NISTARINI COLLEGE PURULIA
DEPARTMENT OF ZOOLOGY

COURSE OBJECTIVES AND OUTCOMES

FOR FOUR-YEAR UNDER
GRADUATE COURSE OF ZOOLOGY
(With effect from the session 2023)

ZOOLOGY -Major Course

Major
First Year
Semester I

UGZOOMJT101: Non-chordates and Cytogenetics

Theory=4 credits

Group- A: Non-chordates

Protozoa

1. General characteristics and Classification with examples up to phylum (according to Levine et. al., 1981)
2. Conjugation in *Paramoecium*.

Porifera

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Canal system in sponges

Cnidaria

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Metagenesis in *Obelia*

Ctenophora

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Platyhelminthes

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Life cycle and pathogenicity and control measures of *Fasciola hepatica*

Nematoda

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Life cycle, pathogenicity and control measures of *Wuchereria bancrofti*

Annelida

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Excretion in Annelida through nephridia.

Arthropoda

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Metamorphosis in Lepidopteran Insects.
3. Respiration in Arthropoda (Gills in prawn and trachea in cockroach)

Mollusca

1. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
2. Nervous system and Torsion in Gastropoda

Onychophora

1. General characteristics and Evolutionary significance

Echinodermata

2. General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)
3. Water-vascular system in Asteroidea

Hemichordata

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Different larval forms of Invertebrates

Group B: Cytogenetics

Overview of Cells

Basic structure of Prokaryotic and Eukaryotic cells

Nucleus

1. Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus

2. Chromatin: Euchromatin and Hetrochromatin and packaging (nucleosome)

Cell Division: Mitosis and Meiosis: Basic concept and their significance.

Mendelian Genetics and its Extension

1. Principles of inheritance, Incomplete dominance and co-dominance, Epistasis Multiple alleles, Lethal alleles, Pleiotropy.
2. Sex-linked, sex- influenced and sex-limited inheritance, Polygenic Inheritance.

Linkage, Crossing Over and Chromosomal Mapping

1. Linkage and Crossing Over, molecular basis of crossing over, Measuring Recombination frequency and linkage intensity using three factor crosses, Interference and coincidence

Sex Determination

1. Mechanisms of sex determination in *Drosophila*
2. Sex determination in mammals
3. Dosage compensation in *Drosophila* & Human

Chromosomal disorder

1. Down syndrome, Turner syndrome, Klinefelter syndrome

UGZOOMJP 101: Practical 2 Credits

Group A: Non-chordates

1. Identification with reason:

Protozoa: *Amoeba, Euglena, Opalina, Paramecium*

Porifera: *Sycon,* Neptune's Cup

Cnidaria:*Obelia, Physalia, Aurelia, Gorgonia, Metridium, Pennatula, Fungia*

Platyhelminthes: *Fasciola hepatica, Taenia solium*

Nematoda: *Ascaris lumbricoides*

Annelida: *Aphrodite, Nereis, Sabella, Serpula, Hirudinaria*

Arthropoda: *Limulus, Daphnia, Balanus, Cancer, Eupagurus, Bombyx, Periplaneta*

Mollusca: *Chiton, Pila, Doris, Unio, Pinctada, Sepia, Octopus*

Echinodermata:*Pentaceros/Asterias, Ophiura, Cucumaria*

Hemichordata: *Balanoglossus*

2. Study of digestive system and septal nephridia of earthworm

3. Mount of mouth parts and dissection of digestive system of cockroach

4. Staining/mounting of any protozoa from gut of cockroach

Group B: Cytogenetics

1. Chi-square analyses

2. Pedigree analysis of some human inherited traits

3. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
4. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.

Laboratory Note Book must be prepared on day-to-day basis and should be signed by the concerned teacher immediately after the laboratory work. The Laboratory Note Book should contain all the items in the syllabus and must be submitted on the day of examination.

Reference Books:

Group A: Non-chordate

Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.

Invertebrates by Brusca & Brusca. Second edition, 2002.

The Invertebrates: A New Synthesis, III Edition, Blackwell Science.

Group B: Cytogenetics

Lewin's Cells – 3rd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers

Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc

Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings

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

Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.

COURSE OBJECTIVE:

It is required to generalize about certain things and to dismiss others because the field of invertebrate biology is so extensive and runs across so many disciplinary lines that it is necessary to generalize about some topics. Classification, Structure and function were chosen as the primary focus for the curriculum that we devised for studying invertebrates so that we could establish common threads of interest. As a result, the most important objective that we have set for ourselves is to pique the students' interest in learning about the mystical world inhabited by animals that do not possess any notochords.

Genetics is one of the fastest-moving fields of science, with new discoveries being made every month. The study of genetics is timely, important, and fascinating because of the many new discoveries and applications of genetics that have substantial economic and ethical implications.

COURSE OUTCOMES:

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

1. Understand basics of classification of non-chordates.
2. Learn the diversity of habit and habitat of these species.
3. Study the functional biology of non-chordates through their body organization and its function.
4. Develop the skills to identify different classes and species of animals and their evolutionary relationships.
5. Enhance the basic laboratory skill like keen observation and drawing.
6. Understand the principles of inheritance, Mendel ‘s laws and the deviations
7. Comprehend the facts of sex determination in Drosophila sp.
8. Detect chromosomal aberrations in humans and study of pedigree analysis.

Semester II

UGZOOMJT201: Chordate and Physiology

Theory= 4 credits

Group A: Chordate

1. General characteristics of Phylum Chordata

2. Classification with characteristic features and examples with scientific names of:

a) Up to Classes: Sub-Phyla Urochordata and Cephalochordata – as per J. Z. Young (1981)

b) Up to Order: Superclass Agnatha – as per J. Z. Young (1981)

c) Up to Sub-classes: Chondrichthyes and Osteichthyes – as per Berg (1940); and Aves – as per J. Z. Young (1981)

d) Up to living Orders: Amphibia – as per Duellman and Trueb (1986),

e) Up to living Orders: Reptilia and Mammalia – as per J. Z. Young (1981)

2. Retrogressive metamorphosis in *Ascidia.*

3. Type study of Chordata: *Branchiostoma*

4. Anatomical peculiarities, distribution and evolutionary significance of Dipnoi

5. Metamorphic Events in Frogs Life cycle

6. Neoteny and Paedogenesis

7. Anatomical peculiarities, distribution and importance of Sphenodon

8. Salient features and affinities of Monotremata

Group B: Physiology

1. **Physiology of Digestion**

Structural organization and functions of gastrointestinal tract and associated glands, Physiology of digestion and absorption of protein, carbohydrates and lipid

2. **Physiology of Respiration**

Mechanism of Respiration, Respiratory volumes and capacities, transport of Oxygen and Carbon dioxide in blood, Dissociation curves and the factors influencing it

3. **Physiology of Circulation**

Composition and constituents of blood, Blood groups and Rh factor, Factors and mechanisms of coagulation, Structure of heart, Origin and conduction of the cardiac impulse and Cardiac cycle

4. **Physiology of Excretion**

Structure of nephron and urine formation, Counter current mechanism

5. **Physiology of Nerve**

Structure of neuron, conduction of nerve impulse, Synaptic transmission, Neurotransmittors

6. **Physiology of Muscles**

Types of muscles and mechanism of contraction of skeletal muscles, Effects of exercise on muscles.

7. **Physiology of Reproduction**

Histology of testis and ovary (mammalian), Physiology of Reproduction (mammalian)

8. **Endocrine System**

Histology and hormonal function of pituitary, thyroid, pancreas and adrenal

UGZOOMJP201: Practical 2 Credits

Group A: Chordate

1. **Identification with reason:**

Protochordata: *Ascidia, Doliolum, Branchiostoma*

Agnatha:*Petromyzon, Myxine,* Ammocoete larva

Chondrichthyes & Osteichthyes:*Scoliodon, Torpedo, Hippocampus, Heteropneustes, Clarias, Exocoetus, Syngnathus*

Amphibia: Tadpole*, Bufo, Rana, Ambystoma, Rhacophorus, Necturus, Hyla, Alytes, Axolotl* larva*, Pleurodeles (=Tylototriton)*

Reptilia: Chelone, *Trionyx, Hemidactylus, Varanus, Draco, Typhlops, Chamaeleo, Naja , Ptyas, Daboia (=Vipera), Hydrophis*

Aves:*Psittacula, Passer, Pycnonotus, Alcedo*

Mammalia:*Pteropus, Funambulus, Suncus*

2. Pecten of Fowl
3. Dissection of Tilapia: Digestive system, Brain, pituitary, urinogenital system

Group B: Physiology

1. Preparation of temporary mounts: Squamous epithelium
2. Microtomy: Preparation of permanent slide of any five mammalian (Goat/white rat) tissues
3. Differential count of blood of man
4. ABO and Rh Blood group testing
5. Recording of blood pressure using a sphygmomanometer

Laboratory Note Book must be prepared on day-to-day basis and should be signed by the concerned teacher immediately after the laboratory work. The Laboratory Note Book should contain all the items in the syllabus and must be submitted on the day of examination.

Reference Books:

Group A: Chordate

Hildebrand, M. (1995). Analysis of Vertebrate Structure. John Wiley & Sons.

Chaki, K.K. Kundu, G. & Sarkar, S. (2005). Introduction to General Zoology. Vol. 1. New Central Book Agency (P) Ltd. Kolkata.

Jordan, E.L. & Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.

Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd. Kolkata.

Parker, T. J. & Haswell, W. (1972). Text Book of Zoology, Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press, London.

Young, J. Z. (1981). The Life of Vertebrates. 3rd Ed. ELBS.

Chatterjee and Chatterjee Practical Zoology

Ghosh, K.C. and Manna, B. (2015): Practical Zoology, New Central Book Agency, Kolkata

Sinha, J.K. , Chatterjee, A.K. and P. Chattopadhyay Advanced Practical Zoology

Group B: Physiology

Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.

Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons

Christopher D. Moyes, Patricia M. Schulte 2016 Principles of Animal Physiology. 3rd Edition, Pearson Education.

Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills

COURSE OBJECTIVE:

Chordate biology helps students gain an awareness and comprehension of scientific concepts that combine and reflect on how science works. As John A. Moore put it, science is the “way of knowing”. The comparative anatomy of vertebrates reveals distinct differences and similarities between the organisms. Using this section of the lesson, students will learn about

the exciting journey of vertebrates and how evolution has shaped them to fit the demands of their surroundings.

The study of the structural and functional plans found in animals is known as animal physiology. Understanding how animals' function on all levels as a whole integrated organism, from cells to tissues to organs, can be aided by knowledge gained through the study of animal physiology. Clarifying the functions of all cells in all organs and all animals in relation to the neurological, respiratory, circulatory, muscular, cellular communication, and transport systems, as well as any other physiological systems, falls under the purview of the scientific discipline known as physiology.

COURSE OUTCOMES:

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

1. Learn about the diversity, morphology, anatomy, and physiology of different chordate groups.
2. Comprehend the identification of species and their evolutionary relationships.
3. Understand the animal world and pursuing further studies and research that are directly linked to human welfare, such as disease control, animal husbandry, and functional studies.
4. Develop the skills to identify different classes and orders of Chordates.
5. Enhance of basic laboratory skill like keen observation and drawing.
6. Comprehend the regulatory mechanisms for maintenance of function in the body.
7. Develop the skills to identify different types of blood cells.
8. Enhance basic laboratory skill like keen observation, analysis and discussion.

Second Year

Semester III

UGZOOMJT301: Ecology and Evolution

Theory - 4 credits

.Group A: Ecology

Theory

- Concept of ecosystem – Structure and function.

Autecology and synecology, levels of organization, laws of limiting factors.

Linear and Y-shaped food chains, food web, energy flow, ecological pyramids and ecological efficiencies.

- Population attributes – Demographic factors.

Life tables, fecundity tables.

Survivorship curves.

Dispersal and dispersion.

Age distribution.

- Population growth models – Natality and mortality.

Geometric, exponential and logistic growth, equation, deduction and patterns.

r and K strategies.

Density dependent and independent factors.

- Population interactions – Emergence of competition by Tansley, Gause and Park.

Competition exclusion principle.

Intraspecific and interspecific competition.

Lotka-Volterra model.

- Community characteristics and resource partitioning.

Species diversity, abundance, dominance, richness, ecotone and edge effect.

- Ecological succession – Types of ecological succession with examples.

Concept of climax.

Connell and Slatyer model of succession.

Tilman’s resource ratio hypothesis.

- Types of ecosystem with an example (in detail) – Freshwater and tropical rainforest.

- Resource utilization – Coupled oscillation of predator and prey population modeling.

Group B: Evolution

Theory

- Life's beginnings – RNA world hypothesis.

Origin of life (Chemical origin only).

- Historical review of Evolutionary concepts – Lamarkism, Darwinism and Neo Darwinism, Neutral theory of molecular evolution, punctuated equilibrium.

- Natural selection – concept of fitness, types of selection, selection coefficient, mode of selection heterozygous superiority.

Synthetic theory.

Concept of selection: stabilizing, directional and disruptive with example.

- Population genetics – Hardy-Weinberg law, statement and derivation of equation, application of law to biallelic population.

Calculating allele and genotype frequency.

Evolutionary forces upsetting H-W equilibrium.

Mathematical calculation of frequency changes in mutation, and migration.

LOD score

- Genetic drift mechanism – founder's effect and population bottleneck phenomenon.

- Species concept – Isolating mechanisms, modes of speciation.

- Zoogeographical realms – names and animal distribution according to Wallace scheme, Avian and Mammalian faunal distribution in different realms.

- Colouration and mimicry (Batesian and Müllerian mimicry).

- Adaptation – Fossorial, cursorial, scansorial and arboreal.

- Adaptive radiation/macroevolution of beak of Galapagos finches.

- Geological time scale and Zoogeographical realms.

Molecular clock.

Fossil records of hominids (from *Australopithecus* to *Homo sapiens*), molecular analysis of human origin.

- Phylogenetic trees – Construction and interpretation of phylogenetic tree using parsimony.

Convergent and divergent evolution.

