Bodoland University
Kokrajhar, Assam

As per National Education Policy -2020

Syllabus for Theory and Practical for Undergraduate Programme

Subject: Zoology

Under auspices of Department of Higher Education

Assam

Semester-wise Titles of the papers in B. Sc. (Zoology)

YEAR	SEMESTER	PAPER CODE	PAPER TITLE	CREDITS TH+PR	Marks TH+PR+IN	TOTAL MARKS
UG Certificate in Zoological Techniques with internship of 4 credits						
1	1	ZOOMAJ101-4	Cell Biology and Histology	3+1	50+30+20	100
	1	ZOOMIN101-4	Cell and Molecular Biology	3+1	50+30+20	100
	1	ZOOIDC101-3	Environmental Studies and Wildlife Conservation	2+1	40+10	50
	1	ZOOSEC101-3	Non-Mulberry Sericulture	2+1	40+10	50
	1	ZOOVAC101-4	Basic Ecotourism	2+2	50	50
	1	ZOOINT101-4	Summer Internship	4		
	2	ZOOMAJ102-4	Biological Techniques	3+1	50+30+20	100
	2	ZOOMIN102-4	Biostatistics and Bioinstrumentation	3+1	50+30+20	100
	2	ZOOIDC102-3	Basic Lab safety & Techniques	2+1	40+10	50
	2	ZOOSEC102-3	Aquaculture	2+1	40+10	50
	2	ZOOVAC102-4	Vermicompost Technology	2+2	50	50
UG Diploma in Zoological Techniques with internship of 2 years						
2	3	ZOOMAJ201-4	Basics of Biochemistry	3+1	50+30+20	100
	3	ZOOMAJ202-4	Principles of Ecology and Animal Behaviour	3+1	50+30+20	100
	3	ZOOMIN201-4	Evolutionary Biology and Genetics	3+1	50+30+20	100
	3	ZOOIDC201-3	Human-Wildlife Conflict and Management	2+1	40+10	50
	3	ZOOSEC201-3	Animal Husbandry and Livestock Management	2+1	40+10	50
	4	ZOOMAJ203-4	Physiology: life sustaining systems	3+1	50+30+20	100
	4	ZOOMAJ204-4	Principles of Genetics	3+1	50+30+20	100
	4	ZOOMAJ205-4	Animal Biotechnology	3+1	50+30+20	100
	4	ZOOMIN202-4	Physiology and Biochemistry	3+1	50+30+20	100

	4	ZOOINT201-4	Internship	2		
Bachelor's Degree in Zoology						
3	5	ZOOMAJ301-4	Basic systematic and Diversity of life-I (Non-chordates)	3+1	50+30+20	100
		ZOOMAJ302-4	Developmental Biology	3+1	50+30+20	100
		ZOOMAJ303-4	Organic Evolution	3+1	50+30+20	100
		ZOOMAJ304-4	Biochemistry of metabolic processes	3+1	50+30+20	100
		ZOOMIN301-4	Taxonomy and Diversity of life-I (Non-chordates)	3+1	50+30+20	100
		ZOOINT301-4	Internship	4		
	6	ZOOMAJ305-4	Diversity of life-II (Chordates)	3+1	50+30+20	100
		ZOOMAJ306-4	Comparative Anatomy of vertebrates	3+1	50+30+20	100
		ZOOMAJ307-4	Molecular Biology	3+1	50+30+20	100
		ZOOMAJ308-4	Biostatistics & Bioinformatics	3+1	50+30+20	100
		ZOOMIN302-4	Diversity of life-II (Chordates)	3+1	50+30+20	100
Bachelor Degree in Zoology with Honours						
4	7	ZOOMAJ401-4	Gene and Genomes	3+1	50+30+20	100
		ZOOMAJ402-4	Immunology	3+1	50+30+20	100
		ZOOMAJ403-4	Endocrinology	3+1	50+30+20	100
		ZOOMAJ404-4*	Nutrition and Health	3+1	50+30+20	100
		ZOOREM404-4*	Research Methodology	3+1	50+30+20	100
		ZOOMIN401-4	Ecology & Environment	3+1	50+30+20	100
	8	ZOOMAJ405-4	Applied Zoology	3+1	50+30+20	100
		ZOOADL401-4	Reproductive Biology	3+1	50+30+20	100
		ZOOADL402-4	Evolutionary Biology and Biosystematics	3+1	50+30+20	100
		ZOOADL403-4	Ecology and Environmental Biology	3+1	50+30+20	100
		ZOOADL409-4	Applied Entomology and Fishery	3+1	50+30+20	100

		ZOOMIN402-4	Developmental Biology	3+1	50+30+20	100
Bachelor Degree in Zoology with Research						
	8	ZOOADL409-4	Applied Zoology	3+1	50+30+20	100
		ZOODISS	Dissertation/ Research project	12		
Total Credits				**160**		

* Research Methodology is compulsory for Degree in Zoology with Research. Whereas all theory papers are compulsory for Degree with Hons.

*2 credit of VAC may be Yoga education/sports and fitness/community engagement, NSS/NCC etc.

Subject prerequisite

To study Zoology in undergraduate, a student must have studied Biology, Biotechnology or Life science in Class 12

Programme Outcomes (POs)

PO 1: This will improve both the fundamental theoretical understanding and practical knowledge of Zoology.

PO 2: This will assist students in developing the foundational concepts necessary for future projects and advanced studies.

PO 3: It will promote an understanding of the evolutionary foundations of diverse animal species and their development, while also addressing the current state of animal diversity.

PO 4: It will enable students to comprehend the principles related to different applied sciences.

PO 5 It will contribute to the conservation of wild animals and enhance the economic value of the zoological content present in the environment.

PO 6 All the above POs will lead to a mind that can develop modern technologies to

address the problems and to give solution to it.

4 Year Degree-Programme-under CBCS (NEP)

Syllabus on Core Course

Zoology

SEMESTER I

Cell Biology and Histology

Course Code: ZOOMAJ101-4

No. of Credits – 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objects

The course aims to develop a comprehensive understanding of cell structure and function, histology principles, and practical skills for cellular analysis and tissue identification.

Course Outcomes

- Upon completion of the course, students will have acquired sufficient knowledge on the fundamental structure, function, and biochemistry of the cell.

Course Contents

Theory **Credit: 03**

Cell Biology: Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure, Active and Passive transport, Facilitated transport, Cell junctions.

Structure and Function of different cell components: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Mitochondria and Peroxisomes, Microtubules, Microfilaments and Intermediate filament; Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus, Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome); Cell Division: Mitosis, Meiosis, Cell cycle and its regulation and Cell Signaling: Receptors (types) and signaling molecules.

Histology: Structure of epithelium, connective tissue, cartilage, bone, smooth, striped and cardiac muscles, nervous tissue and histology of organs: gonads, liver, lung, pancreas and kidney in mammals. Basic principles of fixation and staining; Classification, Composition and properties of dye, Use of mordants and metachromatic dyes. Principle and procedure of histological staining of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Practical C**redit: 01**

1. Study of prokaryotic and eukaryotic cells.
2. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
3. Study of various stages of meiosis in grass hopper testis.
4. Preparation of permanent slide to show the presence of Barr body in human female blood cells/buccal epithelial cell.
5. Study of different tissue through permanent slides: Epithelial (simple, squamous, cuboidal, columnar Compound, stratified, transitional) muscular tissue, Connective tissue (bone, cartilage, areolar, tendon, adipose, reticular) and nervous tissue.

SUGGESTED READINGS

- De Roberties, E. D. P. *et al. Cell and Molecular Biology* TMH
- Bhaskaran, K. K. &Biju Kumar, A. *Cell Biology, Genetics & Molecular Biology*.
- Karp G. (2005). *Cell and Molecular Biology*.4 e, John Wiley & Sons, Inc.
- Sadava, D. E. *Cell Biology*. Jones & Bartlett Publishers, London
- Sheeler, P. and Bianchi D. E. *Cell Biology - Structure, Biochemistry andFunctions*.
- Verma, P. S. &Agarwal, V. K. *Cytology*. S. Chand & Co.
- Vijayakumaran Nair, K. & Jayaprakash, M. *Cell Biology, Genetics, Molecular Biology*, Academica.

Semester I

Cell and Molecular Biology

Course Code: ZOOMIN101-4

No. of Credits – 4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objects

The course aims to develop a comprehensive understanding of cell structure and function, histology principles, and practical skills for cellular analysis and tissue identification.

Course Outcomes

- Upon completion of the course, students will have acquired sufficient knowledge on the fundamental structure, function, and biochemistry of the cell.

Course Contents

Theory **Credits: 03**

Overview of Cells, Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions. Plasma Membrane: Various models of plasma membrane structure. Transport across membranes: Active and Passive transport, Facilitated transport.

Endomembrane System, Structure and Functions: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Mitochondria: Structure, Semi-autonomous nature, Peroxisomes. Cytoskeleton: Structure and Functions: Microtubules, Microfilaments and Intermediate filaments. Nucleus: Structure and Function of Nucleus, Chromatin: Euchromatin and Heterochromatin. Cell Division: Mitosis, Meiosis, Cell cycle and its regulation.

Nucleic Acids: Salient features of DNA and RNA, Watson and Crick model of DNA. DNA Replication: Replication in prokaryotes and eukaryotes, mechanism of DNA replication, Semi-conservative, bidirectional and semi-discontinuous replication. Transcription. RNA polymerase and transcription Unit, mechanism of transcription in prokaryotes and eukaryotes.

Practical **Credits: 01**

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis
2. Study of various stages of meiosis
3. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
4. Study of Polytene chromosomes from Chironomus / Drosophila larvae

SUGGESTED READINGS

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.

- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
- 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.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Semester I

Environmental Studies and Wildlife Conservation
Course Code: ZOOIDC101-3
No. of Credits – 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of studying the anthropogenic impact on the environment is to understand the detrimental effects of human activities on ecosystems and biodiversity.

Course outcome

The outcome of such studies is to foster a sense of responsibility and encourage sustainable practices for the preservation and conservation of the environment. This knowledge can help in formulating policies and strategies to mitigate the damage caused by human activities and work towards achieving a more harmonious relationship between man and nature.

Course content

Theory **Credits: 02**

Anthropogenic impact on environment: Man, as an animal species in the ecosystem. Population explosion. carrying capacity, exploitation of resources due to urbanization, industrialization and agricultural practices. Generation of agricultural, municipal, industrial waste; Pollution of air, water, soil and noise; radioactive pollution. Eutrophication. Deforestation; Threats to biodiversity, Extinction of species. Greenhouse effect and global warming; climate change; Shrinking of glaciers. Threats to sustainable development.

Value of wildlife and its conservation: Definition, value and importance of wildlife; Types of ecosystems. Causes of depletion of wildlife; Inventory and classification of wetland and animal inhabitants; Factors responsible for the extinction of animals; Biodiversity conservation– In-situ e.g., Sanctuaries, National Parks, Biosphere Reserves, World Heritage Sites; Ex-situ e.g., botanical gardens, gene banks, cryopreservation etc. Contour farming, reforestation; Rainwater harvesting, groundwater water recharge. Green technologies, Eco-cities, Social and Joint forestry.

Practical **Credits: 01**

1. Visit to an area to document environmental assets including natural resources/flora/fauna, etc.
2. To determine the chemical conditions of water: pH, temperature, conductivity, dissolved oxygen and carbon-di-oxide, hardness etc.

Suggested readings

Odum, E.P, 1971. Fundamentals of Ecology. W.B .Saunders Co. USA 57

Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.

Wilson, E. O. 1985. The Biological Diversity Crisis. BioScience 35: 700-706.

Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. Climate Change and India. Universities Press, India.

Gaston, K J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.

Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.

Semester I

Non-Mulberry Sericulture
Course Code: ZOOSEC101-3
No. of Credits – 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective

By the end of this section, students will have a clear understanding of sericulture, its historical significance, and the current status of mulberry and non-mulberry sericulture.

Course outcome

They will also have knowledge of the life cycles of Eri and Muga silkworms, the structure of silk glands, and the characteristics of silk. Additionally, readers will be informed about the food plants suitable for Eri and Muga silkworm rearing. Overall, this section will lay a strong foundation for understanding the subsequent topics related to sericulture.

