Structure, occurrence,

properties and functions of Disaccharides and Polysaccharides. Suitability in the context of their different functions- cellular structure; energy storage; signalling; Glycosylation of other biomolecules - glycoproteins and glycolipids.

#### Unit III: Amino acids and Proteins

Amino acids: structure and functional group properties and reactions; Peptides and covalent structure of proteins; Protein structure: Elucidation of primary and higher order. End group analysis and protein sequencing. Forces stabilizing protein structure; Structure-function relationships in model proteins like ribonuclease A; myoglobin; haemoglobin; chymotrypsin etc.; Tools to characterize expressed protein.

#### Unit IV: Nucleic acid

Structure, diversity and functions; DNA: Double helical structure, A-DNA, B- DNA & Z-DNA; The RNA world- Structure, types and roles of RNA; Nucleic acid Sequencing; G-Quadruplex.

#### **Unit V: Lipids**

Fatty acid: structure and functions; Lipids in the formation of membranes; Saponification structural lipids; Lipid functions: cell signals, cofactors, pigments; Lipoproteins.

#### **Unit VI: Enzymes**

General principles of catalysis; Quantitation of enzyme activity and efficiency; Enzyme characterization and Michaelis-Menten kinetics; Relevance of enzymes in metabolic regulation; activation; inhibition and covalent modification; Single substrate enzymes. Structure and function of Vitamins and coenzymes. Immobilized enzymes and their applications

#### **Unit VII: Bioenergetics**

Basic principles; Laws of thermodynamics, free energy, entropy, high energy bonds; Coupled processes.

#### Unit VIII: Basic Techniques in Biochemistry

Biomolecule purification by various types of chromatography, estimation by using colorimeter/spectrophotometer and characterization by spectroscopy and electrophoresis.

#### Suggested Readings

- 1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
- 2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
- 3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W. H. Freeman
- 4. Berg JM, Tymoczko JL, Gatto Jr, GJ and Stryer L (2019) Biochemistry, 9th Edition, W. H. Freeman and Company
- 5. Nelson DL and Cox MM (2017) Lehninger Principles of Biochemistry, 7th Edition, W.H. Freeman and Company,
- 6. Voet, D. and Voet J.G (2005) Biochemistry 3rd edition, John Wiley and Sons.
- 7. Segel Irvin H (1997) Biochemical Calculations, 2nd Ed., John Wiley and Sons, New York.
- 8. Palmer, T (2001) Enzymes: Biochemistry, Biotechnology & Clinical chemistry, Horwood Pub. Co, Eng.

## Paper Code: ZOOPGCCT05 Paper Title: Chordates and Animal Physiology

#### **Course Objective:**

- To provide scope, historical background and origin of chordates.
- Understanding the characteristics and classification of animals with notochord.
- Understanding exclusive phenomena present in chordates like biting mechanism in snakes, flight adaptations in birds etc.
- To provide adequate explanation to the students regarding various systems of animals like Integumentary, Skeletal, Circulatory, Nervous system and physiological mechanisms involved in thriving survival of the animals within their geographic realms.

#### Learning Outcomes:

After successfully completing this course, students will be able to:

- Understand different classes of chordates, level of organization and evolutionary relationship between different sub-phylums and classes, within and outside the phylum.
- Make students understand about their distinguishing features of phylum.
- Understand similarities and differences in life functions among various groups of animals in Phylum Chordata.
- To develop a holistic understanding of the physiological systems of chordates.
- Explain how the circulatory system, nervous system and a skeletal system along with other systems give proper shape and support to diverse forms of chordates.
- Describe how Chordates exist in diverse habitats, including marine, freshwater and terrestrial.

**Unit I:** Introduction General characteristics and Classification of all phylum. Modern interpretation of origin of early chordate

Unit II: Integumentary system Cell association, Glandular System

**Unit III**: Skeletal system Origin of jaw and modification of jaw bones and types; functional and evolutionary significance. Jaw kinetics in relation to feeding

Unit IV: Circulation Heart and circulation in fetal and neonatal mammals. Evolution of portal system

Unit V: Nervous system & Sense organ Sensory receptors and classification. Organ of olfaction and taste.

**Unit VI:** Structural Adaptation Structural elements of body and their properties. Mechanics of support and movement. Swimming adaptation. Cursorial adaptation. Flying mechanism.

Unit VII: Principles of animal physiology Mechanistic and evolutionary approaches; Size and scaling of animals

**Unit VIII:** Physiological homeostasis Positive and negative feedback, Controlled variable, Set point. Thermal physiology: Heat transfer mechanism between animal and environment. Supercooling, Anti-freeze compound, Behavioural thermoregulation, Pejus and Critical temperature, adaptational trend in sub zero condition.

**Unit IX:** Physiology of behavior Pheromones in colonial interactions, foraging and mating. Allelo-chemicals in Plant-Insect interaction

#### Suggested Readings

- 1. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
- 2. Pough H. Vertebrate life, VIII Edition, Pearson International.
- 3. Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.

- 4. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
- 5. Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.

## Paper Code: ZOOPGCCT06 Paper Title: Metabolism and Endocrinology

#### **Course Objective:**

- To introduce the interaction, network and regulation of certain important metabolic pathways and their roles in health and diseases.
- To inculcate the awareness and impart knowledge of the control and regulation of body functions and the maintenance of homeostasis involving the endocrine and neuro-endocrine system.

#### Learning Outcomes:

- Students will come to know the detailed concept of catabolism and anabolism.
- Students would acquire the knowledge and understanding of evolutionary design of each metabolic pathway and its intermediates.
- They would be able to predict the futuristic outcome of failure of metabolic pathways.
- Students will gain knowledge of the distribution, morphology/anatomy of endocrine glands and their role in chemical integration.
- They will understand the role of chemical messengers in cellular communication and signalling pathways.
- Consequences of the hormonal dysregulations would be understood.

#### Unit I: Basic concepts of Metabolism

Concept of catabolism and anabolism: metabolic strategies, organization, clustering of enzymes, Regulation of Metabolic Pathways: energy charge, phosphorylation potential etc.

#### Unit II: Carbohydrate metabolism

Glycolysis, glycogenolysis, gluconeogenesis, pentose phosphate pathway, glucoronic acid pathway (emphasis on regulation). The Citric acid cycle: Cyclic overview and reactions. Metabolic sources of acetyl CoA. Regulation and amphibolic nature of the cycle

#### Unit III: Lipid Metabolism

β-oxidation of unsaturated and saturated fatty acid and its regulation. Propoinyl coA metabolism, significance of ketone bodies, Biosynthesis of palmitate and its regulation. Mitochondrial and microsomal pathways of chain elongation, Biosynthesis of cholesterol, its regulation, lipoprotein metabolism, chylomicrons, LDL, HDL, VLDL.

#### Unit IV: Amino acid metabolism

Transamination, deamination, Fate of amino acid skeleton, urea cycle, precursors for compounds other than proteins, Genetic diseases.

#### **Unit V: Introduction to Endocrinology**

Hormones, Classification, Characteristic and Transport of Hormones, Neuro-secretions and Neuro-hormones: Examples and Functions; Mechanism of action of steroidal, non-steroidal hormones with receptors (cAMP, IP3-DAG)

#### Unit VI: Hypothalamo-Hypophyseal Axis

Structure and functions of hypothalamus and Hypothalamic nuclei, Regulation of neuroendocrine glands, Feedback mechanisms, Hypothalamo-Hypophyseal-Gonadal Axis. Structure of pituitary gland, Hormones and their functions, Hypothalamo-hypophyseal portal system

#### **Unit VII: Peripheral Endocrine Glands**

Structure, Hormones and Functions of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis. Disorders of endocrine glands (Diabetes mellitus type I & Type II; Graves' Disease).