UGZOOMJP301: Practical - 2 credits

Ecology and Evolution

- Study of life tables and plotting of survivorship curves of different types from the hypothetical / real data provided.
- Determination of population density in a natural / hypothetical community by quadrat method and calculation of Shannon-Wiener diversity index for the same community.

- Study of an aquatic ecosystem - Quantitative and qualitative estimation of freshwater zooplankton, Measurement of Temperature, Transparency of light by Secchi disc,

Determination of pH, and Dissolved O_2content (Winkler's method), Chemical oxygen demand (COD) and free CO_2.

- Report on a visit to National Park / Biodiversity Park / Wild life sanctuary / Sea coast.
- Study of fossils from models / pictures.
- Study of homology and analogy from suitable specimens.
- Study and verification of Hardy-Weinberg Law by chi square analysis.
- Graphical representation and interpretation of data of height / weight of a sample of minimum 100 humans in relation to their age and sex.

References

Group A: Ecology

Krebs, C.J. (2014). Ecology: The Experimental Analysis of Distribution and Abundance, 6th Edition.

Odum, E.P. (2008). Fundamentals of Ecology, 2nd Edition.

Smith, R.L. (1998). Ecology and Field Biology.

Stilling, P. (2012). Ecology: Global Insights and Investigations.

Bowman, W.D., Hacker, S.D. and Cain, M.L. (2017). Ecology, 4th Edition.

Ricklefs, R.E. and Miller, G.L. (2001). Ecology, 4th Edition.

Smith, T.M. and Smith, R.L. (2012). Elements of Ecology, 8th Edition.

Group B: Evolution

Campbell, N.A. and Reece, J.B. (2011). Biology, 9th Edition.

Futuyma, D.J. (2005). Evolution.

Moody, P.A. (1962). Introduction to Evolution, 3rd Edition.

Rastogi, V.B. (2012). Organic Evolution, 13th Edition.

Ridley, M. (2004). Evolution, 3rd Edition.

Russell, P.J. (2016) iGenetics: A Molecular Approach, 3rd Edition.

COURSE OBJECTIVES:

Ecology deals with concept of ecosystem. The goal of this course to understand the basics of ecology. It includes population growth models, population genetics, community

characteristics ecological succession etc. These disciplines of ecology help to develop an appreciation of the modern scope of scientific inquiry in the field of ecology and develop an understanding of the differences in the structure and function of different types of ecosystems.

In evolutionary study it aims to acquire knowledge about the evolutionary history of earth - living and non-living, to acquire basic understanding about evolutionary concepts and theories. It also includes the distribution of animals on earth, its pattern, evolution and causative factors which impart basic knowledge on animal behavioural patterns and their role.

COURSE OUTCOMES

On completion of this subject, students should be able to:

- Become familiar with the variety of ways that organisms interact with both the physical and the biological environment.
- Develop an understanding of the differences in the structure and function of different types of ecosystems.
- Learn techniques of data analysis as well as methods of presenting scientific information in figures and tables.
- Develop an appreciation of the natural world through direct experience with local ecosystems.
- Learn techniques for gathering data in the field.
- Develop an understanding on Life's beginnings – RNA world hypothesis along with natural selection which is one of several processes that can bring about evolution.Demonstrate knowledge of the concept of speciation, population genetics, Zoogeographical realms, Adaptation, Geological time scale, Phylogenetic trees etc. that will give a better understanding of how evolutionary science generates knowledge by way of hypothesis testing, systematic observations, and the comparative

Semester IV

UGZOOMJT401: Molecular Biology and Developmental Biology

Theory - 4 credits

Practical - 2 credits

Group A: Molecular Biology

Theory

- Nucleic acids - Salient features of DNA, Chargaff's Rule, Hypo and Hyperchromic shift. Watson and Crick Model of DNA. RNA types and Function.
- DNA replication - Mechanism of DNA replication in prokaryotes, Semi-conservative, bidirectional and discontinuous replication, RNA priming, Replication of telomeres.
- Transcription - Mechanism of transcription in prokaryotes and eukaryotes, Transcription factors, Difference between prokaryotic and eukaryotic transcription.
- Translation - Genetic code, Degeneracy of the genetic code and Wobble hypothesis. Mechanism of protein synthesis in prokaryotes.
- Post transcriptional modifications and processing of eukaryotic RNA - Capping and Poly A tail formation in mRNA, Split genes, concept of introns and exons, splicing mechanism, alternative splicing and RNA editing.
- Gene regulation - Regulation of transcription in prokaryotes, *lac* operon and *trp* operon.
- Regulation of transcription in eukaryotes - Activators, enhancers, silencer, repressors, miRNA mediated gene silencing.
- Epigenetic regulation - DNA methylation, Histone methylation and acetylation.
- DNA repair mechanisms - Types of DNA repair mechanisms, RecBCD model in prokaryotes, nucleotide and base excision repair, SOS repair.
- Molecular techniques - PCR, Western and Southern blot, Northern Blot.

Group B: Developmental Biology

Theory

- Basic concepts developmental biology - Phases of development, Cell - cell interaction, Differentiation and growth, Differential gene expression.
- Gametogenesis: Spermatogenesis, Oogenesis (sea urchin and mammal).
- Types of eggs, Egg membranes.
- Fertilization in sea urchin and mammal.
- Planes and patterns of cleavage, Types of Blastula (frog and chick).
- Fate map in chick embryo, fate mapping using vital dye and radioactive technique.
- Gastrulation in frog and chick.
- Embryonic induction and organizers in *Xenopus* (Spemann and Mangold's experiment).
- Extra-embryonic membranes in chick.
- Implantation of embryo in humans, Placenta (structure, types and functions of placenta).
- Development of brain and eye in chick, molecular induction in brain and eye development.

- Regeneration - Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).

UGZOOMJP401: Practical - 2 credits

Group A: Molecular Biology

1. Demonstration of polytene from *Drosophila* larva and lampbrush chromosome from photograph.
2. Isolation and quantification of genomic DNA using spectrophotometer (A260 measurement).
3. Agarose gel electrophoresis for DNA.

Group B: Developmental Biology

1. Study of whole mounts of developmental stages of chick through permanent slides - 24, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
2. Study of different sections of placenta (photomicrograph/ slides).
3. Study of the developmental stages and life cycle of *Drosophila*(Visual simul;ation/slides/photo).

References: Group A: Molecular Biology

Lodish, H. et al. (2013). Molecular Cell Biology, 7th Edition.

Watson, J.D. et al. (2013). Molecular Biology of the Gene, 7th Edition.

Russell, P.J. (2016) iGenetics: A Molecular Approach, 3rd Edition.

Twyman, R.M. (1998). Advanced Molecular Biology.

Group B: Developmental Biology

Gilbert, S.F. and Barresi, M.J.F. (2016). Developmental Biology, 11th Edition.

Slack, J.M.W. (2013). Essential Developmental Biology, 3rd Edition.

Wolpert, L. et al. (2002). Principles of Development, 2nd Edition.

COURSE OBJECTIVE

Molecular biology deals with nucleic acids and proteins and how these molecules interact within the cell to promote proper growth, division, and development. It is a large and ever-changing discipline. This course (Group A) will emphasize the molecular mechanisms of DNA replication, repair, protein synthesis. In the part of developmental biology (Group B) student will gain a detailed understanding of the molecular, biochemical and cellular events that regulate the development of specialised cells, tissues and organs during embryonic

development. In particular, cell signalling pathways that regulate embryonic induction, tissue interactions and pattern formation, and expression of regulatory genes. A particular focus is the experimental strategies and techniques that are used to identify molecular and cellular mechanisms of development.

COURSE OUTCOMES

On completion of this subject, students should be able to:

- Describe the core principles of molecular biology.
- Describe the genetic structure and types of chromatins.
- Elucidate the types, damage and repair of DNA, types of RNAs, genetic code, Understand the concept of mutations.
- Explicate the mechanism of gene regulation in prokaryotes.
- Understand the concept of gene expression in eukaryotes.
- Describe the morphological processes that transform a fertilised egg into a multicellular organism.
- Explain the molecular, biochemical and cellular events that regulate the development of specialised cells, tissues and organs during embryonic development.
- Identify model organisms used to investigate developmental biology and compare the developmental programmes of different organisms.
- Describe genetic, molecular and cellular techniques, including genome editing, used to investigate developmental and molecular biology processes in various organisms.
- Gain higher level thinking skills that is necessary for research.

UGZOOMJT402:

Parasitology and Immunology

Theory - 4 credits

Group A: Parasitology

Theory

- Introduction to parasitology - Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector), Host parasite relationship.

- Parasitic protists – Parasitic adaptation and study of morphology, life cycle, prevalence, epidemiology, pathogenicity, diagnosis, prophylaxis and treatment of *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Plasmodium* sp.
- Parasitic helminthes - Parasitic adaptation and study of morphology, life cycle, prevalence, epidemiology, pathogenicity, diagnosis, prophylaxis and treatment of *Schistosoma haematobium, Taenia solium, Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti.*
- Parasitic arthropods - Biology, importance and control of ticks (soft tick *Ornithodoros,* hard tick *Ixodes*), lice (*Pediculus*), and bug (*Cimex*).
- Basic idea on zoonosis and zoonotic diseases.

Group B: Immunology

Theory

- Overview of immune system - Basic concepts of health and diseases, Historical perspective of immunology, Cells and organs of the immune system.
- Innate and adaptive immunity - Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral).
- Antigens - Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens.
- Immunoglobulins - Structure and functions of different classes of immunoglobulins, Antigen- antibody interactions, Monoclonal antibody production
- Immunology of diseases – Autoimmune diseases (rheumatoid arthrites and Type I diabetes)
- Vaccines - Various types of vaccines. Active and passive immunization (Artificial and natural).

UGZOOMJP402: Practical - 2 credits

Group A: Parasitology

- Study of life stages of *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Taenia solium*, *Ancylostoma duodenale*, through permanent slides / micro photographs.
- Study of *Pediculus humanus*, *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides / photographs.
- Study of nematode / cestode parasites from the intestines of poultry bird.

Group B: Immunology

- Demonstration of lymphoid organs.
- Histological study of spleen, thymus and lymph nodes through slides / photographs.

References

Group A: Parasitology

Arora, D.R and Arora, B. (2001). Medical Parasitology, 2nd Edition.

Noble, E.R. and Noble, G.A. (1982). Parasitology: The Biology of Animal Parasites, 5th Edition.

Ahmed, N. et al. (2007). Biology of Disease.

Parija, S.C. (2013). Textbook of Medical Parasitology, Protozoology and Helminthology, 4th Edition.

Ichhpujani, R.L. and Bhatia, R. (2003). Medical Parasitology, 3rd Edition.

Dailey, D. (1996). Meyer, Olsen and Schmidt's Essentials of Parasitology.

Chatterjee, K.D. (2009). Parasitology: Protozoology and Helminthology. 13th Edition.

Group B: Immunology

Kuby, J. et al. (2006). Immunology, 6th Edition.

Abbas, K. et al. (2003). Cellular and Molecular Immunology, 5th Edition.

COURSE OBJECTIVES:

1. To provide students with knowledge regarding parasitological terms, types of parasites and host parasite relationship.
2. To provide students with knowledge concerning biological and epidemiological aspects of parasites causing diseases to humans.
3. To enable students to understand the pathogenesis, clinical presentations and complications of parasitic diseases.
4. To enable students to learn diagnosis and know the general outline of treatment, prevention and control of parasitic infections.
5. To provide students with knowledge regarding basic idea of zoonosis and zoonotic diseases.To provide an adequate knowledge about the basic concepts of health and diseases.
6. To provide students with knowledge regarding cells and organs of the immune system.
7. To enable students to understand the innate and adaptive immunity.
8. To provide students with knowledge about antigens and immunoglobulins.
9. To enable students to understand the antigen-antibody interactions and monoclonal antibody production.
10. To provide an adequate knowledge regarding vaccines and autoimmune diseases.

COURSE OUTCOMES:

At the end of the course, students should be able to:

1. Identify the different types of parasites.
2. Classify parasites causing diseases to humans.
3. Assess the reasons of infections with parasites.

4. Explain the life cycles of various parasites.
5. Discuss the relationship between each parasite and its host.
6. Conduct procedures related to isolation of some parasites.
7. Define the principles of management for some common parasitic diseases.
8. Outline the methods of parasitic disease treatment, prevention and control.
9. Functioning in multi-disciplinary teams to advise the general public on scientific basis to prevent infections with parasite.Discuss the function of cells and organs involved in immunity.
10. Explain features and mechanisms of innate and adaptive immunity.
11. Describe the mechanisms involved in acute and chronic inflammation.
12. Explain about autoimmune diseases.
13. Clarify the antigen-antibody interactions and monoclonal antibody production.
14. Apply the acquired knowledge to explain defence mechanisms against infectious agents.
15. Advise the general public why vaccination is necessary.

Third Year

Semester V

UGZOOMJT501

Theory=4 credits

Group A: Taxonomy and Biostatistics

1. **Basics of Animal Classification**
   - **1.1.** Definitions: Classification, Systematics and Taxonomy; Taxonomic Hierarchy, Taxonomic types
   - **1.2.** Codes of Zoological Nomenclature; Principle of priority; Synonymy and Homonymy; Six kingdom concept of classification (Carl Woese)
   - **1.3.** Introduction to phylogenetics

2. Statistical approach to Biological sciences

2.1. Concept of data and distribution

2.1.1. Definition of data.

2.1.2. Concept of qualitative, quantitative, discrete, continuous, nominal, ordinal, interval and ratio data.

2.1.3. Types of distribution: Normal, skewed, uniform, symmetric bimodal, non-symmetric bimodal, spread, spread with outlier.

2.1.4. Basic concept and types of Kurtosis.

2.2. Probability and its use in Biological Sciences

2.2.1. General concept of probability.

2.2.2. The sum rule and the product rule.

2.2.3. Usage of probability in Biological Sciences (Genetics mainly).

2.3. Analytical Methods

2.3.1. Correlation, Regression t Test, and chi square test

Group B: Biophysical techniques and Bioinformatics

1. Biophysical techniques:

1.1. Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties)

1.2. Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds), stability of proteins.