Course contents

Theory **Credits: 02**

Introduction**:** Sericulture: Definition, history and present status of Mulberry and Non-Mulberry Sericulture; Silk route. Varieties of Silk; Types and distribution of non-mulberry or wild or vanya sericigenous insects in N-E India. Life cycle of silkworm- Eri and Muga. Structure of silk gland and Nature of Silk. Food plants of Eri and Muga Silkworm. Rearing Operation: Rearing house/Site and rearing appliances. Disinfectants: Formalin, bleaching powder. Rearing technology: Early age and Late age rearing. Environmental conditions in rearing-temperature, Humidity, Light and Air. Types of mountages. Harvesting and storage of cocoons. Spinning and Reeling of silk.

Pests and Diseases: Pests of eri and muga silkworm. Pathogenesis of eri and muga silkworm diseases: Protozoan, viral, fungal and bacterial. Prevention and control measures of pests and diseases. Entrepreneurship in Non-Mulberry Sericulture: Varieties of Non-Mulberry Silk products and economics in India Prospectus of Non-Mulberry Sericulture in India: Non-Mulberry Sericulture industry in different states, employment generation and potential.

Practical **Credit: 01**

1. Study of life cycle of Muga and Eri silkworm.
2. Visit to various sericulture Govt. /Private Farm/ Centers and report submission.

Suggested readings

- F.A.O. (1984). Manual on Sericulture published by Food and Agriculture Organization
- S.B. Dandin, J. Jayaswal and K. Giridhar (2001). Handbook of Sericulture Technologies. Publisher-Central Silk Board, Bangalore.

- Muga Culture. 2013. Author: RN Singh, CM Vaspayi, A. Tikader and B. Sarat Chandra. Publisher – APH Publishing Corporation, New Delhi.
- Ericulture- A comprehensive Profile. Authors: MC Sarmah, BN Sarkar, SA Ahmed and J Dewry. 2013.
- Directorate of Sericulture, BTC, Silkworm Egg Production. 1997. Publisher – Oxford and IBH Publishing Co. Pvt. Lt.
- Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

Semester I

Basic Ecotourism
Course Code: ZOOVAC101-4
No. of Credits – 4: {2(T) + 2(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of this course is to provide a comprehensive understanding of tourism as a concept and its basic components.

Course outcome

- Students will understand the concepts of tourism demand and supply and will be able to identify the unique features of the tourism industry.
- Overall, this course will equip students with a solid foundation in tourism studies, enabling them to analyze and understand the various aspects and impacts of the industry.

Theory **Credits: 02**

Definition of Tourism; Basic Components and types of Tourism: accessibility, attraction and accommodation; Motivation for Tourism; scope; leisure, recreation and tourism, and their interrelationship. Components of Tourist Resources: Tourist oriented resources, resident oriented resources, background of tourism resources and retrieval tourist resources. Tourism Demand and Supply: concept, unique features, constraint and opportunity in creating ideal destination; Ethnic hospitality: nature and dimensions.

Economic impacts of Tourism: income and employment; Socio-cultural impacts of Tourism; Ecological and Environmental impacts of Tourism; Tourism planning: Concept, nature and type of tourism planning; Tourism policy of Assam; Planning for the development of a tourist destination; Definition and types of Tour operator and Travel agency; Marketing: concept and definition and its significance in tourism industry; Basic concept of need, demand and services. Definition and types of tourist guide, Job description, duties and responsibilities of tourist guide: Importance of tourist guide in tourism industry; Income source of a tourist guide.

Practical **Credits: 02**

Theory related practical

Suggested readings

- Introduction to Tourism : A. K. Bhatia
- Tourism System : Mill R.C & Morrison
- Tourism Development : R. Garther
- Successful Tourism Management : Pran Nath Seth

Semester II

Biological Techniques
Course Code: ZOO MAJ 101-4
No. of Credits – 4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objectives of the course are to understand the principles, techniques, and applications of various bio-instrumentation methods and to gain knowledge of diagnostic methods used for blood and urine analysis, including detection and prevention of diabetes and hypertension.

Course Outcomes

- After completing the objectives related to Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure, Active and Passive transport, Facilitated transport, Cell junctions, Structure and Function of different cell components, Cell Division, and Cell Signaling, students will be able to demonstrate a comprehensive understanding of the structure, function, and processes involved in cellular biology.
- Upon achieving the objectives related to Histology and Bio-instrumentation, students will acquire the ability to apply principles and techniques of microscopy, histological staining, and diagnostic methods for blood and urine analysis. They will also develop skills in utilizing various bio-instrumentation tools and methods for research, analysis, and diagnostic purposes in the field of biology.

Course Contents

Theory **Credits: 03**

Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Fluorescent, Phase Contrast, Electron Microscope, and Microtome.

Principle & Applications of Centrifuge machine, Ph Meter, Spectrophotometry, Paper Chromatography, Partition Chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Ion Exchange, Affinity Chromatography and Introduction to HPLC, Electrophoresis and PCR.

Diagnostics Methods Used for Analysis of Blood: Blood composition, Preparation of blood smear and cell count using haemocytometer, Urine Analysis: Physical characteristics; Abnormal constituents, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose.

Practical **Credits: 01**

1. Preparation of blood smear and cell counting
2. Detection of blood Group
3. Detection of sugar in urine
4. Demonstration of instrumentations
5. Detection of pH level from different samples

SUGGESTED READINGS

- Wilson, K. and Walker, J. Principles and Techniques of Practical Biochemistry Cambridge University Press.
- Scopes, R. Protein Purification - Principles and Practices. Springer Verlag.
- Pattabhi V and Gautham N. Biophysics, Kluwer Academic Publishers.
- Narayanan P. Essentials of Biophysics, New Age International Pvt Ltd.
- Volkenshtein, M.V. General Biophysics Academic Press, Inc.
- Daniel, M. Basic Biophysics for biologists Agrobios.

Semester II

Biostatistics and Bioinstrumentation
Course Code: ZOOMIN102-4
No. of Credits – 3: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course on Introduction to Biostatistics and Laboratory Techniques is to provide students with a foundational understanding of biostatistics and key laboratory techniques used in biological research.

Course Outcome

- By the end of this course, students will have a solid understanding of the principles and concepts of biostatistics. They will be able to utilize appropriate terminology, symbols, and statistical methods to analyze and interpret biological data.
- Additionally, students will gain practical knowledge of laboratory techniques such as microscopy, centrifugation, spectrophotometry, various chromatography techniques, electrophoresis, and PCR. Overall, this course will equip students with the necessary statistical and laboratory skills to conduct and analyze biological research effectively.

Couse Contents

Theory **Credits: 03**

Introduction to Biostatistics, Terminology and Symbols, Research and Types of Research, sampling design, Applications of Statistics in Biological Research, Data, Collection and Representation of Data (Pie Chart, Bar Diagram, Histogram, Frequency Polygon and Gantt Chart), Measures of Central Tendency (Mean, Median, Mode), Variance, Coefficient of Variation, Standard Deviation, Standard Error of Mean.

Analysis of Variation (ANOVA), One Way ANOVA and Two-Way ANOVA. Measures of Dispersion, Distribution Patterns (Binomial, Poisson & Normal), Tests of Significance (‘T’ Test, ‘F’ Test & Chi-Square Test), Probability, Correlation and Regression Analysis.

Principles and Techniques of Microscopy; Magnification and Resolution Parameters of Light, Fluorescent, Phase Contrast, Electron Microscope, and Microtome. Principle & Applications of Centrifuge machine, Ph Meter, Spectrophotometry, Paper Chromatography, Partition Chromatography, Column Chromatography, Thin Layer Chromatography, Gas Chromatography, Ion Exchange, Affinity Chromatography and Introduction to HPLC, Electrophoresis and PCR.

Practical **Credits: 01**

- To learn graphical representations of statistical data with the help of computers.
- To calculate mean, median and mode of a given data
- To perform a “two-sample t- test” for a given set of data
- Demonstration of instrumentations

SUGGESTED READINGS

- Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc. and Dorling Kindersley Publishing Inc.USA.
- Antonisamy, B., Christopher S. and Samuel, P. P.(2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.

Semester II

Basic Lab safety & Techniques
Course Code: ZOOIDC102-3
No. of Credits – 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of the course on Introduction to Laboratory Safety is to provide students with a comprehensive understanding of laboratory safety principles and practices.

Course outcome

- Understand the importance of laboratory safety and the consequences of inadequate safety practices.
- Recognize their roles and responsibilities as laboratory personnel in maintaining a safe working environment.

Identify and assess common laboratory hazards, including chemical, biological, and physical hazards.

Course contents

Theory **Credits: 02**

Introduction to Laboratory Safety: Importance of laboratory safety, Roles and responsibilities of laboratory personnel, Regulatory agencies and guidelines, Hazard Identification and Risk Assessment: Common laboratory hazards (chemical, biological, physical) Hazard communication and labeling, Risk assessment and mitigation strategies, Personal Protective Equipment (PPE): Selection and proper use of PPE (e.g., gloves, lab coats, goggles), PPE maintenance and disposal, PPE for specific hazards (e.g., respiratory protection, cryogenic protection).

Chemical Safety: Safe handling and storage of chemicals, Hazardous chemical waste management, Chemical spill response and cleanup procedures. Biological Safety: Handling and disposal of biological materials, Biosafety levels and containment practices, Safe use of biological safety cabinets and other equipment. Physical Safety: Fire safety and emergency procedures, Electrical safety and equipment usage, Ergonomics and injury prevention, Equipment and Instrument Safety: Proper operation and maintenance of laboratory equipment, Calibration and validation of instruments, Safety precautions for specific equipment (e.g., centrifuges, autoclaves). Emergency Preparedness and Response: Emergency evacuation procedures, First aid and medical emergencies.

Practical **Credits: 01**

Visit to any advance laboratory in or outside the state

SUGGESTED READINGS

- Fuscaldo, AA, Erlick, BI, Hindman, B. Laboratory Safety: Theory and Practice. New York: Academic Press, 1980.
- CRC Handbook of Laboratory Safety. **(**A. Keith Furr, ed.). 5th ed.: CRC Press, 2000.
- Laboratory Biosafety Manual. Edition: 2nd ed.: World Health Organization, 1993.

Semester II

Aquaculture
Course Code: ZOOSEC102-3
No. of Credits – 3: {2(T) + 1(P)}
Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of the course on Aquaculture Theory is to provide students with a comprehensive understanding of the principles, practices, and techniques involved in aquaculture.

Course Outcome

- Understand the historical development and current state of aquaculture.
- Identify and describe important aquaculture species.
- Apply principles and criteria for site and species selection in aquaculture.

Course contents

Theory **Credits: 02**

Introduction to Aquaculture: History and present state. Important aquaculture species. Site and species selection. Water-quality criteria for Aquaculture. Types of culture systems. Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Integrated fish farming. Aquatic weed management. Sustainable Aquaculture;

Fish Seed: natural collection, Bundh breeding, Induced breeding. Construction and layout of fish ponds. Productivity and its measurement. Concept of brood fish pond, hatchery, nursery and grow out ponds. Care and stocking rate, Management of finfish hatcheries. water quality management. Preparation of compound diets for fish. Breeding and culture of carps. Ornamental fish culture: Preparation and maintenance of fish aquarium. Common diseases: Bacterial, viral and parasitic. Application of biotechnology in fish production.

Practical **Credit: 01**

1. Identification and study of some important Indian common cultivable freshwater fish species.
2. Determination of dissolved oxygen, Free CO_2, alkalinity, hardness of given water sample.
3. Study of common phytoplankton and zooplankton from natural resources.
4. Collection and identification of aquatic weeds and aquatic insects.
5. Demonstration of Induced breeding of Indian major carps/catfishes

References:

1. Jhingran V.G. 1997. Fish and Fisheries of India. Hindustan Publications, Delhi, India.
2. Srivastava, C.B.L. A Text Book of Fishery Science and Indian Fisheries, Kitab Mahal, Allahabad
3. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House

Semester II

Vermicompost Technology

Course Code: ZOOVAC102-4

No. of Credits – 4: {2(T) + 2(P)}

Total hours: 30 (Theory) (2 hour/ Week)

Objective

The objective of the course on Introduction to Vermiculture is to provide students with a comprehensive understanding of vermiculture, its definition, history, and economic importance.

