KAZI NAZRUL UNIVERSITY

[Kalla Bypass More, North, P.O, C H Kalla, Asansol, West Bengal 713340]

SYLLABUS

B.Sc. HONOURS IN ZOOLOGY

(With effect from the academic session: 2020-21)

SCHEME AND SYLLABUS

(As per Learning Outcomes based Curriculum Framework)

SEMES-TER	Core Course CC (14)	Ability Enhancement Compulsory Courses AEC (2)	Generic Elective Courses GE (4)	Skill Enhancement Courses SEC (2)	Discipline Specific Elective DSE (4)
I	CC 1: Systematics & Diversity of Life – Protists to Chordates CC 2: Ecology	Environ-mental Science	GE 1- Th+Pr To be selected from Other than Zoology (like-Botany, Physiology, Chemistry, etc)		
II	CC 3: Comparative Anatomy & Physiology of Non-chordates CC 4: Cell Biology and Histology	English Communi-cation	GE 2- Th+Pr -DO-		
III	CC 5: Comparative Anatomy & Physiology of Chordates CC 6: Genetics CC 7: Biochemistry		GE 3 - Th+Pr -DO-	SEC-I (Th only) Beekeeping / Public Health and Hygiene	
IV	CC 8: Behaviour and Chronobiology CC 9: Developmental Biology & Evolution CC10: Molecular Biology		GE 4- Th+Pr -DO-	SEC-II (Th only) Sericulture/ Insect Pest, Vector Biology and Management	
V	CC 11: Biotechniques CC 12: Microbiology, Parasitology & Immunology				DSE 1:- Th+Pr Genetic Engineering and Biotechnology DSE 2: Th+Pr Livestock Management and Animal Husbandry
VI	CC 13: Biostatistics & Bioinformatics CC 14: Applied Zoology				DSE 3: Th+Pr Wild Life Conservation and Management DSE 4: Th+Pr Human Reproductive Biology

ASSIGNMENTS OF DIFFERENT SEMESTERS							
Semester	COURSE DETAILS	PPT PRESTN.	PROJECT REPORT	FIELD REPORT	EXCURSION	LAB/FARM VISIT	ALBUM/VIDEO DOCUMENTARY
I	CC-1	√		√	√		√ (Album)
	CC-2	√		√	√		
II	CC-3	√					√ (Video)
	CC-4	√					
III	CC-5	√	√				
	CC-6	√	√				
	CC-7	√					
	SEC-1						
IV	CC-8	√		√		√	√ (Ethogram)
	CC-9	√					√ (Video)
	CC-10	√					
	SEC-2						
V	CC-11	√		√		√	
	CC-12	√					
	DSEC-1	√					
	DSEC-2	√					
VI	CC-13	√					
	CC-14	√					
	DSEC-3	√		√	√		
	DSEC-4	√					

Guidelines for Individual/ Team Projects and Field Reports

The aim of the individual/ team project/s is to develop an aptitude for research in Zoology and to inculcate proficiency to identify appropriate research topic and presentation. The topics of biological interest and significance can be selected for the project. Project is to be done by a group not exceeding 5 students. The project report should be submitted on typed A4 paper, 12 Font, 1.5 Space in spirally bound form and duly attested by the supervising teacher and the Head of the Department on the day of practical examination before a board of two Examiners for End Semester. The viva-voce based on the project is conducted individually. Project topic once chosen shall not be repeated by any later batches of students. The project report may have the following sections: 1. Preliminary (Title page, declaration, certificate of the supervising teacher, content etc.) 2. Introduction with relevant literature review and objective 3. Materials and Methods 4. Result 5. Discussion 6. Conclusion / Summary 7. References.

Field Study/ Study tour

Students have to visit one research institute and one wild life sanctuary / museum / zoo. Scientifically prepared hand-written study tour report along with photographs of candidate at the places of visit must be submitted by each student for End Semester on the day of the examination of project.

Video presentation

Students have to develop a short film (2-5 min duration) based on relevant animal/topic given solely by themselves along with voice command/floating comments. It will help them to be competent in video documentation of a matter also a career prospect too.

CONTENTS

SEMESTER - I

Course Name	SYSTEMATICS AND DIVERSITY OF LIFE : PROTISTS TO CHORDATES		
Course Code	BSCHZOOC101		
Course Type	Core		L-T-P: 4-0-4
Course Details	CC-1	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course is a walk for the Bachelor's entrant through the amazing diversity of living forms from simple to complex one. It enlightens how each group of organisms arose and how did they establish themselves in the environment with their special characteristics. It also deals with the differences and similarities between organisms on the basis of their morphology and anatomy which led to their grouping into taxa and clades.

Learning outcomes :

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

- Develop understanding on the diversity of life with regard to protists, non-chordates and chordates.
- Group animals on the basis of their morphological characteristics / structures.
- Develop critical understanding how animals changed from a primitive cell to a collection of simple cells to form a complex body plan.
- Examine the diversity and evolutionary history of a taxon through the construction of a basic phylogenetic/ cladistics tree.
- Understand how morphological change due to change in environment helps drive evolution over a long period of time.
- The project assignment will also give them a flavour of research to find the process involved in studying biodiversity and taxonomy besides improving their writing skills.
- It will further enable the students to think and interpret individually due to different animal species chosen

THEORY (CC-1)

Unit I: Principles and practice of taxonomy (15 Lectures)

1. Multicellularity : from simple collections of poorly differentiated cells to complex body plans.
2. Species concept : Biological, evolutionary
3. Definitions : Systematics, taxonomy, Hierarchy, taxonomic levels / types (alpha, beta, gamma, omega, cytotaxonomy, numerical taxonomy, chemotaxonomy).
4. Principles of codes of zoological Nomenclature : Binomial nomenclature and utility of scientific names. Principle of priority; Principle of typification (Holotype, Syntype, Allotype, Paratype, Lectotype, Paralectotype, Neotype); Principle of Homonymy and synonymy.
5. Classification : morphological and evolutionary (molecular) : Artificial, Natural and phylogenetic concept.
6. Basic idea of Phenetics and Cladistics.
7. Types of clades- paraphyly, monophyly, polyphyly, holophyly, haplogroups.
8. Traits of Phylogeny (Basic idea)- apomorphy, plesiomorphy, symplesiomorphy, autapomorphy, synapomorphy.
9. Basic idea of Phylogenetic trees, Molecular phylogeny, multiple sequence alignment, construction of phylogenetic tree.

Unit II: Diversity in Protists and Acoelomate Metazoa (11 Lectures)

1. Structure and diversity in Protists (classification up to Phylum).
2. Origin of Metazoans: diploblastic and triploblastic organization; symmetries; body cavities; protostomes and deuterostomes.
3. Porifera : Classification up to classes ; Structural diversity of skeletal organization.
4. Cnidaria : Classification up to classes ; Polymorphism and division of labour ; coral reef forming cnidarians, coral reef: types, formation & significance.
5. Concept of Bilateria and acoelomate.
6. Basic organization and adaptive radiations in flatworms, classification of Platyhelminthes up to classes.

UNIT III: Diversity in Pseudocoelomate and Coelomate Non chordates (13 Lectures)

1. The Ecdysozoa: characteristics of the representative taxa.
2. Pseudocoelomates; Basic organization and Classification of Nematoda up to classes.
3. Adaptive radiations in roundworms.
4. The coelomates: Basic organization.
5. Classification of arthropods up to classes.
6. Adaptive radiations in Crustaceans, Myriapods, Chelicerates, Insects, Ancestors/fossil arthropods. etc.
7. Basic organization and diversity (classification up to classes) in Annelids.
8. Basic organization and diversity (classification up to classes) in Molluscs.
9. Disruption of bilateral symmetry and its significance.
10. Basic organization and classification (up to classes) of Echinoderms; their affinity to Chordates.

Note: ***Classification to be followed from Ruppert and Barnes Invertebrate Zoology VI edition, except for Protozoa (American Association of Protozoologist ref: Levine 1980) and Porifera (Brusca and Brusca 2002; IV edition. Invertebrate Zoology).***

UNIT IV: Diversity in Protochordates and Chordates (13 Lectures)

1. Chordates – Primitive Chordates and their affinities.
2. Characters and affinities of Hemichordates, Urochordates and Cephalochordates.
3. Advent of vertebrates: Cyclostomes, their evolutionary status and affinities.
4. Basic organization and diversity (classification up to sub-class) of fishes, their evolutionary transitions from Water to Land invasion- Early Tetrapodes.
5. Amphibians' diversity (classification up to living order) and adaptability to dual mode of life.
6. Adaptive radiations in reptiles, classification of reptiles up to living order ; the avian ancestors.
7. Birds : classification up to sub-class, Adaptation from terrestrial to aerial mode of life.
8. Origin of Mammals- Special features of Monotremes and Marsupials.
9. Characteristics and classification of mammalian groups (up to orders) with special reference to primates.

Note: ***Classification from Young, J. Z. (1981) to be followed except for classification fishes. For Pisces classification scheme to be followed from Nelson, J. S. (2006).***

PRACTICAL (CC-1)

1. **Study** of animals through slides and museum specimens/photographs in the laboratory with their classification, biogeography and diagnostic features **(record book)**. Animals to be included for the study are as follows:

a. **Non-chordates :**	b. **Chordates :**
i. **Protista:** *Euglena*, *Amoeba, Paramecium.* *ii.* **Porifera:** *Euspongia, Scypha.* *iii.* **Cnidaria:** *Obelia, Physalia, Porpita, Aurelia, Tubipora,* Sea Anemone*, Pennatula, Fungia.* *iv.* **Platyhelminthes:** *Fasciola hepatica*, *Taenia solium.* *v.* **Nematoda:** *Ascaris.* *vi.* **Annelida:** *Aphrodite, Sabella, Chaetopterus, Pheretima.* *vii.* **Arthropoda:** *Carcinoscorpius*, *Macrobrachium, Balanus*, *Julus*, *Periplaneta*, *Peripatus.* *viii.* **Mollusca:** *Chiton*, *Pila, Pinctada, Sepia.* *ix.* **Echinodermata:** *Astropecten, Cucumaria* and *Antedo*	*i.* **Protochordata:** *Balanoglossus, Branchiostoma, Ascidia.* *ii.* **Fishes:** *Scoliodon, Torpedo, Mystus vitattatus, Catla, Exocoetus, Hippocampus,* *iii.* **Amphibia:** *Ichthyophis*, *Necturus, Bufo, Rachophorous* *iv.* **Reptiles:** *Chelone, Calotes, Chamaeleon, Draco, Bungarus, Vipera, Naja.* *v.* **Birds:** *Psittacula, Pycnonotus.* *vi.* **Mammals:** *Sorex*, *Pteropus*, *Funambulus.*

2. **Excursion:** Study of animals in nature during a survey of a National Park or Forest area or any local biodiversity rich area.
3. **Collection** of **five species** or presentation through photographic plates (preferably invertebrates, insects) belonging to a clade. A project report to be submitted based on their generic identification, description and illustration with a note on their locality. Also, the assessment of their relationship by constructing a cladogram using characters and character states.
4. **Comparison** of two species of birds belonging to same genus (Interspecific difference).
5. **Comparison and weighting** of characters of two birds belonging to same family but dissimilar genera.
6. **Group discussion** or **Seminar presentation** on following topics.

Pool of Topics for Group discussion or Seminar presentation :		
1. Tree of Life. 2. Polymorphism. 3. Freshwater sponges. 4. Parasitic adaptations.	5. Molecular systematics vs Traditional taxonomy. 6. Phenoplasticity and its relevance. 7. Reliability of taxonomic characters.	8. Coral reefs and their role in ecosystem generation. 9. Molluscs of industrial value. 10. Molecular system of classification.

Format for conducting CA and ESE practical examination :

CA (30 marks)	**ESE (20 marks)**
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Identification - 4 items (2 non-chordate, 2 chordate)- [Sc. Name, systematic position (3 taxa), generic characters, habit & habitat,] 0.5+0.5+1+0.5=2.5 **(2.5x4=10)** 2. Cladogram construction based on provided data (Item no 3) **-3** 3. Field Report (Item no 2) **-3** 3. LNB (Laboratory Note Book) **-2** 4. Viva **-2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *Study of specimen should include-Scientific name, common name, Taxa as per theory syllabus, Habit (Nutritional, ecological, Reproductive, special habit if any) and Habitat (Distribution, endemic / cosmopolitan/sporadic, climatic type), Conservation status (if available), Generic character only, economic importance (if any).*
- *LNB should be prepared (item 1 & 3) in inter-leaf practical note book with date & Teacher's sign.*
- *Album should be prepared on item 4 & 5.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings

1. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, VII Edition. Thompson Brooks Cole (International Edition)
2. Barnes, R.S.K., Callow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
3. Barrington, E.J.W. (1979). Invertebrate Structure and Functions. II Edition.
4. Young, J. Z. (1981). The Life of Vertebrates. III Edition. Oxford university press.
5. Pough H. Vertebrate life, VIII Edition, Pearson International.
6. Darlington P.J. The Geographical Distribution of Animals, R.E. Krieger Pub Co.
7. Hall B.K. and Hallgrimsson B. (2008), Strickberger's Evolution. 4th Edition. Jones and Bartlett Publishers Inc.
8. Nelson, J. S. (2006). Fishes of the World, Wily.
9. Chattopadhyay, S (2014) LIFE: Evolution, adaptation, ethology, 2nd Ed, Books & Allied.
10. Lomolino, M. V. et al (2010) Biogeography, 4th Edition, Sinauer Associates.
11. Simpson, G G (2012) Principles of animal taxonomy, Scientific publishers.
12. Mayr, E and Ashlock P D (2014) Principles of systematic zoology, 2nd, McGraw-Hill Education.
13. Verma, A (2017) Principles of animal taxonomy, 1st Ed, Narosa.
14. Ghosal, S (2020) Taxonomy Principle and Problems, 1st Ed, Techno world.
15. Quicke, Donald L (1993) Principles and Techniques of Contemporary Taxonomy (Tertiary Level Biology), 1st Ed, Springer
16. Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. I & II. New Central Book Agency (p) Ltd.
17. Kapoor, V C (2019) Theory And Practice Of Animal Taxonomy And Biodiversity 8Ed, Oxford & IBH Publishing
18. Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
19. Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
20. Miller S.A. & Harley J.P. (2015) Zoology. 10Ed., McGraw-Hill Education
21. Hickman C., *et. al.* (2019) Integrated principles of zoology., 18Ed., McGraw-Hill Education.

SEMESTER - I

Course Name	ECOLOGY		
Course Code	BSCHZOOC102		
Course Type	Core		
Course Details	CC-1	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

This course will take students on a journey through the physical workings of the Earth, the interactions between species and their environments. The course highlights on some of the important aspects *viz.* growth and survival of populations and communities in different habitats, energy flow in the ecosystems, interactions between the communities, exclusion of niches and consequences of changing environment on the biodiversity.

Learning outcomes :

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

- **Know the evolutionary and functional basis of animal ecology.**
- **Understand what makes the scientific study of animal ecology a crucial and exciting endeavour.**
- **Engage in field-based research activities to understand well the theoretical aspects taught besides learning techniques for gathering data in the field.**
- **Analyse a biological problem, derive testable hypotheses and then design experiments and put the tests into practice.**
- **Solve the environmental problems involving interaction of humans and natural systems at local or global level.**

THEORY (CC-2)

UNIT I: An overview of Ecology, Ecosystems and Biomes (13 Lectures)

1. Introduction and scope of Ecology. Multidisciplinary relevance in current perspective.
2. Structure and function of ecosystem;
3. Abiotic factors affecting survival and sustenance of organisms e.g., water, temperature, light, pH and salinity.
4. Role of limiting factors in survival of biotic components.
5. Major ecosystems of the world: Ecological features, limiting factors, zonation and classification of organisms of fresh water and marine ecosystems.
6. Introduction to Biome: Ecological features of Tundra, Desert, Savannah and Tropical Rain Forest Biomes.
7. Energy flow in ecosystem, food chain and food web.
8. Productivity and ecological efficiencies.
9. Mineralization and recycling of nutrients: C, N, P & S.

UNIT II: Population ecology (13 Lectures)

1. Ecology of populations: Unitary and Modular populations.
2. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves.
3. Unique and group attributes of population: mortality, age ratio, sex ratio, dispersal.

4. Concept of carrying capacity, Factors regulating population dispersal and growth: Exponential and logistic growth.
5. Population regulation: density-dependent and independent factors; r and K strategies.

UNIT III: Biotic community, characteristics and attributes (13 Lectures)

1. Community characteristics: stratification; Dominance, diversity, species richness, abundance, Evenness, Similarity.
2. Diversity and food-web indices.
3. Ecotone and edge effect;
4. Positive interactions: commensalism, proto-cooperation, and mutualism.
5. Negative interactions: parasitism and allelopathy; predation and predator-prey dynamics; herbivory.
6. Interspecific competition and coexistence, Inter and intra-specific; abundance.
7. Niche concept, types, Niche overlap and Resource partitioning.
8. Gause's Principle with laboratory and field examples.
9. Ecological succession: Definition, Process, types, theories of succession.

UNIT IV: Environmental degradation; Biodiversity, Environmental movement etc. (13 Lectures)

1. Environmental degradation : Environmental ethics; Pollution: Air, water and noise pollution and their control; Solid Waste management and EIA ; Natural resources: Mineral, water and forest, their significance and conservation.
2. Biodiversity : Types and Hotspots of biodiversity. Threat and Major drivers of biodiversity. Conservation strategies ; Biodiversity status in India, monitoring and documentation; Biodiversity mapping using GPS, GIS and remote sensing. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value. Application of ecology in management and Conservation programmes.
3. Environmental movement : Role of gender and cultures in environmental conservation. Environmental movements: Bishnois. Chipko, Silent valley, Big dam movements. Environmental education and public awareness, Green bench.

PRACTICAL (CC2)

1. To **measure microclimatic variables** *viz*., temperature, humidity and light conditions in a microhabitat.
2. **Making an ecosystem** in a wide-mouthed bottle.
3. **Constructing a food web** by observing organisms from a given area.
4. Preparing **an essay (write up)** based on few ecology related publications.
5. **Studying the impact of herbivore** on plant species (planted in pots under specific conditions).
6. **Constructing distribution map of species** of a genus through **GPS** by estimating the coordinates (virtual demonstration).
7. Estimation of the ratio of the producers and consumers.
8. Determination of **pH**, and Dissolved $\mathbf{0_2}$ (Winkler's Method) and Free $\mathbf{CO_2}$ in water.

9. Preparation of **nested quadrate and estimation** of effective quadrate size.
10. **Study of an aquatic ecosystem**: Major Phytoplankton (Up to Family) and zooplankton (Up to Genus).
11. Group discussion or **Seminar presentation** on one or two related topics (Given Below).
12. Field study in a biodiversity rich area like national park, biosphere reserve, sea shore or nearby places.