1.3. Conformation of nucleic acids [helix (A, B, Z), t-RNA, micro-RNA], stability of nucleic acid

1.4. Microscopy: SEM, TEM, Confocal, Phase-Contrast, DIC, FRET, Fluorescence.

1.5. Imaging Technique: PET, CT, MRI.

1.6. Electro-measurement: ECG, EEG.

1.7. Concepts and principles of Colorimetry, Spectroscopy, & Elementary Crystallography.

2. Bio-informatics:

2.1.Basic concept of Bioinformatics: Goals, scope, application and limitations.

2.2. Biological databases: Primary, secondary, and specialised databases.

2.3. Pitfalls of biological databases

UGZOOMJP501: practical Group A and B- 2 credits

1.1. Biostatistics, Analytical tools and Bio-informatics:

1.2. Calculation of mean, median, mode, standard deviation, and standard error (both manually and using software).

1.3. Construction of bar diagrams and pie diagrams using software.

1.4. Submission of a project report on field generated data with application of at least one statistical tool (i.e. correlation, regression, t Test, mean, median, mode, standard deviation, and standard error)

1.5. Basic concept and demonstration of BLAST and primer design

1.6. Demonstration of tools used in biomedical research (Phase contrast microscope, flow cytometer FACS, GC MS, qRT PCR)

1.7. Basic concept and demonstration of BLAST and primer design

Reading References:

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.

2. Invertebrates by Brusca&Brusca. Second edition, 2002.

3. Essential Bioinformatics by Jin Xiong, 1st Edition, 2006, Cambridge University press

5. Biostatistics: A guide to design, analysis and discovery by Ronald Forthofer Eun Lee Mike Hernandez, 2nd Edition, 2006, Academic Press (Elsevier)

6. Nelson, D. L. & Cox. M. M. (2004). Lehninger's Principles of Biochemistry. 2nd ed., Macmillan Worth Publishers.

7. Wilson, K. & Walker, J. (1999). Practical Biochemistry: Principles and Techniques. Fifth Edition. Cambridge Univerity Press

COURSE OBJECTIVE:

Taxonomy is the science of classification in general, but more specifically the classification of living and extinct organisms—i.e., biological classification. The term comes from the Greek words taxis (arrangement) and nomos (law). Taxonomy is thus the methodology and principles of systematic Botany and Zoology that organizes plant and animal species into hierarchies of superior and subordinate groups. In 1813, the Swiss botanist Augustin Pyramus de Candolle proposed the term for plant classification. This course is designed to clear the basic fundamental idea regarding traditional and molecular taxonomy. In the portion of Biostatistics, the students will have an exposure on the basic statistical tools that are an essential part of modern biological research.

The second unit of this course provides some of the most important and fundamental analytical tools used in Biological Sciences that will engorge the students with technical knowledge that could help them in better understanding of biological processes in broad range.

COURSE OUTCOMES

Taxonomy & Analytical tools in Biological science

Students will have learning about the basic taxonomy and systematics and classification of animal kingdom. In this course students will also learn about various data analyzing tools and techniques such as central tendency, t-test, chi-square, ANOVA, correlations and regression etc. They will handle common software used in statistical analysis and bio-informatics. They are expected to gather knowledge on implementation of various tools in biomedical research works.

UGZOOMJT502

Theory=4 credit

Economic Zoology

Theory

1. Aquaculture

- Aquaculture resources in India

- Fish culture
- Prawn culture

Sericulture

- Types of silk
- Silkworms and their host plants
- Life cycle of *Bombyx mori*
- Structure of silk gland and secretion of silk
- Natural enemies and their control and prevention of pests and diseases.

Apiculture

- History, Classification and Biology of Honey Bees.
- Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth
- Diseases and Enemies of Honey bees
- Control and Preventive measures
- Products of Apiculture Industry and its Uses (Honey, Bees Wax, Propolis)

Lac culture

- Lac insect and its life cycle
- Cultivation of lac insect host plants, processing and uses of lac.

5.Poultry

- Types of breeds (fowl)
- Rearing method
- Diseases and control measures

6. Pest control methods.

- Basic idea of Pest control
- Life history, damage and control of the following pests *Apion corchori* and *Sitophilus oryzae*
- Principles of Integrated Pest Management (IPM).

Reference Books

- A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI, Mysore 1989.
- Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore.
- Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore
- Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore, 1986
- Silkworm Rearing; Wupang—Chun and Chen Da-Chung, Pub. By FAO, Rome 1988
- Shukla and Upadhyaya : Economic Zoology (Rastogi Publishers, 1999-2000)
- Shrivastava: Test book of Applied Entomology, Vol. I &II (Kalyani Publishers, 1991)
- Mani: Insects, NBT, India, 2006.
- Jabde: Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture,

- Agricultural Pests and their Control , 2005 Publisher Vedams eBooks (P) Ltd. New Delhi
- Bisht D.S., Apiculture, ICAR Publication.
- Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
- Singh S., Beekeeping in India, Indian council of Agricultural Research, New Delhi.

UGZOOMJP502: Practical - 2 credits

- Visit to local fish culture site to study the fish culture methods.
- Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids
- Visit to Sericulture Information Linkages and Knowledge System centre to get knowledge about Sericulture.
- Study of life cycle of honey bee through chart or specimens/ Study of life cycle of lac insect through chart.
- Visit to local poultry to study the rearing methods.

Reference books

- Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach- David B. Lindenmayer, Jerry F. Franklin. 2013.
- Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
- Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). *Problem-Solving in Conservation*
- Joseph, B., Environmental studies, Tata Mc Graw Hill.
- Michael Allabay, Basics of environmental science, Routledge Press.
- Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5th edition) Books/Cole,
- Mohapatra Textbook of Environmental Biotechnology IK publication.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
- Practical Approaches to the Conservation of Biological Diversity- Richard KenithBaydack, Henry Campa, Jonathan B. Haufler. 1999
- Rana SVS, Environmenta lpollution – Health and Toxicology, Narosa Publication.
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
- Sutherland, W.J. (2000). *The Conservation Handbook: Research, Management and*
- Thakur, I. S., Environmental Biotechnology, I K Publication.
- Valuation and Conservation of Biodiversity: Interdisciplinary Perspectives… Michael Markussen, Ralph Buse, HeikoGarrelts, MaríaManez Costa, Susanne Menzel, Rainer Marggraf. 2005.
- Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). *People and Wildlife, Conflict or Co-existence? Cambridge University.*

COURSE OBJECTIVE:

Mother Nature offers us a plethora of animal diversity, and if we are able to conserve them properly they could generate a source of income being exploited for the betterment of mankind. Thus, studying Aquaculture, Sericulture, Lac Culture, Apiculture and Poultry farming are the burning topics of the day especially in view of population explosion and need of more animal protein and other animal products. Additionally pest management is another big issue that will be addressed.

COURSE OUTCOMES

Economic Zoology,

Economic Zoology: In this section students will learn about the concepts and methods of aquaculture, sericulture apiculture, lac culture and poultry farming. They will also learn the methods of integrated pest management. After learning such concepts and tools they will be able to employ these strategies in their practical life and will be able to establish or manage farms.

Semester: VI

UGZOOMJT601

Theory=4 credits

Title: Clinical Physiology.

Tissue types

- Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue; Structure and types of bones and cartilages, Ossification

Physiology of Digestion and absorption

- Anatomy of digestive system
- Digestion process and adsorption.

Physiology of Cardiovascular System

- Anatomy and histology of the heart. Properties of cardiac muscle. Origin and propagation of cardiac impulse.

- Cardiac cycle: Events. Heart sounds. Heart rate. Cardiac output: Determination by following Fick principle, factors affecting, regulation.
- Structure of arteries, arterioles, capillaries, venules and veins.
- Blood pressure and its regulation and factors controlling. Baro- and chemoreceptors. Vasomotor reflexes. Measurement of blood pressure. Peculiarities of regional circulations: coronary and cerebral.

Physiology of Nervous System

- A brief outline of organization and basic functions (sensory, motor and association) of the nervous system, central and peripheral nervous system.
- Ascending tracts carrying touch, kinaesthetic, temperature and pain sensations. Descending tracts: pyramidal tract and brief outline of the extra-pyramidal tracts.
- Reflex action - definition, reflex arc, classification, properties. Functions of the spinal cord. Outline of functions of brain stem.
- A brief idea of the structure, connections and functions of cerebellum. Different nuclei and functions of thalamus and hypothalamus.
- Cerebral cortex: histological structure and localization of functions.
- CSF : composition, formation, circulation and functions.
- A brief description of the organization of the autonomic (sympathetic and parasympathetic) nervous system. Functions of sympathetic and parasympathetic nervous system.
- A brief idea of speech, aphasia, conditioning, learning and memory. (Recommendation for reduction)

Physiology of Special Senses

- Classification of general and special senses and their receptors.
- Olfaction and Gustation: Structure of sensory organ, neural pathway of olfactory and gustatory sensation. Physiology of olfactory and gustatory sensation. Olfactory and gustatory adaptation. After-taste.
- Audition: Structure of ear, auditory pathway, mechanism of hearing.
- Vision: Structure of the eye. Histology of retina. Visual pathway. Light and dark adaptation. Elementary idea of colour vision. and colour blindness.

Physiology of Endocrine system

- Anatomy of endocrine system.
- Hormones – classification and mechanism of actions
- Hypothalamus: Basic concept of neurohormone. Hypothalamo-hypophyseal tract and portal system. Pituitary: Histological structure, hormones, functions.
- Thyroid: Histological structure. Functions of thyroid hormones (T_4 ,T_3). Thyrocalcitonin. Hypo and hyper-active states of thyroid.
- Parathyroid: Histological structure, functions of parathyroid hormone.
- Adrenal Cortex and Medulla: Histological structure and functions of different hormones, relation of adrenal medulla with the sympathetic nervous system.
- Pancreas: Histology of islets of Langerhans. Origin and functions of pancreatic hormones.
- Endocrine diseases and disorders od Hypothalamus, Pituitary, Thyroid. Adrenal glands and pancreas.
- Elementary idea of gastrointestinal hormones.

UGZOOMJP601: Practical 2 credits

- Study of permanent slides of Mammalian skin, Cartilage, Bone, Spinal cord, Nerve cell, Pituitary, Pancreas, Testis, Ovary, Adrenal, Lungs, Kidney, Thyroid and Parathyroid
- Estimation of haemoglobin using Sahli's haemoglobinometer
- Enumeration of red blood cells and white blood cells using haemocytometer
- Recording of simple muscle twitch with electrical stimulation (or Virtual)
- Measurement of blood pressure using sphygmomanometer

Reading References:

Reference Books

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.
- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Eckert Animal Physiology: Mechanisms and adaptations Randall, Burggren and FrenchVander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
- Histology: A Text and Atlas. Sixth Edition. Ross &Pawlina. Lippincott Williams & Wilkins.
- Eckert Animal Physiology by David Randall and Warren Burggren. 4th edition.
- W.H.Freeman.
- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Slack JMW , Essential Developmental Biology.
- Developmental Biology: A Very Short Introduction (Very Short Introductions). Lewis Wolpert. (1st Edition)

COURSE OBJECTIVE:

Clinical Physiology is the study of life,especially how cells, tissues and organs function. It is a core and fundamental scientific discipline that underpins the health and well-being of living organisms. This paper provides a course of study in mammalian (principally human) systems and their physiology, based on the knowledge of basic physiological principles already studied in Semester II. The main objective of this paper is to expand some areas touched in Semester II and also introduce new and more complex physiological functions.

COURSE OUTCOMES

Clinical Physiology: Students will learn about basics of histology. They will also understand the physiology of muscles, nerves, reproductive systems and bone. They will learn details of endocrinology with classification of hormones, their biosynthesis, receptors, mode of molecular actions, physiological function, feedback controls and related disorders. Students will know the physiology of digestion, respiration, circulation, excretion etc.

Reproductive Biology: In this section students will learn about the basic concept and mechanism of reproductive physiology as well as practical implications of the reproductive biology such as IVF, contraception, and how to medically manage menopause and andropause.

UGZOOMJT602

Title: Biochemistry

Theory=4 credits

1. Basic concept of pH, normality, morality, molality, osmolality

1.1 Protein, Carbohydrates and Lipid metabolism

1.2. Proteins: Protein folding and protein stability, Ramachandran Plot, Amino acid sequencing.

1.3. Carbohydrates: Glycolysis, Glycogenolysis, Gluconeogenesis, TCA cycle

1.4. Lipids: Biosynthesis and transport of cholesterol. 1.5. Amino- acid metabolism: Urea cycle.

2. Enzymology

2.1. Kinetic analysis of enzyme – Mechanism of enzyme catalysis

2.2. Regulation of enzyme activity

2.3.: Co-enzymes and Isoenzymes.

3. Growth and growth factors

3.1. Brief knowledge of growth factors and their mechanism of action in normal cell growth.

4. Bioenergetics

4.1. Thermodynamic principles and steady-state conditions of living organisms

4.2. Energy production and utilization, redox potential, electron transfer and oxidative phosphorylation

5. Concept of free radicals and anti-oxidants

5.1. Free radicals and antioxidants. Cytochrome p45 and other haemoproteins.

UGZOOMJP602: Practical:- 2 Credits

Colorimetric / Spectrophotometric estimation of Glucose, RNA, DNA and Proteins.

Demonstration of proteins separation by SDS-PAGE. **(Hands on / Virtual mode of learning)**

To study the enzymatic activity of Trypsin and Amylase.

Preparation of Normal. Molar and Standard solutions, Phosphate Buffers, Serial dilutions.

Determining the effects of substrate concentration and temperature on enzyme activity.

Estimation of sugars by any standard method

Reference Books:

1. Ganong, W. F.: Review of Medical physiology. Mc. Graw Hill.

2. Greenspan, F. S. and Gardener, F. G.: Basic and Clinical Endocrinology. McGraw Hill.

3. Larsen, P. R.; Krongberg, H. M.; Melmed, S. and Polonsky, K. S.: Williams Textbook of Endocrinology. Larsen PR, Saunders.