#### Unit VIII: Homeostasis and hormonal regulation

Calcium and Glucose homeostasis in mammals. Estrous cycle in rat and menstrual cycle in human

#### Suggested Readings:

- 1. Nelson DL and Cox MM, Lehninger Principles of Biochemistry, 7th Edition, W.H. Freeman and Company,
- 2. Voet, D. and Voet J.G (2005) Biochemistry 3rd edition, John Wiley and Sons.
- 3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W. H. Freeman
- 4. Comparative Endocrinology by Gorbman, Dickhoff, Vigna, Clark & Ralph (John Wiley & Sons)
- 5. Vertebrate Endocrinology by Norris (Lea and Febigar)
- 6. Comparative Vertebrate Endocrinology by Bentley (Cambridge University Press)
- 7. Basic & Clinical Endocrinology by Greenspan and Strewler
- 8. Guyton and Hall, Textbook of Medical Physiology, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.

#### **Paper Code:** ZOOPGCCT07 **Paper Title:** Biostatistics and Bioinformatics

#### **Course Objective:**

- To introduce students to the basic concepts of statistics, probability and probability distributions.
- To teach them the different probability distributions and their application in statistical analysis
- To familiarize them with various tests of fit analysis methods.
- To introduce the concept of database, in-silico tools for biological sciences
- To expose them about the various stages of drug development.

#### **Learning Outcomes:**

After completion of the course the students would be

- Well versed with sampling methods for biological sciences and their statistical analysis.
- Able to analyse of data for test of fit analysis
- Able to access the various biological databases and retrieve the information
- Enabled to analyse the data using different in-silico tools.

#### **Unit I: Descriptive Statistics**

- a) Data in Biology: Development in biostatistics, samples and populations, techniques of sampling (random and stratified), sampling and non-sampling errors, variables in biology, univariate and bivariate frequency distributions
- b) Measures of Central Tendency: means, mode, median.
- c) Measures of Dispersion: Range, standard deviation, coefficient of variance and covariance.
- Measures of Skewness: Pearson's coefficients of skewness; coefficient of skewness using moments. Measures of Kurtosis.

#### Unit II: Probability and Probability Distributions

- a) Probability: Basic concepts, addition and multiplication rules of probability, conditional probability
- b) Probability Distributions: Probability mass function, probability density function and distribution function. Binomial distribution, Poisson distribution, normal distribution and exponential distribution along with their properties and relationships.

#### Unit III: Correlation and Linear Regression

- a) Correlation Analysis: Scatter diagrams, Pearson's and Spearman's coefficients of correlation, coefficient of determination.
- b) Regression Analysis: Method of least squares, equations of lines of regression and their applications in biostatistics.

#### **Unit IV: Hypothesis Testing**

- a) Sampling distributions and standard error, null and alternate hypothesis, basic concept and illustrations of type I and type II errors, concept of confidence interval estimation.
- b) Student's t-distribution: test for single mean, difference of means and paired t- test, chi-square distribution.

#### Unit V: Biological databases and genome browsers

Introduction to various databases and their classification (primary and secondary databases) e.g. NCBI, DDBJ, EMBL, ENSEMBL, UCSC and their uses

#### Unit VI: Sequence alignment

Local and global sequence alignments (Needleman-Wunsch and Smith-Waterman algorithms), pair-wise (BLAST and FASTA algorithms) and multiple sequence alignment (Clustal W) and its importance. s-value and e-value, p value.

#### Unit VII: Phylogenetic analysis

Basic concepts of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, Neighbour joining, Maximum parsimony, Maximum likelihood).

#### Unit VIII: Structure predictions for nucleic acids and proteins

Approaches for the prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models, Basic approaches for protein structure predictions, comparative modelling, fold recognition/threading and *ab-initio* prediction

#### Unit IX: Overview of drug development

Drug life cycle, stages of drug discovery and strategic issues in drug discovery. Lead Generation; HTS, clinical trials, characterization of binding site, virtual screening, protein-ligand interactions, prediction of pharmacological properties, Lipinski's rule of five, concept of energy minimization and force fields, introduction to rational drug design using example, Introduction to drug databases

#### Suggested Readings

- 1. Bioinformatics: Sequence and Genome analysis, 2<sup>nd</sup> edition (2004), David W. Mount, Cold Spring Harbour Laboratory Press
- 2. Bioinformatics: A practical guide to the analysis of genes and proteins, 3<sup>rd</sup> edition (2004), Andreas D. Baxevanis and B.F. Francis Ouellette, John Wiley and Sons.
- 3. The Process of New Drug Discovery and Development, 2<sup>nd</sup> edition (2006), C.G. Smith and J.T. O"Donnell, Informa Healthcare
- 4. Cheminformatics (2003), J. Gasteiger, Thomas Engel; Wiley-VCH
- 5. Molecular odelling Principles and Applications, (2003), A. R. Leach, Pearson Education
- 6. Cheminformatics in Drug Discovery (2006), edited by. T.I. Opera; Wiley Publishers,
- 7. Primer of Biostatistics, 7th edition (2011), Stanton Glantz, McGraw-Hill Medical.
- 8. Biostatistics: A Foundation for Analysis in the Health Sciences, 10<sup>th</sup> edition (2013), Wayne W Daniel and Chad L. Cross, Wiley.
- 9. Principles of Biostatistics, 2<sup>nd</sup> edition (2000), Marcello Pagano and Kimberlee Gauvreau, Thompson learning
- 10. Biostatistical Analysis, 5th edition (2009), Jerrold H. Zar, Pearson.

## Paper Code: ZOOPGCCT08 Paper Title: Immunology and Parasitology

#### **Course Objective:**

- To make the students understand the anatomy of the immune system, and components and functioning of humoral and cell mediated immune responses.
- To introduce the students to various detection systems and to the development of monoclonal antibody and hybridoma technology in general.
- To broaden the knowledge of students about vaccinology and tumour immunology.
- To make them understand antibody genes and antibody engineering.
- To broaden the knowledge of students about intricacies of the host system in sub/optimum/hyper immune responses and various immunological techniques.
- To make the students understand the role of the immune system in hypersensitivity and autoimmune complications.
- To learn the Life-cycle, Pathogenicity and Control of different parasites.

#### Learning Outcomes:

After completion of the course, a student will be able to achieve these outcomes:

- Students will gain an overview of the immune system including cells, organs and receptors.
- They will understand the structure and functions of different classes of immunoglobulins, the genetic basis of antibody diversity and the importance of humoral, cell-mediated and innate immune responses in combating pathogens.
- They will also understand mechanisms involved in different types of hypersensitivity, and the importance of conventional vs recombinant vaccines.
- They will be acquainted with the importance of antigen-antibody interaction in disease diagnosis.
- Students will be in a position to explain the principles of tolerance, autoimmunity and the role of immunity in protection against pathogens.
- They will acquire knowledge about the Life-cycle, Pathogenicity and Control measures of different parasites.

#### Unit I: Fundamental concepts and anatomy of the immune system

Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory; Haematopoesis and its regulation; Cells and Organs of immune system; Lymphatic system; Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.

#### Unit II: Immune cell receptors

Detailed structure and development of B cell (Ig) and T cell (TcR) receptors; Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR); Markers of suppressor / regulatory cells - CD4+, CD25+, Foxp3+, Treg , iNKT.

#### Unit III: Genetic organization

Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors. Antigen Processing and Presentation; Peptide loading and expression of MHC-I and MHC-II molecules.

#### Unit IV: Immune response and signaling

Humoral and cell-mediated immune response; Inflammatory events and signaling; Innate immune response and pattern recognition; Recent advances in innate immune response especially NK-DC interactions; Important cytokines, their role in immune mechanisms: TNF, IFN-γ, IL-1, IL-2, IL-4, 1L-6, 1L-12, IL-17, TGFb; Co-stimulation and inhibitory signalling; Cell signalling through MAP kinases and NF-kB;

#### Unit V: Tolerance and autoimmunity

Central and peripheral tolerance, and their mechanism; Mechanisms of autoimmunity; Immune checkpoints, Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), pernicious anaemia; Infections leading to autoimmune diseases.