Pool of Topics for Group discussion or Seminar presentation		
1. Biodiversity Hotspots.	2. Marine zooplanktons and their ecological importance including oxygen evolution.	3. Negative interactions in Ecosystem
4. Biodiversity mapping.	5. Biodiversity under climate changing scenario.	6. Ecological indices.
7. Niche segregation.	8. Air pollution and climate change.	9. Bioprospecting and Biopiracy.
10. Population explosion.	11. Climate change: threat to food security.	12. Water regulation in marine animals.
13. Carrying capacity.	14. Stratospheric Ozone depletion and marine productivity.	15. Good ozone vs. bad ozone.

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment : (Sl no 8); Principle-1, Method-2, Result and inference-2, Precaution-1 (6) 2. Nested Quadrat : Preparation-2 and estimation-2 (4) OR Estimation of ratio of producers and consumers based on provided data. (4) 3. Identification (one zooplankton & one phytoplankton)- Sc. Name-0.5, systematic position-0.5, Habit & habitat-0.5, characters-0.5 (2 x 2=4) 4. LNB & Excursion Report-2+2 5. Viva-2

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Colinvaux, P. A. (1993) Ecology (2nd edition) Wiley, John and Sons, Inc.
2. Krebs, C. J. (2001) Ecology (6th edition) Benjamin Cummings.
3. Odum, E.P., (2008) Fundamentals of Ecology. Indian Edition. Brooks/Cole.
4. Ricklefs, R.E. (2000) Ecology (5th edition) Chiron Press.
5. Southwood, T.R.E. and Henderson, P.A. (2000) Ecologial Methods (3rd edition) Blackwell Sci.
6. Kendeigh, F C. (1984) Ecology with Special Reference to Animal and Man. Prentice Hall Inc.
7. Stiling, P. D. (2012) Ecology Companion Site: Global Insights and Investigations. McGraw Hill Education.

SEMESTER – II

Course Name	COMPARATIVE ANATOMY AND PHYSIOLOGY OF NON-CHORDATES		
Course Code	BSCHZOOC201		
Course Type	Core		
Course Details	CC-3	CA (Continuous Assessment)	Theory : 10 marks Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course makes a detailed comparison of the anatomy of the different taxa of non-chordates. It also highlights how in the taxonomic hierarchy, there is an increase in-the complexity of structure and function. The course thus gives an overview of the intricate life processes and adaptive radiations in non-chordates.

Learning outcomes :

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

- Develop an understanding of the characters used to classify besides being able to differentiate the organisms belonging to different taxa.
- Acquire knowledge of the coordinated functioning of complex human body machine.
- Have hands on experience of materials demonstrating the diversity of protists and non-chordates.
- Understand the relative position of individual organs and associated structures through dissection of the invertebrate representatives.
- Realize that very similar physiological mechanisms are used in very diverse organisms.
- Get a flavor of research by working on project besides improving their writing skills. It will further enable the students to think and interpret individually.
- Undertake research in any aspect of animal physiology in future.

THEORY (CC-3)

Unit I: Diversity of Tegument and Digestive system (13 Lectures)

1. Cell membrane in protists.
2. Tegument in non-chordates (Helminthes, Annelida, Arthropoda, Echinodermata) and its derivatives (Cuticular appendages in Arthropoda, Byssus thread, shell in Mollusca).
3. Nutrition and feeding modes in protists.
4. Evolutionary changes in digestive system, feeding mechanism and physiology of digestion (from food vacuoles to complex digestive organs) in major phyla of non-chordates.

Unit II: Diversity of Locomotory, Respiratory, Circulatory and Excretory systems (13 Lectures)

1. Diversity of locomotory organs in protists and non-chordates [Cilia & Flagella, Pseudopodia, tentacle, epitheliomuscular cell, seta, parapodia, wing, tube feet].
2. Muscle (annelids, arthropods, mollusca) and modes of locomotion [swimming, looping, gliding, creeping, flying, etc].
3. Structure and diversity of skeletal elements in protists and major non-chordate phyla (Spicule, Spongin, Coral, Exoskeleton, Shell, ossicle/pedicellariae).

4. Diversity of respiratory organs (skin, trachea, gill, book lung, book gill, ctenidia, pulmonary sac, papullae, etc),
5. Modes of respiration and Respiratory pigments in major non-chordate phyla.
6. Circulation and the diversity of circulatory system in major non-chordate phyla
7. Excretion (protists): endocytosis, exocytosis.
8. Excretion and diversity of excretory organs in major non-chordate phyla.

UNIT III: Diversity of Nervous and Reproductive systems (13 Lectures)

1. Nervous system with special reference to diversity in brain and nerve chord in major non-chordate phyla.
2. Neuroendocrine systems, pheromones in different classes of arthropods.
3. Sense organs: mechanoreceptors: photoreceptors, chemoreceptors, thigmoreceptors, rheoreceptors and proprioceptors in major non-chordate phyla.
4. Diversity of the reproductive organs and accessory sex organs (in different classes of annelids and arthropods).
5. Modes of reproduction- asexual and sexual reproduction in major non-chordate phyla
6. Diversity of larval forms in non-chordates (Cnideria, Annelida, Arthropoda, Mollusca, Echinodermata)

UNIT IV: Evolution and characteristics of important Non-Chordate taxa (13 Lectures)

1. Affinities of living fossils: Limulus and Peripatus.
2. Evolutionary significance of Polymorphism and colony formation (Termite).
3. Evolution of Parasitism, Parasitic adaptations and life cycle patterns in parasites belonging to different taxa- A generalized study
4. Invertebrate model organisms (*Planaria, Ascaris, Pheretima, Palaemon, Pila, Asterias*) and their importance (reason as typical representative of respective phylum and affinities).
5. Types of canal systems in sponges and their significance.
6. Torsion and detorsion in Mollusca.
7. Components and functions of water vascular system in echinoderms.

PRACTICAL (CC-3)

1. Study of **slides or models or photographs** of specimens of
   a) Protozoans of agricultural importance (*Bodo, Naegleria, Hyalosphenia, Oxytricha, Vampyrella).*
   b) Coral-reef forming Cnidarians (*Gorgonia, Fungia, Tubipora, Heliopora, Alcyonium*)
   c) Plant parasitic nematodes (*Meloidogyne, Radopholus*)
   d) Nematodes used as models in experimental biological research-*Caenorhabditis elegans*
2. Dissection of ***Periplaneta*** to expose- (a) Digestive, (b) Nervous and (c) Reproductive system.
3. Dissection of ***Palaemon*** to expose- Appendages and Statocyst (mount).
4. Dissection of ***Pila*** to expose the Digestive system and mount Radula.
5. Study of **larval forms**: *Ephyra*, *Planula*, *Trochophore*, *Zoea*, Metazoea, *Veliger*, Bipinnaria, *Echinopluteus*.

6. Group discussion or **Seminar presentation** on following related topics :

Pool of Topics for Group discussion or Seminar presentation :	
1. Tree of Life.	7. Living fossils.
2. Connecting links	8. Polymorphism.
3. Parthenogenesis in animals.	9. Water regulation in marine animals
4. Helminth infection in human.	10. Parasitic adaptations.
5. Zoonotic diseases	11. Evolution of terrestrial animals.
6. Locomotory organs in non-chordates	12. Respiratory organs in non-chordates

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
5. Assessment based on practical topics (class test)-**10** 6. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 7. Attendance and Participation in class-**5** 8. Practical skills, laboratory reports, etc-**5**	1. Dissection- (Sl no 2, 3, 4); Dissection-4, Display-1, Drawing-1.5, Labelling-1.5. (**8**) 2. Mounting (Sl no 2 and 3)- Preparation-2, Drawing-1, Labelling-1. (**4**) 3. Identification (Sl no 1 and 5, 1 item from each gr)- Sc. Name-0.5, Characters-1, Habit & habitat-0.5, (2x2=**4**) 4. LNB -**2** 5. Viva-**2**

NOTE :

- Study of specimen should include-Scientific name, Habit and Habitat, Diagonostic feature, importance/values if any.
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Barrington, E J W. (1967) Invertebrate structure and function, Nelson, London.
2. Barnes, R. D. (1968) Invertebrate Zoology, 2nd Ed. Saunders, Philadelphia.
3. Hyman, L H. (1940-67). The Invertebrates, Vol. I-VI. McGraw-Hill, New York.
4. 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.
5. Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. I . New Central Book Agency (p) Ltd.
6. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
7. Marshall, A.J and Williams, W.D. (1995) Text book of Zoology-Invertebrates. VII Ed., Vol. I, A.L.T.B.S. Publishers.
8. http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf
9. Miller S.A. & Harley J.P. (2015) Zoology. 10Ed., McGraw-Hill Education
10. Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
11. Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
12. Nigam, H C (2020) Biology of Non-chordates, Vishal publication
13. Hickman C., *et. al.* (2019) Integrated principles of zoology., 18Ed., McGraw-Hill Education

SEMESTER – II

Course Name	CYTOLOGY AND HISTOLOGY		
Course Code	BSCHZOOC202		
Course Type	Core		
Course Details	CC-4	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course provides a detailed insight into basic concepts of cellular structure and function. It also gives an account of the complex regulatory mechanisms that control cell function.

Learning outcomes :

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

- Understand the functioning of nucleus and extra nuclear organelles and understand the intricate cellular mechanisms involved.
- Acquire the detailed knowledge of different pathways related to cell signaling and apoptosis thus enabling them to understand the anomalies in cancer.
- Develop an understanding how cells work in healthy and diseased states and to give a 'health forecast' by analyzing the genetic database and cell information.
- Get new avenues of joining research in areas such as genetic engineering of cells, cloning, vaccines development, human fertility programme, organ transplant, etc.
- Understand how tissues are produced from cells in a normal course and about any malfunctioning which may lead to benign or malignant tumor.

THEORY (CC-4)

UNIT I: The structure and organelles of prokaryotic and eukaryotic cells (13 Lectures)

1. Cell biology, its scope in modern perspective.
2. Cell theory and its modern version and interpretation.
3. General structure of prokaryotes, bacteria, archaea and eukaryotes.
4. Extra-nuclear cell organelles: Ultrastructure and functions of Endoplasmic reticulum, Ribosome, Golgi apparatus, Lysosome, Peroxisomes.
5. Semi-autonomous organalle: Mitochondria: Origin, structure, composition, and function.
6. Cytoskeleton : Composition, assembly and functions; Microtubules, Intermediate Filament and microfilaments; MT *vs* Actin filament ; Cytoskeletal organization-centrosome cycle.
7. Nucleus: size, shape, structure and functions of interphase nucleus ; Ultrastructure of nuclear membrane and pore complex ; Nucleolus: general organization.

UNIT II: Cell membrane and transport mechanism (12 Lectures)

1. Cell membrane organization: origin, structure, composition, models and function.
2. Fluid mosaic model : Architecture and significance; Lipid Composition, inner and outer leaflets ; Structure and functions of membrane proteins : Integral, peripheral and lipid-anchored membrane proteins.
3. Cell junction : Junctional complexes, microvilli, desmosomes and plasmodesmata.
4. Transport across membrane : Diffusion and osmosis, Active and passive transport, Endocytosis and exocytosis

UNIT III: Cell cycle, cell signalling and cell culturing (12 Lectures)

1. Cell cycle : cell division- mitosis and meiosis ; Cell division check points and their regulation ; Mutations in the genes (p53, pRB) that regulate cell cycle and division and their role in causing cancer ; Programmed cell death (Apoptosis).
2. Cell signalling through GPCR.
3. Cell culture : Types of cell culture- monolayer and suspension culture ; Basic Types and characteristics of tissue culture media ; Subcellular fractionation by differential centrifugation.

UNIT IV: Structural and functional significance of animal tissues (15 Lectures)

1. Introduction to tissues.
2. Epithelial tissue : Types, structure and characteristics, Surface modifications (cilia, villi, micro-villi) ; Basement membrane: structure and characteristics ; Exocrine and endocrine glands: types and structure.
3. Connective tissue : Structure and function of loose, dense and adipose tissue ; Cartilage and bone: classification, and ultra-structure ; Blood: plasma, blood cells, lymph– their structural and functional details ; Structure and function of spleen.
4. Muscular tissue : ultrastructure of smooth, skeletal and cardiac muscles ; Muscle-tendon attachment.
5. Nervous tissue : Structure and classification of neurons ; Types of supporting (glial) cells and their function ; Types of sensory nerve endings ; Membranes of the brain and spinal cord.

PRACTICAL (CC-4)

1. Study of prokaryotic and eukaryotic cell types with the help of chart, slide and video.
2. Study of chromosome segregation in mitosis and meiosis through permanent slide.
3. **Preparation of chromosome squashes** from grasshopper/cockroach testes for the observation of stages of meiosis.
4. **Microscopic study:** Study of types of tissue through permanent slides-Epithelial tissue, Connective tissue, Muscular tissue, Nervous tissue, etc.
5. **Histological Slide Preparation through microtomy**: Study of histology of tissues by preparing permanent stained slides (mammalian) - Liver, Kidney, Pancreas, Intestine & Spleen.
6. **Experiment :** Isolation (Ethanol ppt) and estimation (Diphenylamine reaction) of DNA (blood/liver tissue).
7. **Group discussion** or **Seminar presentation** on following topics :

Pool of Topics for Group discussion or Seminar presentation :	
1. Bone marrow transplant.	6. Apoptosis.
2. Recent advances in tissue culture and engineering.	7. Mutations and cancer.
3. Somatic hybridization.	8. Epithelial tissue and its importance.
4. Neurodegenerative disorder.	9. Stem cell technology.
5. Popular cell lines and their importance.	10. Stem cell & IPS cells.

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Histological preparation- (Sl no 5); Tissue fixation-1, Block preparation-2, Sectioning-2, Slide preparation-1, Staining-2 (**8**) OR, Experiment-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 2. Squash preparation (Sl no 3)- Preparation-2, Identification-1, characterization-1. (**4**) 3. Identification (Sl no 2 and 4, 1 item from each gr)- Identification-0.5, Characters-1.5 (2x2=**4**) 4. LNB -**2** 5. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments (6th edition) John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006) Cell and Molecular Biology (8th edition) Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. (5th edition) ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M.; Kleinsmith, L.J.; Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. (7th edition) Pearson Benjamin Cummings Publishing, San Francisco.

SEMESTER - III

Course Name	COMPARATIVE ANATOMY AND PHYSIOLOGY OF CHORDATES		
Course Code	BSCHZOOC301		
Course Type	Core		
Course Details	CC-5	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course offers insight into the physiology of chordates while giving an account of their anatomy. This course also explores vertebrate morphology with the aims of understanding major events in the history of vertebrate evolution and integrating the morphology of vertebrates with their ecology, behaviour and physiological adaptation in diverse habitats. Thermal relations encountered in endo- and ectothermic animals will be explained. Selective pressures that shape to different physiological phenotypes will also be addressed in the course.

Learning outcomes :

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

- Develop an understanding of the evolution of vertebrates thus integrating structure, function and development.
- Have an overview of the evolutionary concepts including homology and homoplasy, and detailed discussions of major organ systems.
- Understand how cells, tissues, and organisms function at different levels. The course content also provides the basis of understanding their abnormal function in animal and human diseases and new methods for treating those diseases.
- Develop an understanding of the related disciplines, such as cell biology, neurophysiology, pharmacology, biochemistry etc.
- Get a flavor of research besides improving their writing skills and making them well versed with the current trends. It will further enable the students to think and interpret individually due to different aspects chosen.
- Undertake research in any aspect of animal physiology in future.

THEORY (CC-5)

UNIT- I: Structure and function of integument, skeletal and muscular systems (11 Lectures)

1. **Integumentary system** (Comparative Anatomy and functional significance): Integument from fishes to mammals: Scales of fishes and reptiles, Feather of birds, Epidermal glands from fish to mammals. Horn, hoof, claw, nail, hair.
2. **Skeletal system (Comparative Anatomy and functional significance):** Axial and appendicular skeleton from fishes (bony) to mammals. Pelvic and pectoral girdles from fishes (bony) to mammals.
3. **Muscular system:** Types of muscles from fishes to mammals, Properties of skeletal muscle. Physiology of skeletal muscle contraction.

UNIT-II: Structure and function of digestive, circulatory and endocrine systems (13 Lectures)

1. **Digestive system**-Comparative anatomy of jaw suspension. Dentition in mammals. General Structure and diversity of alimentary canal and digestive glands in vertebrates. Physiology of ruminating stomach. Physiology of digestion with special reference to enzymes involved in vertebrates. Concept of BMR.
2. **Circulatory system:** Evolution of aortic arches and their significance. Visceral arches and their functional significance in vertebrates. Structure and evolution of heart in vertebrates. Functional anatomy of human heart w.r.t. junctional tissues and valves, cardiac cycle, cardiac output, neural Integration of cardiovascular

function, electrocardiogram. Composition of blood, biochemistry of ABO blood groups, Rh and MN group, Mechanism of blood coagulation (intrinsic and extrinsic pathway).

3. **Endocrine glands:** Comparative structure & function of pituitary, thyroid gland in chordates. Mechanism of hormone action.

UNIT-III: Structure and function of respiratory and excretory systems (14 Lectures)

1. **Respiratory system**-Types and structure of fish gill. Accessory respiratory organs in fishes. Transitional respiration in Dipnoans. Transition from water to air breathing: w.r.t. comparative anatomy and functional significance of lungs in amphibians, reptiles, birds and mammals. Breathing and gas exchange, gas transport, Hb and O2 dissociation,
2. **Excretory system**: Types and development of kidneys and their ducts in anamniotes and amniotes. Nephron- structure, types and their function. Physiology of excretion (Ammonotelic, Uricotelic, Ureotelic) in vertebrates; Urine formation in mammal, counter current mechanism, Role of ADH and RAAS in excretion. Mechanisms of osmoregulation in fresh water and marine organisms (fishes, birds and mammals); stenohalinity and euryhalinity.

UNIT- IV: Structure and function of nervous and reproductive systems (14 Lectures)

1. **Nervous system**: Introduction to central and peripheral nervous (autonomic) systems. Structural and functional evolution of brain and spinal cord in various classes of vertebrates. Types of cranial nerves in major classes of vertebrates. Structure, type and functions of neuron, Ionic basis of resting and action potentials, Nerve impulse and its transmission (myelinated and non-myelinated). Synapse and synaptic transmission, Structure of reflex arc and mode of Reflex action. Types of sense organs- vision, hearing, taste, smell and touch in chordates. Mechanism of thermoregulation in homeotherms and poikilotherms.
2. **Reproductive system**: Comparative details of testes and ovaries from fishes to mammals; Reproductive strategies (ovipary, ovo-vivipary and vivipary) in vertebrates, Estrous and menstrual cycle, Gestation, parturition, lactation and Birth control (in mammals).