Course outcome

- Recognize the economic importance of vermiculture in various sectors.
- Appreciate the value of vermiculture in maintaining soil structure and fertility.
- Comprehend the role of vermiculture in the four R's of recycling: reduce, reuse, recycle, and restore.
- Understand the bio-transformation process of residues generated by human activities through vermiculture.

Course contents

Theory **Credits: 02**

Introduction to vermiculture: definition, meaning, history, economic important, their value in maintenance of soil structure, role as four r's of recycling reduce, reuse, recycle, restore. It's role in bio transformation of the residues generated by human activity and production of organic fertilizers. Ground population, transformation process in organic matter. Choosing the right worm.

Useful species of earthworms. Local species of earthworms. Exotic species of earthworms. Complementary activities of auto evaluation. Key to identify the species of earthworms. Biology of suitable species for vermicompost (i.e. *Eisenia fetida, Eudrilus eugeniae*, etc.). Small Scale Earthworm farming for home gardens - Earthworm compost for home gardens and Conventional commercial composting. Enemies of Earthworms.

Practical **Credits: 01**

1. Key to identify different types of earthworms
2. Field trip- Collection of native earthworms & their identification
3. Study of Systematic position, habits, habitat & External characters of studied earth worms
4. Study of Life stages & development of studied earth worms
5. Field visit

Suggested readings

- Bhatt J.V. & S.R. Khambata (1959) “Role of Earthworms in Agriculture” Indian Council of Agricultural Research, New Delhi
- Dash, M.C., B.K.Senapati, P.C. Mishra (1980) “ Verms and Vermicomposting” Proceedings of the National Seminar on Organic Waste Utilization and Vermicomposting Dec. 5-8, 1984, (Part B), School of Life Sciences, Sambalpur University, Jyoti Vihar, Orissa.
- Edwards, C.A. and J.R. Lofty (1977) “Biology of Earthworms” Chapman and Hall Ltd., London.

Semester-III

Basics of Biochemistry

Course Code: ZOO MAJ 201-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

A comprehensive understanding of the structures, functions, and significance of carbohydrates, lipids, proteins, and nucleic acids, as well as the ability to apply the knowledge of biological catalysts in analyzing enzyme reactions and their regulation.

Course outcomes

- After completing the objectives, the students will understand the structure, classification, and biological significance of carbohydrates, including monosaccharides, disaccharides, polysaccharides, and glycoconjugates, as well as the structure and importance of lipids, such as saturated and unsaturated fatty acids, triacylglycerols, phospholipids, glycolipids, and steroids.
- Besides, they will know about the structure and classification of amino acids, including α-amino acids, and their physiological importance, along with the bonds stabilizing protein structure, levels of organization in proteins, denaturation, introduction to simple and conjugate proteins, as well as the structure of nucleic acids, including purines, pyrimidines, nucleosides, nucleotides, and nucleic acids. Additionally, to understand the nomenclature, classification, specificity, mechanism, kinetics, and regulation of enzyme action as biological catalysts.

Theory **Credits: 03**

Carbohydrates and Lipids: Carbohydrates: Structure and Biological importance: Monosaccharides, Disaccharides, Polysaccharides and Glycoconjugates; Lipids: Structure and Significance: Physiologically important saturated and unsaturated fatty acids, Tri-acylglycerols, Phospholipids, Glycolipids, Steroids.

Proteins and Nucleic acids: Structure, Classification and General properties of α-amino acids; Physiological importance of essential and non-essential α-amino acids. Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Denaturation; Introduction to simple and conjugate proteins; Nucleic Acids: Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids.

Biological Catalysts: Nomenclature and classification; Cofactors; Specificity of enzyme action; Isozymes; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Concept of Km and Vmax, Lineweaver-Burk

plot; Multi-substrate reactions; Enzyme inhibition; Allosteric enzymes and their kinetics; Regulation of enzyme action.

Practical **Credits: 01**

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Protein Estimation by Lowry's method.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH in salivary amylase enzyme

SUGGESTED READINGS

- Cox, M.M and Nelson, D.L. (2008). Lehninger's Principles of Biochemistry, V Edition,W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well,
- P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.
- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub.

Semester-III

Principles of Ecology and Animal Behaviour

Course Code: ZOO MAJ 202-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a basic understanding of ecosystems and their services to mankind.

Course outcome

The course aims to provide students with a basic understanding of ecosystems and their services to mankind. They will learn about the interrelationships between living organisms and their environment, and how ecosystems contribute to human well-being.

Course Contents

Theory **Credit: 03**

Introduction to Ecology: History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors. Population: Unitary and Modular populations. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion, Exponential and logistic growth, equation and patterns, r and K strategies, Population regulation - density-dependent and independent factors. Population interactions, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation, functional and numerical responses

Community: Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example. Theories pertaining to climax community. Ecosystem: Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies. Anthropogenic impact on ecosystem.

Animal Behaviour: Introduction to Ethology. Scope and methods of ethology, Behaviour Equipment-Sign, stimuli, stimulus filtering, Patterns of Behaviour. Individual behavioural Pattern. Homeing behaviour, Genetic basic of behaviour. Neural and hormonal control of behaviour. Circadian rhythm. Motivation: Models of motivation of motivation, feeding and drinking. Learning behavior, Types of learning, Habituation Conditional reflex, Insight learning, Association learning, Reasoning and Imprinting. Social organization, Individual Social interactions, Animal communications, Dance language of honey bees, Aggregation, Social behavior of Insects.

Practical **Credits: 01**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO2.
4. To submit report on a visit to National Park/Biodiversity Park/Wild life sanctuary within N.E. India.
5. Use of apparatus for to study ecological parameters (eg. pH meter, Hygrometer, Maximum & minimum thermometer)
6. Students are required to submit a brief project report on animal behavioural study with appropriate photographs, drawings etc. conducted on domestic animals/ pets).

Suggested readings

- Colinvaux, P. A. (1993). Ecology. I Edition. Wiley, John and Sons, Inc.
- Krebs, C. J. (2001). Ecology.VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Robert Leo Smith. Ecology and field biology Harper and Row publisher
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Press.

Semester-III

Evolutionary Biology and Genetics

Course Code: ZOOMIN201-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

It aims to familiarize individuals with the historical development of evolutionary concepts, the evidences supporting evolution, and the various mechanisms that drive genetic variation and inheritance. Additionally, it aims to explore the role of mutations, chromosomal aberrations, and genetic elements in shaping the genetic makeup of organisms.

Course outcome

- The outcome of studying these topics is to equip individuals with a solid foundation in evolutionary biology, genetics, and inheritance, enabling them to apply this knowledge to various fields such as medicine, agriculture, and conservation.
- Individuals will develop critical thinking and analytical skills necessary for evaluating scientific evidence and conducting further research in these areas.

Course contents

Theory **Credits: 03**

Life's Beginnings: Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record, Molecular evolution, molecular clock. Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution. Natural selection, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift, mechanism, founder's effect, bottleneck phenomenon; Role of Migration and Mutation in changing allele frequencies. Origin and evolution of man.

Mendelian Genetics and its Extension: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked inheritance. Linkage, Crossing Over and Chromosomal Mapping: Linkage and crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization. Mutations: Types of gene mutations (Classification) and chromosomal aberrations.

Chromosomal mechanisms of sex determination in Drosophila and Man. Extra-chromosomal Inheritance: Criteria for extra-chromosomal inheritance. Polygenic inheritance with suitable examples. Recombination in Bacteria and Viruses: Conjugation, Transformation, Transduction,

Complementation test in Bacteriophage. Transposable Genetic Elements: Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans

Practical **Credit 01**

1. To study the Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from *Drosophila* crosses.
4. Study of human karyotype (normal and abnormal).
5. Study of fossils from models/ pictures
6. Study of homology and analogy from suitable specimens
7. Study and verification of Hardy-Weinberg Law by chi square analysis

Suggested readings

1. Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett Publishers.
2. Campbell, N.A. and Reece J.B (2011).Biology. IX Edition. Pearson, Benjamin, Cummings.
3. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
4. Snustad.S Principles of Genetics.

Semester-III

Human-Wildlife Conflict and Management

Course Code: ZOO IDC 201-3

No. of Credits –3: {2(T) + 1(P)}

Total hours: 30 (Theory) (3 hour/ Week)

Objective

This paper deals with the conflicts that have arisen as a result of shrinkage of wildlife habitats and the same being shared by human communities. It raises questions about the moral obligations of humans, need for conservation, and social impacts of conflicts. The paper aims at introducing the students to the scientific and social perspective of conservation.

Course outcome

- The course provides students with a comprehensive understanding of the evolution of wildlife management, the importance of conservation efforts, the significance of protected areas, and the socio-economic aspects of conflicts and coexistence between humans and wildlife.
- Students will develop critical thinking skills and gain insights into the complexities of wildlife conservation and sustainable development.

Course contents

Theory **Credit: 02**

Evolution of the concept of wildlife management Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetkawall paintings; conservation of wildlife in the reign of king Ashoka: excerpts from rock edicts; Bishnoi community; understanding wildlife management, conservation and policies regarding protected areas in 21st century; positive values provided by wildlife conservation (monetary, recreational, scientific and ecological benefits). What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology.

Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of 1972, Forest act 1927, Status of current protected areas in India. Socio-economic and legal basis of conflicts: Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: forest produce as a need vs. forest exploitation, introduction to tribal rights in India. Human wildlife coexistence: Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices.

Practical **Credit: 01**

Practical: Based on the theory.

Suggested readings

- Woodroffe, R. 2005. People and Wildlife: Conflict and Coexistence. Cambridge.
- Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Coexistence? (No. 9). Cambridge University Press. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
- Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation 13: 458- 466.
- Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation 45: 97- 102.
- Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
- Treves, A. & Karanth, K. U. 2003. Human---carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17: 1491-1499.

Animal Husbandry and Livestock Management

Course Code: ZOO SEC 201-3

No. of Credits –3: {2(T) + 1(P)}

Total hours: 30 (Theory) (3 hour/ Week)

Objective

The objective of the course "Introduction to Poultry Husbandry" is to provide participants with a comprehensive understanding of poultry farming.

Course outcome

- Demonstrate proficiency in housing management, providing appropriate facilities for the comfort, health, and productivity of dairy cattle.
- Understand the principles and practices of meat production, abattoir management, and processing of meat and milk products.
- Comprehend the importance of animal welfare and apply relevant guidelines to ensure the ethical treatment of dairy cattle.

Course contents

Theory **Credit: 02**

Introduction to poultry husbandry: Anatomy and physiology of poultry, Different species of poultry, Housing management, Feeds Management, Management of chicken, Selection of eggs and hatchery management, Diseases of poultry, rearing of duck, turkey, and quail, Husbandry of pet birds, record keeping of farming, economics of poultry farm, Sanitation and hygiene of farm, management of waste disposal Introduction to Diary Farming: Dairy farming in India and world, cattle breeds, Farm management – feed, fertility, newborn and pregnant animal management, housing management, meat, milk and milk products, Wholesome milk production, Processing of meat and abattoir management, meat products, Zoonotic diseases, Animal welfare, and food safety guidelines, management of waste disposal

Introduction to piggery sector in India and Assam, Scientific piggery farming, Types of pig breeds and its selection, Breeding management, Care during pregnancy and farrowing, Piglet care, Creep feeding, Orphan pigs, Feeding management, Feeding of pregnant animal, Flushing; Housing: Important points for pig housing, Diseases and health Care, Other managemental practices; Livelihood with piggery, Sanitation and hygiene of farm, management of waste disposal.

Practical **Credits: 01**

1. Identification of locally available poultry breeds.
1. Identification of locally available cattle breeds.
2. Identification of locally available pig breeds.
3. Designing of housing for local small pig breeders

4. Visit of nearby poultry/dairy/pig farm and submission of a project report.

Suggested Books

- Das D, Das BC and Nayak N (2021). Text Book on Poultry Management. Publisher: Narendra Publishing House
- Singh RA. (2009). Poultry Production. Publisher: Kalyani Production
- Prasad J. (2016). Principles and Practices of Dairy Farm Management
- Eri Board (2008). Hand Book of Pig Farming. Publisher: Engineers India Research Institute
- Sharda DP. (2005). Swine Production. Publisher: ICAR, New Delhi
- Training Manuals provided by different Govt. Departments.