4. Norris, D. O.: Vertebrate Endocrinology. Academic Press.

5. Sherwood, L.: Human Physiology: From cells to systems. Thomson Brooks Cole.

6. Willmer, P. *et al*.: Physiological Adaptations. W. H. Freeman.

7. Schiemdt-Nielson, K.: Animal Physiology. Cambridge University Press.

8. Berg, J. M.; Tymoczko, J. K. and Stryer, L.: Biochemistry. W. H. Freeman & Company.

9. Metzler, D. E.: Biochemistry: The Chemical reactions of living cell..Vol. 1 & 2. Academic Press.

10. Murray, R. K.; Granner, P.; Mayes A. and Rodwell, V. W.: Harper's Illustrated Biochemistry. McGraw-Hill.

11. Nelson, D. L. and Cox, M. M.: Lehninger's Principles of Biochemistry. Macmillan Worth Publishers.

12. Switzer, R. L. and Garrity, L. F.: Experimental Biochemistry. W. H. Freeman & Company.

13. Voet, D.; Voet, J. G. and Pratt, C. W.: Fundamentals of Biochemistry. John Wiley & Sons.

14. Ernest Hodgson: A text book of Modern Toxicology. Wiley-Liss, New York.

15. Duffus, J.H. and Worth H.G.J.: Fundamental Toxicology. RSC publishing.

16. Klaassen, C. D.: Casarett & Daul's Toxicology: The Basic Science of Poisons. McGraw-Hill, New York.

17. Elliot, W. H. and Elliot, D. C.: Biochemistry and Molecular Biology. Oxford University Press.

18. Devlin, T. M.: Text Book of Biochemistry with clinical correlation, Wiley-Liss, New York.

COURSE OBJECTIVES:

Students in this advanced course in Biochemistry and metabolic processes will learn about thermodynamics, interplay, catalysis, how cellular reactions are possible in living systems, and how important metabolic pathways work, viz: regulation and inter-dependence of the pathways on one another, their roles in both health and disease will be studied. Enzymes, enzyme kinetics of first- and second-order processes, inhibitions, and regulators are all topics covered in the course. Biochemistry courses in undergraduate programmes expose students to advanced topics including free radicals and their roles in living systems, growth factors, and other aspects of their own biochemistry as well.

COURSE OUTCOMES:

Biochemistry: Students will understand the basic and fundamental biochemistry of carbohydrates, proteins, lipids and nucleic acids. They will also understand the nature, mechanism, and kinetics of enzyme action. The students are expected to learn to prepare various types of solutions. Some instrumentation such as Colorimetry/ Spectrophotometry, SDS-PAGE etc. will also be learnt.

UGZOOMJT603

ADAPTATION AND ANIMAL BEHAVIOUR

Theory=4 credits

1. Adaptation

- Introduction, Adaptive radiation & adaptive convergence in mammals.
- Xeric adaptation (camel and lizard), Aquatic (Whale) adaptation.
- Adaptive radiation with special reference to Darwin's finches.
- Migration of fish and bird.
- Zoogeographical realms, Plate tectonic and Continental drift theory, distribution of birds and mammals in different realms.
- Mimicry: Types, Adaptive significance.

2. Animal behaviour: Concept and classification:

- Introduction, Ethology as a branch of biology, Animal psychology.
- Classification of behavioral patterns.

- Analysis of behavior (Ethogram).
- Innate Behavior

3. Control of behavior:

- Introduction
- Neural behaviour
- Hormonal behaviour

4. Developmental behavior:

- Introduction,
- Genetic components
- Environmental components

5. Communication:

- Introduction
- Chemical, Visual, Light, Audio, Specific specificity of Songs
- Evolution of Language (primates)

6. Ecological aspects of behavior:

- Introduction
- Habitat selection, Food selection
- Optimal forage theory, Anti predation defences
- Aggression, Homing, Territoriality, Dispersal

7. Social behavior:

- Introduction
- Social behavior of group living mammals
- Group selection, Kin selection
- Example of eusociality and haplodiploidy

8. Reproductive behavior:

- Introduction
- Evolution of Sex and Reproductive strategies
- Mating systems, Courtship

9. Introduction to Chronobiology

- Historical developments in chronobiology
- Biological oscillation: the concept of Average, amplitude, phase and period, Circadian and Circa-annual rhythms,

10. Learning:

- Introduction
- Conditioning
- Habituation
- Insight learning
- Association learning
- Reasoning and Cognitive skills

UGZOOMJP603: Practical 2 credits

- Study of homology and analogy from suitable specimens.
- To study mimicry in insect (Using photography).
- To study the behavioural responses of wood lice to dry and humid conditions.
- To study geotaxis behaviour in earthworm.
- To study the phototaxis behaviour in insects.
- Visit to Wild life Sanctuary/Biodiversity Park/National Park/ reserves of the biosphere/ Sea cost to study behavioural activities of animals and prepare a short report.
- Study of circadian functions in humans (daily eating, sleep and temperature patterns).

Reference Books

- Alcock: Animal Behaviour: An evolutionary approach (9 ed. 2009, Sinauer)
- Biological Rhythms: Vinod Kumar (2002) Narosa Publishing House, Delhi/ Springer-Verlag, Germany.
- David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.
- Drickamer, Vessey and Jacob: Animal Behaviour (5th ed. 2002, McGraw Hill)
- Goodenough et al.: Perspectives on Animal Behaviour (1993, Wiley)
- John Alcock, Animal Behaviour, Sinauer Associate Inc., USA.
- Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge,University Press, UK.
- Paul W. Sherman and John Alcock, Exploring Animal Behaviour, Sinauer Associate Inc., Massachusetts, USA.

COURSE OBJECTIVE:

Animal Behavior has been associated with educational curricula for introductory courses in biological science for more than 40 years. When it comes to studying animal behaviour, a more integrated approach is needed to stay up to date with the developments in this field. This course emphasizes research that links behaviour to the brain, genes and hormones as well as to environmental and social factors. It also aims to test out fresh theories on how animal behaviour has evolved. Finally, its fundamental objective is to provide students with a window into the multiple levels of analysis that researchers employ to explain why all living things behave, often in complex ways

COURSE OUTCOMES

Biochemistry: Students will understand the basic and fundamental biochemistry of carbohydrates, proteins, lipids and nucleic acids. They will also understand the nature, mechanism, and kinetics of enzyme action. The students are expected to learn to prepare various types of solutions. Some instrumentation such as Colorimetry/ Spectrophotometry, SDS-PAGE etc. will also be learnt.

Adaptation and Animal behavior: Students will know in details about patterns of behaviors, survival strategies, social and cooperative behaviors, design of signals and chronobiology.

Fourth Year

Semester VII

UGZOOMJT701

GROUP A: NON-CHORDATE STRUCTURE AND FUNCTION

1. General Organization:

1.1. Organelles in Protozoans- Cilia, flagella, pseudopodia, vacuoles, Kinetoplast, Pellicle and skeleton.

2. Feeding and Digestion:

2.1. Nutrition in Protozoa -Types and mode of feeding.

2.2. Feeding diversity in Rotifers, Bryozoans and Echinoderms (Selected major and minor phyla)- Structural diversities.

3. Movements:
3.1. Movements in Amoeba, Annelids (Earthworm); Echinoderms (Starfish).

4. Blood Circulation:
4.1. Circulation in Earthworm, and Pila.
4.2. Types of blood circulation (open and close types).

5. Excretion:
5.1. Structure and function of kidneys in cephalopods

6. Nervous System:
6.1. Brief introduction to Nervous Organization with special reference to Cephalopods

7. Reproduction:
7.1. Budding and regeneration in Hydra and Plannarians.
7.2. Invertebrate hormones of reproduction with special emphasis on Crustaceans.

8. Growth and Development:
8.1. Moulting in Crustaceans: Hormonal regulation
8.2. Larval forms in echinoderms and hemichordates.

Group B: Entomology

1. Insect Diversity & Classification:
1.1. Insect diversity and adaptive features.
1.2. Outline classification of Insects up to the orders with examples (After Richards and Davies, 1977 with minor revision).

2. Integument of Insects:
2.1. Basic structure and functions; structure of cuticle, types of cuticle, sclerotization, epidermis and basement membrane.

3. Feeding mechanism and feeding structure in Insects:
3.1. Insect mouth parts
3.2. Structure of the gut, digestion and absorption of food, & fat body.

4. Insect Blood Circulation:
4.1. Composition, Structure, and Function.
4.2. Diaphragm and heart, haemolymph and its functions

5. Photogenic Organ and Light Production in Insects.

6. Mechanism of Stridulation in insects:
6.1. Types of insect sound and its significance.

7. Introduction to Insect Nervous System.
7.1. Mechanism of impulse conduction.

8. Reproductive Mechanism:

8.1. Basic idea of Parthenogenesis, Viviparity, Polyandry, Hermaphroditism in Insects.
8.2. Hormonal regulation of reproduction in Insects.

9. Growth and Development:
9.1. Metamorphosis, Diapause in insects; types and hormonal regulation.

10. Insect-Plant interaction:
10.1. Insect-Plant co-evolution
10.2. Categories of insect-plant interaction
10.3. Plant defense against insects

UGZOOMJP701: Practical 2 credits
1. Non-Chordate Anatomy
1.1. Comparative anatomy of excretion, nervous system in arthropoda & mollusca (Demonstration/ Model)
1.2. Special structure – stomatogastric nervous system in cockroach, sting apparatus of honey bee/ant
1.3. Distinctive features and identification of non-chordate from museum specimen
1.4. Demonstration of live protozoa and Rotifer (free living and parasitic) under microscope.
2. Entomology:
2.1. Collection, preservation and identification of insects
2.2. Identification of different larval stages of mosquito
2.3. Mounting of mouthparts of mosquito and housefly

Books Recommended:

1. Barrington, E. J. W. (2012). Invertebrate structure and Function. 2nd edition, Affiliated EastWest Press Pvt. Ltd.-New Delhi.

2. Barnes, R. D. & Ruppert, E. E., (1996). Invertebrate Zoology. 6th ed. Brooks Cole.

3. Anderson, D.T. (2002). Invertebrate Zoology, 2nd edition, Oxford University Press.

4. Meglitsch, P.A., & Schram, F.R. (2020). Invertebrate Zoology, 3rd edition, Oxford University Press.

5. Pechenik, J. A. (2019). Biology of the Invertebrates, 7th edition, McGraw Hill Education.
6. Brusca, R.C., Moore, W., & Shuster, S.M. (2016). Invertebrates, 3rd edition, Sinauer Associates.

7. Schierwater & DeSalle (2018). Invertebrate Zoology, A Tree of Life Approach. 1st edition. CRC press, Taylor & Francis group, Garland Science.

8. Gillott, C. (2005). Entomology. 3rd ed. Springer Online Book - ISBN-13 978-1-4020-3183- 0 (e-book)

9. Chapman, R.F. (1998) The Insects: structure and function 5th edition, Cambridge University Press.

10. Imms, A.D., Richard, O.W., & Davies, R.G. (1977) IMMS' General Textbook of Entomology: (2 volumes), 10th edition, Springer.

11. Klowden, M. J. (2007). Physiological systems in Insects, 2nd edition, Elsevier.

12. Wigglesworth, V. B. (1984). Principles of Insect Physiology, 8th edition, Springer.

13. Gullan, P. J. and Cranston, P. S. (2014). The Insects – an outline of Entomology. 4th ed. Blackwell Publishing

COURSE OBJECTIVE:

The field of invertebrate biology is so vast and runs across so many disciplinary lines so, it is necessary to make certain generalisation and to avoid others. Structure and function are the two primary focuses for the curriculum which is necessary to build up common threads of interest among students. The first topic, structure gives the general idea about the fundamentals of functional body architecture. The second group of themes emphasises on the degree to which the structure has been adapted over time to fulfil a specific function for the organism that bears it. After the completion of this course the student's interest will be widen in knowing about the complex diversity of our living world inhabited by the animals which does not have notochord in any stage of their life cycle.

COURSE OUTCOME:

This curriculum will provide a wide and vast understanding about the evolutionary changes of the invertebrate systems which depends upon their survival and reproduction within the natural habitat.

UGZOOMJT702

Theory=4 credits

CHORDATE STRUCTURE & FUNCTION

Integumentary System

Structure, function and derivatives of integument in birds and mammals

Skeletal System

Overview of axial and appendicular skeleton, Visceral arches, Vertebrate jaw suspension

Digestive System

Comparative anatomy of stomach, Ruminant stomach in Mammals, dentition in mammals

Respiratory System

Respiratory organs in fish, amphibian, birds and mammals, Accessory respiratory organ

Circulatory System

General plan of circulation, Comparative account of heart and aortic arches

Urinogenital System

Succession of kidney, Evolution of urinogenital ducts

Nervous System

Comparative account of brain, Cranial nerves in mammals

Sense Organs

Classification of receptors, Brief account of auditory receptors in vertebrate

Specialized features

Migration in Fish and parental care in fish and amphibia

Swim bladder in fishes.

Poison apparatus and biting mechanism in snakes.

Migration in bird, principles and aerodynamics of birds

Adaptive radiation in mammals with reference to locomotor appendages

Echolocation in chiropterans and cetaceans

Thermal biology of endotherms

Osmoregulation in aquatic vertebrates

UGZOOMJP702: Practical 2 credits

1. Dissection of brain and pituitary of Tilapia
2. Power point presentation on study of habit, habitat or behaviour of any one animal by student – for internal assessment only
3. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
4. Study of disarticulated skeleton of Toad, Pigeon and Guineapig
5. Identification of mammalian skulls: One herbivorous (Guineapig) and one carnivorous (Dog) animal

Reading References:

Reference Books

Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.

Pough H. Vertebrate life, VIII Edition, Pearson International.

Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.

Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.

Parker, T. J. &Haswell, W. (1972). Text Book of Zoology , Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press,London.

Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill.

Kent, G. C. & Carr, R. K. (2001). Comparative anatomy of the Vertebrates. 9th Ed.

McGraw Hill.

Nelson, J.S., (2006) : Fishes of the World, 4th Edn., Wiley.

Romer, A. S. & Parsons, T. S. (1986). The vertebrate body. 6th Ed. Saunders College Publishing.

Jordan, E.L. &Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.

Sinha, K. S., Adhikari, S., Ganguly, B. B. &BharatiGoswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd.