PRACTICAL (CC–5)

1. Temporary mount of external scales in fishes (cycloid, placoid, ganoid, ctenoid).
2. Comparative study of brain with the help of models and charts.
3. Comparative study of urinogenital system with the help of models and charts.
4. Comparative study of heart with the help of models and charts.
5. Study of axial and appendicular skeleton of vertebrates.
6. Expose and display afferent Branchial system, weberian ossicles and IX-Xth cranial nerve of fish (carp).
7. Quantitative determination of nutrients: Carbohydrate (Anthrone method), Proteins (Lowry's method), Cholesterole (Solkowski's test).
8. Estimation of haemoglobin.
9. Counting of different types of blood cells (RBC & WBC) using haemocytometer..
10. Submit a report based on-

(a) Rate of oxygen uptake in fish and

(b) Effect of temperature on opercular movement of fish.

11. Group discussion or Seminar presentation on topics given below :

Pool of Topics for Group discussion or Seminar presentation :		
1. Evolution of terrestrial animals	2. Thermoregulation in vertebrates	3. Osmoregulation in fish
4. Estrous and menstrual cycle	5. Blood groups and their importance	6. Scales in fishes and reptiles
7. Deep-sea Adaptation in mammals	8. Kidney development in vertebrates	9. Evolution of aortic arches
10. Cranial nerves in vertebrates	11. Integumentary derivatives in bird and mammals	12. Jaw suspension in vertebrates

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment (Sl no 7, 8, 9)- Performance in experiment-3, Principle-1, Procedure-2 result and inference-2, (**8**) OR, Dissection (Sl no 6)- Exposing and display-5, Drawing-2, Labelling-1. (**8**) 2. Identification (Sl no 1 to 5)- Naming-0.5, Characters-1.5 (2x3=**6**) 3. LNB and Project report -2+2 = **4** 4. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report should be done on specified topics and distributed among students.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Weichert, C.K. (1970) Anatomy of Chordates (4th edition).
2. Jordan, E. L. and Verma, P. S. (2013) Chordate Zoology (14th edition). S. Chand & Company Ltd. New Delhi.
3. Saxena, R. K. and Saxena, S. (2015) Comparative Anatomy of Vertebrates (2nd edition).
4. Vander, A.; Sherman, J. and Luciano, D. (2003) Human Physiology (9th edition).
5. Randall, D. *et al*. (2002) Eckert Animal Physiology (5th edition) Freeman.
6. Hill, R.W. *et al.* (2008) Animal Physiology (3rd edition) Sinaur Associates.
7. Guyton, A.C. *et al*. (2008) Textbook of Medical Physiology (12th Ed) W.B. Saunders Co.
8. Withers, P.C. *et al.* (1992) Comparative Animal Physiology (1st edition) Brooks Cole.
9. Kent, G. C. and Carr, R. K. (2018) Comparative anatomy of vertebrates (9Ed), Mc Graw Hill.
10. Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd.
11. Miller S.A. & Harley J.P. (2015) Zoology. 10Ed., McGraw-Hill Education
12. Hickman C., *et. al.* (2019) Integrated principles of zoology., 18Ed., McGraw-Hill Education.
13. Hildebrand, M. (1995). Analysis of Vertebrate Structure. John Wiley & Sons.
14. Chaki, K.K. Kundu, G. & Sarkar, S. (2005). Introduction to General Zoology. Vol. 1. New Central Book Agency (P) Ltd. Kolkata.
15. Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill.
16. Kent, G. C. & Carr, R. K. (2001). Comparative anatomy of the Vertebrates. 9th Ed. Mc Graw Hill.
17. Nelson, J.S., (2006) : Fishes of the World, 4th Edn., Wiley.
18. Romer, A. S. & Parsons, T. S. (1986). The vertebrate body. 6th Ed. Saunders College Publishing.
19. Pough, F.H., Heiser, J.B. & McFarland W. N. (1985). 3rd Ed. Vertebrate Life. Macmillan Publishing Company, New York.
20. Parker, T. J. & Haswell, W. (1972). Text Book of Zoology , Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press,London.
21. Young, J. Z. (1981). The Life of Vertebrates. 3rd Ed. ELBS.
22. Weichert, C. K. & Presch, W. (1984). Elements of Chordate Anatomy. Tata-McGraw Hill Pub. Comp.

SEMESTER – III

Course Name	GENETICS		
Course Code	BSCHZOOC302		
Course Type	Core		
Course Details	CC-6	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course is designed to revise basic concepts of Genetics and then move on to advanced concepts. Some key aspects include the mechanism of inheritance, gene structure and function, sex chromosomal and autosomal anomalies, aspects of human genetics, etc. will be covered. A strong emphasis will be laid on the modern tools and techniques used in genetics.

Learning outcomes :

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

- Understand how DNA encodes genetic information and the function of mRNA and tRNA.
- Apply the principles of Mendelian inheritance.
- Understand the cause and effect of alterations in chromosome number and structure.
- Relate the conventional and molecular methods for gene manipulation in other biological systems.
- Discuss and analyse the epigenetic modifications and imprinting and its role in diseases.
- Get new avenues of joining research in related areas such as genetic engineering of cells, cloning, genetic disorders, human fertility programme, genotoxicity, etc

THEORY (CC-6)

UNIT I: Concept of Genes and Genomics (13 Lectures)

1. Genetics: scope and importance.
2. Classical and Modern concept of Gene (Cistron, muton, recon), Alleles etc.
3. Mendel's laws of inheritance
4. Chromosomal basis of inheritance and its applications.
5. Mendelian traits in man: Sex linked, Sex limited, Sex influenced inheritance
6. Exceptions to Mendelian Inheritance: Incomplete dominance, Codominance, Multiple allelism, Lethal alleles, Pleiotropy, Epistasis - Recessive, Duplicate recessive, Dominant and Duplicate dominant. Phenocopy, Polygenic inheritance.

UNIT II: The recombination and interaction of Genes (13 Lectures)

1. Linkage crossing over & chromosomal mapping: Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including Holliday model of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization
2. Extra chromosomal Inheritance: Criteria for extra-chromosomal inheritance, Mitochondrial mutations in *Saccharomyces,* Infective heredity in *Paramecium* and Maternal effects in snail.
3. Sex-Determination: Sex Chromosomes and sex-linkage: XX/XO, XX/XY, ZZ/ZW and haploidy/diploidy types, Dosage Compensation in Drosophila and Man,
4. Structural and numerical alterations of chromosomes,

UNIT III: Regulation of Gene expression, regulation and mapping (13 Lectures)

1. Gene Expressions and regulation**:** One gene-one enzyme hypothesis /one polypeptide hypothesis.
2. Concept of operon of bacteria (Lac & Trp)
3. Transposon in Bacteria, maize and human.
4. Transformation, Conjugation, and transduction.
5. Genetic complementation and mapping.
6. Basic idea of Genetic screens as a basis for functional genomics.
7. Mutagenesis (physical and chemical induced), mutation detection test (AMES, CLB, Attatched X), Recombination assay (FLP-FRT & Cre-Lox System),
8. Utility of the model organisms as genetical research tool: *Escherichia coli*, *Arabidopsis thaliana*, *Neurospora crassa*, *Caenorhabditis elegans*, *Drosophila melanogaster* & *Mus musculus*.

UNIT IV: Human Population Genetics and Genetic Counselling (13 Lectures)

1. Human Genetics: Pedigree analysis; Karyotype, banding and nomenclature of chromosome subdivisions.
2. Genetic disorders: chromosomal aneuploidy (Down, Turner and Klinefelter syndromes),
3. Chromosome translocation (Chronic Myeloid Leukemia) and deletion ("cry du chat" syndrome),
4. Gene mutation (sickle cell anemia). Genetic counselling,
5. Modern techniques in Genetics: Principle and applications of: Polymerase Chain Reaction. DNA Sequencing, Southern, Western & Northern Blotting, *In situ* Hybridization, FISH, SNPs, RFLPs, ESTs, STS and Oligonucleotide arrays. Nuclear transplantation, stem cells and IPS cells.

PRACTICAL (CC-6)

1. Application of probability in the law of segregation with coin tossing method.
2. Study of Mendelian Inheritance using suitable examples. Verify the results using Chi-square test (Goodness of fit).
3. Pedigree analysis of some human inherited traits.
4. Prepare a **study/survey report** on-
   (a)Frequency of the following genetic traits in human: widow's peak, attached ear lobe, dimple in chin, hypertrichosis, colour blindness, PTC tasting and
   (b) Study of mode of inheritance of the following traits by pedigree charts – attached ear lobe, widow's peak
5. Familiarization with techniques of handling *Drosophila*, identifying males and females; observing wild type and mutant (white eye, wing less) flies, and setting up cultures
6. Demonstration of law of segregation (monohybrid and test cross) sex-linked inheritance in *Drosophila* making a cross between white eye dumpy winged or sepia eyed and wild type flies (criss-cross inheritance).
7. Demonstration of lethal alleles using Curly (Cy) mutant in *Drosophila.*

8. Demonstration of multiple allelism by showing mutants of white eye series in *Drosophila*
9. Study of structural chromosome aberrations (dicentric, ring chromosomes and inversions in polytene chromosomes) from prepared slides/photographs.
10. Study of human karyotypes and numerical alterations (Down syndrome, Klinefelter syndrome and Turner syndrome).
11. Extraction of Genomic DNA from bacteria (Demonstration).
12. Group discussion or Seminar presentation on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Genome modification/ editing	2. Genetic control of sex determination.	3. Genetic Recombination
4. Mutagenesis	5. Diseases due to chromosomal anomalies	6. Stem cell technology
7. Complementation mapping	8. Recent advances in gene cloning	9. Genetic counseling
10. DNA markers and Genetic diversity	11. Epigenetic disorders in humans	12. Chromosome translocation

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Chi-Square test based on provided data-(Sl no 2)- Analysis-4, Inference-1 (**5**) 2. Pedigree analysis on provided chart-(Sl no 3)-Description-2, analysis-2 and mode of inheritance-1 (**5**) 3. Identification based on provided chart/slide (Sl no 4 to 10)- Naming-0.5, Characters-1.5 (2x2=**4**) 4. LNB and Survey report -2+2 = **4** 5. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Survey report should be done on specified topics and distributed among students.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings :

1. Gardner, E.J. *et al.* (2006) Principles of Genetics (John Wiley).
2. Russell, P.J. (2010) Genetics (Benjamin Cummings).
6. Pierce B.A. (2012) Genetics:A conceptual approach, 4Ed, W. H. Freeman and Co. Ltd.
1. Singh B.D.(2018) Fundamentals of genetics, Kalyani Publishers.
2. Miglani G.S. (2008) Fundamentals of genetics, Narosa publication.
3. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). Principles of Genetics. (VIII edition) Wiley India.
4. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics. (V edition) John Wiley and Sons Inc.
7. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2012). Concepts of Genetics. (X edition) Benjamin Cummings
8. Carroll S.B.; Doebley J.; Griffiths, A.J.F. and Wessler, S.R. (2018) An Introduction to Genetic Analysis. W. H. Freeman and Co. Ltd.
9. Banerjee P.K. (2011) Problems on genetics, molecular genetics and evolutionary genetics,2Ed, NCBA

SEMESTER - III

Course Name	BIOCHEMISTRY		
Course Code	BSCHZOOC303		
Course Type	Core		
Course Details	CC-7	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course provides an introduction to the structure of biomolecules with emphasis on the techniques used for structure determination and analysis. The course covers basic aspects of sample preparation for analysis and aims to enlighten the students how structural information can be utilized for better understanding of biological processes.

Learning outcomes :

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

- Understand about the importance and scope of biochemistry.
- Understand the structure and biological significance of carbohydrates, amino acids, proteins, lipids and nucleic acids.
- Understand the structure and function of immunoglobulins.
- Understand the concept of enzyme, its mechanism of action and regulation.
- Understand the process of DNA replication, transcription and translation.
- Learn the preparation of models of peptides and nucleotides.
- Learn biochemical tests for amino acids, carbohydrates, proteins and nucleic acids.
- Learn measurement of enzyme activity and its kinetics.

THEORY (CC-7)

UNIT I: Introduction to Biochemistry and biology of Carbohydrates (12 Lectures)

1. Introduction, scope and importance of Biochemistry.
2. Basic concept of Bioenergetics and redox system.
3. Water as biological solvent.
4. Carbohydrates: Structure (isomeric forms of hexose) and biological importance.
5. Classification - Reducing and non-reducing sugars, monosaccharides, Oligosaccharides (Disaccharides), Polysaccharides (glycogen, peptidoglycans and glycosaminoglycans).
6. Catabolism of carbohydrates and ATP production: Glycolysis, Krebs cycle, Functioning of Electron transport system and ATP synthesis (Paul Boyer's model), Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

UNIT II: Lipids: Structure and Biological significance (13 Lectures)

1. Lipids: Structure and Biological significance.
2. Fatty acids- Types and nomenclature (saturated and unsaturated).
3. Classification- Triglycerides, Phospholipids, Sphingolipids, Cholesterol,
4. Metabolism: β- oxidation of saturated fatty acids with even and odd number of carbon atoms, ω-oxidation -significance, Biosynthesis of palmitic acid; Ketogenesis.

UNIT III: Biology of Proteins and Enzymes (16 Lectures)

1. Proteins: Composition and Biological significance.
2. Amino acids -Structure, classification and properties, Ionization, titration curve, pK and pI.
3. Physiological importance of essential and non-essential amino acids.
4. Catabolism of amino acids: Transamination, Deamination, Urea cycle.
5. Structural organization (primary, secondary, tertiary, quartarnary structure, Ramachandran plot, motif, domain).
6. Biological Bonds: H-bond, Di-sulphide bond,ionic bond, vander-waal interaction, hydrophilic and hydrophobic bonds, covalent bond.
7. Enzymes: Nomenclature and classification, general properties, specificity of enzyme action, cofactors, isozymes, clinical and industrial application.
8. Mechanism of enzyme action (ES complex and lowering of activation energy, chemical catalysis).
9. Kinetics (determination of Km and Vmax using Michaelis-Menten and Lineweaver-Burk plots).
10. Regulation of enzyme activity: substrate level, Feed-back, allosteric regulation, role of covalent modifications.
11. Enzyme inhibition-Competitive, Non-Competitive, Un-Competitive, Suicide.
12. Ribozymes and concept of abzymes.

UNIT IV: Nucleic acids and chromosome (11 Lectures)

1. Structure -Bases, nucleosides, nucleotides and sugar pucker.
2. DNA structure: Conformation (A, B and Z), Base pairing, Structural Determination using X-ray crystallography.
3. DNA double helix (Watson and Crick model).
4. Chromosomes, Chromatin, Organization of nucleosomes and higher order structure, Histones, Histone-modifications.
5. Structure and Function of RNA, Ribosomal RNA (rRNA), Transfer RNA (tRNA), Messenger RNA (mRNA), Noncoding RNAs.

PRACTICAL (CC-7)

1. Ninhydrin test for α-amino acids.
2. Determination of pK and pI values of glycine.
3. Benedict's test for reducing sugars (Qualitative).
4. Iodine test for starch.
5. Determination of acid value of oil.
6. Determination of the activity of enzyme (Urease/salivary amylase).
   - 6.1. Effect of [S] and determination of Km and Vmax.
   - 6.2. Effect of temperature.
   - 6.3. Effect of time.
10. **Group discussion or Seminar presentation** on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Advances in DNA hybridization	2. Essential and non-essential amino acids	3. Important body lipids
4. Vital body enzymes	5. Proteins are the key regulators-Justify	6. Carbohydrate and life
7. Hormonal disorders	8. Structural prediction of DNA by XRD	9. Enzyme kinetics
10. Biological bonds	11. Chemiosmosis and redox potential and ATP production	12. Fatty acid oxidation

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment A (Sl no 2, 4,5,6)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 2. Experiment B (Sl no 3, 8, 9)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 3. LNB -**2** 4. VIVA-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings :

1. Nelson, D.L. & Cox, M.M. (2017) Lehninger's Principles of Biochemistry (7th edition)Worth.
2. Berg, J.M.; Tymoczko, J.L. and Stryer, L. (2012) Biochemistry (7th edition) Freeman.
3. Zubay, G. (2017) Biochemistry (4th edition) McGraw-Hill.
4. Conn, E.E.; Stumpf, P.K.; Bruening, G. and Doi, R.H. (2006) Principles of Biochemistry (5th edition) Wiley
5. Chatterjea M.N & Shinde R. (2012) Textbook of Medical biochemistry, 8Ed, Jaypee
6. Satyanarayana U & Chakrapani U. (2020) Biochemistry, 5Ed, Elsevier/Books & allied.
7. Murray R.K. et al., (2012) Harper's illustrated biochemistry, 29Ed, Lange
8. Rao AVVSR (2009) Textbook of Biochemistry, UBS Publishers' Distributors Pvt. Ltd.
9. Voet, D., Voet, J. G. & Pratt C. W. (1999). Fundamentals of Biochemistry. Upgrade edition. John Wiley & Sons.
10. Hames, B.D. and Hooper, N.M. (2000). Instant Notes in Biochemistry. II Edition, BIOS Scientific Publishers Ltd., U.K.

SEMESTER - III

Course Name	BEE-KEEPING		
Course Code	BSCHZOOSE301		
Course Type	Skill Enhancement Course		
Course Details	SEC-1	CA (Continuous Assessment)	Theory : 10 marks
		ESE (End Semester Examination)	Theory : 40 marks
Credits	Theory 4 = Total 4 credits		

About the course :
This course tells the students what tools and equipment will be needed, the main activities in the beekeepers year, the laws and by laws governing keeping bees; discover the principles of sustainable beekeeping and how these principles can guide your Beekeeping into an enduring practice.

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

- Explain what are the prerequisite to get started in beekeeping.
- Describe the laws around beekeeping in Vancouver.
- Discuss the responsibilities of urban beekeepers.
- Identify where to purchase equipment and demonstrate how to assemble it.
- Name and identify major parts of the honeybee such as the stinger or mandibular parts.
- Describe bee biology and anatomy from the perspective of managing bees.
- Describe the importance of wax and identify what to look for in comb during hive inspections.

THEORY (SEC-1)

Unit I: **Introduction to Apiculture** **(12 Lectures)**

1. History of Bees and Beekeeping,
2. Systematics, Bee species,
3. Bee morphology (*Apis indica*),
4. Colony organization and Polymorphism,
5. Caste system, Division of labour,
6. Bee pasturage
7. Foraging and Honey flow periods.

Unit II: **Bee keeping as an occupation** **(13 Lectures)**

1. Extent of Beekeeping in West Bengal and India,
2. Limitations on the development of beekeeping,
3. Advantages of extensive Beekeeping.
4. Beekeeping equipments: Bee box and tools and initiation into keeping a colony,
5. The future of beekeeping.