#### Unit VI: Immunological disorders and hypersensitivity

Immunodeficiencies: Deficiency/ defects of T cells, B cells, and phagocytic cells; Comparative study of Type I-V hypersensitivities with examples.

#### Unit VII: Transplantation and tumor immunology

Alloreactive response; Graft rejection and GVHD; HLA-matching; Use of CRISPR-Cas for generating transgenic animals for xenotransplantation; Tumor antigens, immune response to tumors and immunotherapy of tumors.

#### **Unit VII: Immunological Techniques**

Precipitation and agglutination; RIA; ELISA; ELISPOT assay; Western blotting; immunofluorescence; Flow cytometry and immunoelectron microscopy; Hybridoma technology and monoclonal antibodies; Antibody engineering including bispecific antibodies; Phage display; Development of animal models for studying diseases.

#### Unit VIII: Vaccinology

Active and passive immunization; Live; killed; Attenuated; Subunit vaccines; Vaccine technology- Role and properties of adjuvants; Vaccines based on recombinant DNA, mRNA, peptide and protein; Conjugate vaccines; Plant-based vaccines; Reverse vaccinology.

#### **Unit IX: Parasitology**

Basic concept and overview of Host-Parasite relationship. Parasitic adaptations, interrelationships between host and parasite. Life history, Mode of infection, pathogenicity and control measures of the following parasites: *Plasmodium vivax*, *Entamoeba histolytica*, *Trypanosoma* spp. *Leishmania* spp. *Fasciola hepatica*, *Ascaris lumbricoides*. Parasitic adaptation of *Fasciola*, *Taenia* and *Ascaris*. Vectors: Examples, structures associated with disease transmission and names of diseases transmitted by fleas, ticks and mosquitoes.

#### Suggested Readings

- 1. Kuby Immunology by Kindt TJ, Goldsby RA, Osborne BA, Kuby J: WH Freeman; 2006
- 2. Cellular and Molecular Immunology by Abbas AK, Lichtman AH, Pillai S: Saunders Elsevier; 2007.
- 3. Immunobiology: The immune system in health and disease by Janeway CA, Travers P, Walport M, Shlomchik MJ: 6th edition. New York. Garland Science Publishing; 2005.
- 4. Fundamental Immunology by Paul WE: 4th edition. New York. Raven Press; 2000.
- 5. Roitt's Essential Immunology by Delves PJ, Martin SJ, Burton DR, Roitt IM; 11th edition. Blackwell Publishing/Oxford Univ. Press; 2006.
- 6. Anderson RM, May RM. (1985) Helminth infections of humans: mathematical models, population dynamics, and control. *Adv Parasitol.*:1-101.
- 7. Cox F. E. G. (1993) Modern Parasitology: A Textbook of Parasitology.
- 8. Chatterjee (1967) K. D. Parasitology: Protozoology & Helminthology.
- 9. Gardner MJ et al (2002) Genome sequence of the human malaria parasite P. falciparum, Nature
- 10. Ivens AC et al. (2005) The genome of the kinetoplastid parasite, Leishmania major. Science.

## **Paper Code:** ZOOPGCCT09 **Paper Title:** Molecular Biology

#### **Course Objective:**

- Understanding the detailed molecular structure, organization, and function of genetic material of prokaryotes and eukaryotes.
- To understand molecular mechanisms of cellular processes like DNA replication, Transcription, Post-transcriptional processes, Translation, and Post-translational processes etc.
- Understanding the regulation of all the molecular processes.
- Provide an overview of cell structure and function at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes in prokaryotes and eukaryotes.

#### Learning Outcomes:

- Students will understand the scientific process, in the context of learning the fundamental biological and chemical 'facts' of molecular biology.
- Students will gain skills required to effectively do scientific research.
- Explain that the growth, development, and behavior of organisms are activated through the expression of genetic information in context.
- Students will be able to Describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function
- Represent and illustrate structural organization of genes and the control of gene expression
- Conceptualize and describe protein synthesis, modification, folding etc.

#### **Unit I: Genetic material**

The structure of DNA and RNA; Melting of DNA, Superhelicity, Comparative Organization and features of Microbial Genomes and Eukaryotic Genomes

#### **Unit II: DNA replication**

Arrangement of replicons in a genome, Various modes of replication, continuous, discontinuous synthesis, various replication Enzymes, Replication Fork and priming, leading and lagging strand, elongation, termination, Plasmid replication, specific features of replication in Prokaryotes and Eukaryotes, action of topoisomerases, Telomere maintenance and Chromatin Assembly, Single stranded DNA replication, Relationship between DNA replication and cell cycle, DNA copy number maintenance.

#### Unit III: Recombination and Repair of DNA

DNA repair and recombination, DNA Mismatch Repair, Double Strand Break Repair, Recombination as a molecular biology tool. CRISPR-Cas9, Principle, Variations involved and applications.

#### **Unit IV: Transcription**

Transcription machinery of prokaryotes, various transcription enzymes and cofactors, initiation, elongation and termination, sigma factors, Transcription machinery of eukaryotes, various forms of RNA polymerase and cofactors, initiation, elongation and termination, promoters, enhancers, silencers, activators, effect of chromatin structure, regulation of transcription.

#### Unit V: Post-transcriptional processes

RNA processing, splicing, capping and polyadenylation, rRNA and tRNA processing, RNA Editing; RNAi and miRNAs, Antisense RNA, Post-transcriptional gene regulation

#### Unit VI: Operon

Gene structure, concept of Operon, Lac and Trp operon, organization and role in regulation of expression

#### **Unit VII: Translation**

The genetic code and protein structure, Mechanisms of translation in prokaryotes, Mechanisms of translation in eukaryotes, initiation complex, ribosomes and tRNA, factors, elongation and termination, *in vitro* translation systems, polycistronic / monocistronic synthesis, Regulation of translation, RNA instability, inhibitors of translation, stringent response in bacteria

#### Unit VIII: Post-translational processes

Protein modification, inteins and exteins, folding, chaperones, transportation; The Signal Hypothesis, proteasome.

#### Suggested Readings

- 1. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
- 2. Molecular Biology by R.F. Weaver, 4th edition, McGraw Hill. New York. USA, 2007.
- 3. Molecular Biology of the Gene by JD Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick, 6th
- 4. edition, Benjamin Cummings, San Francisco, USA, 2007.
- 5. Molecular Biology of the Cell by B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, 5th
- 6. edition, Garland Science, New York and London, 2007.
- 7. Biochemistry (5th edition) by J.M. Berg, J.L. Tymoczko, L. Stryer, W.H. Freeman and Company, New York, USA, 2008.
- 8. Current Protocols in Molecular Biology Edited by: Fred M. Ausubel; Roger Brent; Robert E. Kingston; David D. Moore; John A. Smith; Kevin Struhl, John Wiley and Sons, Inc. 2007

## Paper Code: ZOOPGCCT10

### Paper Title: Evolution and Animal Behaviour

#### **Course Objective:**

- To give insight into the origin of life and the related evolutionary processes.
- To learn about deciphering of evidence ranging from fossil records to molecular data and arrange them to establish phylogenetic relationships of species.
- To provide a platform to understand various forces which bring about variations between populations of a species and cause them to diversify into new species.
- To explain the natural behaviour patterns, how behaviour varies among individuals and species, how current and past environments and ecology influence the behavior and biological rhythm.

#### Learning Outcomes:

After completion of the course, a student will be able to achieve these outcomes:

- Explain various evolutionary forces in action.
- Application of knowledge on populations in real time, while studying speciation, behavior and susceptibility to diseases will be possible.
- Explain about the relationship of the evolution of various species and the environment they live in.
- Knowledge gained from study of variation; genetic drift can be applied to ensure that conservation efforts for small threatened populations are focused in the right direction.
- Understand types of animal behaviour and their importance to the organisms.
- Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetic basis of the behaviour.