COURSE OBJECTIVE:

The biology of chordates provides awareness and understanding about the fundamental scientific concepts that reflects upon the concepts of how science of the natural world works. As John A. Moore put it, science is the "way of knowing". The comparative anatomy of vertebrates provides comparison between the organisms of the living world. The skeleton system of animals relies upon the basic anatomy while evolution of vertebrates deals with the progression and development of a complicated interrelated system of organs and their functions. The anatomy of vertebrates gives a strong example of how the evolution of an integrated organism works. From this section of the lesson, students will learn about the exciting journey of vertebrates and how evolution has shaped them to fit the demands of their surroundings.

COURSE OUTCOME:

After completion of the course students will gain knowledge about the diversity, morphology, basic anatomy, and physiology of the different groups of chordates which will help them to understand the animal world and the further studies that are directly linked to human welfare, such as disease control, animal husbandry, and functional studies.

UGZOOMJT703

Theory=4 credits

Ecosystem Structure and Function

- Theories on relation between biodiversity and ecosystem function.

i. Species complementarity

ii. Sampling effect

iii. Redundancy

- Population growth models.

Population regulations.

Metapopulation and Metacommunity concept.

- Resource - consumer interactions.

Modelling species interactions – apparent competition, intraguild predation, succession, bipartite network and application.

- Natural resources and sustainable development – principles and models.

Environmental world views.

Wildlife resources, aquatic living resources, forest resources, Ecosystem services valuation, links with biodiversity.

Ecological footprint analysis; ecosystem health.

- EIA and EPA
- Ecological processes in wetland and mangrove ecosystem.

- Decline of global biodiversity and loss of ecosystem function.

- Functional diversity and ecosystem functioning.

- Insurance hypothesis and habitat fragmentation and dispersal on ecosystem functioning.

- Ecosystem services, biodiversity and ecological economics.

UGZOOMJP703: Practical2Credits

- Study of an aquatic ecosystem: Determination of Conductivity, Biochemical oxygen demand, Primary productivity (light bottle-dark bottle method), Chlorinity, Salinity, Alkalinity, and Total hardness.

- Study of an terrestrial ecosystem: Determination of pH, Organic Carbon and Organic Matter.

- Qualitative analysis of sampled terrestrial community.

- Quantitative and qualitative estimation of zooplankton communities.

References:

Paper XVI: Ecosystem Structure and Function

Reference readings

Smith, T.M. and Smith, R.L. (2012). Elements of Ecology, 8th Edition.

Atlas, R.M. and Bartha, R. (1997). Microbial Ecology: Fundamentals and Applications.

Townsand, J. et al. (2006). Ecology: From Individuals to Ecosystems, 4th Edition.

Odum, E.P. (2008). Fundamentals of Ecology, 2nd Edition.

Chapman, J.L. and Reiss, M.J. (1998). Ecology: Principles and Applications.

Krebs, C.J. (2014). Ecology: The Experimental Analysis of Distribution and Abundance, 6th Edition.

Faurie, C. et al. (2008). Ecology: Science and Practice.

Mackenzie, A. et al. (2001). Instant Notes in Ecology, 2nd Edition.

Walker, C.H. et al. (2012). Principles of Ecotoxicology, 4th Edition.

Saha, G.K. (2016). Wetland Crisis and Options.

Ricklefs, R.E. and Miller, G.L. (2001). Ecology, 4th Edition.

Miller, G. and Spoolman, S. (2014). Essentials of Ecology.

Gotelli, N.J. (2008). A Primer of Ecology, 4th Edition.

Hunter et al. (2021). Fundamentals of Conservation Biology.

Wilson, E.O. (1999). Biodiversity.

Laurila-Pant, M. et al. (2015). How to value biodiversity in environmental management? Ecological Indicators, 55, 1-11.

Brauman, K.A. and Daily, G.C. (2008). Ecosystem Services. In: Human Ecology, 1148-1154.

Costanza, R. (2012). Ecosystem health and ecological engineering. Ecological Engineering, 45, 24-29.

Duncan, C. et al. (2015). The quest for a mechanistic understanding of biodiversity – Ecosystem services relationships. Proceedings of Royal Scoiety B, 282, 20151348.

Dormann, C.F. et al. (2009). Indices, graphs and null models: Analyzing bipartite ecological networks. The Open Ecological Journal, 2, 7-24.

COURSE OBJECTIVE:

The term "Ecology" refers to the study of inter-relationships between organisms and their physical environment. There are various ways in which these relationships can regulate the natural ecosystem such as distribution and abundance of living organisms, the variety of species living together, and the energy flow in natural ecosystem. Since environmental change is occurring at a rapid rate in the early twenty-first century it is vital that we better comprehend the ecology of the planet. While most people associate ecologists with fieldwork, ecologists who develop theoretical models or do laboratory research have made some of the most significant contributions to ecological theory. We can clearly see that our simplistic description of ecology does not adequately convey its vastness or the diversity of its practitioners. Let's talk at this course to have a better grasp of what ecology is all about.

COURSE OUTCOME:

After completion of this course the student will know about the basic information about ecosystem and figure out how to use it. The following is part of this information: population growth and the factors influencing this growth, Resource - consumer interactions, models of natural resources and sustainable development, ecological footprint analysis, ecosystem health etc

Semester VIII

UGZOOMJT801:

Theory=4 credits

Cell, Tissue Structure and Function

1. Cell membranes and their functions:

Ultra structure and composition of Plasma membrane: Fluid mosaic model

1.1. Membrane pumps, carriers, channels. 1.2. Transport across membrane: Diffusion, Active and Passive transport, ion pumps, uniport, symport and antiport. Facilitated transport.

2. Cytoplasmic organelles

Basic structure and functions of cell organelles:

2.1. Nucleus, Golgi apparatus, Mitochondria, Lysosome and Endoplasmic Reticulum

3. Cell adhesion molecules:

3.1. Extracellular matrix molecules, Cellular adhesion, Intercellular junctions, Connective tissues, microtubules and cytoskeleton (RBC cytoskeleton as a model).

4. Cell signalling:

4.1. G- protein and signal transduction. 4.2. Signal hypothesis, Intracellular protein trafficking.

5. Cytoskeleton and cellular motility:

5.1. Motor proteins: Actin and myosin binding proteins. 5.2. Cytoskeletal structures: microtubules, microfilaments, & intermediate filaments.

6. Cell to cell communication:

6.1. Basic structure of extracellular matrix. 6.2. Fundamental idea of: Tight Junctions, Gap junctions, Desmosomes, Hemi-desmosomes, Focal adhesion.

7. Cell cycle:

7.1. Cell cycle check-points, role of cyclins and CDKs. Regulation of CDK-Cycline activity. 7.2. Functional role of the following proteins: APC, Mcm, Aurora and Polo like Kinase, Condensins, & Kinesins.

8. Cancer biology: Basic concepts.

9. Somatic cell fusion:

9.1. Human – rodent hybrid cells, radiation hybrid mapping.

10. Programmed cell death:

10.1. Regulators of programmed cell death, cell death pathways, relationship with cancer. 10.2. Apoptotic cell detection: Annexin V Assay.

11. Histology and histological methods:

11.1. Types & Organization of Tissues. 11.2. Principle and methods of staining. 11.3. Histological stains (Haematoxylin & Eosin). 11.4. Types of fixatives & chemistry of fixation. 11.5. Tissue processing (Dehydration, Clearing, & Embedding). 11.6. Microtomy: Types of microtome, sectioning & paraffin blocks. Overview of ultra microtomy.

UGZOOMJP801: Practical 2 credits

1. Cell, Tissue Structure and Function:

1.1. Cell separation techniques.

1.2. Primary culture of Cells.

1.3. Determination of cell size and granularity. Annexin V staining by flowcytometry / fluorescent imaging. DAPI nuclear blabbing imaging.

1.4. Identification of different mammalian tissues.

1.5. Microtechnique.

Books Recommended:

1. Alberts, B. *et al.*: Molecular Biology of the Cell. Garland Science.

2. Becker, W. M. *et al.*: The World of the Cell. Benjamin-Cummings.

3. Cooper, G. M. and Hausman, R. E.: The Cell-A molecular approach. Sinauer Associates.

4. Townsend-Nicholson, A. *et al.*: Cell Biology: A Short Course, Wiley-Blackwell.

5. Harvey, L. *et al.*: Molecular Cell Biology. W.H. Freeman.

6. Karp, G.: Cell and Molecular Biology - Concepts and experiments. John Wiley.

7. Lodish *et al.*: Molecular Cell Biology. W. H. Freeman.

8. Ploper, G., Sharp, D. and Sikorski, E.: Lewin's CELLS, Jones & Bratlett.

9. Bancroft, J. D. and Stevens, A.: Theory and Practice of Histological techniques, Churchill-Livingstone.

10. Bancroft, J. D. and Gamble, M.: Theory and Practice of Histological techniques, Churchill Livingstone, Elsevier.

11. Bloom, W. and Fawcett, D. W.: A Textbook of Histology. 12th edition, CRC Press.

12. Junqueira, L. C. and Carneiro, J.: Basic Histology: Text and Atlas. 11th edition, McGraw Hill Lange Med. Pub.

13. Ross, M. H.; Reith, E. J.; and Romell, L. J.: Histology: a text and atlas. 2nd edition, Williams and Wilkins.

14. Robertis, De. and Robertis Jr., De.: Cell and Molecular Biology. CBS Publishers & Distributors Pvt. Ltd.

15. Pollard, T. D.; Earnshaw, W. C.; Lippincott-Schwartz, J.; and Johnson, G. T.: Cell Biology: Elsevier.

16. John, R. W. Masters (Editor): Animal Cell Culture - a practical approach. Oxford University Press.

17. Frifelder, D. M.:Physical Biochemistry: Applications to Biochemistry and Molecular Biology (Life Sciences/Biochemistry). W. H. Freeman.

18. Kumar, A.; Galaev, I. Y.; and Mattiasson, B.: Cell Separation - Fundamentals, Analytical and Preparative Methods. Springer.

COURSE OBJECTIVE:

To understand the complicated cellular chemistry, a comprehensive study of sub-cellular component is prerequisite. Recently developed mathematical/computational approaches explained cellular behaviour through the generation of quantitative information, some of which have yet to be invented. Emerging approaches in the evaluation of quantitative information has now become the primary focus for cell biologists.

COURSE OUTCOME:

The students will know more about the key concepts that underlies the cellular biochemistry. The importance of well-synchronised activity of the cell is necessary for the continued existence of a living organism.

UGZOOMJT802

Theory=4 credits

Clinical Immunology and Infection Biology

Major Histocompatibility Complex

Structure and functions of MHC molecules.

Structure of T cell Receptor and its signalling, T cell development & selection

Cytokines

Types, properties and functions of cytokines.

Complement System

Components and pathways of complement activation.

Hypersensitivity

Gell and Coombs' classification and brief description of various types of hypersensitivities.

Immunologic Tolerance and Autoimmunity

Autoimmune disorders – Rheumatoid arthritis, Systemic lupus erythematosus, Inflammatory bowel disease

Immunity to Tumors

Tumour microenvironment and immune cells- TAM, T reg cells and others, Immune check point inhibitors

Transplantation Immunology

Different types grafting, Graft rejection, Graft versus host disease (GvHD),Genetics of HLA typing and disease association

Immune Response to Infectious Diseases

Mechanism of Immune Response During: Viral Infections [Influenza, HIV, corona virus, Adenovirus], Bacterial Infections [*Corynebacteria* and *Mycobacterium*] Protozoan Infection [*Plasmodium, Trypanosoma and Leishmania*], Helminthes Infections [Ascaris and Schistosoma].

Immunotechnology

Vaccine – different types of vaccine, strategies of vaccine development - subunit vaccine, mRNA vaccine and others, Hybridoma technology, Antibody engineering Immunoassays- Types and applications, Immunophenotyping,

Principle, Methodology and Application of Following Techniques: ELISA [Enzyme Linked Immunosorbent Assay], RIA [Radio Immuno Assay], Western Blotting. Allergy Evaluation: Principle and Methodology of Skin Prick Test for Allergy.

UGZOOMJP802: Practical 2 credits

1. Demonstration of ELISA
2. Demonstration of macrophages.
3. Bone marrow smear preparation and staining.
4. Identification of the prepared slides:

Trypanosoma, Leishmania sp, (Promastigote and amastigote), *Opalina* sp., *Nyctotherus*, *Sicuophora, Balantidium, Stomatophora, Monocystis, Giardia, Entamoeba histolytica, Gregarina, Eimeria, Haemoproteus, Plasmodium* (*vivax & falciparum* species), *Conchophthirus, Myxobolus, Taenia solium, Taenia saginata, Raillietina sp*., (mature proglottid and scolex), *Echinococcus, Fasciola, Isoparorchis, Paramphistomum, Ascaris* (male and female), *Argulus, Pediculus, Phthirus, Cimax, Xenopsylla, Ctenocephalids, Boophilus, Phlebotomus*, mosquitoes (adult male & female, mouth parts of Anopheles, Culex, and Aedes)

Reference Books:

- Abbas, A. K., Lichtman, A. H. and Pillai, S. (2018).
- Cellular and molecular Immunology. 9th ed. Elsevier. Abbas, A. K. and Lichtman, A. H. (2019).
- Basic Immunology. 6thed. Elsevier. Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2019). Immunology. 8thed. W. H. Freeman and Co. Murphy, K and Casey W. (2016).
- Janeway's Immunobiology. 8thed.Garland Science. Roitt, I. M. and Delves, P. J. (2017).
- Roitt’s Essential Immunology. 13th ed. Blackwell Science Ltd.
- Mukhopadhyay, A. & De, A. K. (2002). Perspectives in Environmental Health: Vector and Water Borne Diseases, Section-I, ORIGINALS D.K. Publishers Distributors(P) Ltd, New

Delhi-110002 70 M.SC, ZOOLOGY SYLLABUS, SKBU (W.E.F. FROM 1ST NOVEMBER, 2022)

- Roberts, L. & Janovy, J. Jr. (2008). Foundations of Parasitology. 8th edition, McGrawHill Education.
- Schmidt, G. D. & Roberts, L. S. (2001). Foundation of Parasitology, 3rd edition, McGraw-Hill Education.
- Smyth, J. D. (1994). Animal Parasitology, 3rd edition, Cambridge University Press
- Cheng, T. C. (1999). General Parasitology, 2nd edition, Academic Press, Inc.
- Chatterjee, K. D. (2009). Parasitology: Protozoology, And Helminthology in Relation to Clinical Medicine, 13th edition, CBS Publishers And Distributors Pvt. Ltd., New Delhi

COURSE OBJECTIVE:

This topic gives emphasis on the advanced immunological aspects including treatments related to immunity. The students will be able to understand the theoretical framework about the complex molecular mechanisms involved in the immunity and the related immunological methods. Along with these the students will be able to understand about tolerance, immunodeficiency and vaccination, immunology of transplantation, the immunology of tumors, immunomodulation, and immunopharmacology.