Semester-IV

Physiology: life sustaining systems
Course Code: ZOO MAJ 203-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of the course is to provide students with a fundamental understanding of the physiology of digestion, respiration, renal function, blood, and the heart.

Course outcome

- Students will be gaining knowledge on important life sustaining systems.
- Students will have detail knowledge on important processes of animal body.
- Students will have laboratory-oriented knowledge for handling some of important physiological& biochemical tests.

Course contents

Theory **Credits: 03**

Physiology of Digestion: Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins. Hormonal control of secretion of enzymes in Gastrointestinal tract. Physiology of Respiration: Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

Renal Physiology: Structure of kidney and its functional unit (Nephron); Mechanism of urine formation; Regulation of water balance; Regulation of acid-base balance. Blood: Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Kallikrein-Kinninogen system, Complement system & Fibrinolytic system, Haemopoiesis. Blood groups: Rh factor, ABO and MN.

Physiology of Heart: Structure of mammalian heart; Coronary circulation; Structure and working of conducting myocardial fibers. Origin and conduction of cardiac impulses Cardiac cycle; Cardiac output and its regulation, Frank-Starling Law of the heart, nervous and chemical regulation of heart rate. Electrocardiogram, Blood pressure and its regulation.

Practical **Credits: 01**

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Estimation of haemoglobin using Sahli’s haemoglobinometer
4. Preparation of haemin and haemochromogen crystals

5. Recording of blood pressure using a sphygmomanometer.
6. Examination of permanent slide of mammalian oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

Suggested readings:

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

Principles of Genetics

Course Code: ZOO MAJ 204-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The course aims to provide students with a comprehensive understanding of Mendelian genetics and its extensions, equipping them with the knowledge to analyze and interpret complex genetic phenomena.

Course outcome

- Demonstrate a comprehensive understanding of the principles of inheritance and the various extensions of Mendelian genetics, including incomplete dominance, co-dominance, multiple alleles, lethal alleles, epistasis, pleiotropy, sex-linked inheritance, linkage, crossing over, chromosomal mapping, mutations, sex determination, extra-chromosomal inheritance, polygenic inheritance, recombination in bacteria and viruses, and transposable genetic elements.
- Apply their knowledge to analyze and interpret complex genetic phenomena, enabling them to explain patterns of inheritance, predict outcomes of genetic crosses, and understand the molecular basis of genetic mutations.
- Develop critical thinking and problem-solving skills in the field of genetics, allowing them to approach genetic research and practical applications with a solid foundation of knowledge and analytical abilities.

Course Contents

Theory **Credits: 03**

Mendelian Genetics and its Extension: Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked inheritance. Linkage, Crossing Over and Chromosomal Mapping: Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

Mutations: Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB method, attached *X* method. Sex Determination: Chromosomal mechanisms of sex determination in Drosophila and Man. Extra-chromosomal Inheritance: Criteria for extra-chromosomal inheritance, Antibiotic resistance in *Chlamydomonas*, Mitochondrial mutations in *Saccharomyces*, Infective heredity in *Paramecium* and Maternal effects

Polygenic Inheritance: Polygenic inheritance with suitable examples; simple numerical based on it. Recombination in Bacteria and Viruses: Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposable Genetic Elements: Transposons in bacteria, Ac-Ds elements in maize and P elements in *Drosophila*, Transposons in humans

Practical **Credits: 01**

1. To study the Mendelian laws and gene interactions.
2. Chi-square analyses using seeds/beads/*Drosophila*.
3. Linkage maps based on data from conjugation, transformation and transduction.
4. Linkage maps based on data from *Drosophila* crosses.
5. Study of human karyotype (normal and abnormal).
6. Pedigree analysis of some human inherited traits.

Suggested Readings

- Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). *Principles of Genetics*. VIII Edition. Wiley India
- 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. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co
- Fletcher H. and Hickey I. (2015). *Genetics.* IV Edition. GS, Taylor and Francis Group, New York and London.

Animal Biotechnology
Course Code: ZOO MAJ 205-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective
Introduce students to biotechnology concepts and molecular techniques in gene manipulation.

Course outcome
- Students will have a concept and aids of technology on biological study.
- They will learn culture techniques and their application.

Course contents

Theory **Credits: 03**

Introduction: Concept and scope of biotechnology

Molecular Techniques in Gene manipulation: Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, artificial vectors (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 DNA micro array

Genetically Modified Organisms: Production of cloned and transgenic animals: Nuclear Transplantation, Retro-viral Method, DNA microinjection Applications of transgenic animals: Production of pharmaceuticals, production of donor organs, knock out mice. Production of transgenic plants: *Agrobacterium* mediated transformation. Applications of transgenic plants: insect and herbicide resistant plants. Culture Techniques and Applications: Animal cell culture, Expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia) Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

Practical **Credits: 01**
1. Genomic DNA isolation from *E. coli.*
2. Estimation of DNA by colorimetric method.
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 photographs:
    a) Southern Blotting

b) Northern Blotting
c) Western Blotting
d) DNA Sequencing (Sanger's Method)
e) PCR
f) DNA fingerprinting

Suggested Readings

- 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.
- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). *An Introduction to Genetic Analysis*. IX Edition. Freeman and Co., N.Y., USA.
- Snustad, D.P. and Simmons, M.J. (2009). *Principles of Genetics.* V Edition, John Wiley and Sons Inc.

Physiology and Biochemistry
Course Code: ZOO MIN 202-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of the course is to provide students with a fundamental understanding of the physiology of digestion, respiration, renal function, blood, and the heart.

Course outcome

- Students will be gaining knowledge on important life sustaining systems.
- Students will have detail knowledge on important processes of animal body.
- Students will have laboratory-oriented knowledge for handling some of important physiological& biochemical tests.

Course contents

Theory **Credits: 03**

Physiology of Digestion: Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins. Physiology of Respiration: Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Control of respiration.

Renal Physiology: Structure of kidney and its functional unit (Nephron); Mechanism of urine formation. Blood: Components of blood and their functions; Structure and functions of haemoglobin; Haemostasis: Blood clotting system, Blood groups: Rh factor, ABO and MN. Structure of mammalian heart; Origin and conduction of cardiac impulses Cardiac cycle, Blood pressure and its regulation.

Biomolecules of Life: Structure and Biological importance of Monosaccharides, Disaccharides, Polysaccharides; Structure and Significance of lipids, saturated and unsaturated fatty acids, Tri-acylglycerols, Proteins and Nucleic acids: Structure, Classification and General properties of α-amino acids; essential and non-essential α-amino acids. Proteins: Levels of organization in proteins; Enzymes and Cofactors; Specificity of enzyme action; Mechanism of enzyme action; Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions; Derivation of Michaelis-Menten equation, Lineweaver-Burk plot; Enzyme inhibition; Allosteric enzyme. Enzyme regulation.

Practical **Credits: 01**

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Protein Estimation by Lowry’s method.
3. Determination of ABO Blood group.
4. Preparation of haemin and haemochromogen crystals
5. Recording of blood pressure using a sphygmomanometer.

Suggested readings:

- Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons,
- Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.
- Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc

Semester V

Basic Systematics and Diversity of Life-I (Non-Chordates)

Course Code: ZOO MAJ 301-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

To provide the students the basic knowledge in Taxonomy& systematics and to provide knowledge on diversity of Non-chordates.

Course outcome

By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately. They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course Contents

Theory **Credits: 03**

Introduction to Animal Taxonomy: Definition, Basic concepts and importance of Systematics and Taxonomy. Concepts of different conventional taxonomy, alpha(α) and beta (β) taxonomy. Newer aspects in biosystematics: Chemotaxonomy, Cytotaxonomy, Molecular taxonomy. Taxonomic procedures: taxonomic collection, preservation, Components of classification. Taxonomical hierarchy - taxon, category and rank, Linnaean hierarchy, Concepts of taxonomic terms. Nomenclature: Principles of nomenclature. International Code of Zoological Nomenclature (ICZN). Rules of nomenclature. Binominal and trinominal nomenclature. Mention taxonomic aids.

Diversity of Life: Protista, Parazoa and Metazoa: General characteristics and Classification up to classes. Study of *Euglena*, *Amoeba* and *Paramecium* Locomotion and Reproduction in Protista. Evolution of symmetry and segmentation of Metazoa. Porifera Cnidaria & Ctenophora: General characteristics and Classification up to classes. Canal system and spicules in sponges. Metagenesis in *Obelia,* Polymorphism in Cnidaria, Corals and coral reefs. Evolutionary significance of ctenophora. Platyhelminthes & Nemathelminthes: General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica, Taenia solium, Ascaris lumbricoides* and *Wuchereria bancrofti.* Parasitic adaptations in helminthes.

Annelida: General characteristics and Classification upto classes, Excretion in Annelida. Arthropoda & Onychophora: General characteristics and Classification upto classes. Vision, and Respiration in Arthropoda. Evolutionary significance of onychophoran. Mollusca & Echinodermata. General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda, Pearl formation in bivalves. Water-vascular system in Asteroidea, Affinities of echinoderms with Chordates.

Note: Classification to be followed from "Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition"

Practical **Credits: 01**

1. Observation on morphological characters of Cockroach as a part of taxonomical study. Students will note down and draw mouth parts and wing venation of cockroach.
2. To perform morphometric and meristic study of locally available fish.
3. Study of whole mount of *Euglena, Amoeba* and *Paramecium,* Binary fission and Conjugation in *Paramecium.*
4. Study of *Sycon* (T.S. and L.S.), *Hyalonema, Euplectella, Spongilla*
5. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*
6. One specimen/slide of any ctenophore
7. Study of adult *Fasciola hepatica, Taenia solium* and their life cycles (Slides/microphotographs)
8. Study of adult *Ascaris lumbricoides* and its life stages (Slides/micro-photographs)
9. Museum specimen: *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria* Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta,* termites and honey bees Onychophora - *Peripatus* Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus* Echinodermates - *Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria* and *Antedon*
10. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
11. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta.*

Note: Classification to be followed from "Ruppert and Barnes (2006) *Invertebrate Zoology,* 8th edition, Holt Saunders International Edition"

Suggested readings

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- **Online Tools and Web Resources**:
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) ·
- ePGPathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35.

Developmental Biology
Course Code: ZOO MAJ 302-4
No. of Credits –4: {4(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

Acquiring Knowledge on Embryonic Development:

Course outcome

- Students will be able to acquire knowledge on embryonic development of sexually reproducing animals.
- They also obtain knowledge on metamorphic changes and the role of placenta in mammals.

Course contents

Theory **Credits: 03**

Introduction: Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Early Embryonic Development: Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers. Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

Post Embryonic Development: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories. Implications of Developmental Biology: Teratogenesis: Teratogenic agents and their effects on embryonic development; *In vitro* fertilization, Stem cell (ESC), Amniocentesis.

Practical **Credits: 01**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture

4. Study of different sections of placenta (photomicropgraph/ slides)
5. Project report on *Drosophila* culture/chick embryo development

Suggested readings

1. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
2. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
3. Carlson, R. F. Patten's Foundations of Embryology
4. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
5. Lewis Wolpert (2002).Principles of Development. II Edition, Oxford University Press.

Organic Evolution

Course Code: ZOO MAJ 303-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the origins and processes of life on Earth.

Course outcome

- Students will be able to acquire knowledge on origin of life
- They also obtain knowledge micro evolutionary of the life forms on earth.

Course contents

Theory **Credit: 03**

Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse, Molecular evolution, molecular clock, example of globin gene family, rRNA/cyt c. Sources of variations: Heritable variations and their role in evolution.

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection. Genetic Drift (mechanism, founder's effect, bottleneck phenomenon; Role of Migration and Mutation in changing allele frequencies.

Product of evolution: Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches). Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction. Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin.

Practical **Credits:01**

1. Study of fossils from models/ pictures
2. Study of homology and analogy from suitable specimens
3. Study and verification of Hardy-Weinberg Law by chi square analysis
4. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
5. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

Suggested readings

- Ridley, M (2004) Evolution III Edition Blackwell publishing
- Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition.Jones and Barlett Publishers.
- Campbell, N.A. and Reece J.B (2011).Biology. IX Edition. Pearson, Benjamin, Cummings.
- Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
- Snustad.S Principles of Genetics.
- Pevsner, J (2009). Bioinformatics and Functional Genomics. II Edition Wiley-Blackwell

Biochemistry of Metabolic Processes
Course Code: ZOOMAJ304-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the principles and processes involved in metabolism, focusing on catabolism and anabolism.