#### Unit I: Natural Selection and Adaptation

Ascent of Darwinism and Synthetic Darwinism; Methods of studying natural selection and Models of selection; Recognizing adaptation; Punctuated equilibrium and stasis.

#### **Unit II: Evolutionary Process**

Mechanisms producing genetic diversity (mutation, migration and genetic drift); Phenotypic variation and plasticity; Molecular evolution; Species & Speciation; Genetic basis of species difference and reproductive barriers.

#### **Unit III: Gene Frequencies in Population**

The Hardy-Weinberg principle and analysis of gene frequencies in the natural population; Major factors influencing gene frequencies (migration, inbreeding), effects of selection and mutation on gene frequencies; Constructing evolutionary trees, measures of genetic relationship among organisms; Tools of studying human evolution.

#### **Unit IV: Evolutionary Genetics**

Anagenesis and Cladogenesis; Genetic identity and genetic distance; Molecular tools in phylogeny; DNA hybridization, Protein sequence analysis, Immunology and electrophoresis; Neutrality theory of molecular evolution; Molecular clock; Evolution of genome size

#### **Unit V: Animal Behavior**

The science of behaviour: History, scope and terminology; Stereotyped Behaviours (Orientation, Reflexes); Individual Behavioural patterns; Instinct vs. Learnt Behaviour; Associative learning, classical and operant conditioning; Habituation, Imprinting.

#### Unit VI: Social and Sexual Behaviour

Aggregation, Schooling in fishes, Flocking in birds; Group selection, kin selection, Altruism, Foraging in honey bee and advantages of the waggle dance; Sexual Behaviour: Asymmetry of sex, Sexual dimorphism; Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice); Sexual conflict in parental care.

#### **Unit VII: Biological Rhythms**

Circadian and circaannual rhythms, Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic and non-photic zeitgebers; Orientation and navigation, Migration of fishes & birds; Biological Clock, Role of Melatonin.

#### Suggested Readings:

- 1. Ridley, M (2004) Evolution III Edition Blackwell publishing
- 2. Hall, B.K. and Hallgrimson, B (2008). Strickberger's Evolution IV Edition. Jones and Barlett Publishers
- 3. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson
- 4. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates
- 5. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. V Edition, John Wiley and Sons Inc.
- 6. Manning A & Dawkins MS, An Introduction to Animal Behaviour, Cambridge University Press
- 7. David McFarland, Animal Behaviour, Pitman Publishing Limited, London
- 8. John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
- 9. V Agarwal, Animal Behavior, S Chand Publications
- 10. Vinod Kumar, Biological Rhythms, Narosa Publishing House, Delhi

## CORE COURSE PRACTICAL (CCP) PAPERS CONTENT

## Paper Code: ZOOPGCCP01 Paper Title: Core Course Practical I

#### **SECTION A Cell Biology**

- 1. Isolation of mitochondria and their visualization with Janus green B
- 2. In situ visualization of microfilaments and microtubules by fluorescent labelling.
- 3. *In silico* analysis (sequence comparison) of mitochondrial and chloroplast genes for identification of the loci for interspecific discrimination.
- 4. Immunostaining of nuclei
- 5. Immunostaining of chloroplast / mitochondria.
- 6. Demonstration of
  - a. cell culture media preparation
  - b. visualization of cells in culture
  - c. maintenance of cell culture

#### **SECTION B Biochemistry**

- I. Basic and standardization Methods
  - 1. Preparation of Acid & Alkali solutions and acid-base titration.
  - 2. Concept of pH. Measuring pH of different solutions
  - 3. Preparation of buffers: Acetate, Phosphate and Tris buffers.
- II. Estimation of micromolecules
  - 1. Estimation of inorganic phosphate
  - 2. Estimation of sugar (glucose)
  - 3. Estimation of Amino acid (Tyrosine)
  - 4. Estimation of Base (Guanine)
- III. Estimation of macromolecules
  - 1. Determination of Blue Value of Starch
  - 2. Estimation of Proteins
  - 3. Estimation of nucleic acids (DNA)

#### IV. Enzyme kinetics

An enzyme purification theme (such as E. coli alkaline phosphatase or any other enzyme.

- 1. Preparation of cell-free lysates / Ammonium sulphate precipitation.
- 2. Ion-exchange / Affinity / Gel filtration chromatography.
- 3. Assessing purity of protein by PAGE.
- 4. Enzyme Kinetic Parameters: Km, Vmax and Kcat.
- 5. Determination of Units and specific activity of an enzyme

## Paper Code: ZOOPGCCP02 Paper Title: Core Course Practical II

#### SECTION A: Ecology

#### I. Habitat studies:

- 1. Physical and chemical characteristics of soil.
- 2. Physico-chemical properties of water.

#### II. Community/ecosystem studies:

3. Assessment of density, frequency and abundance of plants/ animals in a community using various techniques i.e., transect, quadrate etc.

- 4. Diversity index by Simpsons and Shannon; Insect diversity
- 5. Understanding ecosystem succession by studying various stages of vegetation/community assemblages' development.
- 6. Identification of aquatic organisms of different trophic levels, construction of food chain, food web

#### III. Landscape studies:

- 1. Principles of GIS, GPS and RS technology.
- 2. Interpretation (visual and automated) of remote sensing information for landscape differentiation

#### IV. Aquatic ecology studies:

- 1. Estimation of dissolved O2 / free CO2 in water
- 2. Estimation of pH of water
- 3. Quantitative counting of zooplankton

#### **SECTION B Non-Chordates**

- 1. Study of whole mount of Euglena, Amoeba and Paramecium,
- 2. Examination of pond water collected from different places for diversity in protista
- 3. Study of Sycon (T.S. and L.S.), Hyalonema, Euplectella, Spongilla
- 4. Study of Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora.
- 5. Study of adult Fasciola hepatica, Taenia solium, Ascaris lumbricoides and its life stages (Slides/microphotographs)
- 6. To submit a Project Report on any related topic on life cycles/coral/ coral reefs
- 7. Study of following specimens:
  - a. Annelids Aphrodite, Nereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria
  - b. Arthropods Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta, termites and honeybees.
  - c. Onychophora Peripatus.
  - d. Molluscs Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus.
  - e. Echinoderms Pentaceros/Asterias, Ophiura, Clypeaster, Echinus, Cucumaria and Antedon.
- 8. Study of the digestive system of earthworms; digestive system and nervous system of Periplaneta,
- 9. To submit a Project Report on any related topic to larval forms (crustacean, molluscs and echinoderm).
- 10. Study of Freshwater planktons, collection, sorting, identification of samples of zooplanktons: protozoans, rotifers, crustaceans. (Including study of permanent specimens)

#### **SECTION C Bioinformatics**

- 1. Sequence alignment using BLAST and Clustal W.
- 2. Phylogenetic analysis using PHYLIP.
- 3. Microarray analysis using Bioconductor.
- 4. Molecular format conversion and hands-on molecular visualization program for displaying, animating and analyzing large bio-molecular systems using 3-D graphics.
- 5. Homology Modelling using SPDBV, model structure refinement using SPDBV and model validation using What Check and Pro Check.
- 6. Comparing structures, mutations, studying interactions creating electrostatic potential diagrams.
- 7. Virtual screening and molecular docking using AUTODOCK.
- 8. Computer-based practical's using any statistical software like 'R'. MATLAB, SPSS, Spreadsheets, etc. to understand the following concepts:
  - a. Graphical data representation
  - b. Measures of central tendency and dispersion
  - c. Probability and probability distributions: binomial, Poisson and normal distribution
  - d. Correlation and linear regression analysis
  - e. Student's t- test, Chi-square test

## Paper Code: ZOOPGCCP03 Paper Title: Core Course Practical III

#### **SECTION A: Chordates & Animal Physiology**

- 1. Study of following specimens: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamander, Rhacophorus Draco, Uromastix, Naja, Viper, model of Archaeopteryx, any three common birds-(Crow, duck, Owl), Squirrel and Bat.
- 3. Preparation of temporary mounts: Neurons and Blood film.
- 4. Estimation of haemoglobin using Sahli's haemoglobinometer.
- 5. Examination of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.
- 6. Histology: Basic histochemistry and staining of tissues-theory and practical

#### **SECTION B: Immunology**

- 1. Antibody titer by ELISA.
- 2. Double diffusion, immuno-electrophoresis and radial Immunodiffusion.
- 3. Complement fixation test.
- 4. Determination of blood groups.
- 5. Isolation and purification of IgG from serum or IgY from chicken egg.
- 6. SDS-PAGE, Immunoblotting, Dot blot assays
- 7. Blood smear identification of leukocytes by Giemsa stain
- 8. Separation of leucocytes by Dextran density gradient method
- 9. Separation of mononuclear cells by Ficoll-Hypaque.