Unit III: **The first step in beekeeping** **(14 Lectures)**

1. Purchase of a colony,
2. the Apiary site, how to manage (Seasonal and Routine) a colony, the manipulation of a colony.
3. Bee products: Honey, Bee wax, Pollens, Royal Jelly, Propolis and Bee venom.
4. Taking care of bee (brood and adult) diseases and enemies.

5. Establishment of a colony.
6. Bee flora and planned pollination services (Modern Methods in employing artificial Beehives for cross pollination in horticultural gardens)

Unit IV: **Entrepreneurship in Beekeeping industry (13 Lectures)**

1. Harvesting and marketing of bee products.
2. Bee Keeping Industry – Recent Efforts.
3. Important Institutions pertinent to Apiculture: National Bee keeping.

Recommended readings

1. Abrol , D. P. (1997) Bees and Beekeeping. Kalyani Publisher, New Delhi.
2. Abrol, D. P. (2010) A Comprehensive guide to Bees and Beekeeping. Scientific Publisher, New Delhi.
3. Withhead, S. B. (2010) Honey bees and their management Axis books Publisher, Jodhpur.
4. Nagaraja, N. and Rajagopal , D. (2013) Honey bees: Diseases, Parasites, Pests, Predator and their management. M.J.P Publisher, Chennai.
5. Dharamsing and Singh, D. P. A Handbook of Beekeeping, Agrobios India (Publisher),Jodhpur.

SEMESTER – III

Course Name	PUBLIC HEALTH AND HYGIENE		
Course Code	BSCHZOOSE302		
Course Type	Skill Enhancement Course		
Course Details	SEC-1	CA (Continuous Assessment)	Theory : 10 marks
		ESE (End Semester Examination)	Theory : 40 marks
Credits	Theory 4 = Total 4 credits		

About the course :
The course designed for public health and hygiene at graduation level will give understanding for health hygiene, dietary issues, diseases related to malnutrition, communicable and non-communicable diseases.

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

- **Identify current national and global public health problems.**
- **Aware about the issues of food safety, water safety, vaccination, exercise and obesity, exposure to toxins.**
- **Frame a public health plan during any epidemic or spread of infectious disease etc.**
- **Analyze case studies of infant mortality and obesity.**
- **Assess the health inequalities with regard to gender, race, ethnicity, income etc.**

THEORY (SEC-1)

Unit-I: Maintenance of personal and community hygiene (13 Lectures)

1. Introduction to public health and hygiene- determinants and factors.
2. Pollution and health hazards; water and air borne diseases.
3. Radiation hazards: Mobile Cell tower and electronic gadgets (recommended levels, effects and precaution).
4. Role of health education in environment improvement and prevention of diseases.
5. Personal hygiene, oral hygiene and sex hygiene.
6. Importance and maintenance Community Hygiene.

Unit-II: Nutrient deficiency diseases (13 Lectures)

1. Classification of food into micro and macro nutrients.
2. Balanced diet, dietary plan for an infant, normal adult, pregnant woman and old person.
3. Importance of dietary fibres.
4. Significance of breast feeding.
5. Malnutrition anomalies – Anaemia (Iron and B12 deficiency), Kwashiorkar, Marasmus, Rickets, Goiter (cause, symptoms, precaution and cure).
6. Substitution of diet with required nutrients to prevent malnutrition disorders.

Unit-III: Communicable and contagious diseases (13 Lectures)

1. Infectious agents responsible for diseases in humans.

2. Communicable viral diseases (causative agent, symptoms, precaution and remedy)- measles, chicken pox, poliomyelitis, swine flu, dengue, chickungunya, rabies, leprosy and hepatitis.
3. Communicable bacterial diseases (causative agent, symptoms, precaution and remedy)- tuberculosis, typhoid, cholera, tetanus, plague, whooping cough, diphtheria, leprosy.
4. sexually transmitted diseases (causative agent, symptoms, precaution and remedy)- AIDS, syphilis and gonorrhoea.
5. Health education and preventive measures for communicable diseases.

Unit-IV: Non-communicable diseases and cure (13 Lectures)

1. Non-communicable diseases such as hypertension, stroke, coronary heart disease, myocardial infarction. Osteoporosis, osteoarthritis and rheumatoid arthritis-cause, symptom, precautions.
2. Diabetes- types and their effect on human health.
3. Gastrointestinal disorders- acidity, peptic ulcer, constipation, piles (cause, symptoms, precaution and remedy) etc. Obesity (Definition and consequences).
4. Mental illness (depression and anxiety).
5. Oral and lung cancer and their preventive measures.

Recommended readings :

1. Mary Jane Schneider (2011) Introduction to Public Health.
2. Muthu, V.K. (2014) A Short Book of Public Health.
3. Detels, R. (2017) Oxford Textbook of Public Health (6th edition).
4. Gibney, M.J. (2013) Public Health Nutrition.
5. Wong, K.V. (2017) Nutrition, Health and Disease.

SEMESTER-IV

Course Name	**BEHAVIOUR AND CHRONOBIOLOGY**		
Course Code	**BSCHZOOC401**		
Course Type	**Core**		
Course Details	**CC-8**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 6 + Practical 2 = Total 6 credits**		

About the course :

The course aims to explain the natural behaviour patterns, how the behaviour varies among individuals and species (wild, domestic, and captive), how current and past environments and ecology influence not only behaviour, but also the underlying gene environment interactions that shape it.

Learning outcomes :

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

- Learn a wide range of theoretical and practical techniques used to study animal behaviour.
- Develop skills, concepts and experience to understand all aspects of animal behaviour.
- Objectively understand and evaluate information about animal behaviour and ecology encountered in our daily lives.
- Understand and be able to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.
- Consider and evaluate behaviour of all animals, including humans, in the complex ecological world, including the urban environment.

THEORY (CC-8)

UNIT I: Introduction and patterns of Behaviour (12 Lectures)

1. Animal behaviour. Scope and importance of study.
2. Proximate and ultimate causes of behavior and the evolutionary approach to studying behaviour.
3. Methods and recording of a behavior
4. Types of stimuli invoking response: internal and external cues.
5. Patterns of behaviour: Stereotype (Spatial orientation, Reflexes, Instinct); Learning (Associative, Non-associative, Latent, Insight, Imprinting); Innate/ Instinct behaviour. vs. Learnt Behaviour.
6. Kinds of behaviour: Foraging behaviour, Territorial behaviour.
7. Allelomimetic and maladaptive (abnormal) behaviour.

UNIT II: Innate behaviour; Evolution of reproductive behavior (13 Lectures)

1. Innate behaviour: Communication (primates, bees and ants).Ritualization. Behaviour of solving ecological obstacles through Decision making
2. Motor Output: leech swimming/crawling, escape behavior, cricket vocalizations.
3. Sensorimotor integration: electric fish, bird song instinct and motivation. territorial behaviour, schooling behaviour.
4. Displacement activities, Habitat selection, food selection and foraging behaviour in African ungulates.
5. Mimicry and colouration.
6. Migratory behaviour in birds and fishes.

Unit III: Reproductive behaviour and socio-biology (14 Lectures)

1. Reproductive behaviour: Mate selection and courtship behaviour. Parental care (Fish, Amphibia, Bird), defensive behaviour. Evolution of reproductive behavior, mating systems and parental care. Asymmetry in sex, sexual dimorphism.
2. Sociobiology: Social and cultural transmission of Behaviour; Aggregation, Group selection; Social organization (e.g., Honey bee, Naked Mole Rat and Monkey). Elements of Socio-biology: Selfishness, cooperation, altruism, kinship and inclusive fitness.

UNIT IV: Genetic, Neural, and Hormonal regulation of behavior (13 Lectures)

1. Genetic basis of behaviour.
2. Neural Regulation of behaviour: kineses, taxes, simple reflexes.
3. Sensory processing: toad prey capture, sound localization (owls), echolocation (bats).
4. Hormonal control in Biological clocks: Advantages of biological rhythms. Circadian and circannual rhythms. Photoperiodism, tidal, solar and lunar rhythms, Jet-lag, entrainments. Biological oscillation: the concept of Average, amplitude, phase and period, Role of melatonin.
5. Applications of Chronobiology : Chronopharmacology, Chronomedicine, Chronotherapy.

PRACTICAL (CC-8)

1. **Study of Orientation** of an Insect to light.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study **geotaxis behaviour** in earthworm.
4. To study the **phototaxis behaviour** in insect larvae.
5. **Constructing an ethogram** (Documentation and drawing by studying the following Canine's behaviour -movement, feeding, caring of child, foraging, vigilance, vocalization, afraid, anxious/nervous, mating, aggressive, alert, playful, submissive).
6. **Study of Chemical communication** in ants (Ancestral, perception, communication, etc).
7. **Selective predation** of coloured prey items (Demonstration through video).
   OR,
   Predatory behaviour of a carnivorous animal (Demonstration through video).
8. **Study of Nests and nesting habits of the birds** [Tailor bird (cup nest), Weaver bird (hanging/Pendant nest), Bustard/ostrich (Scrape nest), Kingfisher (Burrow nest), Bower bird (round nest), Parrot/owl (cavity nest), crow/osprey (flat/platform nest)] and social insects [Honey bee, Wasp, Termite].
9. **Study of circadian functions in humans** (daily eating, sleep and temperature patterns).
10. **Study of courtship behaviour** in birds and insects from short videos/films.
11. **Field Visit** to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.
12. **Group discussion or Seminar presentation** on topics (Given Below).

Pool of Topics for Group discussion or Seminar presentation :		
1. Parental care in animals	2. Instinctive behaviour invertebrates	3. Ethogram and its application
4. Learning in birds	5. Application of animal behaviour studies	6. Bee dance and Foraging
7. Circadian rhythm	8. Social behaviour in primates	9. Biological clock
10. Behaviour in captivity	11. altruism, kinship and inclusive fitness	12. Neural regulation of behaviour
13. Chronobiology	14. Mate selection and courtship behaviour.	15. Genetic basis of behaviour

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment (Sl no 1-4, any one)-Principle-1, procedure-2, Experiment-3, result and inference-2, (8) 2. Identification of behaviour (Sl no 5, 6, 8,10; one from each)-Naming-0.5 and features-1 (1.5 x 4=6) 3. LNB & Field report-4 4. VIVA-2

NOTE :

- *Identification of behaviour/nest/ethogram could be done by using card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. McFarland, D. (1999) Animal Behaviour (3rd edition) Pitman Publishing Limited,London, UK.
2. Manning, A. and Dawkins, M. S. (2012) An Introduction to Animal Behaviour (6th edition) Cambridge, University Press, UK
3. Alcock, J. (2005) Animal Behaviour (8th edition) Sinauer Associate Inc., USA.
4. Sherman, P. W. and Alcock, J. (2013) Exploring Animal Behaviour (6th edition) Sinauer Associate Inc., assachusetts, USA.
5. Dunlap, J. C.; Loros, J.J. and DeCoursey, P. J. (2009) Chronobiology Biological Timekeeping (1st edition) Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
6. Danchin, E., Giraldeau, L. A., & Cezilly, F. (2008). Behavioural Ecology: An Evolutionary Perspective on Behaviour. Oxford University Press,
7. Drickamer LC , Vessey SH . (2001). Animal Behaviour. McGraw-Hill
8. Dugatkin LA. 2014. Principles of Animal Behaviour. 3rd Edn. W.W.Norton and Co.
9. Krebs J. R. & N. B. Davies – An introduction to Behavioural Ecology – Blackwell Scientific
10. Natarajan, P and Arumugam, N.; (2018) 1st ed, Saras publication
11. Chattopadhyay, S (2021) LIFE: Evolution, adaptation, ethology, 4nd Ed, Books & Allied.
12. Mathur, R.; (2018) Animal behaviour, 5th Ed Rastogi publication
13. Ruhela A, Sinha M. 2010. Recent Trends in Animal Behaviour. Oxford Book Co
14. Arora, M.P. (2014) Animal behaviour , 13th Ed, Himalaya Publishing House.
15. Shukla, J.P. (2021) Fundamentals of Animal Behaviour, 1st Ed, Atlantic
16. Agarwal V.K.; (2010) Animal behaviour, 1st Ed, S Chand & Company
17. Kumar, V. (2002). Biological Rhythms: Narosa Publishing House, Delhi/ Springer - Verlag, Germany.
18. Feature Article -- Types of Bird Nests and Nesting Schemes (utahbirds.org)

SEMESTER-IV

Course Name	**DEVELOPMENTAL BIOLOGY & EVOLUTION**		
Course Code	**BSCHZOOC402**		
Course Type	**Core**		
Course Details	**CC-9**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 4 + Practical 2 = Total 6 credits**		

About the course :

The course explains the sequence of events starting with a single cell to the production of a very complex organism. The course not only describes how embryos develop (embryology), but also highlights how the processes of development are brought about by changing individual cells into specialized cells with specific functions (the cellular level), and how genes within the genome of the organism drive and guide these changes (the molecular level). It also deals with a comparative account of development in some select groups of animals.

Learning outcomes :

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

- Develop critical understanding how a single-celled fertilized egg becomes an embryo and then a fully formed adult by going through three important processes of cell division, cell differentiation and morphogenesis.
- Understand how developmental processes and gene functions within a particular tissue or organism can provide insight into functions of other tissues and organisms.
- Realize that very similar mechanisms are used in very diverse organisms; and development is controlled through molecular changes resulting in variation in the expression and function of gene networks.
- Understand how the field of developmental biology has changed since the beginning of the 19th century with different phases of developmental research predominating at different times.
- Examine the evolutionary history of the taxa based on developmental affinities.
- Understand the relevance of developmental biology in medicine or its role in development of diseases.

THEORY (CC-9)

UNIT I: **How does reproduction start, commence and modify in living system? (12 Lectures)**

1. **Basics of reproduction:** Reproduction: a basis of species sustenance; Asexual and sexual reproduction and their relevance in corresponding environments; How are germ cells "special"?
2. **Gametogenesis:** Gamete formation, types, their diversity and competence,
3. **Fertilization:** Merit and demerits of external and internal fertilization; Structural and biochemical changes in gametes during and after fertilization in Human, Block to polyspermy in sea urchin and Human.
4. **Early embryogenesis:** Establishment of the major embryonic axes (in *Drosophila*), polarity, morphogen gradients and their interpretation; Fate maps, their relevance (Toad, Chick)

UNIT II: How does development affect organization of phenotypes and their variation? (12 Lectures)

1. **Developmental commitments:** Mosaic and regulative development. Direct and indirect development. Cleavage: types and patterns. Body plan and symmetries. Germ layer differentiation. Tubulation. Morphogenesis: Epiboly, emboly/ invagination, involution and ingression.
2. Cell-cell interactions (cell signaling, cell adhesion etc.) during tissue organization, lateral inhibition, induction, and recruitment.

3. **Organogenesis:** formation of Eye, Brain and Heart, in Chick.
4. Concept of organizer and competence,
5. Determination and differentiation and growth, molecular mechanism involved.
6. Totipotency, Pleuropotency.
7. Stem cell biology and tissue repair.

UNIT III: Tracing the evolutionary biology of development (12 Lectures)

1. Role of extra embryonic membranes in development of amniota and anamniota,
2. Placenta: types, formation and functions.
3. Metamorphosis in insect and frog.
4. Regeneration: epimorphosis, morphollaxis and compensatory regeneration.
5. Development, Ageing and apoptosis.
6. Developmental mechanisms of evolutionary change (Evo-devo). *[Ref-Gilbert ch 23]*
7. Ecological Developmental Biology. *[Ref-Gilbert ch 22]*
8. Developmental biology in understanding of disorders: Teratogenic agents and their effects on embryonic development; Wound healing, Birth defects, Developmental brain disorders; Neurodegeneration; Endocrine disruptors & Cancer.

UNIT IV: Understanding evolution through natural selection, adaptation and optimal models trade offs (24 Lectures)

1. **Life's Beginning and animal evolution:** Direct and indirect evidences of early life (chemogeny, biogeny, major theories); Evolution and radiation of metazoan (fundamental idea), Major evolutionary transitions: mass extinction. Anthropocene and its uniqueness.
2. **Evidences of Evolution,** Molecular clock, Neutral theory.
3. **Theories of evolution:** Lamarckism, Darwinism, modern synthetic theory, Hardy-Weinberg Equilibrium (gene and genotype frequency, simple problems and implications),
4. **Mechanism of evolution: Variations (**mutation, recombination, epigenetic variation, Evolution of mutation rates); Genetic drift; Phenotypic plasticity, Selection (Natural & artificial), Migration, Linkage disequilibrium; Nonrandom mating, Cost/ benefit of sex, Sexual conflict, Evolution in asexual systems, Life-history adaptations, Trade-offs, Number and size of offspring; Parent-offspring conflict.
5. **Product of evolution: Speciation:** Micro-evolutionary changes (inter-population variations, clines, Ring species, races), Species concept, Isolating mechanisms, Modes of speciation, Adaptive radiation/macroevolution (Darwin finches, marsupials, Red Queen Hypothesis), Phyletic gradualism and punctuated equilibrium.
6. **Genome evolution:** Mobile genetic elements; gene duplication.
7. **Human evolution:** Trend, major hominids
8. **Evolution and Health:** Evolution of antibiotic Resistance, Virulence, Evolutionary medicine.

PRACTICAL (CC-9)

1. Types of eggs based on quantity and distribution of yolk: sea urchin, insect, frog, Chick.
2. Comparative study of cleavage patterns in Frog and Amphioxus models.
3. How do cells move, change shape and size during morphogenetic movement of Blastulation, Gastrulation in Frog, Amphioxus, Chick.
4. Study of development of chick embryo through incubated chick eggs at 24, 48, 72 & 96 h.
5. Extra embryonic membranes of chick through permanent slides/photograph.
6. Some videos to develop understanding on the process of development.
7. Study of adaptive radiations in feet of birds and mouth parts of insects.
8. Understanding embryological evidence of evolution (through charts and videos).
9. Study of types of fossils (through photograph/model/video).
10. Analogy and homology (wings of birds and insects, forelimbs of bat and rabbit).
11. Serial homology in appendages of *Palaemon.*
12. **Group discussion or Seminar presentation** on one or two related topics (Given Below).

Pool of Topics for Group discussion or Seminar presentation :		
1. Origin of life	2. Scope of evo-devo (Evolutionary developmental biology)	3. Animal connecting links
4. Living fossils	5. Latest trends in developmental biology	6. Mass extinction phenomenon
7. Metamorphosis	8. Evolution of major animal lineages	9. Pleuripotency and its relevance
10. Fate map	11. Relevance of Palaentology in current scenario	12. Were dinosauers warm blooded?