Course outcome

- Students will have acquired a comprehensive understanding of the fundamental principles and processes involved in metabolism.
- They will be able to explain and analyze the various metabolic pathways, their regulation, and the interconnections between different metabolic processes.
- Students will also develop the ability to apply this knowledge to understand the metabolic basis of various physiological and pathological conditions.

Course Contents

Theory **Credits: 03**

Overview of Metabolism: Catabolism *vs* Anabolism, Stages of catabolism, Compartmentalization of metabolic pathways, Shuttle systems and membrane transporters; ATP as “Energy Currency of cell"; coupled reactions; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanisms.

Carbohydrate Metabolism: Sequence of reactions and regulation of glycolysis, Citric acid cycle, pentose phosphate pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis. Oxidative Phosphorylation: Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of ETC.

Lipid Metabolism: β-oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis. Protein Metabolism: Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

Practical **Credits: 01**

1. Estimation of total protein in given solutions by Lowry’s method.
2. Detection of SGOT and SGPT or GST and GSH in serum/ tissue.
3. To study the enzymatic activity of Trypsin and Lipase.
4. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.

Suggested readings

- Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.
- Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). Biochemistry, VI Edition, W.H. Freeman and Co., New York.
- Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry, XXVIII Edition, International Edition, The McGraw-Hill Companies Inc.
- Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry, II Edition, BIOS Scientific Publishers Ltd., U.K.

Semester V

Taxonomy and Diversity of life-I (Non-chordates)
Course Code: ZOOMIN 301-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objectives

To provide the students the basic knowledge in Taxonomy& systematics along with the knowledge on diversity of Non-chordates.

Course outcome

By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately. They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course contents

Theory **Credits:03**

Introduction to Animal Taxonomy: Definition, Basic concepts and importance of Systematics and Taxonomy. Alpha(α) and beta (β) taxonomy. Molecular taxonomy. Taxonomic procedures: taxonomic collection, preservation, Components of classification. Nomenclature: Principles of nomenclature. International Code of Zoological Nomenclature (ICZN). Rules of nomenclature. Binominal and trinominal nomenclature. Mention taxonomic aids.

Diversity of Life: Protista, Parazoa and Metazoa: General characteristics and Classification up to classes. Study of *Euglena*, *Amoeba* and *Paramecium* Locomotion and Reproduction in Protista. Evolution of symmetry and segmentation of Metazoa. Porifera Cnidaria & Ctenophora: General characteristics and Classification up to classes. Canal system and spicules in sponges. Metagenesis in *Obelia*, Polymorphism in Cnidaria, Corals and coral reefs. Evolutionary significance of Ctenophora. Platyhelminthes & Nemathelminths: General characteristics and Classification up to classes. Life cycle and pathogenicity of *Taenia solium.* Parasitic adaptations in helminths.

Annelida: General characteristics and Classification upto classes, Excretion in Annelida. Arthropoda & Onychophora: General characteristics and Classification upto classes. Vision, and Respiration in Arthropoda. Evolutionary significance of onychophoran. Mollusca & Echinodermata. General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Water-vascular system in Asteroidea, Affinities of echinoderms with Chordates.

Note: Classification to be followed from "Barnes, R.D. (1982). *Invertebrate Zoology*, V Edition"

Practical **Credits:01**

1. Observation on morphological characters of any specimen as a part of taxonomical study.
2. Study of whole mount of *Euglena, Amoeba* and *Paramecium,* Binary fission and Conjugation in *Paramecium.*
3. Study of *Sycon* (T.S. and L.S.)
4. Study of *Obelia, Physalia, Millepora, Aurelia, Tubipora, Corallium, Alcyonium, Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*
5. One specimen/slide of any ctenophore
6. Study of adult *Taenia solium*
7. Museum specimen: *Aphrodite, Nereis, Heteronereis, Sabella, Serpula, Chaetopterus, Pheretima, Hirudinaria* Arthropods - *Limulus, Palamnaeus, Palaemon, Daphnia, Balanus, Sacculina, Cancer, Eupagurus, Scolopendra, Julus, Bombyx, Periplaneta,* termites and honey bees Onychophora - *Peripatus* Molluscs - *Chiton, Dentalium, Pila, Doris, Helix, Unio, Ostrea, Pinctada, Sepia, Octopus, Nautilus* Echinodermates - *Pentaceros*/*Asterias, Ophiura, Clypeaster, Echinus, Cucumaria* and *Antedon*
8. Study of digestive system, septal nephridia and pharyngeal nephridia of earthworm
9. Mount of mouth parts and dissection of digestive system and nervous system of *Periplaneta.*

Note: Classification to be followed from "Ruppert and Barnes (2006) *Invertebrate Zoology*, 8th edition, Holt Saunders International Edition"

Suggested readings

- Ruppert and Barnes, R.D. (2006). *Invertebrate Zoology*, VIII Edition. Holt Saunders International Edition.
- Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science
- **Online Tools and Web Resources**:
- Advances in Animal Diversity, Systematics and Evolution (https://swayam.gov.in/courses/5300-zoology) ·
- ePGPathshala (MHRD) Module 10, 18, 19 of the paper P-08 (Biology of Parasitism) https://epgp.inflibnet.ac.in/ahl.php?csrno=35.

Semester VI

Diversity of Life-II (Chordates)
Course Code: ZOO MAJ 305-4
No. of Credits –4: {4(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objectives

- To learn the general characteristics and classification of different classes of vertebrates.
- To understand the vertebrate evolutionary tree.
- To understand general aspects of applied interest in relation to vertebrates.

Course outcome

- By the end of the course, students will have acquired a strong foundation in animal taxonomy, enabling them to understand and apply systematic principles, perform taxonomic procedures, and classify various organisms accurately.
- They will also gain insight into the diversity of life and the evolutionary significance of different animal groups.

Course contents

Theory **Credits: 03**

Diversity of Life: Salient features and outline classification (up to order) of various chordate groups as covered under respective taxonomic groups. Protochordata: Salient features of body organisation and systematic position of *Balanoglossus* and *Amphioxus* as a type and its affinities. Agnatha**:** External features of *Petromyzon*.

Pisces: Scales and fins in fishes. Parental care in fishes. Fishes in relation to man. Amphibia: General characters and affinities of Gymnophiona. Parental care in Amphibia. Reptilia: A brief knowledge of extinct reptiles. Poisonous and non- poisonous snakes. Poison apparatus of snake. Snake venom and anti-venom. Adaptive radiation in reptiles. Adaptations of reptiles to desert life.

Aves: Flightless birds and their distribution. Flight adaptations in birds. Mammalia: General organisation, distribution and affinities of Prototheria. Economic importance. Adaptive radiation with particular reference to aquatic mammals.

Practical **Credits: 01**

1. Study of the following specimens: *Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo,Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis, Any six common birds from different orders, Bat, Funambulus, Loris*.

2. Key for Identification of poisonous and non-poisonous snakes.
3. Preparation of permanent slides of fish scales.
4. To prepare an "**animal album**" containing drawing photographs, cut outs, with appropriate write up about the above-mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose.

Suggested readings

- Hickman, Roberts & Hickman: Integrated principles of Zoology (7^{th}) ed Times- mirror, Mosby
- Kotpal R.L: Modern Textbook Of Zoology: Invertebrates. Rastogi
- Nigam: Biology of Non-Chordates, Nagin Chand.
- Parker TJ & haswell WA: Textbook of zoology Vol I & II, Mcmillan.
- Hyman L: Invertebrate Series, Academic Press

Comparative Anatomy of Vertebrates

Course Code: ZOO MAJ 306-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective is to acquire a comprehensive understanding of the structure, function, and evolutionary significance of the integumentary system, skeletal system, digestive system, respiratory system, circulatory system, urinogenital system, nervous system, and sense organs.

Course outcome

- Students will be gaining knowledge on development and modifications of important anatomical structures in vertebrates.
- Students will have detail knowledge body organization in terms of different tissues.
- Students will have laboratory-oriented knowledge to study microscopic structure of tissues and cells.

Course contents

Theory **Credit: 03**

Integumentary System: Structure and derivatives of integument, functions of skin. Skeletal System: Outline of axial and appendicular skeleton: basic plan of bones of skull, girdles and limbs. Classification of vertebrae, structure of a typical vertebra, Jaw suspensorium, Visceral arches. Digestive System: Brief account of alimentary canal and digestive glands, dentition.

Respiratory: Skin, gills, lungs and air sacs; swim bladder and Accessory respiratory organs. Circulatory System: General plan of circulation, Evolution of heart and aortic arches. Urinogenital System: Succession of kidney, Evolution of urinogenital ducts Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

Nervous System: Comparative account of brain; Autonomic nervous system, Spinal cord, Cranial nerves in Mammals. Sense Organs. Types and Classification of receptors; Brief account of visual and auditory receptors in man.

Practical **Credit: 01**

1. Disarticulated skeleton of fowl and rabbit
2. Study of different types of beaks found in birds.
3. Mammalian skulls: One herbivorous and one carnivorous animal.
4. Study of different tissue through permanent slides: Epithelial (simple, squamous, cuboidal, columnar Compound, stratified, transitional) muscular tissue, Connective tissue (bone, cartilage, areolar, tendon, adipose, reticular) and nervous tissue.

Suggested readings

- Kardong, K.V. (2005) *Vertebrates' Comparative Anatomy, Function and Evolution*. IVEdition. McGraw-Hill Higher Education.
- Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition,The McGraw-Hill Companies.
- Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate Structure*, John Wiley and SonsWalter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House.

Molecular Biology

Course Code: ZOO MAJ 307-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the fundamental principles and concepts in genetics.

Course outcome

- By the end of the course, students will have acquired a comprehensive understanding of the history, development, and scope of genetics.
- They will be able to explain the nature of genetic material, including DNA and RNA, understand the processes of DNA replication, transcription, and translation, and comprehend the concepts of gene expression and gene regulation.
- Students will also gain knowledge about the genetic code, its deciphering, and the contributions of key scientists in the field of genetics.

Course contents

Theory **Credit: 03**

Introduction: History, development and scope of genetics. Nature of genetic material: search for the genetic material, Griffith's experiment, transformation, contributions of Avery, Mac Leod and Mc Carty, Hershey & Chase's experiment, and transduction. Composition and structure of nucleic acids - Watson - Crick model of DNA, clover leaf model of tRNA, different types of DNA and RNA; DNA replication in prokaryotes and eukaryotes-Semi-conservative method. Messelson & Stahl experiment, replication machinery and mechanism; modification and repair of DNA.

Gene Expression: contributions of Garrod, one gene - one enzyme hypothesis, one genome polypeptide hypothesis, central dogma of Molecular Biology, central dogma reverse, colinearity of genes and gene products. Genetic code - deciphering / cracking the genetic code, characteristics of genetic code, codon assignment and wobble hypothesis. Contributions of Nirenberg and his associates, Khorana and his associates. Transcription of RNAs - RNA polymerases, transcription factors, mechanism of transcription, post-transcriptional modifications of mRNA, rRNA and tRNA, reverse transcription, translation - machinery and mechanism; post translational modification of proteins.

Gene regulation: in prokaryotes (inducible and repressive systems); operon concept -Lac operon and Trp operon. Bacterial Recombination: transformation, conjugation and transduction (general and specialized transduction)

Practical **Credit: 01**

1. Models of ribosome structure
5. Preparation of DNA by Feulgen reaction.
6. Study of Polytene chromosomes from Chironomous / Drosophila larvae.
7. Identification of male and female Drosophila.
8. Study and interpretation of electron micrographs/ photograph showing
    a) DNA replication b) Transcription.
9. Study of genetic syndromes and abnormal karyotypes of human (Klinefelter's syndrome. Turner's syndrome. Down syndrome and Edward syndrome (Through diagrams)

Suggested readings

· Alberts, B. et al. Molecular Biology of the Cell. Garland Pubg. Inc., New York
· Karp G. (2005). *Cell and Molecular Biology*.4 e, John Wiley & Sons, Inc.
· Kleinsmith, L. J. & Kish, V. M. (1995). *Principles of Cell and Molecular Biology*. Harper Collins College Pubs
· Sheeler, P. and Bianchi D. E. *Cell Biology - Structure, Biochemistry and Functions*.
· Veera Bala Rastogi. (2006). *Fundamentals of Molecular Biology* 1 e. Ane Books, India
· Watson, J.D. *et al., Molecular Biology of the Gene*, 4e, Benjamin Cummings.