#### **SECTION C: Metabolism**

- 1. Determination of ABO Blood group
- 2. Enumeration of red blood cells and white blood cells using haemocytometer
- 3. Recording of blood pressure using a sphygmomanometer
- 4. Detection of SGOT and SGPT or GST and GSH in serum/ tissue
- 5. To perform the Acid and Alkaline phosphatase assay from serum/ tissue
- 6. Study of the permanent slides of all the endocrine glands
- 7. Demonstration of Castration/ ovariectomy in laboratory bred rat\*
- 8. Estimation of plasma level of any hormone using ELISA

## DISCIPLINE SPECIFIC ELECTIVE (DET AND DEP) PAPERS CONTENT

## Paper Code: ZOOPGDET01 Paper Title: Genetics

#### **Course Objective:**

- Students will learn the basic principles of Mendelian inheritance.
- Come to know the basics of genetics and classical genetics covering prokaryotic and higher eukaryotic domains
- Learn the fine structure and molecular aspects of genetic material.
- Understand the cause and effect of alterations in chromosome number and structure.
- Understand how DNA encodes genetic information and the function of mRNA and tRNA
- Students will be exposed to concepts of population genetics, quantitative genetics encompassing complex traits, clinical genetics and genetics of evolution.
- Relate the conventional and molecular methods for gene manipulation in other biological systems.

#### Learning Outcomes:

On successful completion of this unit, students will be able to:

- Understand and articulate the roles for inheritance/genetic mechanisms in human health & disease, and environment & society along with ethical issues associated with genetic knowledge;
- Understand and describe key processes involved in the inheritance and expression of genes;
- Analyse and interpret biological and evolutionary problems in terms of genetic/genomics concepts and be able to utilise modern genetic/genomic tools to conduct further investigation;
- Clearly communicate genetic concepts so they are understood across a wide range of scientific disciplines; Apply the principles of Mendelian inheritance
- Work effectively as independent researcher and in teams within a laboratory setting; and
- Develop an awareness of genetic issues as they are viewed within society and across cultural boundaries.

#### Unit I: Basic concepts of inheritance

Overview of history of scientific progress leading up to modern-day genetics; concepts of inheritances, traits, genes, alleles, genotypes, phenotypes, dominance, recessive, monohybrid cross, dihybrid cross, testcross, backcross, standard genetic symbols; Mendel's laws of inheritances based on Mendel's experiments; Predicting outcome of genetic crosses by Punnett's square and Probability methods; Goodness-of fit Chi-Square test.

#### Unit II: Extensions and modifications of Mendel:

Chromosomal theory of inheritance; Incomplete dominance, codominance, penetrance and expressivity, lethal alleles, multiple alleles, pseudo alleles; Gene interactions with epistasis; Complementation tests; Sex-determination and sex-linked inheritance; Sex-influenced and sex-limited inheritance and expression of genes; Cytoplasmic inheritance; Genetic maternal effect; Genomic imprinting and epigenetics; Anticipation; Environmental effects on genotype expression; Pleiotropy.

#### Unit III: Gene mapping methods, Pedigree analysis and genetic testing

Pedigree analysis; Pedigree characteristics of autosomal recessive, autosomal dominant, X-linked recessive, Xlinked dominant, and Y-linked traits; Concordance of twins; Genetic testing and karyotyping; Genetic diseases; Concept of linked genes and linkage group, recombinants and non-recombinants; Relation between crossing over and linkage; Recombination frequency; Concept of coupling and repulsion; Concept and construction of genetic maps, determination of gene orders; Interference and coefficient of coincidence; Lod scores; Physical gene mapping methods.

#### **Unit IV: Microbial genetics**

Brief introduction of microorganisms that are used as study models for genetics; Basic structures of bacterial

and viral genomes; Gene transfers methods- conjugation, transformation and transduction; Gene mapping methods in bacteria; Benzer's mapping techniques.

#### Unit V: Gene mutations and alteration of chromosomes

Concept of gene mutation; Types of gene mutation, causal factors and detection techniques of gene mutation; Phenotypic effects of gene mutation; Concept of chromosomal mutation; Types of chromosomal mutations-rearrangements, aneuploids and polyploids; Transposition of genes.

#### **Unit VI: Quantitative genetics**

Concept of continuous and discontinuous inheritance; Types of quantitative characteristics; Polygenic inheritance; statistical methods in quantitative genetics; Concept of heritability- phenotypic variance, environmental variance and genetic variance; Types of heritability, calculation of heritability; Limitations of heritability; Quantitative Trait Loci (QTLs) mapping.

#### Suggested Readings:

- 1. Genetics: A Conceptual Approach, Benjamin A. Pierce. Macmillan learning, ISBN:9781319297145
- 2. Gene IX by Benjamin Lewin, Jones and Bartlett Publishers, Sudbury, Massachusetts, 2007.
- 3. Principles of Genetics, 6th edition (2011), Snustad DP and Simmons MJ, John Wiley and Sons, Inc

4. Concepts of Genetics, 10th edition, (2011). William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino; Pearson Education

5. Russell, P. J. (2009). Genetics- A Molecular Approach.III Edition. Benjamin Cummings

6. Griffiths AJF, Wessler SR, Lewontin RC and Carroll SB Introduction to Genetic Analysis. Freeman Co.

### Paper Code: ZOOPGDEP01 Paper Title: Discipline Elective Practical I

#### **SECTION A: Molecular Biology**

- 1. Isolation of plasmid DNA and Isolation of genomic DNA.
- 2. Estimation of purity & concentration of DNA.
- 3. Amplification of DNA by PCR
- 4. Restriction digestion analysis by agarose gel electrophoresis.
- 5. Ligation of DNA fragments.
- 6. Cloning of a DNA fragment
- 7. Alpha-complementation / Blue-white screening
- 8. Overexpression of proteins and analysis by SDS-PAGE
- 9. Purification of recombinant protein
- 10. Western Blotting analysis

#### **SECTION B: Genetics**

- 1. Observation of wild type and mutant phenotypes in eukaryotic organisms.
- 2. Preparation of culture media for *Drosophila* and study different stages of the life cycle of *any one eukaryotic organism*
- 3. Verification of Mendelian laws through Drosophila / seeds dominant, recessive and sex-linked
- 4. Preparation of Barr body
- 5. Karyotyping with the help of photographs (normal and abnormal karyotypes)
- 6. Pedigree charts of some common characters like blood group, color blindness, etc
- 7. Study of polyploidy in onion root tip by colchicine treatment.