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Identification (Dev biol) based on provided chart/slide (Sl no 1 to 6)- Naming-0.5, Characters-1.5 (2x5=**10**) 2. Identification (Evolution) based on provided chart/slide (Sl no 7 to 11)- Naming-0.5, Characters-1.5 (2x3=**6**) 3. LNB -**2** 4. VIVA-**2**

NOTE :

- *Identification could be done by using slide, card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Gerhart, J. *et al*. (1997) Cells, Embryos and Evolution. Blackwell Science.
2. Gilbert, S.F. (2010) Developmental Biology (9th edition). Sinauer.
3. Wolpert, L. (2007) Principles of Developmental Biology (3rd edition). Oxford University Press.
5. Campbell, N. and Reece, J. (2014) Biology (10th edition). Benjamin Cummings.
6. Chattopadhyay, S (2018) An introduction to Developmental biology, 1st Ed, Books & Allied
7. UK. Balinsky (2012). Embryology. 5th Ed, Thompson Brooks Cole (India) Pvt. Ltd.
8. Browder, L. W. (1984). Developmental Biology. 2nd Ed., CBS College Publishing.
9. Arumugam, N. (2014) An introduction to embryology (Developmental Zoology), Saras Publication.
10. Rastogi, V.B.; (2012) 1st Ed, Chordate Embryology, Kedar Nath Ram Nath
11. Carlson, B. M. (1999). Patten's Foundations in Embryology. 6th Ed. McGraw Hill.
12. Kalthoff, K., (2001). Analysis of Biological Development. 2nd Ed. McGraw Hill.
13. Moody, S.A. (Ed.) (2007). Principles of Developmental Genetics. Academic Press.
14. Shostak, S. (1991). Embryology - An Introduction to Developmental Biology. Harper Collins.
15. Slack, J. M. W. (2006). Essential Developmental Biology. 2nd Ed. Blackwell Publishing.

16. Twyman, R.W. (2001). Instant notes-Developmental Biology. Viva Books Private Ltd.
17. Verma, P.S. & Agarwal, V.K. (2005). Chordate Embryology. S. Chand & Company Ltd. New Delhi.
18. Wilt, F. H. & Hake, S. C. (2004). Principles of Developmental Biology. W. W. Norton Company.
19. Kardong K. (2004). An Introduction to Biological Evolution. McGraw Hill.
20. Page RDM, Holmes EC. (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell Sc
21. Rauchfuss H. (2010). Chemical Evolution and the Origin of Life. Springer.
22. Ridley M. (1996). Evolution. 2nd Edn. Blackwell Science.
23. Smith JM. (1998). Evolutionary Genetics. 2nd Edn. Oxford Univ Press.
24. Volpe EP, Rossenbaum PA. (1999). Evolution. McGraw Hill.
25. Darlington PJ. The Geographical Distribution of Animals, R.E. Krieger Pub Co
26. Dobzhansky T, Ayala FJ, Stebbins JL, Valentine JW. 1977. Evolution. Surajeet Pub., N.Delhi
27. Freeman S, Herron JC. 2016. Evolutionary Analysis. Pearson Education Limited, Noida, India.
28. Futuyma DJ. 1997. Evolutionary Biology. SinauerAssociates.
29. Ridley, M. (2004). *Evolution*. III Edition. Blackwell Publishing.
30. Barton, N.H., Briggs, D.E.G., Eisen, J.A., Goldstein, D.B. and Patel, N.H. (2007). *Evolution*. Cold Spring, Harbour Laboratory Press.
31. Hall, B. K. and Hallgrimsson, B. (2008). Strickberger's *Evolution*. IV Edition. Jones and Bartlett Publishers
32. Chattopadhyay, S (2014) LIFE: Evolution, adaptation, ethology, 3rd Ed, Books & Allied

SEMESTER-IV

Course Name	**MOLECULAR BIOLOGY**		
Course Code	**BSCHZOOC403**		
Course Type	**Core**		
Course Details	**CC-10**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 4 + Practical 2 = Total 6 credits**		

About the course :

The course provides an insight into the life processes at the subcellular and molecular levels. Other important aspects include DNA and molecular genetics including gene cloning, sequencing and gene mapping in addition to the powerful techniques that revolutionized the pharmaceutical, health and agricultural industries.

Learning outcomes :

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

- Develop an understanding of concepts, mechanisms and evolutionary significance and relevance of molecular biology in the current scenario.
- Get well versed in recombinant DNA technology which holds application in biomedical & genomic science, agriculture, environment management, etc. Therefore, a fundamental understanding of Molecular Biology will help in career building in all these fields.
- Apply their knowledge in problem solving and future course of their career development in higher education and research.
- Get new avenues of joining research in related areas such as therapeutic strategies or related opportunities in industry.

THEORY (CC-10)

Unit -1: Central dogma; Genome and Nuclic acid properties (13 Lectures)

Introduction to Molecular Biology,

1. Central Dogma of Molecular Biology.
2. Origin and evolution of Prokaryotic and Eukaryotic Genes and Genomes. Model Genomes (*E. coli, Arabidopsis thaliana)*; Mitochondrial genome.
3. DNA forms: Plasmid DNA, Genomic DNA and Repetitive DNA.
4. Structure and Topology of DNA (triple helix, G-quadruplex, supercoiled forms, linking number),
5. Physical properties of DNA: Denaturation-renaturation, cot curve, Hyperchromic shift, C-value paradox
6. DNA methylation; DNA-Protein interaction,
7. DNA polymorphisms (SNPs, SSLP, RAPD, RFLP, VNTR, RAPD, AFLP).
8. DNA and RNA as genetic material.

Unit –II: DNA replication, mismatch and repair (13 Lectures)

1. DNA Replication
2. Mesenson-Sthal Experiment
3. Replication models (Cairn's/D-loop, theta, rolling circle and linear model)
4. DNA replication in Prokaryote and Eukaryotes

5. DNA polymerases, other regulatory proteins,
6. Telomeric DNA replication and its significance,
7. DNA repair, mismatch repair, single strand- and double strand DNA repair.
8. Inhibitors of DNA replication.

Unit –III: RNA transcription, processing, editing, splicing etc. (13 Lectures)

1. Transcription in Prokaryotes & Eukaryotes: Chromatin remodeling (Acetylation, methylation and phosphorylation). Enzymes and Factors, Transcription unit and mechanism of transcription, Inhibitors of Transcription.
2. RNA processing: 5'-capping and 3'-polyadenylation of mRNA, Splicing of hnRNA into mRNA (Spliceosome complex), rRNA and tRNA modifications and processing; RNA editing, alternative splicing.

Unit –IV: Genetic Code and Translation (13 Lectures)

1. Genetic Code and its features, Wobble hypothesis, Discovery of genetic code.
2. Mechanism of Translation in *E. coli* and eukaryotic cell *(*Aminoacylation of tRNA, initiation, elongation, peptide bond formation, translocation, termination, Recycling of ribosome, Inhibitors of translation)
3. Regulation of Translation and codon bias.
4. Post-translational modifications and processing of proteins, protein trafficking.

PRACTICAL (CC-10)

1. Preparation of ball and stick model for B-DNA molecule (A=T and G=C base pairs).
2. Isolation of genomic DNA by ethanol precipitation method.
3. Isolation of the plasmid DNA from the *E. coli* culture by alkaline lysis method (Chart demonstration).
4. Agarose gel electrophoresis of the plasmid DNA and the genomic DNA (Chart demonstration).
5. Staining of β-galactosidase activity in the DH5 alpha cells with pBlue script plasmid by IPTG+X-Gal as an example of induction of gene expression (Chart demonstration).
6. Qualitative and quantitative test for DNA (Diphenylamine method) & RNA (Orcinol method)
7. Study and interpretation of electron micrographs/ photograph showing- (a) DNA replication (b) Transcription (c) Split genes, (d) chromosomal bandings, (e) DNA types.
8. Group discussion or Seminar presentation on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Eukaryotic genome	2. Regulation of gene expression	3. Genetic code
4. DNA damage and repair	5. Central dogma of molecular biology	6. Why Lagging strand?
7. RNA editing and splicing	8. Why Telomerase is crucial in eukaryote DNA replication?	9. DNA polymorphisms & significance
10. RNA interference	11. Chromatin remodeling	12. Splicing & its significance

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment (Sl no 2,6 / any one)-Principle-1, procedure-2, Experiment-3, result and inference-2, (**8**) 2. Identification (Sl no 7)-Naming-0.5 and features-1.5 (2 x 4=**8**) 3. LNB -**2** 4. Viva-**2**

NOTE :

- *Identification could be done by using slide, card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Watson, J.D. *et al.* (2013) Molecular Biology of the Gene (7th edition) CSHL Press Pearson.
2. Green, M. R and Sambrook, J. (2012) Molecular Cloning: a Laboratory Protocol (4th edition) CSHL Press.
3. Walter, P. (2007) Molecular Biology of the Cell (5th edition) Garland Science.
4. Alberts B et al. (2008). Molecular Biology of the Cell. V Edition, Garland publishing Inc.
5. Allison LA. (2007). Fundamental Molecular Biology. Blackwell Publishing.
6. Karp G. (2008). Cell and Molecular biology: Concepts and Application. 5th Edn, John Wiley.
7. Lackie JM. (2013). Dictionary of Molecular Biology. Academic Press.
8. Lodish, B, Matsudaira, K B, Plough, A and Martin ;(2016). Molecular Cell Biology. W.H. Freeman
9. Meyers R.A. – Molecular Biology and Biotechnology; VCH Pub.
10. Pal A.(2011). Textbook of Cell and Molecular Biology 3rd Ed, Books and Allied, Kolkata.
11. Russel PJ. (2010). iGenetics: A Molecular Approach, Pearson Benjamin
12. Strachan T. & A. Read – Human Molecular Genetics; BIOS Scientific
13. Turner, McLennan, Bales & White ;(2005). Instant Notes in Molecular Biology. Taylor Francis
14. Twyman R.M. (2005) – Advanced Molecular Biology; Springer

SEMESTER-IV

Course Name	**SERICULTURE**		
Course Code	**BSCHZOOSE401**		
Course Type	**Skill Enhancement Course**		
Course Details	**SEC-2**	**CA (Continuous Assessment)**	**Theory : 10 marks**
		ESE (End Semester Examination)	**Theory : 40 marks**
Credits	**Theory 4 = Total 4 credits**		

About the course :
The course gives insight into the principles of sustainable sericulture and how these principles can guide your silkmoth rearing into an enduring practice. The students will know about the laws and by laws governing keeping silkmoth.

Learning outcomes
Upon successful completion of this course, students should be able to:

- Generation of skilled man power in the field of sericulture,
- To impart training in extension management and transfer of technology,
- To impart training in Post Cocoon Technology,
- To provide field exposure.

THEORY (SEC-2)

Unit I: Silkworm distribution and races (12 Lectures)

1. The silkworms. Its morphological characteristics.
2. Distribution and types of races. Exotic and indigenous races of silkworm.
3. World silk production World map and silk road, spread of Sericulture to China, Europe, South Korea, Japan, India and other countries.
4. Tasar practices in tropical and temperate climate.

Unit II: Biology of silkworm and rearing technology (13 Lectures)

1. Mulberry and non-mulberry Sericulture (Silk worm and respective host plants).
2. Biology of silkworm (Mulberry and Tasar).
3. Selection of mulberry variety and establishment of mulberry garden (emphasis on chawki garden),
4. Incubation- definition, requirement of environmental conditions, incubation devices; identification of stages of development; black boxing and its importance.
5. Model Rearing house and uses of rearing appliances.
6. Silkworm rearing technology: Early age and Late age rearing Selection of silkworm races/breeds for rearing.
7. Types of mountages, Spinning, harvesting and storage of cocoons.

Unit III: Diseases & pests of silk worm with prevention & control (14 Lectures)

1. Introduction; classification of silkworm diseases.
2. Protozoan disease: symptomatology due to *Nosema bombycis* infection, source, mode of infection and transmission, cross infectivity, prevention and control.

3. Bacterial, Viral, Fungal diseases: causative agents, symptoms, transmission prevention and control.
4. Pests of silk worms (Uzi fly, Dermestid beetle).
5. Disinfectants: Formalin, bleaching powder RKO.

Unit IV: Prospects of Sericulture in India (13 Lectures)

1. Importance of mulberry silk.
2. Forestry and non-mulberry sericulture.
3. Silk industry in different states, employment, potential in mulberry and non-mulberry sericulture.
4. Employment generation in sericulture: Role of women in sericulture.
5. Sericultural practices in rain-fed and irrigated conditions;
6. Sericulture organization in India; Role of state departments of Sericulture, Central Silk Board, Universities and NGOs in Sericulture development.

Recommended readings:

1. Manual on sericulture (1976). Rome : Food and Agriculture Organization of the United Nations, Agricultural Services Division.
2. Ullal, S.R. and . Narasimhanna, M.N. (1987) Handbook of Practical Sericulture: CSB, Bangalore.
3. Silkworm Rearing and Disease of Silkworm (1956) Ptd. By Director of Ptg., Stn. & Pub. Govt. Press, Bangalore
4. Jolly, M. S. (1986) Appropriate Sericultural Techniques; Ed., Director, CSR & TI, Mysore.
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1 (1972) Fuzi Pub. Co. Ltd., Tokyo, Japan.
6. Narasimhanna, M. N. (1988) Manual of Silkworm Egg Production;, CSB, Bangalore.
7. Sengupta, K. (1989) A Guide for Bivoltine Sericulture. CSR & TI, Mysore.

SEMESTER-IV

Course Name	**INSECT PEST, VECTOR BIOLOGY AND MANAGEMENT**		
Course Code	**BSCHZOOSE402**		
Course Type	**Skill Enhancement Course**		
Course Details	**SEC-2**	**CA (Continuous Assessment)**	**Theory : 10 marks**
		ESE (End Semester Examination)	**Theory : 40 marks**
Credits	**Theory 4 = Total 4 credits**		

About the course :
The course provides an insight into the types of insect pests and vectors and the factors driving their spread. It also enlightens about the methods used to bring down their population below the threshold for a better management.

Learning outcomes
Upon successful completion of this course, students should be able to:

- **Identify the types of insect pests particularly the most common one.**
- **Know the methods of sampling of the pests.**
- **Understand the mode of action of nematicides and the consequences of their use.**
- **Understand the effective way of insect pest management strategy.**

THEORY (SEC-2)

UNIT I : Background to Insect Pests and Vectors (13 Lectures)

1. Insect pests and vectors of plant and animal diseases.
2. Pest status: (major, minor, occasional, migrant).
3. Human practices and pest occurrence. Disease outbreaks.
4. Population dynamics of pest.
5. Density dependent and independent factors affecting pest and vector population.
6. Allocation of sampling units. Sampling and monitoring methods of arthropod pests.

UNIT II: Approaches to Insect Pest and Vector Management (13 Lectures)

1. Insecticides. Types of insecticides, Formulation; Toxicity and safety.
2. Application of insecticides: Droplet size;
3. Application equipment Problems associated with using insecticides.
4. Environmental and cultural control (Irrigation, Fertilizer, Sanitation, Alternate hosts, Multiple and intercropping, Separation in time and space, Crop geometry).
5. Host resistance: Basis for resistance, mechanisms of resistance.

UNIT III: Approaches to Insect Pest and Vector Management (14 Lectures)

1. Biocontrol agents: Predators, Parasitoids, Parasites.
2. Pathogens as biocontrol agent: fungi, viruses, bacteria, microsporidia, nematodes, arthropods.
3. Transmission of pathogens. Area-wise management of pest.
4. Techniques of biocontrol: constraints and reasons for failure of biocontrol.

5. Use of pheromones/ allelochemicals in pest management; Mating disruption/confusion, Alarm pheromones and oviposition deterrents; repellents.
6. Exclusion and barriers, Traps. Physical disturbance.
7. Use of Larvivorous Fish and plants in vector control.

UNIT IV: Legislation and other alternatives of pest control (12 Lectures)

1. Exclusion and routes of entry.
2. Risk assessment; Damage thresholds Forecasting;
3. Genetically modified organisms: pest control property and concerned issues.
4. Integrated vector management. The integrated control/ IPM; Constraints towards IPM adoption.
5. Eradication versus management concept.
6. Increasing agroecosystem resistance Legislation for Pesticide use; Effects of regulation;

Recommended readings:

1. Van Emden, H.F. and M.W. Service. (2004) Pest and Vector Control. Cambridge University Press.
2. Cameron, M. & Lorenz, L. (2013) Biological and Environmental Control of Disease Vectors. CABI, UK
3. Chaterjee, K.D. (1981) Parasitology : Protozoology and Helminththology : Introduction to Clinical Medicine.(12th .Edition) Chaterjee Medical Publishers
4. Mullen, G. and Durden L. (2009). Medical and veterinary entomology, Academic press, London.
5. Kochchar, S.K. (2009). A Text Book of Parasitology. Wisdom Press

SEMESTER-V

Course Name	**BIOTECHNIQUES**		
Course Code	**BSCHZOOC501**		
Course Type	**CORE**		
Course Details	**CC-11**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 6 + Practical 2 = Total 6 credits**		

About the course :

This is the only laboratory course taught independently of lecture courses. It has full hands on approach to expose the students to modern techniques and methodologies. The diverse techniques from microscopy to spectroscopy, calorimetry, chromatography ELISA, tissue culture to cloning etc. are included to make the student well versed with these protocols and methods.

Learning outcomes

Upon successful completion of this course, students should be able to:

- Understand the purpose of the technique, its proper use and possible modifications/ improvement.
- Learn the theoretical basis of technique, its principle of working and its correct application.
- Learn the construction repair and adjustment of any equipment required for a technique.
- Learn the accuracy of technique.
- Learn the maintenance laboratory equipments / tools, safety hazards and precautions.
- Understand the technique of cell and tissue culture. Learn the preparation of solution of given percentage and molarity.
- Understand the process of preparation of buffer. Learn the techniques of separation of amino acids, proteins and nucleic acids.

THEORY (CC-11)

UNIT I : Microscopy (13 Lectures)

1. Microscopy: Introduction to Microscopy (Discovery, General structure).
2. Definitions-Resolving Power, Limit of Resolution and Magnification, Numerical Aperture.
3. Types of Light microscopes; bright field, dark-field, phase contrast.
4. Basic principles and applications of Light, Electron (SEM, TEM, STEM), Fluorescence and Confocal Microscopy.
5. Measurements (Micrometer), Drawings (Camera Lucida) and photomicrography [Imaging living cell and tissues (Wilson-walker,6Ed, p-151/Principle and Application)].
6. Tissue processing in SEM.

UNIT II : Tools and techniques in Biochemistry and Physiology (13 Lectures)

1. Biochemistry and Physiology: Physiological Salines, Concept of Normality and Molarity. Buffers and the use of pH meter.
2. Extraction of Tissue Glycogen, Proteins, Lipids and Nucleic Acids by Graaf's Method.
3. Principles and types of Centrifugation, Differential centrifugation.
4. Basic Principle and Application of Colorimetry and Spectrophotometry, Beer-Lambert's Law.

5. Principle and applications of Electrophoresis: Separation of Biomolecules by Native PAGE, 2D PAGE. Agarose gel electrophoresis.
6. Principle and Applications of Paper chromatography, Thin layer chromatography, Gel-filtration chromatography.