Semester VII

Biostatistics & Bioinformatics

Course code- ZOO MAJ 308-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the fundamental concepts and principles of genetics.

Course outcome

- By the end of the course, students will have acquired a solid understanding of genetics, enabling them to analyze genetic patterns, interpret pedigrees, and understand the molecular basis of inheritance.

- They will be able to apply their knowledge to real-world situations and make informed decisions regarding genetic testing, genetic engineering, and ethical considerations in genetics.

Course contents

Theory **Credits: 03**

Biostatistics: Introduction to Biostatistics, Terminology and Symbols, Research and Types of Research, sampling design, Applications of Statistics in Biological Research, Data, Collection and Representation of Data (Pie Chart, Bar Diagram, Histogram, Frequency Polygon and Gantt Chart), Measures of Central Tendency (Mean, Median, Mode), Variance, Coefficient of Variation, Standard Deviation, Standard Error of Mean, Analysis of Variation (ANOVA), One Way ANOVA and Two-Way ANOVA. Measures of Dispersion, Distribution Patterns (Binomial, Poisson & Normal), Tests of Significance ('T' Test, 'F' Test & Chi-Square Test), Probability, Correlation and Regression Analysis.

Bioinformatics: Introduction to Bioinformatics: Importance, Goal, Scope; Genomics, Transcriptomics, Systems Biology, Functional Genomics, Metabolomics, Molecular Phylogeny; Applications and Limitations of Bioinformatics. Applications of Bioinformatics: Structural Bioinformatics (3-D protein, PDB), Functional genomics (genome- wide and high throughput approaches to gene and protein function), Drug discovery method (Basic concepts).

Biological Databases: Introduction to biological databases; Primary, secondary and composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD). Data Generation and Data Retrieval: Generation of data (Gene sequencing, Protein sequencing, Mass spectrometry, Microarray), Sequence submission tools (BankIt, Sequin,Webin); Sequence file format (flat file, FASTA, GCG, EMBL,

Clustal,Phylip, Swiss-Prot); Sequence annotation; Data retrieval systems (SRS, Entrez); Basic Concepts of Sequence Alignment: Types of sequence alignment; Local and global alignment, pair wise and multiple sequence alignments; Similarity, identity and homology of sequences.

Practical **Credits: 01**

1. Accessing biological databases
2. Retrieval of nucleotide and protein sequences from the databases.
3. To perform pair-wise alignment of sequences (BLAST) and interpret the output
4. Predict the structure of protein from its amino acid sequence.
5. To perform a "two-sample t- test" for a given set of data
6. To learn graphical representations of statistical data with the help of computers.

SUGGESTED READINGS

- Ghosh Z and Mallick B. (2008). Bioinformatics: Principles and Applications, Oxford University Press.
- Pevsner J. (2009). Bioinformatics and Functional Genomics, II Edition,
- Wiley Blackwell. Zvelebil, Marketa and Baum O. Jeremy (2008). Understanding Bioinformatics, Garland Science, Taylor and Francis Group, USA.
- Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson Education Inc. and Dorling Kindersley Publishing Inc. USA.
- Antonisamy, B., Christopher S. and Samuel, P. P.(2010). Biostatistics: Principles and Practice. Tata McGraw Hill Education Private Limited, India.
- Pagana, M. and Gavreau, K. (2000). Principles of Biostatistics, Duxberry Press, USA

Diversity of life-II (Chordates)
Course Code: ZOOMIN 302-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

To provide the students with an in-depth knowledge of the diversity in form, structure and habits of Chordates.

Course outcome

- To learn the general characteristics and classification of different classes of vertebrates.
- To understand the vertebrate evolutionary tree.
- To understand general aspects of applied interest in relation to vertebrates.

Theory **Credit: 03**

Diversity of Life: Salient features and outline classification (up to order) of various chordate groups as covered under respective taxonomic groups. Protochordata: Salient features of body organisation and systematic position of *Balanoglossus* and *Amphioxus* as a type and its affinities. Agnatha**:** External features of *Petromyzon*.

Pisces: Scales and fins in fishes. Parental care in fishes. Fishes in relation to man. Amphibia: General characters and affinities of Gymnophiona. Parental care in Amphibia. Reptilia: A brief knowledge of extinct reptiles. Poisonous and non- poisonous snakes. Poison apparatus of snake. Snake venom and anti-venom. Adaptive radiation in reptiles. Adaptations of reptiles to desert life.

Aves: Flightless birds and their distribution. Flight adaptations in birds. Mammalia: General organisation, distribution and affinities of Prototheria. Economic importance. Adaptive radiation with particular reference to aquatic mammals.

Practical **Credits: 01**

10. Study of the following specimens: *Balanoglossus, Herdmania, Branchiostoma, Petromyzon, Sphyrna, Pristis, Torpedo,Labeo, Exocoetus, Anguilla, Ichthyophis/Ureotyphlus, Salamandra, Bufo, Hyla, Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis, Any six common birds from different orders, Bat, Funambulus, Loris*.
11. Key for Identification of poisonous and non-poisonous snakes.
12. Preparation of permanent slides of fish scales.
13. To prepare an "**animal album**" containing drawing photographs, cut outs, with appropriate write up about the above-mentioned taxa. Different taxa/ topics may be given to different sets of students for this purpose.

Suggested readings

- Hickman, Roberts & Hickman: Integrated principles of Zoology (7^{th}) ed Times- mirror, Mosby
- Kotpal R.L: Modern Textbook of Zoology: Invertebrates. Rastogi
- Nigam: Biology of Non-Chordates, Nagin Chand.
- Parker TJ & haswell WA: Textbook of zoology Vol I & II, Mcmillan.
- Hyman L: Invertebrate Series, Academic Press

Semester VII

Gene and Genomics

Course Code: ZOO ADL 401-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the structure and organization of genomes and the processes involved in DNA replication, recombination, repair, transcription, post-transcriptional processing, translation, and protein transport.

Course outcome

- By the end of the course, students will have acquired a thorough understanding of the structure and organization of the genome, as well as the processes of DNA replication, recombination, repair, transcription, post-transcriptional processing, translation, and protein transport.
- They will be able to analyze and interpret the mechanisms involved in these processes and understand their significance in gene expression and cellular functions.

Course Contents

Theory **Credit: 01**

Structure and Organization genome – Nucleic acids as genetic material; DNA vs. RNA as genetic material; concept of gene and gene families; non-coding genes; concept of intron; C-value paradox, Secondary structure of DNA and conformation flexibilities, Repetitive DNA; Tertiary structure and super-coiling of DNA; DNA packaging – nucleosome and higher order structure of chromatin, virus and bacterial genomes; organelle genome - mitochondrial genome and chloroplast DNA; RNA based genomes. DNA replication, recombination and repair – General features of prokaryotes and eukaryotes replication; Directions and types of replication; Stahl and Meselson experiment; Enzymes of DNA replication; proof- reading activity; replication in mt and ct-DNAs; telomere maintenance, telomerase and aging; DNA damage and Errors; types of DNA repair mechanisms; cellular response to DNA damage, Double strand break repairs.

Transcription process - Prokaryotic Transcription; Transcription unit; Promoters- Constitutive and Inducible; Operators; Regulatory elements; Initiation; Attenuation; Termination-Rho-dependent and independent; Antitermination; Transcriptional regulation-Positive and negative; Operon concept-lac, trp, and gal operons; Transcriptional control in lambda phage; Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase - I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TBP and TAF; Activators and repressors.

Post-Transcriptional Processing - Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; splicing Mechanisms; Trans splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA; Transcriptional and post-transcriptional gene silencing by

microRNA. Translation and transport - Translation machinery; Ribosomes; Composition and assembly; Universal genetic code; Degeneracy of codons; Termination codons; Isoaccepting tRNA; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic code in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.

Practical **Credit: 01**

1. Study of chromosome banding techniques
2. Extraction of DNA from mammalian tissue
3. Extraction and detection of chromatin from mammalian tissue.
4. Spectrophotometric analysis of DNA
5. Spectrophotometric analysis of DNA

Suggested readings

- Watson et al. 2014. Molecular Biology of the Gene, 7th edition
- Lizabeth A. Allison et al. 2007. Fundamental Molecular Biology. 1st edition
- T.A. Brown. 2007. Genome 3. 3rd edition
- Robert F. Weaver. 2012. Molecular Biology. 5th Edition.
- Jocelyn E. Krebs et al. 2014. Lewin's GENES XI. 11th edition

Immunology

Course Code: ZOO ADL 402-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of the immune system, its components, functions, and the various aspects related to immunology.

Course Outcomes

- By the end of the course, students will have acquired a thorough understanding of the immune system, its components, and their functions. They will be able to explain the principles of innate and adaptive immunity, antigen-antibody interactions, and the roles of immunoglobulins, cytokines, and complement in immune responses.
- Students will also gain knowledge about hypersensitivity reactions, major histocompatibility complex (MHC), and the different types of vaccines. They will be equipped with the ability to apply their knowledge to analyze and interpret immunological processes and their significance in disease prevention, diagnosis, and therapeutics.

Course contents

Theory **Credit: 03**

Overview of Immune System: Historical perspective of Immunology, Early theories 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), Passive: Artificial and natural Immunity, Active: Artificial and natural Immunity, Immune dysfunctions (brief account of autoimmunity with reference to Rheumatoid Arthritis and tolerance, AIDS).

Antigens: Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes. Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA and RIA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Major Histocompatibility Complex: Structure and functions of MHC molecules. Endogenous and exogenous pathways of antigen processing and presentation. Cytokines: Properties and functions of cytokines, Therapeutics Cytokines. Complement System: Components and pathways of complement activation. Hypersensitivity: Gell and Coombs' classification and brief description of various types of hypersensitivities. Vaccines: Various types of vaccines.

Practical **Credits: 01**

1. *Demonstration of lymphoid organs.
2. Histological study of spleen, thymus and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of blood cells.
4. Ouchterlony's double immuno-diffusion method.
5. ABO blood group determination.
6. *Cell counting and viability test from splenocytes of farm bred animals/cell lines.
7. Demonstration of:

a) ELISA

b) Immuno electrophoresis

* The experiments can be performed depending upon usage of animals in UG courses.

Suggested readings

- Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2006). *Immunology*, VI Edition. W.H. Freeman and Company.
- David, M., Jonathan, B., David, R. B. and Ivan R. (2006). *Immunology,* VII Edition,
- Mosby, Elsevier Publication.

Endocrinology

Course Code: ZOO ADL 403-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of this course is to provide students with a comprehensive understanding of endocrinology, including the history of the field, the classification of hormones, the characteristic features of hormones, and the transport of hormones.

Course outcome

By the end of the course, students will have acquired a comprehensive understanding of endocrinology, including the history, classification, characteristic features, and transport of hormones.

Course contents

Theory **Credit: 03**

Introduction to Endocrinology
History of endocrinology, Classification, Characteristic and Transport of Hormones, Neurosecretions and Neurohormones.

Epiphysis, Hypothalamo-hypophysial Axis
Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction. Structure of hypothalamus, Hypothalamic nuclei and their functions, Regulation of neuroendocrine glands, Feedback mechanisms Structure of pituitary gland, Hormones and their functions, Hypothalamo-hypophysial portal system, Disorders of pituitary gland.

Peripheral Endocrine Glands
Structure, Hormones, Functions and Regulation of Thyroid gland, Parathyroid, Adrenal, Pancreas, Ovary and Testis Hormones in homeostasis, Disorders of endocrine glands. Regulation of Hormone Action. Hormone action at Cellular level: Hormone receptors, transduction and regulation Hormone action at Molecular level: Molecular mediators, Genetic control of hormone action.