## **Paper Code:** ZOOPGDET02 **Paper Title:** Aquatic Biology and Fisheries

#### **Course Objective:**

- Study of aquatic life and equip students with skills that can later lead into a profession in aquatic biology.
- Study of characteristics and biodiversity of Freshwater, Estuarine and Marine ecosystems.
- Focuses on research and explains processes, structures and pathways in most aquatic and wet ecosystems.
- Study of fishes as a most promising aquacultural candidate, Fish physiology, Fish Nutrition and Fish Pathology and defence mechanism.
- Knowledge about sustainable technology for aquaculture.

#### Learning Outcomes:

After successfully completing this course, students will be able to:

- Provide a comprehensive understanding of small- and large-scale processes that govern the structure and function of aquatic environments.
- Understand how human activities influence the physicochemical environment of water bodies, what devastating impact it has on aquatic organisms.
- Mention the various composite fish cultures with significance of each type.
- Describe the methods of freshwater prawn culture and its management.
- Explain the methods of pearl culture and pearl harvesting.
- Identify the fish diseases and the causative organisms
- Illustrate the preparation and management of fish culture ponds.
- Illustrate techniques of fish harvesting, preservation & processing.
- Compare the techniques used in fishery development.
- Know about the laws to protect endangered aquatic species.
- Understand and apply relevant scientific principles in the area of aquatic biology and educate others or work to conserve our natural resources.

**Unit I:** Aquatic Biology Characteristics and biodiversity of Freshwater, Estuarine and Marine ecosystems. Bioresources and Bioactive compounds from estuarine and Marine resources. Metapopulation and Metacommunity approaches for fish assemblages, Coarse and Fine filter methods for conservation of aquatic bioresources.

**Unit II:** Aquatic Organisms: Distribution patterns of planktonic organisms. Phytoplankton-zooplankton relationships. Planktonic community organization in relation to predators. Adaptations of planktonic organisms to different aquatic habitats. Periphytic communities. Benthos. Bio-indicators and Biomonitoring.

**Unit III:** Water-quality criteria for Aquaculture: Role of temperature, pH, salinity, dissolved oxygen, ammonia, nitrite, nitrate, phosphate.

**Unit IV:** Fish Nutrition: Regulation of food intake, environmental factors and feed intake, digestive physiology and nutrient digestibility in fishes, nutritional energetics. Feeding schedules and ratio, feed performance, feed formulation, processing, storage and application, Fish growth estimation.

**Unit V:** Fish Immunity: Development of immune system, cells and tissues of the fish immune system, Modulators of fish immune responses, Humoral and cell mediated immune defense, Fish antibody molecules and their effector functions. Host-parasite interaction, immune-evasion mechanisms of fish pathogens

**Unit VI:** Fish Reproduction: Reproductive strategies, Environmental factors regulating reproductive cycles, Hormonal and molecular mechanisms of oogenesis and spermatogenesis, Ovulation, Spawning and Spermiation, Fertilization and Development.

**Unit VII:** Fish Seed Technology and Transport: Natural collection, Bundh breeding, Induced breeding, Global survey of fish breeding practices, Cryopreservation of gametes, Transport of eggs, fry, fingerlings and adults.

**Unit VIII:** Aquaculture Brief account of Sustainable technology for Aquaculture (Freshwater, Estuarine and Mariculture), Advancements in technology for finfish and shellfish culture, Modern hatcheries Technology and management

#### Unit IX: Genetic conservation

#### Suggested Readings

- 1. Computers in Fisheries Research, Megrey, B. A. and Moksness, E. (2009), Springer, USA.
- 2. Biological Invasions in Marine Ecosystems Ecological, Management and Geographic Perspectives. Rilov, G. and Jeffrey, A. C. (2009), Springer-Verlag, GERMANY.
- 3. Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research, ICAR, (2006), DIPA, New Delhi, INDIA
- 4. Fish ponds in Farming Systems. 2007. Zijpp, V. D., Verreth, J. A. J., Tri, L. Q., van Mensvoort, M. E. F., Bosma, R. H., and Beveridge, M. C. M. Wageningen Academic Publishers, Netherlands.
- 5. Aquaculture Principles and Practices. 2005. Pillay, T. V. R. Second edition, Blackwell Publishing
- 6. Aquaculture & Fisheries Biotechnology Genetic Approaches. 2011. Dunham, CABI Publishing, US
- 7. Fish Defenses. Zaccone. 2010. G. Meseguer, J. Garcia-Ayala and Kapoor, B. G. Science Publishers

## Paper Code: ZOOPGDEP02

#### Paper Title: Discipline Elective Practical II

#### Aquatic Biology and Fisheries

- 1. Phylogenetic analysis of bony fish: Morphological analysis; mtDNA polymorphisms; comparison of protein sequences and construction of phylogenetic tree.
- 2. Identification of Indian common fish faunal resources from cold water, warm water, brackish water, marine water and ornamental fishes.
- 3. Physico- chemical parameters of freshwater bodies and estimation of primary productivity.
- 4. Collection of phytoplankton and zooplankton from natural resources and their identification.
- 5. Identification of eggs, spawn, fry & fingerlings of cultivable fishes & estimation of ovarian eggs
- 6. Surgical procedures (effect of hypophysectomy/gonadectomy on fish).
- 7. Determination of age and growth; gonadosomatic index.
- 8. Length-weight relationship and condition factor determination.
- 9. Toxicity testing with zooplankton/fish.
- 10. Formulation and preparation of practical diets for fish.
- 11. Visit to a fish farm and study the socio-economic status of the fisherman community
- 12. Visit to a fish market in West Bengal, identification of dominant and rare finfish and shellfish

#### **Behavior and Evolution**

- 1. Study of fossils from models/ pictures
- 2. Study of homology and analogy from suitable specimens
- 3. Study and verification of Hardy-Weinberg Law by chi square analysis
- 4. Construction of phylogenetic tree with help of bioinformatics tools (Clustal X, Phylip, NJ, its interpretation.
- 5. Study of nests and nesting habits of the birds and social insects.
- 6. Study of geotaxis behaviour in earthworm and phototaxis behaviour in insect larvae
- 7. Study of circadian functions in humans (daily eating, sleep and temperature patterns).

## Paper Code: ZOOPGDET03 Paper Title: Entomology

#### **Course Objective:**

- To understand the concept of entomology.
- To understand insect diversity, society and evolution.
- Attempts to introduce students to the various orders and some of the most important families of insects to distinguish between harmful and beneficial insects.
- Understanding the unique morphological characters of the insects and also their biology and classification.
- Understanding insect societies to appreciate their societal implications.
- Social insects as biocontrol agents.
- Study of the properties, processes, and functions of insect systems.

#### Learning Outcomes:

After successfully completing this course, students will be able to:

- Acknowledge the value and importance of insects
- Know the basic biology and the significant identification characteristics of the insects.
- Understand the latest ideas of comparing these insects in an evolutionary perspective.
- Understanding insect societies, students would develop an ability to appreciate their implications on societal impacts.
- Identify and use various insects as biocontrol agents.

**Unit I:** General organisation of the insect body, head: sutures and area of the cranium, tentorium, gnathal appendages (antenna and mouth parts). Thorax: pterothorax, legs and its modification, wing and wing coupling.

**Unit II:** Circulatory System: Structure of heart and mechanism of circulation, reversal of heart beat; Haemocytes.

**Unit III:** Digestive System: alimentary canal and its modification; salivary glands, nutritional requirements of insect, physiology of digestion, digestion of special food stuffs (wool, collagen, keratin, pollen, silk, wax), intermediary metabolism of carbohydrates, fats and protein, fat body.

**Unit IV:** Respiratory system: general organisation; types of spiracles; respiratory adaptations in aquatic, terrestrial and endoparasitic insects.

**Unit V:** Excretory system: malpighian tubules and other organs of excretion; physiology of excretion, metabolic pathways of synthesis of uric acid, urea and ammonia.