COURSE OUTCOME:

After completion of this elective, student will understand the fundamentals of molecular mechanism behind immunity. They will have a wide knowledge of many immunological techniques that include immunohistochemistry, ELISA, FACS etc. They will simply gain the basics of tolerance, autoimmunity, immunological disease, and cancer immunology. They will also understand the basic idea of immunomodulation and immunopharmacology.

UGZOOMJT803:

Theory=2 credits

BIODIVERSITY; WILD LIFE MANAGEMENT & CONSERVATION

1. Introduction to Biodiversity:

- Concept and types of biodiversity
- Biodiversity and human welfare
- Convention on Biological Diversity (CBD)
- Megadiversity countries
- Biodiversity hotspots with special reference to India.

2. Types of conservation:

- In-situ conservation- conserving ecosystem function and management.
- Protected area -Sanctuary, National Park, Biosphere reserve, Ramsar site and World heritage site in India with special reference to West Bengal.
- Concept of Core Zone, Buffer Zone.
- Exsitu conservation of animals (captive breeding; species reintroduction, species translocation; population reinforcement).
- Bioindicators for biodiversity monitoring.

3. Concept of wildlife:

- Definition of wildlife, keystone, flagship and umbrella species
- Wildlife in India; reasons for wildlife depletion and their conservation strategies; Wildlife Protection Act, 1972
- Concept of threatened fauna, Red data book, and IUCN categories
- Joint Forest Management (JFM) model for conservation.
- Tiger reserves in India, Management challenges in Tiger reserve.

4. Tools and techniques for wildlife census and survey:

- Technologies for Wildlife Research and Management
- Faecal analysis of ungulates and carnivores
- Pug marks and census method
- Basic idea of GIS and GPS and their application in habitat & wildlife conservation.

5. Management planning of wild life in protected areas:

- Estimation of carrying capacity
- Eco tourism / wild life tourism in forests
- Concept of climax persistence
- Ecology of perturbance

UGZOOMJP803: Practical 2 credits

Determination of requisite size of quadrat by species area curve method.

Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)

Reference books

- Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach- David B. Lindenmayer, Jerry F. Franklin. 2013.
- Divan Rosencraz, Environmental laws and policies in India, Oxford Publication.
- Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008). *Problem-Solving in Conservation*
- Joseph, B., Environmental studies, Tata Mc Graw Hill.
- Michael Allabay, Basics of environmental science, Routledge Press.
- Miller, G.T. 2002. Sustaining the earth, an integrated approach. (5th edition) Books/Cole,
- Mohapatra Textbook of Environmental Biotechnology IK publication.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole.
- Practical Approaches to the Conservation of Biological Diversity- Richard KenithBaydack, Henry Campa, Jonathan B. Haufler. 1999
- Rana SVS, Environmentalpollution – Health and Toxicology, Narosa Publication.
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.
- Sutherland, W.J. (2000). *The Conservation Handbook: Research, Management and*
- Thakur, I. S., Environmental Biotechnology, I K Publication.
- Valuation and Conservation of Biodiversity: Interdisciplinary Perspectives… Michael Markussen, Ralph Buse, HeikoGarrelts, MaríaManez Costa, Susanne Menzel, Rainer Marggraf. 2005.

  Woodroffe R., Thirgood, S. and Rabinowitz, A. (2005). *People and Wildlife, Conflict or Co-existence? Cambridge University*.

COURSE OBJECTIVE:

Due to significant loss of biodiversity and deterioration of natural ecosystems, there is little room for argument that all life on earth is currently in jeopardy. As a result, this course is available to all graduate students, regardless of their academic expertise, in order to make them aware of and sensitize them to this survival dilemma. Students who complete this course will have gained a solid foundation in the importance of biodiversity and ecosystem services in supporting life on Earth, as well as an understanding of the dangers posed by the careless behavior of man.

COURSE OUTCOME:

Biodiversity and wildlife: Student will be learning the various issues related to biodiversity loss and conservation as well as status, conditions and conservation of forests and wildlife. They will also be able to use various tools used in field biology.

UGZOOMJT804:

Theory=2 credits

REPRODUCTIVE BIOLOGY

Principles of Reproductive Biology

- Potency, commitment, specification, induction, competence.
- Determination and differentiation; morphogenetic gradient, cell fate and cell lineages.
- Cell to cell communication during early development.
- Environmental control of gene regulation, Epigenetic regulation of developmentally relevant genes.

Physiology of Reproduction

- Primary and accessory sex organs and secondary sex characters.
- Testis: histology, testicular hormones and their functions.
- Ovary: histology, ovarian hormones and their functions.
- Oestrous cycle and its hormonal control.
- Maintenance of pregnancy – role of hormones. Development of mammary gland and lactation - role of hormones.

Reproductive system and hormonal regulation

- Female reproductive system: Hormonal regulation of ovulation, gestation, parturition and lactation; Menstrual cycle and its hormonal control
- Male reproductive system: Hormonal regulation of spermatogenesis
- Molecular basis of male and female reproductive disorders, therapeutics, male and female infertility.
- Steroid receptors: Defects, modulators, clinical significance.

Applications of Reproductive Biology

- Artificial Reproductive Techniques (ARTs)
- Types and application of contraception; Male and female contraceptives
- Menopause, andropause and their management.

UGZOOMJP804:
Practical- 2 Credits

1.1. Demonstration of Oestrous stages of mice.
1.2. In vitro study of motility of epididymal spermatozoa.
1.3. Demonstration androgen bioassay.
1.4. Histology of testis and ovary

Reference Books

- Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.

- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Eckert Animal Physiology: Mechanisms and adaptations Randall, Burggren and FrenchVander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
- Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills
- Histology: A Text and Atlas. Sixth Edition. Ross &Pawlina. Lippincott Williams & Wilkins.
- Eckert Animal Physiology by David Randall and Warren Burggren. 4th edition.
- W.H.Freeman.
- Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
- Slack JMW , Essential Developmental Biology.
- Developmental Biology: A Very Short Introduction (Very Short Introductions). Lewis Wolpert. (1st Edition)

COURSE OBJECTIVES :

Reproductive Biology covers principles and techniques in reproduction. It also enlightens the areas including Physiology of human reproductive system and its hormonal regulation, Applications of Reproductive Biology like Artificial Reproductive Techniques (ARTs) etc**.** that will help to develop further practical skills or research ability of the students.

COURSE OUTCOME:

Reproductive Biology: In this section students will learn about the basic concept and mechanism of reproductive physiology as well as practical implications of the reproductive biology such as IVF, contraception, and how to medically manage menopause and andropause.

UGZOOMJT805:

Theory=2 credits

BIOTECHNOLOGY

Introduction

Concept and scope of Biotechnology. Organization of prokaryotic and eukaryotic genome, Concept of genomics

Molecular Techniques in Gene manipulation

1. Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics).Restriction enzymes: Nomenclature, detailed study of Type II. Transformation techniques: Calcium chloride method and electroporation. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization
2. Southern, Northern and Western blotting
3. DNA sequencing: Sanger method
4. Polymerase Chain Reaction, DNA Finger Printing and DNA micro array

Genetically Modified Organisms

1. Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection.
2. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.

Culture Techniques and Applications

Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia)

Environmental Biotechnology

1. Bioremediation-In situ and Ex situ Bioremediation, bioremediation of industrial waste (Paper and Pulp Industry), Bioremediation of Heavy metal, phytoremediation, emerging biotechnological processes in waste water treatment.
2. Biosensor; Type of Biosensor, Environmental industrial and clinical application

Intellectual Property Right and Management of Biotechnology

1. IPR- IPP, Forms of Protection, Patenting strategy, Copy right, Plant variety protection, WIPO, GATT, WTO. Role and regulation of Indian Patent.
2. Biosafety and Bioethics-Risk for Human health, Biosafety guideline and regulation

UGZOOMJP805: Practical 2 credits

1. Genomic DNA isolation from E. coli/Blood genomic through virtual demonstration
2. Plasmid DNA isolation (pUC 18/19) from E. coli through virtual demonstration
3. Restriction digestion of plasmid DNA.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through virtual demonstration

    I. Southern Blotting
    II. Northern Blotting
    III. Western Blotting
    IV. DNA Sequencing (Sanger's Method)
    V. PCR
    VI. DNA fingerprinting

7. Project report on animal cell culture

Reading References:

- Brown, T.A. (1998). Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
- Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
- Weaver. Molecular Biology of Gene. 5th edition.

- Primrose & Twyman. Principles of Gene Manipulation and Genomics. 7th edition.
- Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings
- Environmental Biotechnology, Pradipta Kumar Mohapatra
- Environmental Biotechnology – Concepts and Applications, HansJoachim Jordening and Jesef Winter
- Wastewater Engineering – Metcalf & Eddy.

COURSE OBJECTIVE:

Biotechnology has transformed the planet. Advances in biotechnology now can track many inherited disorders. People may now live in considerably higher population densities due to biotechnology's ability to produce more food per acre. As a result of advance biotechnology, we now know more about genomes of a wide range of creatures, from viruses to trees to people. Science has been shifted from a descriptive to a variety of fields that generate new items such as pharmaceuticals, vaccines, and meals thanks to the application of this knowledge. This course is designed to flash the spotlight of Biotechnology on student to make them equipped with the modern science

COURSE OUTCOME:

The key objective of this class is to provide fundamental knowledge about the structural and functional features of biological macromolecules such as DNA, RNA, and proteins. After completion of this course the students will be able to use this knowledge in their scientific discipline and in future higher studies.

UGZOOMJR806

For Honours with Research

Research Project/ Dissertation

12 Credits

ZOOLOGY -Minor Course

Minor

First Year

Semester I

UGZOOMIT101

Theory=2 credits

Group A: Diversity of Animals

Non-chordates:

Protozoa

General characteristics and Classification with examples up to phylum (according to Levine et. al., 1981)

Porifera

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Cnidaria

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Ctenophora

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Platyhelminthes

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Nematoda

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Annelida

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Arthropoda

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Mollusca

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Onychophora

General characteristics and Evolutionary significance

Echinodermata

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Hemichordata

General characteristics and Classification with examples up to classes (Ruppert and Barnes, 1994, 6th Edition)

Chordates:

1. General characteristics of Phylum Chordata

2. Classification with characteristic features and examples with scientific names of:

f) Up to Classes: Sub-Phyla Urochordata and Cephalochordata – as per J. Z. Young (1981)

g) Up to Order: Superclass Agnatha – as per J. Z. Young (1981)

h) Up to Sub-classes: Chondrichthyes and Osteichthyes – as per Berg (1940); and Aves – as per J. Z. Young (1981)

i) Up to living Orders: Amphibia – as per Duellman and Trueb (1986),

j) Up to living Orders: Reptilia and Mammalia – as per J. Z. Young (1981)

Group B: Cytogenetics

Overview of Cells

1. Basic structure of Prokaryotic and Eukaryotic cells, Viruses, Viroid,
2. Plasma Membrane and Nucleus, Cytoplasmic organelles (Mitochondria, Endoplasmis Reticulum, Golgi Apparatus and Lysosome)

BasicMendelian Genetics and its Extension

1. Principles of inheritance, Epistasis Multiple alleles, Sex-linked, sex- influenced and sex-limited inheritance, Polygenic Inheritance.

Linkage and Crossing Over

Sex Determination in *Drosophila sp.*

Chromosomal disorder: Down syndrome, Turner syndrome, Klinefelter syndrome

UGZOOMIP101: Practical- 2 Credits

Group A: Diversity of Animals

Non-chordates:

1. **Identification with reason:**

Protozoa: *Amoeba, Euglena, Paramecium*

Porifera: *Sycon,* Neptune's Cup

Cnidaria:*Obelia, Physalia, Aurelia*

Platyhelminthes: *Fasciola hepatica, Taenia solium*

Nematoda: *Ascaris lumbricoides*

Annelida: *Aphrodite, Nereis, Hirudinaria*

Arthropoda: *Limulus, Eupagurus, Bombyx, Periplaneta*

Mollusca: *Pila, Pinctada, Sepia, Octopus*

Echinodermata:*Asterias, Ophiura, Cucumaria*

Hemichordata: *Balanoglossus*

2. Mount of mouth parts and dissection of digestive system of cockroach

Chordates:

1. **Identification with reason:**

Protochordata: *Ascidia, Branchiostoma*

Agnatha:*Petromyzon, Myxine,* Ammocoete larva

Chondrichthyes & Osteichthyes:*Scoliodon, Hippocampus, Heteropneustes, Clarias,*

Amphibia:*Bufo, Rana, Ambystoma, Rhacophorus, Necturus*

Reptilia: Chelone, *Hemidactylus, Draco, Typhlops, Chamaeleo, Naja , Ptyas, Hydrophis*

Aves:*Psittacula, Passer, Pycnonotus*

Mammalia:*Pteropus, Funambulus, Suncus*

2. Pecten of Fowl

3. Dissection of Tilapia: Digestive system, Brain, pituitary

Group B: Cytogenetics

1. Pedigree analysis of some human inherited traits

2. Preparation of temporary stained squash of onion root tip to study various stages of mitosis

Reference Books:

Group A: Diversity of Animals

Non-chordates

Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VIII Edition. Holt Saunders International Edition.

Invertebrates by Brusca & Brusca. Second edition, 2002.

The Invertebrates: A New Synthesis, III Edition, Blackwell Science.

Chordates

Hildebrand, M. (1995). Analysis of Vertebrate Structure. John Wiley & Sons.