UNIT III : Tools and Techniques in Endocrinology and immunology (13 Lectures)

1. Immunology and Endocrinology: Introduction to Antigens, Antibodies, Adjuvants.
2. Raising Polyclonal and Monoclonal Antibodies.
3. Antigen-Antibody Interactions- Immunodiffusion, Ouchterlony's Double Immunodiffusion, Immuno-electrophoresis (Counter-Current, Rocket)
4. Principle and methodology: Western Blotting, ELISA, RIA.
5. Application of Immunological techniques (western blot, ELISA, RIA, EIA, Coombs test, Widal test, etc) in disease diagnosis.
6. Tracer techniques: Principle and Applications, Unit of radioactivity, half-life and measurement of radioactivity.

UNIT IV: Cell culture, maintenance of Laboratory animals (13 Lectures)

1. Introduction to Cell Culture**:** Cell culture (in vitro, in vivo, ex vivo) and its basic requirements (laboratory facility), application and limitation of animal cell culture.
2. Culture media Nutrient and Non-nutrient, commonly used media for human cell lines.
3. Sterilization of culture wares and Media, use of laminar flow.
4. Types of animal cell culture (primary and secondary),
5. Cell counting (Flow cytometer, haemocytometer) and cell viability testing (Trypan blue exclusion).
6. **C**ryopreservation (principle, cryopreservant, methodologies, cryoprotectant, revival/thawing, factors for good survivality, banking of cell lines, advantages, applications).
7. Cell harvesting and Storage Methods.
8. *In Vitro* culture of *Entamoeba histolytica, Coenorhabditis elegans*.
9. Maintenance and Handling of cell lines, laboratory rats and rabbits.
10. Good laboratory practice (GLP) & Bioethics.

PRACTICAL (CC-11)

1. Preparation of buffer and determination of pH by pH meter.
2. Identification of amino acids in the mixture using paper chromatography.
3. Verification of laws of spectrophotometry (using standard.
4. Separation of proteins using SDS-PAGE.
5. Testing of Cell viability (Trypan blue exclusion) from onion root tip/blood cell/peritoneal macrophage of mouse.
6. Preparation of permanent slides of microscopic organisms/ small insects.

7. Demonstration of bright field, phase contrast, fluorescence, confocal and electron microscopes.
8. Visit to a Research Laboratory/institute of repute and prepare a report on your learning/understanding/experience.
9. Group discussion or Seminar presentation on a related topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Cryopreservation	2. Immuno-technology & disease diagnosis	3. Animal cell culture
4. SEM vs TEM	5. Techniques involving separation of biomolecules.	6. Hybridoma technology
7. Tracer technique	8. Principles of Florescence and confocal microscopes	9. Light microscopy
10. ELISA & RIA	11. Applications of calorimetry and spectrophotometry	12. Cell fractionation

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment A (Sl no 1, 2)-Principle-1, procedure-1.5, Experiment-1.5, result and inference-2, (**6**) 2. Experiment B (Sl no 4,5,6)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 3. LNB & Field report-2+2=**4** 4. Viva-**2**
NOTE : • *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.* • *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.* • *Report should be made after completion a visit to Research laboratory / reputed Institute..* • *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*	

Recommended readings:

1. Pearse, A.G.E. (1980-1993) Histochemistry - Theoretical and applied, Volume I-III, Churchill-Livingstones.
2. Plummer, D. (2017) An Introduction to Practical Biochemistry (3rd edition) McGraw Hill.
3. Wilson, K. and Walker, J. (2010) Experimental Biochemistry, Cambridge.
4. Boyer, R. (2000). Modern Experimental Biology. Pearson Education. English Universities Cambridge Low-price Ed.
5. Cantor, C.R. & Schimmel, P.R. (2003). Biophysical chemistry (3 vol. set). W. H. Freeman & Co.
6. Bajpai, P.K. (2006). Biological Instrumentation and Methodology. 1st Ed. S. Chand & Company Ltd.
7. Ghoshal & Shrivastava (2009). Fundamentals of Bioanalytical Techniques and Instrumentation. PHI
8. Sharma, V. K. (1991). Techniques in Microscopy and Cell Biology. Tata-McGraw Hill.
9. Arya A & Kumar A, (2018) Methods in biology, 2nd Ed, Drawing Pin Publishing
10. Kumar, P.; (2016) Fundamentals and Techniques of Biophysics and Molecular Biology, 1st Ed, Pathfinder Publication
11. Roy, R.N. (2005). A Text Book of Biophysics. New Central Book Agency (P) Ltd. Kolkata.

SEMESTER-V

Course Name	**MICROBIOLOGY, PARASITOLOGY & IMMUNOLOGY**		
Course Code	**BSCHZOOC502**		
Course Type	**CORE**		
Course Details	**CC-12**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 6 + Practical 2 = Total 6 credits**		

About the course :

This is a composite course with remarkable utility and importance. Microbiology being the study of microorganisms such as viruses, bacteria etc., covers theoretical studies and practical proficiency training which may help in their placement at a clinical microbiological laboratory. Parasitology component takes care of the parasites and parasitism, emphasizing the influence of parasites on the ecology and evolution of free-living species, and the role of parasites in global, public, health. Immunology part provides the students with the fundamental knowledge of the immune system and its protective roles against diseases.

Learning outcomes

Upon successful completion of this course, students should be able to:

- Carry out common procedures for culturing, purifying and diagnostics of micro-organisms understand the disease-causing potential of bacteria and viruses, and the responses of the immune system.
- Summarise and orally present current microbiological problem areas.
- Describe the mechanisms for transmission, virulence and pathogenicity in pathogenic micro-organisms.
- Diagnose the causative agents, describe pathogenesis and treatment for important diseases like malaria, leishmaniasis, trypanosomiasis, toxoplasmosis, schistosomiasis, cysticercosis, filariasis etc.
- Assess the importance of incidence, prevalence and epidemiology in microbiological diagnostic activities. Know how resistance development and resistance transfer occur.
- Identify the major cellular and tissue components which comprise the innate and adaptive immune system.
- Understand how are immune responses by CD4 and CD8 T cells, and B cells, initiated and regulated.
- Understand how does the immune system distinguish self from non-self.
- Gain experience at reading and evaluating the scientific literature in the area.

THEORY (CC-12)

UNIT-I: Microbiology: A brief account of pathogenic viruses, bacteria and fungi. (13 Lectures)

1. Brief history of microbiology- germ theory of disease, discovery of penicillin.
2. Diversity of microbes- viruses and bacteria.
3. Host pathogen interaction: invasion, antigenic heterogeneity, toxins and enzymes secretions.
4. Kinetics of bacterial growth and principles of staining techniques.
5. **Viral diseases:** polio, rabies, hepatitis, influenza, NIPA, COVID-19, chicken pox, swine flu, dengue, chikungunya with emphasis on their causative agents, pathogenesis, diagnosis, prophylaxis and chemother[illegible].
6. **Bacterial diseases** caused by *Streptococcus pyogenes, Streptococcus pneumoniae, Salmonella typhi, Escherichia coli, Helicobacter pylori, Mycobacterium tuberculosis, Vibrio cholerae* with emphasis on pathogenesis, diagnosis, prophylaxis and chemotherapy.
7. **Fungal diseases:** Ringworm infection, aspergillosis, candidiasis with emphasis on pathogenesis, diagnosis, prophylaxis and chemotherapy.

UNIT-II: Parasitology: an overview of common parasitic infections. (13 Lectures)

1. Introduction to parasites and parasitic diseases.
2. Concept of zoonotic diseases.
3. Mode of transmission, portal of entry and implications (histological) of parasitism.
4. Parasitic adaptations in helminths.
8. Protozoan diseases of medical importance: amoebiasis, giardiasis, malaria, leshmaniasis (Life cycle, pathogenesis, prophylaxis and Treatment).
9. Helminthic diseases of medical importance: taeniasis, ascariasis, enterobiasis, and filariasis (Life cycle, pathogenesis, prophylaxis and Treatment).

UNIT-III: Immunology: Immune mechanism and related pathways. (13 Lectures)

1. Definition and classification.
2. Cells and organs of immune system- primary and secondary lymphoid organs.
3. Innate immunity: First and second lines of defense.
4. Characteristics of antigen- antigenicity and immunogenicity, epitopes, haptens, adjuvant. Factors influencing immunogenicity.
5. Classical and molecular structure of immunoglobulin.
6. Classification, properties and functions of immunoglobulins.
7. Antigenic determinants: isotype, allotype and idiotype.
8. Antigen and antibody interactions, affinity, avidity.
9. Complement system (Classical, alternative and lectin pathways).

UNIT-IV: Acquired immunity, Hypersensitivity and autoimmune disorders (13 Lectures)

1. Acquired immunity: Humoral and cell mediated immune response.
2. Role of B and T cell in immunity.
3. Receptors, activation and differentiation of B and T cells.
4. Cytokines: Properties and function.
5. MHC complex and molecules with classification and function. Graft rejection.
6. Antigen processing and their presentation; cross presentation of exogenous antigen.
7. Hypersensitivity: Gell and Coomb's classification with mechanism and examples. Concept of tolerance.
8. Autoimmune disorders (with ref to Pernicious anaemia, Rheumatoid arthritis, Hashimoto's disease, Myasthenia gravis)
9. Hybridoma technology, monoclonal antibodies and their applications (therapeutics and diagnosis),
10. Immunotoxins and their applications.

PRACTICAL (CC-12)

1. Study of permanent slides and specimens of parasitic protozoans and helminthes (as per theory syllabus).
2. Pathological study (chart photograph): sputum, blood, urine and stool.
3. Blood: Erythrocyte Sedimentation Rate (ESR), Haematocrit value; ABO Blood group antigen determination by heamagglutination.
4. Staining and identification of Gram positive and Gram negative bacteria.
5. Preparation of thin and thick blood films to diagnose *Plasmodium* infections.
6. Preparation of temporary and permanent slides of faecal matter (cockroach/Ungulate) by saline preparation and concentration techniques to identify cysts of parasitic protozoans and helminthes eggs.
7. Demonstration of antigen-antibody interaction in gel.
8. Separation of γ-globulin by salt precipitation.
9. Group discussion / Seminar presentation on a related topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Autoimmune diseases	2. Hybridoma technology and its applications	3. Helminth infections in humans
4. Concept of Immunity	5. Immunological memory & Vaccination	6. Fungal infections in human
7. Zoonotic diseases	8. Host-parasite interaction	9. Common bacterial diseases
10. Hypersensitivity	11. Antigen-antibody interaction	12. Diseases caused by viruses

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Identification (Sl no 1, 2, 5)- Sc. Name-0.5, Character-1, Pathological importance-0.5 (2x4=**8**) 2. Experiment/slide preparation (Sl no 3 to 8)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 3. LNB -**2** 4. Viva-**2**

NOTE :

- *Study includes identification, systematic position (major taxon), identifying character, pathological significance.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings

1. Paniker CKJ, Ghosh S; (2013). Paniker's Text Book of Medical Parasitology. Jaypee
2. Kanungu R., (2020) Ananthanarayan and Paniker's Textbook of Microbiology, 11th Ed, Universities Press (India) Pvt. Ltd.
3. Jawetz, M. and Adelberg (2015) Medical Microbiology (27th edition).
4. Chatterjee, K.D (2015) Parasitology (13th edition). CBS Publishers
5. Ahmed N, Dawson M, Smith C, Wood Ed. (2007). Biology of Disease. Taylor and Francis Group.
6. Arora D R, Arora B. (2001). Medical Parasitology. II Edition. CBS Publications and Distributors
7. Bogitsch B J, Carter CE, Oeltmann TN. 2013. Human Parasitology. 4th Edn. Elsevier.
8. Bose M. (2017). Parasitoses and zoonoses. New Central Book Agency.
9. Chakraborty P. (2016).. Textbook of Medical parasitology, 3rd edition. New Central Book Agency.
10. Dailey MD. (1996). Meyer, Olsen & Schmidt's Essentials of Parasitology. W.C. Brown Publishers
11. John DT, Petri WA. 2006. Markell and Voge's Medical Parasitology. Elsevier.
12. Marr JJ, Nilsen TW, Komuniecki RW. 2003. Molecular Medical Parasiology. 2nd Edn. Academic Press.
13. Muller R, Wakelin D. 2002. Worms and Human Disease. CAB International Publication.
14. Noble ER, Noble GA. (1982). Parasitology: The biology of animal parasites. Lea & Febiger

15. Parija SC. (2013). Textbook of medical parasitology, protozoology & helminthology II Edition, All India Publishers and Distributers, Medical Books Publishers, Chennai, Delhi.
16. Baveja V. & Baveja C.P.; (2021) Parasitology, 5th Ed, Arya Publishing Company
17. Baveja C.P.; (2018) A textbook of Microbiology,6th Ed, Arya Publishing Company
18. Baker S., et al (2012) BIOS Instant Notes in Microbiology, 4th Ed, Taylor & Francis
19. Madigan M.T.; *et. al.* (2017) Brock Biology of Microorganisms, 4th Ed, Pearson Education
20. Prakash, G.; (2012). Lab Manual on Blood Analysis and MedicalDiagnostics, S. Chand and Co Ltd.
21. Gunn A, Pitt SJ. (2012). Parasitology: an Integrated Approach. Wiley Blackwell.
22. Roitt, I.; Brostoff, J. and Male, D. (2012) Immunology (8th edition).Elsevier
23. Abbas K A, Lechtman H Andrew. (2003). Cellular and Molecular Immunology. Saunders Publication.
24. Abbas KA, Andrew, LH. (2011). Basic Immunology: Functions and Disorders of Immune System. Saunders Elsevier
25. Delves PJ, Martin SJ, Burton DR, Roitt I M. (2010). Roitt's Essential Immunology.11th Ed, Blackwell Pub.
26. Kindt TJ, Goldsby RA, Osborne BA, Kuby J (2006). Immunology, W.H. Freeman and Company.
27. Mohanty SK , Leela KS. (2014). Text book of Immunology. 2nd Edn. Jaypee Pub. N. Delhi
28. Parija SC. (2012). Text book of Microbiology and Immunology. Elsevier.
29. Playfair, JHL, Chain BM (2001). Immunology at a glance. 7 th Edn. Blackwell Pub.
30. Shetty N. (2005). Immunology: Introductory Textbook, New Age International Pub.
31. Fatima D and Arumugam N, (2014)Immunology, Saras publication
32. Ramesh S.R. (2017)Immunology; 1st Ed, McGraw Hill Education India Private Limited
33. Khanna R.,(2011)Immunology; 1st Ed, Oxford University Press
34. Virella G. 2007. Medical Immunology, Informa Healthcare.
35. Chakraborty A.K., (2006) Immunology and Immunotechnology, 1st Ed, Oxford University Press
36. Annadurai B., (2010) A textbook of Immunology and Immunotechnology, 1st Ed, S.Chand Pub.
37. Ghosh S., (2017) Immunology and Immunotechnology, 1st Ed, Books & Allied.
38. Paul A., (2015) Textbook of Immunology : including Immunotechnology & Immunotherapy, 1st Ed, Books & Allied.
39. Pelczar: (1993) Microbiology, Tata McGraw Hill,
40. Davis: (1980) Microbiology, 3rd Ed Harper & Row, Publ. Inc.,
41. Dubey and Maheshwari: An Introduction to Microbiology, S Chand Publications, New Delhi

SEMESTER-V

Course Name	**GENETIC ENGINEERING AND BIOTECHNOLOGY**		
Course Code	**BSCHZOODSE501**		
Course Type	**Discipline Specific Elective**		
Course Details	**DSEC-1 OR DSEC-2**	**CA (Continuous Assessment)**	**Theory : 10 marks**
			Practical : 30 marks
		ESE (End Semester Examination)	**Theory : 40 marks**
			Practical : 20 marks
Credits	**Theory 4 + Practical 2 = Total 6 credits**		

About the course :
This course gives an insight into the direct manipulation of DNA to alter the characteristics of an organism in a particular way. It envisages concepts, mechanisms, biological designs, functions and evolutionary significance of genetic modification or manipulation in special organisms and also discusses the recent advance in recombinant DNA technology.

Learning outcomes
Upon successful completion of this course, students should be able to:

- Develop an understanding of the fundamental molecular tools and their applications of DNA modification and cloning.
- Appreciate shifting their orientation of learning from a descriptive explanation of biology to a unique style of learning through graphic designs and quantitative parameters to realize how such research and innovations have made science interdisciplinary and applied.
- Develop future course of their career development in higher education and research with a sound base.
- Apply their knowledge with problem solving approach to recommend strategies of genetic engineering for possible applications in Biotechnology and allied industry.

THEORY (DSEC-1 or 2)

UNIT I: Introduction to genetic engineering (13 Lectures)

1. Scope of Genetic Engineering and Biotechnology.
2. Enzymes as Tools for Genetic Engineering (basic idea): Restriction Enzymes, Restriction-Modification System, DNA-modifying enzymes, T4 and *E. coli* DNA Polymerase (Klenow), DNA-methylase, Polynucleotide Kinase, Ribonuclease-H, DNA-ligase, Taq DNA polymerase, Reverse Transcriptase, T7 and T3 RNA polymerases.
3. Vehicles for DNA cloning: Features and classification of Plasmid DNA vectors; Structural features of pSC101, pBR322, pUC8 Shuttle vector-pEB10, Cosmid vector, bacteriophage lambda derived vectors (Phagemid, M13), YAC, Ti Plasmid, SV40, Expression vector.

UNIT II: Recombination and cloning (13 Lectures)

1. DNA (Gene) cloning, recombinant DNA,
2. cDNA library, genomic library. Isolation of gene from gene library. Screening and identification of recombinant DNA clone from gene library.
3. Expression of recombinant protein from a DNA clone in bacteria and purification of the protein.
4. Some examples of the useful recombinant proteins: Insulin, Streptokinase, enzymes, antibodies, vaccines.

UNIT III: Recent advances in gene technology (13 Lectures)

1. Transgenic animals: Principle and application; ethical issues.
2. Mechanism of gene technology: Restriction enzyme digestion. Ligation, Cloning, Transformation, Calculation of transformation efficiency.
3. Fundamendal idea on Recent trends in Gene technology: Gene Targeting: Knock-ins and Knock-outs. Targeted Genome Editing: ZFNs, TALENs, CRISPRs. RNAi technology.

UNIT IV: Genomic studies; ethical issues in genetic engineering (13 Lectures)

1. DNA Sequencing (Sanger method) and Genome Analysis,
2. Human Genome Project and Human Genome Sequences.
3. Applications of Genetic Engineering and Biotechnology in agriculture, medicine and its economic and social implications, Ethical precautions.