**Unit VI:** Nervous system: structure of brain and nerve cord. Sense organs: mechanoreceptors; chemoreceptors; auditory organs & hearing; sound and light producing organs and mechanism of sound and light production; visual organs (compound eye) and image formation.

**Unit VII:** Morphology of male and female reproductive systems. Male and female external genitalia and its modification. Reproductive physiology: oogenesis; yolk formation; spermatogenesis and transfer of sperms; mating and fertilization; role of pheromones.

**Unit VIII:** Endocrinology: hormones of neurosecretory cells, corpus cardiacum, corpus allatum and prothoracic gland, Metamorphosis, Diapause- cuticle and moulting.

#### Suggested Reading

- 1. Principles of Insect Morphology by R.E. Snodgrass
- 2. The Insect: Structure and Function by R.F. Chapman
- 3. The Principles of Insect Physiology by V.B. Wigglesworth

- 4. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA
- 5. The Insect Societies, Wilson, E. O., Harward Univ. Press, UK

## Paper Code: ZOOPGDEP03 Paper Title: Discipline Elective Practical III

#### Entomology

- 1. Study of one specimen from each insect order
- 2. Study of different kinds of antennae, legs and mouth parts of insects
- 3. Study of head and sclerites of any one insect
- 4. Study of insect wings and their venation.
- 5. Study of insect spiracles 6. Methodology of collection, preservation and identification of insects.
- 6. Morphological studies of various castes of Apis, Camponotus and Odontotermes
- 7. Study of any three insect pests and their damages
- 8. Study of any three beneficial insects and their products

#### **Behavior and Evolution**

- 1. Study of fossils from models/ pictures
- 2. Study of homology and analogy from suitable specimens
- 3. Study and verification of Hardy-Weinberg Law by chi square analysis
- 4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
- 5. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.
- 6. Study of nests and nesting habits of the birds and social insects.
- 7. Study of geotaxis behaviour in earthworm and phototaxis behaviour in insect larvae
- 8. Study of circadian functions in humans (daily eating, sleep and temperature patterns)

## GENERIC ELECTIVE COURSE (GEC) PAPERS CONTENT

## **Paper Code:** ZOOPGGEC01 **Paper Title:** Genetic Engineering

#### **Course Objective:**

- To illustrate use of tools and techniques for manipulation and analysis of genomic sequences.
- To expose students to applications of recombinant DNA technology in biological sciences.
- To train students in strategizing research methodologies employing genetic engineering.
- To expose students to concepts and applications of plant biotechnology

#### Learning Outcomes:

- Technical knowledge of techniques in recombinant DNA technology.
- Understanding applications of genetic engineering techniques.
- Ability to design and conduct genetic manipulation.

#### Unit I: Basics of DNA cloning

Tools of DNA cloning: Different enzymes and vectors used in genetic engineering. Simple cloning and cloning using linkers and adaptors. Selection and screening of clones.

#### **Unit II: Polymerase Chain Reaction**

Concept of PCR and various thermophilic enzymes used in PCR. Gradient PCR versus Touchdown PCR. Designing primers. Cloning PCR products. Long PCR, Inverse PRC, RT-PCR, 5' and 3' RACE, qPCR, MOPAC, Multiplex PCR, Differential Display PCR, Ligation Chain Reaction, Overlap PCR, Rolling Circle Amplification Technology. DNA fingerprinting

#### Unit III: Construction of cDNA and genomic DNA libraries

Vectors used in the construction of cDNA versus genomic DNA libraries. Steps and enzymes involved in the construction of cDNA versus genomic DNA libraries. Screening libraries by colony hybridization and colony PCR. Screening expression libraries. Enriching for clones in cDNA libraries by positive selection and subtractive hybridization.

#### **Unit IV: Genome sequencing**

DNA sequencing by Sanger's method – traditional and cycle sequencing. Physical mapping by restriction fragment fingerprinting of BAC clones and STS mapping. E-PCR. Whole genome shotgun sequencing. Clone-by-clone shotgun sequencing of genome – preparation of BAC/YAC library, map construction, clone selection, subclone library construction, random shotgun phase, finishing phase and sequence authentication. Genome annotation at the nucleotide level, protein level and process level. Next gen sequencing technologies. Mechanism of Pyrosequencing.

#### **Unit V: Transcriptomics**

Reporters used in protein localization and trafficking studies. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, mapping transcriptional start sites by S1 nuclease mapping; Transcriptome analysis by DD-PCR and EST analysis, DNA microarrays (cDNA arrays and oligo arrays), Serial Analysis of Gene Expression (SAGE).

#### Unit VI: Over-expression of recombinant proteins

Overexpression and tagging of recombinant proteins in *E.coli* driven by lac, T7 and Tet-regulatable promoters; Expression in *B. subtilis*; Overexpression systems in *S. cerevisiae*, *P. pastoris*, *S. pombe* and *K. lactis*; Baculovirus overexpression system; Mammalian cell overexpression system; Insertional and deletion mutagenesis; Site directed mutagenesis by conventional and PCR-based methods.

#### Suggested Readings

- 1. Molecular Biology by David P. Clarke, 1st edition; Elsevier Academic Press; 2005.
- 2. Molecular Cloning: A laboratory manual by Joseph Sambrook& David Russell, 3rd edition; CSHL press; 2001.
- 3. DNA Technology: The Awesome Skill by I. Edward Alcamo, 2nd edition; Harcourt Academic Press
- 4. Molecular Biology of the Gene by James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick , 6th Edition; CSHL Press; 2007.
- 5. Methods in Plant Molecular Biology and Biotechnology by B.R.Glick, 2014 2.
- 6. Plant Biotechnology-The genetic manipulation of plants, Second Edition by Adrian Slater, Nigel Scott, and Mark Fowler, 2008

## Paper Code: ZOOPGGEC02 Paper Title: Biotechniques and Bioethics

#### **Course Objective:**

- To educate students about the properties and preparation of buffers, and various basic analytical techniques like dialysis, filtration, spectroscopy, fluorescence techniques, chromatographic techniques, centrifugation techniques and their applications in industrial and research fields.
- The course is also meant to familiarize the students with radioactivity and the applications of radioisotopes in research.
- Also to familiarize students to some more advanced techniques used in biological research.

#### **Learning Outcomes:**

- Students should be able to gather knowledge about the preparation? types, and uses of buffers used in biochemical studies.
- Students should be able to know the principle, working and instrumentation of various chromatographic techniques in detail.
- They will also be able to understand the details of principle, working and instrumentation of various electrophoretic techniques.
- Students should be able to understand the theory and principle of centrifugation. They will be able to differentiate between different types of centrifuges. Also they will be able to enumerate various applications of centrifugation techniques in research.
- Students should be able to understand the different types of radiation emitted by radioisotopes and their measurement. They will know the applications of radioisotopes in biological research, medicine and diagnosis. Also they will understand the research significance and measurement of less abundant non-radioactive isotopes.
- Students should be able to understand the principle, methods and applications of protein crystallization; theory, types, instrumentation and applications of various spectrometry,

#### **Unit I: Separation Techniques**

Different methods of protein precipitation: Precipitation using inorganic salts (salting out) and organic solvents, isoelectric precipitation, Dialysis, Ultrafiltration, Lyophilization.

#### Unit II: Centrifugation

Basic principles; Mathematics & theory (RCF; Sedimentation coefficient etc); Types of centrifuge - Microcentrifuge; High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods.

#### Unit III: Chromatography

Basic principles; Adsorption and partition chromatography; Partition coefficient; Performance parameters; Modes of chromatography; Different types of chromatography: Paper Chromatography, Thin Layer

Chromatography; Gel filtration Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Liquid Chromatography; LPLC and HPLC; IMAC; Preparative and analytical applications.