Chaki, K.K. Kundu, G. & Sarkar, S. (2005). Introduction to General Zoology. Vol. 1. New Central Book Agency (P) Ltd. Kolkata.

Jordan, E.L. & Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.

Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd. Kolkata.

Parker, T. J. & Haswell, W. (1972). Text Book of Zoology, Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press, London.

Young, J. Z. (1981). The Life of Vertebrates. 3rd Ed. ELBS.

Chatterjee and Chatterjee Practical Zoology

Ghosh, K.C. and Manna, B. (2015): Practical Zoology, New Central Book Agency, Kolkata

Sinha, J.K. , Chatterjee, A.K. and P. Chattopadhyay Advanced Practical Zoology

Group B: Cytogenetics

Lewin's Cells – 3rd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers

Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

Bruce Albert, Bray Dennis, Levis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.

Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc

Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings

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

Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B.

COURSE OBJECTIVE:

It is required to generalize about certain things and to dismiss others because the field of non-chordate and chordate biology is so extensive and runs across so many disciplinary lines that it is necessary to generalize about some topics. Classification, Structure and function were chosen as the primary focuses for the curriculum that we devised for studying diversity of animals so that we could establish common threads of interest.

Genetics is one of the fastest-moving fields of science, with new discoveries being made every month. The study of genetics is timely, important, and fascinating because of the many new discoveries and applications of genetics that have substantial economic and ethical implications.

COURSE OUTCOMES:

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

1. Understand basics of classification of non-chordates and chordates.
2. Learn the diversity of habit and habitat of these species.
3. Study the functional biology of animals through their body organization and its function.
4. Develop the skills to identify different classes and species of animals and their evolutionary relationships.
5. Enhance the basic laboratory skill like keen observation and drawing.
6. Understand the structure and function of the cell organelles
7. Understand the principles of inheritance, Mendel ‘s laws and the deviations
8. Comprehend the facts of sex determination in Drosophila sp.
9. Detect chromosomal aberrations in humans and study of pedigree analysis.

Second Year

Semester III/IV

UGZOOMIT201:

Ecology and Evolution

Theory - 2 credits

Group A: Ecology and Evolution

Theory

- Concept of ecosystem – Structure and function, food chains, food web, energy flow, ecological pyramids and ecological efficiencies.
- Population growth models – Natality and mortality, r and K strategies, Survivorship curves.
- Competition exclusion principle, Intraspecific and interspecific competition, Lotka-Volterra model.
- Community characteristics and resource partitioning
- Species diversity, abundance, dominance, richness, ecotone and edge effect.
- Ecological succession – Types of ecological succession with examples.
- Types of ecosystems with an example (in detail).
- Origin of life (Chemical origin only).
- Natural selection – concept of fitness, types of selection, Concept of selection - stabilizing, directional and disruptive with example.
- Population genetics – Hardy-Weinberg law, Calculating allele and genotype frequency.
- Evolutionary forces upsetting H-W equilibrium.
- Genetic drift mechanism – founder's effect and population bottleneck phenomenon.
- Species concept – Isolating mechanisms, modes of speciation.
- Zoogeographical realms – names and animal distribution according to Wallace scheme, Avian and Mammalian faunal distribution in different realms. Geological time scale.
- Molecular clock. Fossil records of hominids (from *Australopithecus* to *Homo sapiens*)

Group B: Molecular Biology and Developmental Biology

Theory

- Salient features of DNA, Watson and Crick Model of DNA. RNA types and function.
- DNA Replication - Mechanism of DNA Replication in Prokaryotes.
- Transcription - Mechanism of Transcription in prokaryotes and eukaryotes.
- Translation - Genetic code, Degeneracy of the genetic code and Wobble Hypothesis.
- Gene Regulation - Regulation of Transcription in prokaryotes: *lac* operon and *trp* operon.
- Regulation of Transcription in eukaryotes - Activators, enhancers, silencer, repressors, miRNA mediated gene silencing.

- DNA Repair Mechanisms and Molecular Techniques - PCR, Western and Southern blot, Northern Blot.
- Basic concepts developmental biology - Gametogenesis: Spermatogenesis, Oogenesis.
- Fertilization in sea urchin and mammal.
- Planes and patterns of cleavage, Types of Blastula.
- Embryonic induction and organizers in *Xenopus* (Spemann and Mangold's experiment).
- Regeneration - Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each).

UGZOOMIP201: Practical- 2 Credits:

Determination of requisite size of quadrat by species area curve method,

Determination of population density in a natural / hypothetical community by quadrat method and calculation of Shannon-Wiener diversity index for the same community.

Quantitative determination of pH, Dissolved O2 content (Winkler's method), and free CO2 from water.

Study of fossils from models / pictures.

Study of homology and analogy from suitable specimens.

DNA gel electrophoresis (Demonstration)

PCR (Virtual/ simulation)

Identification of 24h, 48h, 72h and 96 h chick embryo from slide.

COURSE OBJECTIVE:

Basic concept of how animals interact with their surroundings and what are the factors that regulates the extremely complex multi species dynamics in which each species and individual plays a specific role is absolute necessity to understand impact of human activities, fragility of a system and its outcome, possible ways of restoration and management. Ecological awareness and knowledge how complex interconnected biotic and abiotic components of nature ultimately regulates global outcomes is thus a necessary part of any biological course.

Elementary and fundamental idea regarding how forces of nature and ecological, biological interactions continuously push individual, species and groups to change characteristics to prevent extinction and evolve in to organisms that are different from ancestor is necessary to understand any biological process and even systems that has the capacity to evolve like Artificial intelligence. Last but not the least it provides us with a glimpse of our past elves and our probable future selves.

Understanding of Molecular biology and Developmental biology is now a must have skill as most of the biological processes are studied at molecular level and knowledge of developmental biology prepares a student for further studies that require how different functional organs function, what are probable causes of any dysfunction and how development diseases can be prevented or cured.

COURSE OUTCOMES:

Become familiar with the variety of ways that organisms interact with both the physical and the biological environment.
Develop an understanding of the differences in the structure and function of different types of ecosystems.
Develop an appreciation of the natural world through direct experience with local ecosystems.
Learn techniques for gathering data in the field.
Develop an understanding on Life's beginnings with natural selection which is one of several processes that can bring about evolution.
Demonstrate knowledge of the concept of speciation, Adaptation,
A better understanding of how evolutionary science generates knowledge by providing information regarding how systems and function change over time.
On completion of this subject, students should be able to:
Describe the core principles of molecular biology.
Describe the genetic structure and types of chromatins.
Elucidate the types, damage and repair of DNA, types of RNAs, genetic code, Understand the concept of mutations.
Describe the morphological processes that transform a fertilised egg into a multicellular organism.
Explain the molecular, biochemical and cellular events that regulate the development of specialised cells, tissues and organs during embryonic development.
Identify model organisms used to investigate developmental biology and compare the developmental programmes of different organisms.
Describe genetic, molecular and cellular techniques, including genome editing, used to investigate developmental and molecular biology processes in various organisms.
Gain higher level thinking skills that is necessary for research.

Minor

Third Year

Sem V

UGZOOMIT301

Theory=2 credits

Group A . Biochemistry and Physiology

1. Basic concept of pH, normality, morality, molality, osmolality. 1.1 Protein, Carbohydrates and Lipid metabolism 1.2. Proteins: Protein folding 1.3. Carbohydrates: Glycolysis, Glycogenolysis, Gluconeogenesis, TCA cycle 1.4. Lipids: β oxidation 1.5. Amino-acid metabolism: Urea cycle.

2. Enzymology: 2.1. Enzyme nomenclature 2.2. Enzyme action. 2.3. Regulation of enzyme activity. 2.4. Co-enzymes and Isoenzymes.

3. Bioenergetics: Thermodynamic principles and steady-state conditions of living organism, Energy production and utilization, Electron transfer and oxidative phosphorylation.

5. 4. Free radicals and antioxidants.

6. **Physiology of Respiration**

Mechanism of Respiration, Respiratory volumes and capacities, transport of Oxygen and Carbon dioxide in blood, Dissociation curves and the factors influencing it

Physiology of Circulation

Composition and constituents of blood, Blood groups and Rh factor, Factors and mechanisms of coagulation, Structure of heart, Origin and conduction of the cardiac impulse and Cardiac cycle

7. **Physiology of Excretion**

Structure of nephron and urine formation, Counter current mechanism

8. **Physiology of Nerve and Muscles**

Structure of neuron, conduction of nerve impulse, Synaptic transmission, Neurotransmittors .Types of muscles and mechanism of contraction of skeletal muscles, Effects of exercise on muscles

Group B: Biodiversity & Conservation

1. Introduction to Biodiversity:

- Concept
- Types of biodiversity
- Biodiversity and human welfare
- Convention on Biological Diversity (CBD)
- Megadiversity countries
- Biodiversity hotspots with special reference to India.

2. Types of conservation:

- In-situ conservation-and Ex situ conservation of animals conserving ecosystem function and management.
- Protected area -Sanctuary, National Park, Biosphere reserve, Ramsar site and World heritage site in India with special reference to West Bengal.
- Concept of Core Zone, Buffer Zone.

- Bioindicators for biodiversity monitoring.

3. Concept of wildlife:

- Introduction
- Wildlife heritage of India
- Reasons for wildlife depletion in Indian context.
- Concept of threatened fauna
- Red data book
- IUCN categories
- Key stone, flagship and umbrella species
- Tiger reserves in India, Management challenges in Tiger reserve.
- Human-animal conflict with special reference to elephant migration, causes and concern

5. Management planning of wild life in protected areas:

- Estimation of carrying capacity
- Eco tourism / wild life tourism in forests
- Concept of climax persistence
- Ecology of perturbance.

UGZOOMIP301: Practical- 2 Credits

1. Colorimetric / Spectrophotometric estimation of Glucose, RNA, DNA and Proteins.

2. Demonstration of proteins separation by SDS-PAGE. **(Hands on / Virtual mode of learning)**

3. Measurement of blood pressure using sphygmomanometer

- Colorimetric / Spectrophotometric estimation of Glucose, RNA, DNA and Proteins.
- Demonstration of proteins separation by SDS-PAGE. (Hands on / Virtual mode of learning).
- Measurement of blood pressure using sphygmomanometer.
- Study of permanent slides of Lungs, Kidney, Heart, Nervous tissue, and Spinal Cord.
- Estimation of blood group.
- Determination of requisite size of quadrat by species area curve method.

COURSE OBJECTIVE:

Biochemistry is the wing of biology that deals with the basic bio-molecules and their structure and function. Here an emphasis has been made so that the students can obtain a basic understanding of chemical solutions, metabolic processes of bio-molecules,

enzymes and Bioenergetics. Furthermore, this paper deals with Physiology which is the study of the structural and functional plans found in animals. Understanding how animals' function on all levels as a whole integrated organism, from cells to tissues to organs, can be aided by knowledge gained through the study of animal physiology. Clarifying the functions of all cells in all organs and all animals in relation to the neurological, respiratory, circulatory, muscular systems etc. falls under the purview of the scientific discipline known as physiology.

The other half of this paper deals with Biodiversity and Conservation. Due to significant loss of biodiversity and deterioration of natural ecosystems, there is little room for argument that all life on Earth is currently in jeopardy. As a result, this course is available to all graduate students, regardless of their academic expertise, in order to make them aware of and sensitize them to this survival dilemma.

COURSE OUTCOMES:

Course outcome: Students who complete this course will have gained a solid foundation in the basic Biochemistry and physiological processes and are also expected to be having profound knowledge on the importance of biodiversity and ecosystem services in supporting life on Earth, as well as an understanding of the dangers posed by the careless behavior of man and possible conservation strategies.

MINOR

Fourth Year

Theory=2 credits

Sem VII

UGZOOMIT401

Group A

Title: Parasitology and Immunology

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors (mechanical and biological vector) Host parasite relationship

Study of Morphology, Life Cycle,Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Giardia intestinalis, Leishmania donovani*

Parasitic Helminthes

Study of Morphology, Life Cycle, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides, Ancylostoma duodenale, Wuchereria bancrofti,*

Parasitic Arthropods

Biology, importance and control of ticks (*Ixodes*), Lice (*Pediculus*), and Bug (*Cimex*)

Basic concepts of health and diseases, Cells and organs of the Immune system

Innate and Adaptive Immunity

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens,

Immunoglobulins

Structure and functions of different classes of immunoglobulins, Antigen- antibody interactions, Monoclonal antibody production

Various types of vaccines. Active & passive immunization (Artificial and natural).

Reading References:

Arora, D. R and Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors

E.R. Noble and G.A. Noble: Parasitology: The biology of animal parasites. V Edition,Lea & Febiger.

Ahmed, N., Dawson, M., Smith, C. and Wood, Ed.: Biology of Disease. Taylor and Francis Group

Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi

Rattan Lal Ichhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi

Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers

K. D. Chatterjee: Parasitology: Protozoology and Helminthology. XIII Edition

Group B

Title: Biotechnology and Biostatistics

Introduction

Concept and scope of Biotechnology. Organization of prokaryotic and eukaryotic genome,

Biological tools and techniques

Microscope: Principle of optical and electron microscopies.
Principles and use of analytical instruments- Centrifugation, Spectrophotometer, P H Meter, Chromatography (Paper and TLC), Gel Electrophoresis (Agarose and SDS PAGE)
Molecular Techniques in Gene manipulation

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics). Restriction enzymes: Nomenclature, detailed study of Type II. Transformation techniques: Calcium chloride method and electroporation. Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

Southern, Northern and Western blotting

DNA sequencing: Sanger method

Polymerase Chain Reaction, DNA Finger Printing and DNA micro array

Genetically Modified Organisms

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection. Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice.

Culture Techniques and Applications

Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anaemia).

Statistical approach to Biological sciences

Concept of data and distribution
Definition of data.
Concept of qualitative, quantitative, discrete, continuous data.

Probability and its use in Biological Sciences
General concept of probability.
The sum rule and the product rule.
Correlation, Regression and t Test

UGZOOMIP401: Practical- 2 Credits

Genomic DNA isolation from E. coli/Blood genomic through virtual demonstration

Plasmid DNA isolation (pUC 18/19) from E. coli through virtual demonstration

Construction of circular and linear restriction map from the data provided.