Practical **Credits: 01**

1. Dissect and display of Endocrine glands in laboratory bred rat */ edible fish. *
2. Study of the permanent slides of all the endocrine glands.
3. Compensatory ovarian / adrenal hypertrophy *in vivo* bioassay in laboratory bred rat*
4. Demonstration of Castration / ovariectomy in laboratory bred rat*
5. Estimation of plasma level of any hormone using ELISA.

6. Impact of thyroidectomy in metamorphosis in amphibian (Toad/Frog).

Suggested readings

- General Endocrinology C. Donnell Turner Pub- Saunders Toppan
- Endocrinology: An Integrated Approach; Stephen Nussey and Saffron Whitehead. Oxford: BIOS Scientific Publishers; 2001.
- Hadley, M.E. and Levine J.E. 2007.Endocrinology, 6th Edition.Pearson Prentice-Hall, Pearson Education Inc., New Jersey.
- Vertebrate Endocrinology by David O. Norris.

Nutrition and Health

Course Code: ZOO ADL 404-4*

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of learning the mentioned topics is to develop a comprehensive understanding of various aspects related to food, nutrition, and their impact on human health.

Course outcome

Students will be equipped with knowledge and skills to make informed decisions about their own nutrition and contribute to the well-being of others through appropriate nutritional care and support.

Course contents

Theory **Credits: 03**

Concept of food and nutrition, balanced diet, Nutritional status, malnutrition, nutrients composition, nutrient density and importance; Nutritional care. Human Energy System, Total Energy Requirement, Fatness and Leanness, Body mass index.

Nutritional Biochemistry: Nature, Classification, Importance, Functions, Recommended Intake and imbalance intake of Carbohydrates. Fibre - non-digestible component of carbohydrate. Lipids - Physical and Chemical Nature, Fatty Acids - essential non-essential, MUFA, PUFA and Triglycerides, Food Lipids and Health, Lipid-Related Compounds. Proteins - Physical and Chemical Nature, amino acids, Functions of Protein, Protein and Nitrogen Balance, Protein Quality, Requirements and Intake. Digestion, absorption and metabolism of proteins, carbohydrates and lipids. Vitamins – Fat soluble, water soluble, Minerals and Trace elements.

Nutritional Disorders: Definition, meaning and causes, Diabetes, Protein energy malnutrition, hypertension, hypervitaminosis and hypovitaminosis, Deficiency diseases of minerals and trace elements. Obesity - Meaning, Development of Obesity, Obesity as a Disease and its treatment. Clinical nutrition and diet therapy: Role of Nutrition in Clinical Care, Nutritional requirements of new born, young, adolescents, adults and pregnant mothers. Nutritional needs of patients undergoing treatment, injuries, surgeries; drug-nutrient interactions, nutritional assessment and requirements in diabetes, coronary heart and pulmonary diseases, renal diseases, AIDS, cancer, Alcoholism and its effects.

Practical **Credits: 1**

1. To detect adulteration in a) Ghee b) Sugars c) Tea leaves and d) Turmeric
2. Undertake diet analysis and nutrition counselling for different age groups.

3. Identify nutrient rich sources of foods (fruits and vegetables), their seasonal availability and price.
4. Study of nutrition labelling on selected foods
5. Visit to food testing lab /or any agency of food standards
6. Project work

References:

- Fundamentals of Foods, Nutrition and Diet Therapy, Sumati R. Mudambi and M.V. Rajagopal. 5th Edition. New Age International (P) Ltd., Publishers, New Delhi-110002.
- Williams' Essentials of Nutrition and Diet Therapy. Eleanor D. Schlenker and Joyce Gilbert. 11th Edition. Gilbert Mosby, an imprint of Elsevier Inc. an affiliate of Elsevier Inc. ISBN: 978-0-323-18580-6.
- Lippincott's Biochemistry Seventh Edition Denise R. Ferrier,
- Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA.

Research Methodology

Course Code: ZOO REM 404-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

It aims to familiarize individuals with different types of research, approaches, and research design principles. Additionally, it aims to equip individuals with the necessary skills to critically analyze scientific literature, effectively communicate research results, and adhere to ethical standards in scientific publishing.

Course outcome

- Individuals will develop the ability to critically evaluate scientific literature, communicate research results through various scientific writing formats, and adhere to ethical guidelines and standards in scientific publishing.
- This knowledge and skillset will contribute to the advancement of scientific knowledge, promote intellectual honesty, and foster a culture of integrity in scientific research.

Course contents

Theory **Credits: 03**

Meaning of research, types of research, approaches; Concept of Research Design: meaning, features of a good research design, types of research design; defining aim & objectives. Selection and formulation of Research Problem– Researching a scientific problem; Research Questions and Research hypotheses generation; Validation and interpretation of data.

Reading and critical analysis of scientific literature, Communicating research results in peer-reviewed journals. Writing scientific articles: Various forms of scientific writings, Citations and references; Good presentation. Journal matrix

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconducts: Redundant publications: duplicate and overlapping publications, salami slicing. Selective reporting and misrepresentation of data, Publication Ethics: definition, introduction and importance. Best practices /standards setting initiatives and guidelines: COPE, WAME etc Conflicts of Interest. Predatory publishers and journals. Open access publication. Plagiarism in research. Indexing databases. Citation databases: Web of Science, Scopus etc.

Practical **Credits:01**

1. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
2. Software tool to identify predatory publications developed by SPPU
3. Journal finder /journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc
4. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools

Suggested readings

- Emden, Helmut F.van (2008). Statistics for Terrified Biologists. Blackwell Publishing. 343 pp.
- Elston, R. Johnson, W. (2008). Basic Biostatistics for Geneticists and Epidemiologists: A Practical Approach. John Wiley & Sons, Ltd. 373 pp.
- Fowler, J., Cohen, L. (1989). Statistics for Ornithologists. BTO Guide No. 22. Pp 175.
- Kothari, C.R. (2004). Research Methodology, Methods and Techniques. Second Revised Edition. New Age International Publication. New Delhi. 401 pp.
- Voet, D., Voet, J.G., Pratt, C.W. (2013). Fundamentals of Biochemistry (4th edition). John Wiley & Sons Inc.
- Wilson, K. and Walker, J. (2010). Principles and Techniques OF Biochemistry and Molecular Biology (Seventh edition), Cambridge University Press.
- Zar, J.H. (1984). Biostatistical Analysis (Second Edition). New Jersey: Prentice-Hall International Editions. 718 pp.

Ecology & Environment

Course Code: ZOOMIN 401-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying Introduction to Ecology is to provide individuals with a strong foundation in ecological principles and processes. This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management to contribute to the understanding and preservation of our natural world.

Course outcome

- The outcome of studying Introduction to Ecology is to develop a foundational understanding of ecological principles and processes.
- This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management.

Course contents

Theory **Credits: 03**

Introduction to Ecology: History of ecology, Autecology and synecology, Levels of organization, Laws of limiting factors, Study of physical factors. Population: Unitary and Modular populations Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion. Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density-dependent and independent factors. Population interactions, Gause's Principle with laboratory and field examples, Lotka-Volterra equation for competition and Predation, functional and numerical responses

Community characteristics: species richness, dominance, diversity, abundance, vertical stratification, Ecotone and edge effect; Ecological succession with one example Theories pertaining to climax community

Ecosystem: Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids and Ecological efficiencies Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Human modified ecosystem. Ecology in Wildlife Conservation and Management

Practical **Credits: 01**

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO_2
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

SUGGESTED READINGS

- Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.
- Odum, E.P., (2008). Fundamentals of Ecology. Indian Edition. Brooks/Cole
- Robert Leo Smith Ecology and field biology Harper and Row publisher
- Ricklefs, R.E., (2000). Ecology. V Edition. Chiron Pres

Semester VIII

Applied Zoology

Course Code: ZOO ADL 405-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The course is unique in highlighting the commercial and industrial significance/value of animals. It discusses the techniques/ methods of rearing of animals for commercial usage and the prerequisites for their successful maintenance and sustenance.

Learning outcomes

- Understand the culture techniques of prawn, pearl and fish.
- Understand silkworms rearing and their products.
- Understand the Bee keeping equipment's and apiary management.
- Understand dairy animals' management, the breeds and diseases of goats and learn the testing of egg and milk quality.
- Learn various concepts of lac cultivation.
- Be aware of a broad array of career options and activities in human medicine, biomedical research and allied health professions.

Course Contents

Theory **Credit 03**

Aquaculture

Prawn culture: Culture of fresh water prawn; culture of marine prawn; preparation of farm. preservation and processing of prawn. Export of prawn. Pearl Culture, protocol followed; Fish Culture, Breeding Pond, Fish Seed, Hatching pond. Transport of fish fry to rearing ponds. Harvesting, preservation of fish. Composite fish farming. By products of fishing industry and common fish diseases.

Apiculture, Lac culture and Sericulture

Species of honey bees in India. Life history of *Apis.* Methods of Bee keeping. Bee products and their uses. Natural enemies and their control. Morphology and Biology of honey bees; social behavior of honey bees. Bee keeping and ancillary industries. Newton's Bee hive Extraction of honey. Medicinal value of honey; bee products. Importance of bee colonies in crop pollination. Lac culture: Lac insect and its life cycle. Cultivation of lac insect, host plants, processing and uses of lac. Sericulture: Types of silk; Silkworms and their host plants; Mulberry silkworm culture; Life history of silkworm; Natural enemies and their control.

Dairy management and poultry farming

Introduction to common dairy animals. Techniques of dairy management. Milk and milk products. Cattle Diseases. Poultry: Types of breeds. Rearing method. Diseases and control measures. Breeds of fowl, Housing and Equipment, Deep litter System, Laying cages, Methods of brooding and Rearing, Debeaking. Management of growers, Layers, Broilers; Feed formulations for chicks, Diseases of fowl. Nutritive value of egg and meet. Incubation and hatching of eggs.

Practical **Credit 01**

1. Morphological characterization and Identification of two major carps – *Labeo rohita* and *Catla catla* and their life cycles.
2. Castes (through charts/specimens) study of bees
3. Worker honey bee with emphasis on leg modifications (through specimens/charts) and whole mount preparation of the 3 pairs of legs.
4. Mounting of the sting apparatus.
5. Life cycle of silkworm (model/chart/specimens).
6. External morphology and nomenclature of dairy animals.
7. Test for good quality eggs (Floating test, cracking test) and for fertilized and unfertilized eggs (Light test, Cracking test).
8. Project report on visit to dairy farm/ Poultry farm/fishery farm.

Recommended readings

1. Shukla, G.S. and Upadhyaya, V.B. (1999-2000). Economic Zoology (Rastogi Publishers).
2. Mani, M.S. (2006). Insects, NBT, India.
3. Jabde, P.V. (2005) Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lac culture.

Reproductive Biology

Course Code: ZOO ADK 406-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying reproductive biology is to equip individuals with a comprehensive understanding of the intricate processes involved in reproduction.

Course outcome

The study of reproductive biology aims to provide individuals with a comprehensive understanding of reproductive processes, allowing them to apply this knowledge in various contexts, including human and animal reproduction, reproductive health, research, and conservation.

Course contents

Theory **Credit 03**

Ovarian and testicular physiology: Folliculogenesis and their control mechanisms, steroidogenesis and its hormonal regulation, menstrual cycle and its regulation, Female reproductive disorder, estrus cycle and its regulation, sertoli cell: structure and function; function of leydig cell. Spermatogenesis and oogenesis, Structure of Mammalian gametes mammals, Mechanism of implantation, organogenesis, Capacitation, Signal transduction pathway in acrosome reaction, placental hormones and their functions in mammals, Prevention of Polyspermy, contraception: hormonal and immune-contraception.

Cell specification: The developmental dynamics of the cell specification, Cell commitment and differentiation, Development of gonads, totipotency and pluripotency, stem cells: Embryonic stem cells and adult stem cells. Morphogenesis and cell adhesion molecules: Concept of morphogen gradients, role of paracrine factors in development, Hormonal control of amphibian metamorphosis, Embryonic induction, formation of organ rudiments and nucleo-cytoplasmic interaction in development.