#### **Unit IV: Electrophoresis**

Basic Principle; Paper electrophoresis; Gel electrophoresis; discontinuous gel electrophoresis; PAGE: SDS-PAGE, Native gels, denaturing gels, Isoelectric Focusing of proteins, 2D gel; Agarose gel electrophoresis; PFGE; Buffer systems in electrophoresis; Detection and identification (staining procedures); Molecular weight determination; Protein and nucleic acid blotting.

#### Unit V: Spectroscopy and Crystallography

Molecular spectroscopy; UV-Visible, Raman, IR spectroscopy; Fluorescence spectroscopy; FRET; Bimolecular fluorescence complementation assay; Theory and application of Circular Dichroism; Mass spectrometry; NMR; PMR; ESR and Plasma Emission spectroscopy. Theory and application of X-Ray Crystallography.

#### Unit VI: Microscopy

Principles and applications of Microscopy; Fluorescence; Phase contrast; Confocal; Scanning and Transmission and Cryo- Electron microscopy.

#### Unit VII: Analysis of protein-DNA and protein-protein interactions

Gel retardation assay; DNA foot-printing by DNase I and chemical methods; Yeast one-hybrid assay, ChIPchips. Yeast two hybrids, three-hybrids, split hybrids and reverse hybrids. Co-immunoprecipitations; GFP and FRET; Phage display.

#### **Unit VIII: Radioisotopes**

Radioisotopes and their use in biology and diagnostics; autoradiography; radioactive labeling of biological macromolecules.

#### **Unit IX: Bioethics**

Philosophy and Theories of Bioethics; Clinical ethics; Research Ethics.

#### Suggested Readings

- 1. Physical Biochemistry: Principles and Applications, 2nd edition (2009), David Sheehan, JohnWiley
- 2. Cell and Molecular Biology: Concepts and Experiments, 6th edition (2009), Gerald Karp, Wiley
- 3. Gene cloning and DNA analysis, 6th edition (2010), T.A. Brown. Wiley-Blackwell
- 4. Principles of Gene Manipulation and Genomics, 7th edition (2006), S.B. Primrose and R.M. Twyman. Blackwell Scientific
- 5. Human Molecular Genetics, 3rd edition (2003), Tom Strachan and Andrew Read; Garland Science Publishers

## **Paper Code:** ZOOPGGEC03 **Paper Title:** Entrepreneurship in Biology

#### **Course Objective:**

The overall aim of the course is to give the students an insight into the field of bioentrepreneurship, i.e. business within the life sciences.

#### Learning Outcomes:

At the end of the course the student will be able to:

- Explain the importance of embarking on self-employment
- Understand company Law and commercial knowhow for biotechnological ventures
- Identify issues in protection of biotechnology inventions
- Adapt biosafety and bioethics principles
- Demonstrate a general understanding of the central role that business development plays for the biomedical industry
- Write, and critically review a business plan
- Perform a basic market analysis in the life science sector
- Analyse and critically assess a case study

#### Unit I: Introduction to Biotechnology

Biotechnology: definition, history, thrust areas; Elements of Bio-Process Engineering; Biotech Industries; Basic concepts of GLP, GMP and FDA; Scope and Importance of Biotechnology and allied fields. Role of Biotechnology in economic development of society.

#### Unit II: Entrepreneur and Entrepreneurship

Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.

#### Unit III: Introduction to Bio-entrepreneurship

Definition of Bioentrepreneurship, traits of an entrepreneur; Copyright, Patents, trademark, plant breeders and farmers' rights, biodiversity related issues; Biopiracy, International and Indian business policies with the focus on Bio and Pharmaceutical products.- BIRAC

#### Unit IV: Planning a Small-Scale Enterprises

Opportunity Scanning and Identification; Creativity and product development process; Market survey and assessment; choice of technology and selection of site. Financing new/small enterprises; Techno Economic Feasibility Assessment; Preparation of Business Plan; Forms of business organization/ownership.

#### Unit V: Case study

Any three of the following enterprises (start up, various stages in establishment, etc.,):

- 1) Biotechnology Company
- 2) Pharma company
- 3) Apiculture company
- 4) Aquaculture company
- 5) Mushroom farming company
- 6) Horticulture company

#### Suggested Reading:

- 1. G.G. Meredith, R.E.Nelson and P.A. Neek, The Practice of Entrepreneurship, ILO, 1982.
- 2. Patzelt, Holger, Brenner, Thomas (Eds.). Handbook of Bioentrepreneurship. Springer, 2008
- 3. Bruce R Barringer and R Duane Ireland, Entrepreneurship: Successfully Launching New Ventures, 3rd ed., Pearson Edu., 2013.
- 4. Lee, James W., 2013. Advanced Biofuels and Bioproducts. Springer New York,
- 5. C. T. Hou, Jei-Fu Shaw, 2008. Biocatalysis and Bioenergy Wiley
- 6. Jakobsen PH. (2019): Commercialisation of Biotechnology Research. Saxo Publish, third edition.

## Paper Code: ZOOPGGEC04Paper Title: Disease Biology

#### **Course Objective:**

- To describe the mechanisms of disease processes and to convey to the student an understanding of the natural history and dynamic nature of disease processes;
- To enable students to acquire a knowledge and understanding of the scientific basis of different diseases
- To empower student with knowledge of prevention of diseases and different safety measure of both communicable and non communicable diseases

#### Learning Outcomes:

- Gain knowledge about potential disease causing organisms and thus be able to design effective disease control strategies.
- Identify challenges of epidemics of different communicable diseases to economy, public health system, individuals, and society at large; and take preventive measures to counter it
- Recognise and understand the pathophysiological processes of common health problems, using the background knowledge of normal anatomy and physiology of human body systems.
- Explain the pathophysiological processes, interactions, and controls to maintain homeostasis in the specific areas of different lifestyle disorders

**Unit I:** Introduction to disease- Symptom, Syndrome, Disorder, Disease; Communicable and Non communicable diseases, Epidemiology-Sporadic, Endemic, Pandemic & Epidemic

**Unit II:** Causes, Symptoms, Diagnosis and Management of Nutritional deficiency diseases: •Protein Energy Malnutrition (PEM), •Vitamin A Deficiency (VAD), •Iron Deficiency Anaemia (IDA), •Iodine Deficiency Disorders (IDD), •Zinc Deficiency, • Fluorosis

Unit III: Etiology, clinical features, diagnosis and management of Infections and Fevers:

• Typhoid • Tuberculosis • Dengue • Malaria

Unit IV: Etiology, clinical features, diagnosis and management of few GI Tract Disorders:
Food allergy and food intolerance
Diarrhoea
Constipation
Lactose intolerance
Celiac disease
Liver: Infective Hepatitis

**Unit V:** Etiology, clinical features, diagnosis and management of lifestyle disorders

• Type 1 and Type 2 Diabetes Mellitus • Metabolic Syndrome • Hypertension and Coronary Heart Disease

UnitI VI: Genetic Diseases, Gene therapy in disease biology; Stem cells as tool to repair damaged tissue

#### Suggested Readings:

- 1. Nessar A, Maureen D, Chris S, Wood E, Biology of Disease; Taylor & Francis;
- 2. K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.
- 3. Gibney et al. Public Health Nutrition; 2004; Blackwell Publishing
- 4. Edward S. Tobias , Michael Connor; Essential Medical Genetics; John Wiley and Sons Ltd
- 5. Hati, A. K. (2001). Medical Entomology. Allied Book Agency, Kolkata.
- 6. Nelson KE, Williams CM, Graham NMH; Infectious Disease Epidemiology: Theory and Practice; Aspen Publication

## ALIAH UNIVERSITY COMPULSORY COURSE (AUC) CONTENT

## **Paper Code:** PGAUC01 **Paper Title:** Elementary Arabic and Islamic Studies

## ABILITY ENHANCEMENT COMPULSORY COURSE (AEC) CONTENT

Paper Code: PGAEC01

Paper Title: Disaster Management/ Human Rights & Value Education/ Yoga & Life Skills (Any one)