To study following techniques through virtual demonstration

I. Southern Blotting
II. Northern Blotting
III. Western Blotting
IV. DNA Sequencing (Sanger's Method)
V. PCR
VI. DNA fingerprinting

Project report on animal cell culture

Calculation of mean, median, mode, standard deviation, and standard error.
Construction of bar diagrams and pie diagrams using computer.
field generated data with application of t Test, mean, median, mode, standard deviation, and standard error

Reading References:

Brown, T.A.: Molecular Biology Labfax II: Gene Cloning and DNA Analysis. II Edition, Academic Press, California, USA.
Glick, B.R. and Pasternak, J.J.: Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
Weaver. Molecular Biology of Gene. 5th edition.
Primrose & Twyman. Principles of Gene Manipulation and Genomics. 7th edition.
Russell, P. J.: iGenetics- A Molecular Approach. III Edition. Benjamin Cummings
Environmental Biotechnology, Pradipta Kumar Mohapatra
Environmental Biotechnology – Concepts and Applications, HansJoachim Jordening and Jesef Winter
Wastewater Engineering – Metcalf & Eddy.
Biostatistical Analysis: N.G. Das. Mc Graw Hill Education.
Biostatistics: J. H. Zar. Pearson publication.
Theory and Methods of Statistics: P. K. Bhattacharyya. Academic Press.
Fundamentals of Biostatistics: V. B. Rastogi. ANE Books.
Biostatistics: A guide to design, analysis and discovery by Ronald Forthofer Eun Lee Mike Hernandez, Academic Press (Elsevier).

COURSE OBJECTIVES:

This course is aimed to provide students with knowledge regarding parasitological terms, types of parasites and host parasite relationship .To provide students with knowledge concerning biological and epidemiological aspects of parasites causing diseases to humans.To enable students to understand the pathogenesis, clinical presentations and complications of parasitic diseases.To enable students to learn diagnosis and know the general outline of treatment, prevention and control of parasitic infections. To provide students with knowledge regarding basic idea of zoonosis and zoonotic diseases. To provide an adequate knowledge about the basic concepts of health and diseases. To provide students with knowledge regarding cells and organs of the immune system.To enable students to understand the innate and adaptive immunity. To provide students with knowledge about antigens and immunoglobulins. To enable students to understand the antigen-antibody interactions and monoclonal antibody production. To provide an adequate knowledge regarding vaccines and autoimmune diseases.

Advances in biotechnology now can track many inherited disorders. People may now live in considerably higher population densities due to biotechnology's ability to produce more food per acre. As a result of advance biotechnology, we now know more about genomes of a wide

range of creatures. It is the most promising field that generates pharmaceuticals, vaccines, and treatments . This course is designed to flash the spotlight of Biotechnology on student to make them equipped with the modern science

Statistics is fundamental to experimental science, to prove or disprove or to establish meaningful interpretation of data. This course is designed to clear the basic fundamental idea regarding traditional and molecular taxonomy. In the portion of Biostatistics, the students will have an exposure on the basic statistical tools that are an essential part of modern biological research.

COURSE OUTCOMES:

At the end of the course, students should be able to:

1. Identify the different types of parasites.
2. Classify parasites causing diseases to humans.
3. Assess the reasons of infections with parasites.
4. Define the principles of management for some common parasitic diseases.
5. Outline the methods of parasitic disease treatment, prevention and control.
6. Functioning in multi-disciplinary teams to advise the general public on scientific basis to prevent infections with parasite.
7. Discuss the function of cells and organs involved in immunity.
8. Explain features and mechanisms of innate and adaptive immunity.
9. Explain about autoimmune diseases.
10. antigen-antibody interactions and antibody production.
11. Apply the acquired knowledge to explain defence mechanisms against infectious agents.
12. Advise the general public, why vaccination is necessary.
13. Students will also learn about various data analysing tools and techniques such as, t-test, chi-square, , correlations and regression etc.
14.. They are expected to gather knowledge on implementation of various tools in biomedical research works.
15. Fundamental knowledge about the structural and functional features of biological macromolecules such as DNA, RNA, and proteins.
16. After completion of this course the students will be able to use this knowledge in their scientific discipline and in future higher studies.

COURSE TYPE: MDC

Semester: II

Course Code: BMDCZOO2T

Course Title: Biological Sciences(ZOO)
Credit: 3
Practical/Theory: Theory

Unit: Plant Science: 1.5 credits

1. Plant diversity1.1A brief idea of 5 kingdom concepts;
1.2. Basic idea about cryptogams and Phanerogams with examples including morphological &
anatomical features of Plantae with distribution & importance.- 2 Lectures
2. 2.1.Brief idea about ecology;
2.2. Habitat, ecosystem, factors of ecosystem, Energy flow and biogeochemical cycles;
2.3. Taxonomy of flowering plants including identification, nomenclature & classification;
2.4. Concept of phylogeny and Numerical taxonomy (Basic idea).-3 lectures
3. 1.Morphology of Flowering plants with special reference to root, stem, flower, fruits;
3.2. Anatomical features of tissue systems of root stem & leaves with some adaptive features.-
4. Life Process of plants
4.1. Basic idea about Absorption of mineral nutrients,
4.2. Phloem translocation,
4.3. Photosynthesis – basic outline with diversity;
4.4. Respiration-basic outline with reference to energy production;
4.5. Plant growth & development with special emphasis on phyto-hormones and their role on growth & development;
4.6. Nitrogen metabolism with symbiotic mechanisms.
5. Life Process of Plants II:
5.1. Basic idea about Sexual reproduction in flowering plants with special reference to induction of flower,
5.2. Pollination, Pollen-Pistil interaction,
5.3. Microsporogenesis & male gametophyte development, Megasporogenesis & female gametophyte development; Double Fertilization;
5.4. Fruit & Seed development & Dispersal;
5.5. Inheritance pattern of characters (only Mendelism)
6. Plants in human welfare including food, fuel, fodder, medicines and ecological restorations;
crop improvement strategies with special reference to Breeding, tissue culture & biotechnology.-
7. Modern trends in plant biology including application of bioinformatics, AI, Genomics for the Plant biology research in 21st century.

Unit/Group-Animal Science. - 1.5 Credits.

Diversity of Animals and Origin of diversity

1. Types of animals-Introductions to Different Phyla.
    1. The Invertebrates
    2. Animals with back bone

2. Origin of Diversity-Evolution
2.1 Origin:
Origin of the Universe, Emergence of Heavy elements, Earth –the beginning, Formation of organic and biological molecules-building blocks of life. Origin of first cells.
2.2. Great Oxygenation event-A metabolic switch and Cambrian explosion.
Explosion of life diversity and some extinction. The basic diversity of animals and their proposed evolutionary orders. Cambrian explosion and establishment of animal forms.
2.3. Prokaryotes and Eukaryotes

2.4. From single cell to metazoan.
2.5. How things change? The basic evolutionary theories. Darwin vs Creationists. Natural selection –the blind watchmaker.
2.6. The Mass extinctions. K-T extinction, Adaptive radiation of mammals. Story of Us- Biological and cultural evolution of *Homo sapiens*.
3. Genes and Inheritance.
3.1. Building blocks of life, DNA, RNA, Proteins and lipids.
3.2. Genes are the basic unit of inheritance and evolution.
3.3. Mutation as source of variation- how genes change the destiny of organisms.
3.4. Genetic engineering – Manipulating genes for pharmaceuticals, high yield crops to Cloning.
4. How the Body Works-basics of human physiology.
4.1. Respiration.
4.2. Blood circulation.
4.3. Excretion.
4.3. Nervous system and brain.
4.4. Adaptation: Surviving extreme climates. Arctic, aquatic and desert.
5. Diseases and our defense.
5.1. Virus, bacteria, protozoa and other parasites.
5.2. Respiratory virus, Vector born diseases, Bacterial diseases-prevention and management.
5.3. Our Immune system- Innate and adaptive
6. Behaviour –Nature or nurture?
The basic units of behaviour. How evolution shape animal behaviour. The selfish gene. Arms race and cooperation- why Thompson gazelle prong, cheetah run fast, lemmings commit suicide but Lady Black Widow spider eats her husband?
7. Cognition and consciousness. "I think therefore I am"?
Learning, memory and self-awareness. Cognitive disorders-Autism, Alzheimer's disease, Dementia and Parkinson's Disease-Symptoms, management and treatment.
8. Understanding and protecting Diversity.
8.1. Introduction to Biodiversity.
8.2. Types of Biodiversity.
8.3. Value of Biodiversity.
8.4. Biodiversity hotspots. Biodiversity of India. The IUCN and Red Data Book.
8.3. Protecting Biodiversity through conservation.
8.4. Wild life conservation. Indian acts, Sanctuaries and National parks.
8.5. Protecting endangered flora and fauna.
8.6. India's success in Tiger conservation, conservation of Rhinoceros and Elephants.
REFERENCE BOOKS:

1. A text book of Botany (Vol. I, II, III)- Hait, Bhattacharya & Ghosh,
2. Studies in Botany (Vol. I & II) Guha & Choudhury
3. Udbhidbidda- Sikdar, Sen & Giri
4. College Botany (Vol. I & II) B.P. Pandey,
5. 5.Fundamental Botany- Sen & Giri
6. Krebs, C.J. (2014). Ecology: The Experimental Analysis of Distribution and Abundance, 6th Edition.
7. Odum, E.P. (2008). Fundamentals of Ecology, 2nd Edition.
8. Smith, R.L. (1998). Ecology and Field Biology.
9. Stilling, P. (2012). Ecology: Global Insights and Investigations.
10. Bowman, W.D., Hacker, S.D. and Cain, M.L. (2017). Ecology, 4th Edition.
11. Ricklefs, R.E. and Miller, G.L. (2001). Ecology, 4th Edition.
12. Smith, T.M. and Smith, R.L. (2012). Elements of Ecology, 8th Edition.
13. Campbell, N.A. and Reece, J.B. (2011). Biology, 9th Edition.
14. Futuyma, D.J. (2005). Evolution.
15. Moody, P.A. (1962). Introduction to Evolution, 3rd Edition.

16. Rastogi, V.B. (2012). Organic Evolution, 13th Edition.
17. Ridley, M. (2004). Evolution, 3rd Edition.
18. Russell, P.J. (2016) iGenetics: A Molecular Approach, 3rd Edition. Hildebrand, M. (1995). Analysis of Vertebrate Structure. John Wiley & Sons.
19. Chaki, K.K. Kundu, G. & Sarkar, S. (2005). Introduction to General Zoology. Vol. 1. New Central Book Agency (P) Ltd. Kolkata.
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24. Chatterjee and Chatterjee Practical Zoology.
25. Alcock: Animal Behaviour: An evolutionary approach (9 ed. 2009, Sinauer)
26. David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.
27. Manning, A. and Dawkins, M. S, An Introduction to Animal Behaviour, Cambridge,University Press, UK.

COURSE OBJECTIVE:

Learning Outcome: Students will learn about diversity of plant and animal life on earth, how the diversity evolved, the morphological, Physiological, Biochemical & the molecular basis of life; genetic basis of evolution of diversity, importance of diversity and need for conservation of diversity. Students will appreciate the modern trends in biological research

COURSE OUTCOME:

Students will learn about diversity of plant and animal life on earth, how the diversity evolved, the molecular and genetic basis of evolution of diversity, importance of diversity and need for conservation of diversity.

COURSE TYPE: SEC-

Semester: **1**

Course Code: **BZOOEC01C**

Course Title: **Sericulture**

Credit: **3**

Practical/Theory: **Combined**

Sericulture

Unit 1: Introduction

1. Sericulture: Definition, history and present status; Silk route
2. Types of silkworms, Distribution and Races
3. Exotic and indigenous races
4. Mulberry and non-mulberry Sericulture

Unit 2: Biology of Silkworm

1. Life cycle of *Bombyx mori*
2. Structure of silk gland and secretion of silk

Unit 3: Rearing of Silkworms

1. Selection of mulberry variety and establishment of mulberry garden
2. Rearing house and rearing appliances.
3. Disinfectants: Formalin, bleaching powder, RKO
4. Silkworm rearing technology: Early age and Late age rearing
5. Types of mountages.
6. Spinning, harvesting and storage of cocoons

Unit 4: Pests and Diseases

1. Pests of silkworm: Uzi fly, dermestid beetles and vertebrates
2. Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial

3. Control and prevention of pests and diseases

Unit 5: Entrepreneurship in Sericulture

1. Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture
2. Visit to various sericulture centres.

Practical:

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- Study of the life cycle of different species of silk moths - *Bombyx mori,*

Philosamia ricini, Antheraea proyli/Antheraea mylitta, Antheraea assamensis and silk secreted by them.

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- Study of the sexual dimorphism in caterpillar, pupae and adults of Bombyx mori.
- Study of rearing house and different appliances used in rearing of silk worms.
- Submission of a report on visit to a Sericulture Institute/Sericulture Centres.

Reading References:

- Manual on Sericulture (1976); Food and Agriculture Organisation, Rome
- Ullal, S.R. and Narasimhanna M.N. (1987) Handbook of Practical Sericulture; 3 rd Edition, CSB, Bangalore
- Yonemura, M. and Rama Rao, N. (1951) A Handbook of Sericulture. I. Rearing of silk-worms. Government Branch Press, Mysore.
- Ananthanarayanan, S. K. (2008) Silkworm Rearing. Daya Publishing House
- Aruga, H. (1994). Principles of Sericulture. CRC Press
- Sathe, T. V. and Jadhav, A. (2002) Sericulture and Pest Management. Daya Publishing House Yup-Lian, L. (1991) Silkworm Diseases. Food and Agricultural Organization

COURSE OBJECTIVE:

The course will make the students aware about the significance of sericulture as a profit-making enterprise. It will help the students to understand the biology of silkworms, its nutritional requirement to secrete quality silk, the techniques of silkworm rearing, reeling of silk and various measures to be taken to maximize the benefits.

COURSE OUTCOME:

Upon completion of the course, students shall be able to: Learn about the history of sericulture and silk routes. Recognize various species of silk moths in India, both

exotic and indigenous races. Be aware about the opportunities and employment in sericulture