Introduction to assisted reproduction technologies: IVF, ICSI, GIFT and ZIFT, Teratogenesis and its principle, Teratogens and its effect in development, Contribution of teratology to developmental biology, Role of maternal contribution in early embryonic development in droshopila: maternal effect genes and zygotic genes, vulva formation in Caenorhapdits elegans, homeotic genes, and hox genes in development

Practical **Credit 01**

1. Study of different types of eggs.
2. In vitro culture of chick embryo.
3. Study of developmental stages of frog/chick embryos from permanent slide.
4. Dissection of male/female reproductive system of cockroach/Grasshopper

References

- Gilbert F. Scott, Developmental Biology, (9th Edition), 2010 (Sinauer Associates), Sunderland, Massachutts, USA.
- Arora. P, Mohan and Arora, Himanshu, Embryology, 5th edition, 2017. Himalaya Publishing House.
- Bruce A. White, Susan P. Porterfield, Endocrine and Reproductive Physiology, (4th edition), 2013, ISBN: 978-0-323-08704-9, Elsevier (MOSBY.
- Arhtur. C. Guyton and John E. Hall, Textbook of Medical Physiology, (12th edition), 2006, Elsevier (Saunders) ISBN: 978-1-4160-4574-8.

Evolutionary Biology and Biosystematics

Course Code: ZOO ADL 407-4

No. of Credits –4: {3(T) + 1(P)}

Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying concepts and theories of evolution, the origin of life, mechanisms of evolution, and the diversification of organisms is to understand the processes that have shaped the biodiversity and complexity of life on Earth.

Course outcome

- By studying these topics, students can gain a deeper understanding of the history, diversity, and interconnectedness of living organisms.
- The outcome of such studies is to provide insights into the mechanisms of evolution, the origins of life, and the relationships between different species.

Course contents

Theory **Credit: 03**

Concept and theories of evolution; pre-biotic molecules and origin of life; factors and forces of evolution - mutation, genetic variation, genetic drift and migration; Mendelian population – allele frequencies and genotype frequencies, the founder principle; bottleneck effect of genetic drift. Isolating and selection mechanisms: Classification of isolation – geographic isolation and reproductive isolation; pre-mating & Post-mating isolation. Selection – stabilizing, dispersive, frequency dependent and balancing selection

Origin and diversification of eukaryotes - origin of cells and first organisms; early fossilized cells; evolution of eukaryotic cell from prokaryotes - a symbiosis; evolution of eukaryotic genomes; gene duplication and divergence; polymorphism; balanced polymorphism; Adaptive radiation; Speciation – mode of speciation; concept of speciation; factors responsible for speciation; tempo of evolution; human evolution – history of human evolutionary, Evolution of anthropoid primates; placing humans on tree of life; genomics and humanness.

Systematics - definition and role in biology; biological classification - theories and objectives, types of taxonomy; taxonomic diversity- definition and types; taxonomic characters; origination and extinction; rates of change in origination and extinction; causes of extinction; causes of differential rates of diversification. The universal common ancestor and tree of life, three domain concepts of living kingdom; molecular phylogeny – history, terms, definition and limitations, Molecular taxonomy and barcoding; construction of phylogenetic trees by using rRNA, ITS and COI gene sequences; molecular divergence and molecular clocks; Concept of neutral theory; origin of genomes by horizontal gene

transfer; role of plasmid, transposons, integrons and genomic islands in DNA transfer; life and RNA world.

Practical

1. Construction of molecular of phylogenetic tree using ITS/COI/rRNA
2. Study of population genetics problems

Suggested readings

- Futuyma DJ. (2009) Evolution. Publisher Sinauer Associates is an imprint of Oxford University Press; 4th edition.
- Dobzhansky Th., FJ. Ayala, GL. Stebbins and JM. Balentine (1976) Evolution. Surjeet Publication, Delhi
- Smith JM. (1998) Evolutionary Genetics. Oxford University Press. Oxford.
- Rastogi VB. (2016) Organic Evolution. Publisher – MedTech, India
- Stearns SC. and RF. Hoekstra (2000) Evolution: An Introduction. Oxford University Press, Oxford.
- Strickberger MW. (1990) Evolution. Jones and Bartlett Publishers. Boston

Ecology and Environmental Biology

Course Code: ZOOADL 408-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying Introduction to Ecology is to provide individuals with a strong foundation in ecological principles and processes.

Course outcome

The outcome of studying Introduction to Ecology is to develop a foundational understanding of ecological principles and processes. This knowledge can be applied to various aspects of ecological research, conservation efforts, and environmental management.

Course contents

Theory **Credit: 03**

Introduction to ecology, Organizational level of ecological systems. Abiotic and biotic environment; Biome concept: Major biomes in the world; aquatic and terrestrial ecosystem; Concept of limiting factors: Liebig law of the minimum; Shelford law of tolerance; Climatic Changes & ecosystem: ozone layer depletion, global warming and greenhouse effect; carbon storage and sequestration, Intergovernmental Panel on Climate Change (IPCC) and its role. Population ecology: population structure, population age distribution, age pyramid, natality, mortality, survivorship curve, population dynamics, Logistic model of population growth density dependent & independent factors, Life history strategies: k or r selection, carrying capacity; Community ecology: Community concept, Individualistic and organismic nature of communities, concept of climax; Energy flow and trophic dynamics: Energy flow in ecosystems, Food chains, food webs and trophic levels, Ecological pyramids, concept of productivity; Species interaction: intra-and inter-specific interactions; concept of ecological niche.

Biodiversity and its Conservation: concepts, significance, magnitude and distribution; Biodiversity indices, Biodiversity values: Evolutionary, Economic, Social, Cultural and Intrinsic values; biodiversity hotspots; Ecological succession; Threats to biodiversity: IUCN threat categories, Red data book; in-situ and ex-situ conservation strategies; Protected Area Network: reserve forest, wildlife sanctuary, national park; Man and Biosphere Reserve Programme. Concepts of sustainable development: sustainable way of biodiversity conservation, ethnozoology.

Environmental Pollution and its management: Concept of pollution, primary and secondary pollutants; Sources, effects and control measure of Air pollution: acid rain; Water pollution: concept of DO, BOD and COD; Eutrophication; Waste water treatment and recycling; Land and soil pollution: Fertilizers

and soil pollution; Pesticide pollution of soil, Solid Waste management; Radioactive and thermal pollution sources and their effects. Environmental Legislation: Central and state Pollution boards: powers and functions. Wildlife Protection Act 1972, The Water (Prevention and Control of Pollution) Act 1974. Prevention and Control of Air Pollution Act 1981, Forest Conservation Act 1981, Environment (protection) Act 1986, The Disaster Management Act, 2005; Bio-Medical Waste (Management and Handling) Rules, 1998.

Practical **Credit: 01**

- Physico-chemical properties of soil and water (Dissolved Oxygen, Free Carbon dioxide, alkalinity, Hardness, sulphate).
- Assessing influence of light, temperature and moisture on plant germination and growth/animal behaviour and growth.
- Assessment of density, frequency and abundance of plants/animal in a community using various techniques i.e. transect, quadrate etc.
- Understanding ecosystem succession by studying various stages of vegetation / community assemblages development.

RECOMMENDED BOOKS

1. Elements of Ecology, Thomas M. Smith, Robert Leo Smith, 9th Edition. Pearson Education Publishers
2. Fundamentals of ecology, Eugene Odum, Garry W. Barret. Brooks/Cole;
3. Field Sampling: Principles and Practices in Environmental Analysis, Conklin, A.R. Jr., (2004), CRC Press.
4. Principles and Standards for Measuring Primary Production, Fahey, T.J. and Knapp, A.K., (2007), Oxford University Press, UK
5. Ecological Modeling, Grant, W.E. and Swannack, T.M., (2008), Blackwell.
6. Fundamental Processes in Ecology: An Earth system Approach, Wilkinson, D.M., (2007), Oxford University Press, UK.

Applied Entomology and Fishery
Course Code: ZOOADL 409-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying Entomology is to gain knowledge and understanding of the characteristics, classification, morphological features, and social behaviors of insects- and fishes.

Course outcome

- It provides insights into the economic and cultural importance of insects and fishes.
- This knowledge can be applied in the applied fields of both insects and fishes.

Course contents

Theory **Credit: 03**

Introduction to Entomology: Characteristics of class insecta, Classification of insects up to orders with Salient features and common examples. Morphological features and types of: Eyes, antennae, Mouth parts, Appendages. Social life in insects, Aquatic insects, Economic importance of insects, Food grain pests, Integrated Pest management. Beneficial Insects: Parasitic and predatory insects and their role in weed management and pollination, insects as decomposers and their role in nutrient recycling. Life cycle, commercial culture, and commercial products of Honey Bee, Lac insect and Silkworm. Medical Entomology: Insects as vectors of important diseases in Humans and animals. Insects Adaptation as vectors; Orders with insects as vectors (Diptera, Siphonaptera); External morphology, Life cycle, medical importance and control of Anopheles, Aedes and Culex.

Introduction to Fishery: General anatomy: Internal and External features; Basic osteology, Types of scales and fins, locomotion. Food and feeding habits of cultivable fishes; Feeding habits and habitat adaptations, Length-Weight Relationship and Condition Factor. Taxonomy and Classification of fishes. Fisheries Resources of India: Status, diversity and distribution of freshwater fishes of India and Northeast India. Exotic food fishes of India-history, importance and impact to local environment, Ornamental fishes. Riverine fisheries- important river systems, dams and their impact, fish ladders. Cold water fisheries - ecology of hill streams, biology of important cold-water fishes of India, recreational fishing. Estuarine fisheries- major estuarine systems of India.

Fishing Technology, Management and Conservation: Fishing crafts and gears, Technologies for localizing catches- remote sensing, sonar, radar. Stock assessment and management - Natural and Applied markers- marking and tagging. Post-harvest technology; Fish spoilage, rigor mortis, rancidity, enzymatic spoilage, microbial spoilage; Fish preservation and processing- principles and methods, fishery by-products. Methods of Genetic selection and hybridization of cultured species, Concept of cryopreservation and transgenic species, live gene bank and its importance in conservation. Fishing laws and regulations. Extension services.

Practical **Credit: 01**

1. Identification and collection of pests.

2. Life cycle of economically important insects
3. Identification of fishes
4. Fishing crafts and gears

Suggested readings

- A general text book of entomology, Imms , A. D., Chapman & Hall, UK.
- Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F.,M Saunders College Publication, USA.
- The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK.
- Service, M.W. (1980) A Guide to Medical Entomology. Macmillan Press.
- Fish and Fisheries of India. V.G. Jhingran. Hindustan Publishing Corporation, India.
- The Physiology of Fishes. 2013. Evans, D. H. and Claiborne, J. D., Taylor and Francis
- Handbook of Fisheries and Aquaculture. 2013. Indian Council of Agricultural Research, ICAR, DIPA, New Delhi, India. Group, CRC Press, UK.
- Biology of Fishes. 2008. Bone, Q. and Moore, R., Talyor and Francis Group, CRC Press, U.K.

Developmental Biology

Course Code: ZOOMIN 401-4
No. of Credits –4: {3(T) + 1(P)}
Total hours: 45 (Theory) (3 hour/ Week)

Objective

The objective of studying developmental biology is to equip individuals with a comprehensive understanding of the intricate processes involved in reproduction.

Course outcome

- Students will be able to acquire knowledge on embryonic development of sexually reproducing animals.
- They also obtain knowledge on metamorphic changes and the role of placenta in mammals.

Course contents

Theory **Credits: 03**

Introduction: Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division.

Early Embryonic Development: Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal): Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers. Late Embryonic Development: Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

Post Embryonic Development: Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories. Implications of Developmental Biology: Teratogenesis: Teratogenic agents and their effects on embryonic development; *In vitro* fertilization, Stem cell (ESC), Amniocentesis.

Practical **Credits: 01**

6. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
7. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)

8. Study of the developmental stages and life cycle of *Drosophila* from stock culture
9. Study of different sections of placenta (photomicropgraph/ slides)
10. Project report on *Drosophila* culture/chick embryo development

Suggested readings

6. Gilbert, S. F. (2010). Developmental Biology, IX Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA
7. Balinsky B. I. and Fabian B. C. (1981). An Introduction to Embryology, V Edition, International Thompson Computer Press
8. Carlson, R. F. Patten's Foundations of Embryology
9. Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers
10. Lewis Wolpert (2002).Principles of Development. II Edition, Oxford University Press.