PRACTICAL (DSEC-1 or 2)

1. **Video-graphic demonstrations** on the following topics- Microinjection, selection of recombinant clone, preparation of cDNA library, Knock-out method, CRISPR, RNAi, transgenic animal (zebra fish).
2. Chart presentation of Restriction enzyme digestion.
3. Separation of molecules (protein/DNA) using electrophoresis,
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from calcium chloride method.
6. Identification of vectors mentioned in theory by model/photograph.
7. Models / PPT presentation on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Growth hormone	2. Antibiotics from micro-organisms.	3. Streptokinase
4. Recombinant interferon	5. Microbial degradation of waste materials.	6. Insulin
7. Colony stimulating factors	8. Transgenic tomato & rice	9. Industrial enzymes

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment (Sl no 3 to 5)-Principle-2, procedure-2, Experiment/construction/calculation-4, result and inference-2, (**10**) 2. Identification (Sl no 6)- Sc. Name-0.5, Character-1, importance-0.5 (2x3=**6**) 3. LNB -**2** 4. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Primrose, S.B. and Twyman, R. (2014) Principles of Gene manipulation and Genomics (7th edition) Wiley-Blackwell.
2. Nicholl, D.S.T. (2008) An introduction to Genetic Engineering (3rd edition) Cambridge University Press.
3. Watson, J.D. (2006) Recombinant DNA (3rd edition) Cold Spring Harbor Laboratory Press.
4. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA:Genes and Genomes- A Short Course. III Edition, Freeman and Co.
5. Brown, T.A. (2010) Gene Cloning and DNA Analysis: An Introduction.6th Ed, Wiley-Blackwell.
6. A PBS Documentary entitled, "Playing God" [History of Genetic Engineering].
7. Das, H.K.; (2020) Genetic Engineering: Replication, Expression, Cloning, Manipulation, Wiley India.
8. Singh, B.D.; (2015) Expanding Horizons, 4th Ed, Kalyani Publishers.
9. Kumaresan V. (2014) Biotechnology –Saras publications
10. Balasubramaniam. D. C.F. A. Bryce, Dharmalingam. K. J. Green, Kunthala Jayaraman (2005) Concepts in Biotechnology, University Press (India) Pvt. Ltd.
11. Biotechnology Class XI & XII, (2019) NCERT Publication
12. Ignacimuthu, S. (1995), Basic Biotechnology, Tata McGraw Hill Publishing Company Ltd, New Delhi.
13. Howe, C., (2015) Gene Cloning and Manipulation; Cambridge University Press
14. Satyanarayana, U. and Chakrapani, U.; (2020) Biotechnology, Books & Allied Ltd
15. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology - Principles and Applications of Recombinant DNA. IV Edition, ASM press.
16. Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology; Academic Press.

SEMESTER-V

Course Name	LIVESTOCK MANAGEMENT AND ANIMAL HUSBANDRY		
Course Code	BSCHZOODSE502		
Course Type	Discipline Specific Elective		
Course Details	DSEC-1 OR DSEC-2	CA (Continuous Assessment)	Theory : 10 marks Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :
The course provides intensive study in livestock production, management, marketing, nutrition, breeding, production records, selection, animal health, waste management, and conservation practices.

Learning outcomes
Upon successful completion of this course, students should be able to:

- Understand skills and requirements necessary to find and maintain a job.
- Select and develop a breeding system for a livestock enterprise.
- Understand the importance of genetic improvement in animal production.
- Formulate feed rations for different classes of livestock.
- Identify common problems associated with livestock and horse herd health and solutions.
- Identify current and future issues relating to animal husbandry.
- Understand different marketing opportunities available for livestock production.

THEORY (DSEC-1 OR 2)

Unit I: Animal products and breeding systems (13 Lectures)

1. Scope of Livestock Industry; Livestock Enterprises; Issues in Animal Agriculture.
2. Animal Products: Importance of Animal Products; Beef; Pork; Lamb; Poultry Products.
3. Advanced Reproduction and Breeding: Reproductive Systems, Common Breeding Systems including cattle Breeding, and Goat Breeding,
4. Role of Hormones and environment on animal breeding. Reproductive Technologies (AI).

Unit II: Animal nutrition (13 Lectures)

1. Nutritional requirements: Energy requirements for maintenance, growth; Production of milk, egg, wool, and meat.
2. Carbohydrates & Fats, Protein, Minerals & Vitamins, Water etc. common Feedstuffs Systems for expressing energy value of foods in ruminants, pigs and poultry.
3. Application of Direct and indirect calorimetry. Advanced Ration Formulations.

Unit III: Maintenance of breeds (13 Lectures)

1. Common Breeds of Livestock: Breeds of Cattle, goat and poultry: Selecting live stocks;
2. Facilities and Equipment; Housing,
3. Maintenance and health care;
4. Management of breeding stocks and products.

5. Vaccination programmes and Deworming programmes.

Unit IV: Marketing and related issues. **(13 Lectures)**

1. Planning and Marketing; Culling, Forward Contracting, Backgrounding.
2. Quality control; Future prospects.
3. Basic principles of Genetics and tools for genetic improvement.
4. Current issues affecting the livestock industry

PRACTICAL (DSEC-1 OR 2)

1. Estimation (quantitative) of proteins in feed (Lowry).
2. Virtual demonstration of endocrine glands and their influence on growth of live stock.
3. Estimation of albumen and yolk quantity in eggs (name of test).
4. Estimation of calcium in egg shell (name of test).
5. Estimation of cholesterol and peroxides in meat (name of test).
6. **Group discussion or Seminar** presentation on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Dairy management	2. Breeding system and grading up	3. Livestock feed formulations
4. Poultry management	5. Pink revolution in India	6. Goat breeding and management
7. AI technology	8. White revolution in India	9. Scope of Livestock Industry in India

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment A (Sl no 1, 3)- Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 2. Experiment B (Sl no 4,5)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 3. LNB -**2** 4. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Taylor, R.E and Field, T.G. (2004).Scientific Farm Animal Production: An Induction to Animal Science. Prentice-Hall.
2. Acker, D. and Cunningham, M. (1998). Animal Science & Industry. Prentice-Hall.
3. Blakely, J. and Bade, D. (1985). The Science of Animal Husbandry. Prentice-Hall.
4. Cambell, J. and Lasley, J. (1975). The Science of Animals that Serve Mankind. McGraw-Hill.
5. Cooper, E. L. (1990). Agriscience: Fundamentals & Applications Delmer: Albany.
6. American Youth Horse Council (1999) Handbook: A Guide to Equine Care and Management.
7. Morrison, F. (1949). Feeds and Feeding (8th edition) Morrison: Ithaca
8. Handbook of Animal Husbandry, (2008) ICAR Publication, New Delhi.
9. Prasad, J.; (2016) Animal Husbandry and Dairy Science, Kalyani Publishers.
10. Banerjee, G.C.; (2019) A Textbook Of Animal Husbandry, 8Ed, Oxford & IBH publishing.
11. Banerjee, G.C.; (2019) Principles of animal nutrition and feeds, Revised Ed, Oxford & IBH publishing.
12. Reddy, D.V.; (2018) Principles Of Animal Nutrition And Feed Technology, 3Ed, Oxford & IBH publishing.

<table>
<tr><td>Course Name</td><td colspan="3">ENDOCRINOLOGY</td></tr>
<tr><td>Course Code</td><td colspan="3">BSCHZOODSE503</td></tr>
<tr><td>Course Type</td><td colspan="2">DSE</td><td>L-T-P: 4-0-4</td></tr>
<tr><td rowspan="4">Course Details</td><td rowspan="4">DSEC-1
OR
DSEC-2</td><td rowspan="2">CA (Continuous Assessment)</td><td>Theory : 10 marks</td></tr>
<tr><td>Practical : 30 marks</td></tr>
<tr><td rowspan="2">ESE (End Semester Examination)</td><td>Theory : 40 marks</td></tr>
<tr><td>Practical : 20 marks</td></tr>
<tr><td>Credits</td><td colspan="3">Theory 4 + Practical 2 = Total 6 credits</td></tr>
<tr><td colspan="4">About the course :
The course envisages information on endocrine system with emphasis on the structure of hypothalamus and anterior pituitary. The associated hormones and the related disorders will be explained.</td></tr>
<tr><td colspan="4">Learning outcomes :
After successfully completing this course, the students will be able to:
➢ Understand neurohormones and neurosecretions.
➢ Learn about hypothalamo and hypapophysial axis.
➢ Understand about different endocrine glands and their disorders.
➢ Understand the mechanism of hormone action.</td></tr>
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THEORY (Endocrinology)

Unit-I: The chemical messangers **8 Lectures**

1. Definition and classification of hormores.
2. Endocrine, paracrine and autocrine modes of hormone delivery, Feedback mechanism.

Unit II: Hypothalamo-hypophysial Axis **20 Lectures**

1. Structure of pineal gland, Secretions and their functions in biological rhythms and reproduction;
2. Structure of hypothalamus, Hypothalamic nuclei and their functions;
3. Regulation of neuroendocrine glands, Feedback mechanisms;
4. Structure of pituitary gland, Its hormones and their functions;
5. Hypothalamo-hypophysial portal system;
6. Disorders of pituitary gland.

Unit-III: Peripheral Endocrine Glands **20 Lectures**

1. Structure, Hormones, Functions and Regulation of Thyroid gland;
2. Parathyroid & Adrenal glands; Pancreas; Ovary and Testis;
3. Hormones in homeostasis;
4. Disorders of endocrine glands.

Unit-IV: Regulation of Hormone Action **12 Lectures**

1. Hormone action at Cellular level: Hormone receptors;
2. Transduction and regulation of Hormone action at Molecular level;
3. Molecular mediators; Genetic control of hormone action.

PRACTICAL (Endocrinology)

1. Identification of the permanent slides of endocrine glands (Ovary, Testes, Pancreas, Thyroid, Adrenal).
2. Dissection and demonstration of Endocrine glands in rat.
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(Demo.).
6. Designing of primers of any hormone (Demo.).
7. **Group discussion or Seminar presentation** on topics (Given Below).

*Optional

Pool of Topics for Group discussion or Seminar presentation :		
1. Feedback mechanism	2. Hormone -a chemical messenger	3. Exocrine vs Endocrine system
4. Neurohormone	5. Hypothalamus and biorhythm	6. Catecholamine hormone
7. Pituitary-the master gland	8. Thyroid gland and metabolism	9. Androgenic hormones
10. Hormones in homeostasis	11. Genetic control of hormone action.	12. Hormone action

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Dissection (Sl no 2, any one)-Dissection-4, Display-2, Drawing-2, Labelling -2, (10) 2. Identification (Sl no 1)-Naming-0.5 and features-1.5 (2 x 3=6) 3. LNB-2 4. VIVA-2

NOTE :

- *Identification of behaviour/nest/ethogram could be done by using card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Suggested readings:

1. Turner, C. D. (1971) General Endocrinology, Pub- Saunders Toppan.
2. Nussey, S.S.; and Whitehead, S.A. (2001) Endocrinology: An Integrated Approach, Oxford: BIOS Scientific Publishers.
3. 3. Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey.
4. David, O.N. (2013) Vertebrate Endocrinology.

SEMESTER-VI

Course Name	BIOSTATISTICS & BIOINFORMATICS		
Course Code	BSCHZOOC601		
Course Type	CORE		
Course Details	CC-13	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 6 + Practical 2 = Total 6 credits		

About the course :

The course is aimed at introducing the application of bioinformatics and statistics in biology. The course gives an insight into the key concepts and methods used in bioinformatics; and computer storage, retrieval, analysis, visualization and distribution of information data related to biological macromolecules like DNA, RNA and proteins. It provides foundation on statistical methods to enable students to compute and interpret basic statistical parameters. As an interdisciplinary field it integrates biology, computer science, chemistry and statistics together sequence analysis structure analysis and functional analysis of biological data.

Learning outcomes

Upon successful completion of this course, students should be able to:

- Know the theory behind fundamental bioinformatics analysis methods/tool.
- Be familiar with widely used bioinformatics databases.
- Know basic concepts of probability and statistics.
- Describe statistical methods and probability distributions relevant for molecular biology data.
- Know the applications and limitations of different bioinformatics and statistical methods.
- Perform and interpret bioinformatics and statistical analyses with real molecular biology data.
- Acquire knowledge of various databases of proteins, nucleic acids. Primary, secondary and composite databases. BLAST, FASTA, DOT PLOT
- Make phylogenetic predictions or prediction of structure of proteins and nucleic acids
- Develop understanding in Primer designing
- Understand data mining tool and its practical application in a case study
- Apply the knowledge in future course of their career development in higher education and research.

THEORY (CC-13)

UNIT I: Data collection, distribution, presentation, authentication and analysis (13 Lectures)

1. Collection and classification of data.
2. Graphical representation of data: Pie chart, Bar diagram, Histogram, Frequency polygon.
3. Cumulative frequency curve (Ogive), Box plot.
4. Probability theory: Binomial distribution, Poisson distributions.
5. Measures of central tendency: Arithmetic Mean, Median, Mode;
6. Measures of dispersion: Variance, Standard deviation and Standard error, Concept of Coefficient of variation.

UNIT II: Correlation, regression, analysis of variance etc. (12 Lectures)

1. Correlation: Types of correlation, Calculation of correlation in continuous data and ordinal data.
2. Regression: Linear regression, regression coefficient.
3. Analysis of variance (ANOVA): One way, post-hoc tests.

4. Hypothesis testing: Parametric tests (Paired and unpaired t-test,) & Non-Parametric tests (Chi-square test).

UNIT III: Basics of IT; Data archiving systems etc (12 Lectures)

1. Introduction and scope of bioinformatics: concept of digital laboratory.
2. Basics of protocol (TCP/IP), hypertext, home-page, web-page and uniform resource locators information technology, computer, operating systems (Windows, Linux), network.
3. Concept of internet (URL).
4. Introduction to data archiving systems (FASTA format, Accession, and GI Number)

UNIT IV: Data base management: software, packages and tools (15 Lectures)

1. Basic features and management systems of following: Nucleic acid sequences databases (NCBI), Genome databases (NCBI), Protein sequence (PDB), structures and interacting proteins databases (RASMOL), Literature databases (NCBI/PDB), Biodiversity and ecosystem based databases.
2. Introduction to data retrieval systems, Search engines, Entrez, sequence retrieval system (SRS) and protein identification resource (PIR).
3. Introduction to molecular sequence analysis software packages and tools, Prediction of motifs, folds and domains, Sequence alignments (BLAST and Clustal W) and phylogenetic trees (Clustal W).
4. Comparative analysis of metabolomics databases (Genomics, proteomics and Transcriptomics)
5. Applications of bioinformatics: Clinical informatics (Data compilation and interpretation for community and new resource of pathogen), Cheminformatic resources (Structure and interaction with several different kinds of molecules) and pharmacoinformatics (Drug and vaccine designing).

PRACTICAL (CC-13)

1. Calculation of mean, standard deviation and standard error.
2. Calculation of correlation coefficient values and finding out the probability.
3. Student's t-test: Independent and dependent. Hand calculation and calculation using MS Excel.
4. ANOVA and Tukey's HSD: Hand calculation and calculation using MS Excel.
5. Handling, Sequence retrieval and interpretation of Nucleic acid and protein from respective databases.
6. Pair-wise alignment of sequences (BLAST) and interpretation of the output.
7. Sequence homology and Gene annotation.
8. Translation of a nucleotide sequence and selection of the correct reading frame of the polypeptide from the output sequences (Snap Gene).
9. Construction of phylogenetic tree (Clustal W).
10. Comparative analysis of different databases in Genomics and Proteomics.
11. Group discussion or Seminar presentation on following topic :

Pool of Topics for Group discussion or Seminar presentation :		
1. DNA barcoding	2. Application of metabolomics databases	3. Basics of informaion technology
4. Student -t test & utility	5. Graphical representation of biological results	6. Sequences alignment (BLAST)
7. Database management	8. Use of bioinformatics in biological research	9. MS-Excel and Histogram
10. Central Tendency	11. Information technology in data acquisition and retrieval	12. Bioprospecting and Biopiracy
13. Drug designing	14. Statistical methods of hypothesis testing	15. Phylogenetic tree (ClustalW)

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment A (Sl no 1-5)- Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 2. Experiment B (Sl no 6-12)-Principle-1, procedure-1.5, Experiment-3, result and inference-2, precaution-0.5 (**8**) 3. LNB -**2** 4. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Daniel, W.W. & Cross C.L.; (2012) Biostatistics: A Foundation for Analysis in Health Sciences (10th edition) John Wiley.
2. Milton, J.S. & Tsokos, J.O. (1992) Statistical Methods in the Biological and Health Sciences (2nd edition) McGraw Hill.
3. Zar, J.H. (2013) Biostatistical Analysis (5th edition) Pearson.
4. Rastogi, V.B., (2015) Fundamentals of biostatistics. 3rd Ed, Medtech.
5. Arora P.N & Malhan, P.K.; (2016) Biostatistics, Himalaya Publishing House
6. Antonisamy B., et. al. (2017) Principles and Practice of Biostatistics, Elsevier India
7. Pezzullo, J., (2013) Biostatistics For Dummies, 1st Ed, For Dummies Pub. (Wiley)
8. Motulsky, H., (1996) Intuitive Biostatistics, 1st Ed, OUP USA
9. Motulsky, H., (2017) Intuitive Biostatistics: A Nonmathematical Guide to Statistical Thinking, 4th Ed, OUP USA
10. Barnes, M.R. and Gray, I.C. (2003) Bioinformatics for geneticists, Wiley.
11. Ghosh, J. and Mallick B.; (2008) Bioinformatics: Principles and Applications, OUP India
12. Rastogi, S.C. et. al.; (2013) Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, 4th Ed, PHI Ltd.
13. Bosu, A. & Thukral, S.K.; (2007) Bioinformatics: Experiments, Tools, Databases, and Algorithms, 1st Ed, Oxford Univ. Press.
14. Mount, D.W. (2006) Bioinformatics (2nd edition) CBS

SEMESTER-VI

Course Name	APPLIED ZOOLOGY		
Course Code	BSCHZOOC602		
Course Type	CORE		
Course Details	CC-14	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

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

- Understand the culture techniques of prawn, pearl and fish.
- Understand silkworms rearing and their products.
- Understand the Bee keeping equipments 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

THEORY (CC-14)

UNIT I: Aquaculture (13 Lectures)

1. **Prawn culture:**

   Fresh water prawn culture; Brackish water prawn culture; Preparation of farm. Induced breeding, eye stalk ablation, Disease management, Preservation and processing of prawn. Export of prawn.

2. **Pearl Culture:**

   Pearl formation process, Artificial pearl culture

3. **Fish Culture:**

   Various types of Pond management Induced breeding of common carp; Transport of fish fry to rearing ponds. Harvesting, preservation of fish. Composite fish farming. By products of fishing industry, Common fish diseases and management.

UNIT II: Apiculture, Lac culture and Sericulture (13 Lectures)

1. **Apiculture:**

   Species of honey bees in India. Life history of *Apis.* Indigenous and modern methods of Bee keeping and apiary management, Bee products and their uses. Natural enemies, disease and their control. Extraction and processing of honey.

2. **Lac culture:**

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

3. **Sericulture:**

   Types of silk; Silkworms and their host plants; Mulberry silkworm culture; Life history of silkworm; Natural enemies and their control.

UNIT III: Dairy management and poultry farming (13 Lectures)

1. **Dairy:**

   Introduction to common dairy animals. Techniques of dairy management. Milk and milk products.

   Cattle Diseases and management.

2. **Poultry:**

   Types of breeds. 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 and management. Nutritive value of egg and meet. Incubation and hatching of eggs.

UNIT IV: Vermiculture; (13 Lectures)

Biology of *Eisenia foetida*. Rearing of earthworms, Equipments , devices used in vermiculture, Vermicompost Technology. Methods and products, Vermiwash Collection, Composition and use.

PRACTICAL (CC-14)

1. Identification of *Pinctada*, Palaemon sp, *Bombyx mori, Eisenia foetida, Labeo rohita, Catla catla* and fowl breeds
2. Identification of spawn, fry, fingerling of rohu and catla.
3. Castes (through charts/specimens) study of bees,
4. **Mounting** of the sting apparatus and pollen basket of honey bee.
5. Worker honey bee with emphasis on leg modifications (through specimens/charts) and whole mount preparation of the 3 pairs of legs.
6. **Visit** to a pisciculture farm/ sericulture farm / apiary / poultry farm / cattle farm and submit a report.
7. **Group discussion or Seminar presentation** on following topic :

Pool of Topics for Group discussion or Seminar presentation :		
1. Deep litter Poultry farming	2. Apiculture & prospect in India	3. Pearl culture & prospect in India
4. Dairy management	5. Sericulture & prospect in India	6. Ornamental fishery in India
7. Composite Fish culture	8. Lac culture & prospect in India	9. Prawn culture & prospect in India
10. Poultry Diseases	11. Cattle diseases and their management	12. Vermicompost & organic farming

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Identification (Sl no 1-3)-Naming-0.5, character-1.5 (2X4=**8**) 2. Mounting (Sl no 4, 5)-Mounting-3, Drawing-2, labelling-1 (**6**) 3. LNB -**2** 4. Field report-**2** 5. Viva-**2**

NOTE :

- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

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.
4. Banerjee, G. C. (2014) A textbook of animal husbandry, Oxford & IBH.
5. Arumugam, N. (2014) Aquaculture and Fisheries, Saras Publication
6. Sarkar, Kundu & Chaki, (2014) Introduction to Economic Zoology, 1st Ed, NCBA
7. Banerjee T.K., (2016) Applied Zoology, 1st Ed, NCBA
8. Handbook of Fisheries and Aquaculture, ICAR Pub.

SEMESTER-VI

Course Name	**WILD LIFE CONSERVATION AND MANAGEMENT**		
Course Code	**BSCHZOODSE601**		
Course Type	**Discipline Specific Elective**		
Course Details	DSEC-3 OR DSEC-4	CA (Continuous Assessment)	Theory : 10 marks Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks Practical : 20 marks
Credits	**Theory 4 + Practical 2 = Total 6 credits**		

About the course :
The course is an introduction to wildlife management and gives an account of the tools used by wildlife managers. Topics covered are to equip students with adequate knowledge of various biodiversity monitoring methodologies, conservation and management issues of vertebrate pests, wildlife conflict and over abundant species, wildlife health and diseases.

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

- Develop an understanding of how animals interact with each other and their natural environment.
- Develop the ability to use the fundamental principles of wildlife ecology to solve local, regional and national conservation and management issues.
- Develop the ability to work collaboratively on team-based projects.
- Demonstrate proficiency in the writing, speaking, and critical thinking skills needed to become a wildlife technician.
- Gain an appreciation for the modern scope of scientific inquiry in the field of wildlife conservation management.
- Develop an ability to analyze, present and interpret wildlife conservation management information.

THEORY (DSEC-3 or 4)

Unit-I: Value of wildlife and need for its conservation (15 Lectures)

1. Definition, value and importance of wildlife;
2. Wildlife conservation, ethics and importance of conservation;
3. Ecosystem interaction, animal distribution in biome
4. Classification of wetland and animal inhabitants;
5. Population vulnerability analysis and its components;
6. Causes of depletion of wildlife w. r. t. extinction of animals;
7. Types of protected areas and the concept of zoning within the protected areas;
8. Wildlife Sanctuaries and National Parks in India: general strategies (policy) and issues;
9. Theories of population dispersal; Animal movement, concept of home range and territory;
10. Tracking movement by remote sensing and GIS.

Unit-II: Population and prey-predator dynamics (11 Lectures)

1. Impact of topography, geology, soil and water on wildlife population;
2. Impact of habitat destruction and fragmentation on wildlife population;
3. Biological parameters such as food, cover, forage and their impact on wild life population;
4. Population attributes; concepts of exponential and logistic growth rates of wildlife;
5. Density dependent and independent population regulation;
6. Impact of introduced species on preexisting flora and fauna of wildlife;

7. Identification and estimation of wild animals by fecal sample analysis, hair identification, pug marks and census methods.
8. Predator-prey models (Mathematical model-Lotka and Volterra) and impact of predation.

Unit-III: Wildlife Conservation (13 Lectures)

1. Wildlife conservation objectives- strategies and issues[Poaching, Forest fire, Mining, Hunting and illegal trading; Tourism; Wild life corridor; marine pollution]
2. Captive breeding techniques and translocation and reintroduction;
3. Inviolate area and critical habitats and their impact on wildlife;
4. Different terrestrial habitats of wildlife in India;
5. Restoration of degraded habitat;
6. Damage caused by wildlife in India and its mitigation;
7. Sick animal refuges in protected areas.

Unit-IV: Rehabilitation and management (13 Lectures)

1. Type of wildlife management-manipulative, custodial;
2. Management of over abundant wild animal populations causing damages to nearby inhabitants and their crops and animals;
3. Use of Tools (Compass, Binoculars, Spotting scope, Range Finders, Drone, radio collar, Camera trap) and techniques to control the menace of wild animals;
4. Man wildlife conflict resolution and mitigation;
5. Management of exotic and invasive wetland species in India.
6. Habitat manipulation– control and regulation of grazing. Weed eradication;
7. Major diseases of domestic and wild animals and their control and impact of wild life tourism.

PRACTICAL (DSEC-3 or 4)

1. Identification, ecotype with conservation status and preparation of colour album of flora (***Ginkgo biloba***, Red sandalwood), mammalian fauna (Himalayan musk deer, Gangetic dolphin, Golden langur, Pangolin, Fishing cat), avian fauna (Great Indian bustard, Pink headed duck), herpeto-fauna (Gharial, Rock python, King cobra, Indian star tortoise).
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
3. Familiarization and study by photographic plate of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques (wild life census: Jolly-Seber method) for flora and fauna.
7. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Sorenson's Similarity & Shannon-Weiner diversity indices for the same community.

8. **Visit to Forest**/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report
9. **Group discussion or Seminar presentation** on topics given below.

Pool of Topics for Group discussion or Seminar presentation :		
1. Project Tiger	2. Rhino vision in India	3. Crocodile conservation
4. Elephant project	5. Green corridor	6. Red data book
7. Ecotourism	8. GIS-Remote sensing & GPS	9. Wild life protection act
10. Invasive species	11. Man-wildlife conflict	12. Wetland management

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Estimation of Species abundance/richness from provided data (Sl no 7)-principle-1, Result & discussion-2+2 (**5**) 2. Identification (Sl no 1)- Naming-0.5, Conservation status-0.5, Ecotype-1, characters-1 (3x2=**6**) 3. Spotting (Sl no 3)- Naming-0.5, importance-0.5 (1x3=**3**) 4. LNB & Field report : (2 + 2) = **4** 5. Viva-**2**
NOTE : • *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.* • *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.* • *Field report should be submitted after completion the field visit.* • *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*	

Recommended readings:

1. Caughley, G., and Sinclair, A.R.E. (1994) Wildlife Ecology and Management. Blackwell Science.
2. Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005) People and Wildlife, Conflict or Co-existence? Cambridge University.
3. Bookhout, T.A. (1996) Research and Management Techniques for Wildlife and Habitats (5th Ed) The Wildlife Society, Allen Press.
4. Sutherland, W.J. (2000) The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.
5. Hunter M.L., Gibbs, J.B. and Sterling, E.J. (2008) Problem solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing
6. Mathur, R. (2018) Wildlife conservation and management, 1st Ed, Rastogi Pub.
7. Saha, G.K. and Mazumdar, S.; (2017) Wildlife Biology: An Indian Perspective, PHI Learning.
8. Paul R. Krausman & James W. Cain; (2013) Wildlife Management and Conservation – Contemporary Principles and Practices, Johns Hopkins University Press.
9. Fryxell, J.M., Sinclair, A.R.E and Caughley, G.; (2014) Wildlife Ecology, Conservation, and Management, 3rd Edition, Wiley-Blackwell

SEMESTER-VI

Course Name	MAMMALIAN PHYSIOLOGY		
Course Code	BSCHZOODSE602		
Course Type	DSE		L-T-P: 4-0-4
Course Details	DSEC-3 OR DSEC-4	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The course deals with various physiological functions in mammals. It also gives an account of the metabolic/ biochemical pathways and the probable impact of environment on them.

Learning outcomes :

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

- **Understand the physiology at cellular and system levels.**
- **Understand the mechanism and regulation of breathing, oxygen consumption and determination of respiratory quotient.**
- **Understand how mammalian body gets nutrition from different biomolecules.**
- **Understand the process of digestion and excretion.**
- **Understand the organization of nervous system and process of nerve conduction.**
- **Understand the process of vision and hearing.**
- **Understand the process of muscle contraction.**
- **Learn the determination of haemoglobin content, blood groups and blood pressure.**

THEORY (Mammalian Physiology)

Unit-I: An overview of respiration and circulation in mammals 12 Lectures

1. Respiration: Mechanism and regulation of breathing; Transport of oxygen and carbon dioxide; Respiratory quotient.
2. Circulation: Blood buffers, blood groups, blood cells, cardiac cycle, Haemopoiesis, homeostasis.

Unit-II: An overview of digestion and excretion in mammals 10 Lectures

1. Nutrition and Digestion: Balanced diet; Digestion and absorption of carbohydrates, proteins and fats; Gastrointestinal hormones: role in digestion.
2. Excretion: Nephron; urine formation; Regulation of urine formation: role of renin, ADH, aldosterone.

Unit-III: An overview of nervous system and coordination in mammals 16 Lectures

1. Nervous System: Organization, neuron and glial cells- types and structure;
2. Synapses – types and transmission, resting membrane potential: genesis;
3. Action potential: initiation and conduction.
4. Vision: Structure of eye, retinal components, and photoreceptors: ionic basis of potential generation.
5. Hearing: Structure of ear, Mechanoreceptor: ionic basis of potential generation.

Unit-IV: An overview of Muscular system and muscle contraction in mammals 11 Lectures

1. Muscles: Types, Ultra structure of skeletal, smooth and cardiac muscles, muscle proteins;
2. Neuromuscular junction;
3. Molecular and chemical basis of muscle contraction;
4. Characteristics of muscle twitch, tetanus and fatigue, isotonic and isometric contractions.

PRACTICAL(Mammalian Physiology)

1. Preparation of temporary mounts: Blood film, Squamous epithelium, Striated muscle fibres and nerve cells.
2. Counting of white blood corpuscles and red blood corpuscles
3. Preparation of haemin crystals.
4. Estimation of haemoglobin content
5. Determination of blood groups
6. Measurement of blood pressure using sphygmomanometer
7. Recording of simple muscle twitch with electrical stimulation (or Virtual)
8. Demonstration of reflex action.
9. Study of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney and brain cells.
10. **Group discussion or Seminar presentation** on topics (Given Below).

Pool of Topics for Group discussion or Seminar presentation :		
16. Physiology of Lung	17. CO_2 transport & Chloride shift	18. Oxygen dissociation curve
19. Cardiac cycle	20. Buffer systems in human	21. Gastrointestinal hormone
22. Hemopoiesis	23. Heart valves & its dysfunction	24. Neural regulation of digestion
25. Countercurrent & RAAS	26. Absorption of biomolecules in gut	27. Synaptic transmission
28. Action potential	29. Mechanism of hearing and seeing	30. Muscle physiology

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
5. Assessment based on practical topics (class test)-**10** 6. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 7. Attendance and Participation in class-**5** 8. Practical skills, laboratory reports, etc-**5**	5. Experiment (Sl no 2-8, any one)-Principle-1, procedure-2, Experiment-2, result -1, (6) 6. Mounting (sl no 1)- Mounting-2, Drawing-1 & labelling-1 (4) 7. Identification (Sl no 9)-Naming-0.5 and features-1.5 (2 x 3=6) 8. LNB-2 9. VIVA-2

NOTE :

- *Identification of behaviour/nest/ethogram could be done by using card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Barret, K.; Brooks, H.; Boitano, S. And Barman, S. (2010) Ganong's Review of Medical Physiology (23rd edition) Lange Medical.
2. Guyton, A.C. and Hall, J.E. (2006) A text book of Medical Physiology (11th edition) Saunders.
3. Keele, C.A. & Neil, E. (1989) Samson Wright's Applied Physiology (13th edition) Oxford.
4. Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology. XII Edition, John Wiley and Sons, Inc.
5. Chatterjee C.C. (2020) Human physiology: VOL 1 & 2, 13ED, CBS publishers.

SEMESTER-VI

Course Name	AQUATIC BIOLOGY		
Course Code	BSCHZOODSE603		
Course Type	DSE		L-T-P: 4-0-4
Course Details	DSEC-3 OR DSEC-4	CA (Continuous Assessment)	Theory : 10 marks
			Practical : 30 marks
		ESE (End Semester Examination)	Theory : 40 marks
			Practical : 20 marks
Credits	Theory 4 + Practical 2 = Total 6 credits		

About the course :

The program of study aims to provide students with a broad-based foundation in science together with extensive subject knowledge in the discipline of aquatic biology. It also aims to develop a range of transferable research, analytical and communication skills.

Learning outcomes :

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

- **Understand and apply relevant scientific principles in the area of aquatic biology.**
- **Employ scientific methodologies such as experimentation and data analysis in the area of aquatic biology.**
- **Critically analyse, interpret and evaluate information relevant to aquatic biology.**
- **Appreciate the multidisciplinary nature of the study of aquatic biology and engage positively with people and ideas beyond their own discipline.**
- **Explore some of the unique environmental problems dealing with aquatic environments.**
- **Develop employable skills in freshwater biological water quality analysis.**

THEORY (Aquatic biology)

UNIT – I Abiotic conditions of Freshwater ecosystems **14 Lectures**

1. Physical & chemical properties of water;
2. Brief introduction of the aquatic ecosystems.
3. Freshwater ecosystems (lakes, wetlands, streams and rivers).
4. Physico-chemical Characteristics of fresh water bodies: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity: dissolved gases (Oxygen, Carbon dioxide).
5. Origin and classification of lakes;
6. Streams: Different stages of stream development.

UNIT II Aquatic organisms **10 Lectures**

1. Feeding in aquatic organisms;
2. Respiration in aquatic organisms;
3. Osmoregulation in freshwater and marine organisms;
4. Adaptation of hill-stream fishes.
5. Adaptation of deep-sea organisms.

UNIT – III Abiotic conditions of marine ecosystems **14 Lectures**

1. Classification of marine ecosystem: Estuaries, intertidal zones, Oceanic pelagic zone, marine benthic zone.
2. Coral reefs (types, formation).

3. Physico-chemical environment, Salinity and density of sea water and Continental shelf; other factors viz., Light, Temperature, Thermal stratification, Dissolved Solids, Turbidity: dissolved gases (Oxygen, Carbon dioxide).

UNIT – IV Management of Aquatic Resources **14 Lectures**

1. Aquatic pollution - Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation.
2. Water pollution acts of India.
3. Sewage treatment and water quality assessment - BOD and COD.

PRACTICAL (Aquatic biology)

Practical

1. Physico-Chemical analysis of water - O_2, CO_2, BOD, COD.
2. Biological– Zooplanktons –population density of Zooplanktons of a lake.
3. Determination of Turbidity / transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake / water body.
4. Instruments used in limnology (Sacchi disc, van Dorn bottle, conductivity meter, Turbidity meter) and their utility.
5. Identification of Zooplankton- *Cyclops, Daphnia, Paramecium, Cypris*
6. **Excursion:** Study the topography of a natural lake in nearby area or Ramsar lake and submit a report.
7. **Group discussion or Seminar presentation** on topics (Given Below).

Pool of Topics for Group discussion or Seminar presentation :		
1. Pond Ecosystem	2. Physio-chemical properties of lake	3. Coral-a marine hotspot
4. Riverian Ecosystem	5. Osmoregulation in marine organisms	6. Eutrophication
7. Estuarian Ecosystem	8. Stages of stream development	9. Sewage treatment
10. Classification of lakes;	11. Osmoregulation in freshwater organisms	12. Stratification of ocean.

Format for conducting CA and ESE practical examination :

CA (30 marks)	ESE (20 marks)
1. Assessment based on practical topics (class test)-**10** 2. PPT/Poster preparation, presentation and write up submission-3+4+3=**10** 3. Attendance and Participation in class-**5** 4. Practical skills, laboratory reports, etc-**5**	1. Experiment (Sl no 1-3, any one)-Principle-2, procedure-2, Experiment-3, result -2, (9) 2. Identification (Sl no 4,5)-Naming-0.5 and features-1.5 (2 x 2=4) 3. LNB-2 4. Field report-3 5. VIVA-2

NOTE :

- *Identification of behaviour/nest/ethogram could be done by using card printed with photograph/drawing/data.*
- *CA can be done multiple times even by more than one teacher. An average will be taken for marks capturing.*
- *LNB should be prepared in inter-leaf practical note book with date & Teacher's sign.*
- *Project report (Presentation mandatory), Field report, Write-up, etc to be prepared separately.*
- *A maximum of 4 students can present same topic of GD/seminar presentation, as a group or solo.*

Recommended readings:

1. Goldman, C. (1994) Limnology (2nd edition).

2. Ananthakrishnan, T.N. (1989) Bioresources Ecology (3rd edition).
3. Odum, E.P. and Barrett, G.W. (2004) Fundamentals of Ecology (5th edition).
4. Pawlowski, L. (1980) Physicochemical Methods for water and Wastewater Treatment.
5. Wetzel, R. (2001) Limnology (3rd edition) Elsevier.
6. Trivedi, R.K. and Goyal, P.K. (1986) Chemical and biological methods for water pollution studies.
7. Welch, P.S. (2014) Limnology Vol. I-II.