Student's Handbook

DEPARTMENT OF ZOOLOGY

SCHOOL OF STUDIES IN LIFE SCIENCES
GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR

Personal Details
(Student's copy)

Photograph

Name :…….

Course :…….

Father's Name :…….

Mother's Name :……

Date of Birth :……

Blood Group :……

Address
Permanent :……

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Local :……

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Telephone:……..

Mobile:……

Email:……..

Local Guardian :……

Person to Contact :……..**(in case of emergency)**

Telephone/Mobile :……

Other Information :……

Signature of Local Guardian **Student's Signature**

About the University

Guru Ghasidas Vishwavidyalaya is a Central University of India, established under Central Universities Act 2009, No. 25 of 2009. Formerly called Guru Ghasidas University (GGU), established by an Act of the State Legislative Assembly, was formally inaugurated on June 16, 1983. GGU is an active member of the Association of Indian Universities and Association of Commonwealth Universities. Situated in a socially and economically challenged area, the university is appropriately named to honor the great Satnami Saint Guru Ghasidas, who championed the cause of the downtrodden and waged a relentless struggle against all forms of social evils and injustice prevailing in the society. The National Assessment & Accreditation Council (NAAC) has accredited the University as B+. The jurisdiction of the university is spread across the Bilaspur Revenue Division. Bilaspur is a Metropolitan city in Bilaspur District in the Indian state of Chhattisgarh, situated 120 km north of state capital, Raipur. It is the second-largest city in the state and is the administrative headquarters of Bilaspur district. The city Bilaspur is well connected with all parts of the country by road and rail. The city is connected with Mumbai and Kolkata through the National Highway network. Bilaspur railway station is the busiest junction of Chhattisgarh and fourth busiest of central India. It is the Zonal Head Office of the South East Central Railway and is well connected to the rest of the country through the Indian Railways. The nearest airport from Bilaspur is that of Raipur, situated at a distance of approximately 120 km

Guru Ghasidas Vishwavidyalaya boast of a lush, green, sprawling main campus spread over an area of 875 acres (3.54 km2) , five kilometers from the main Bilaspur town. River Arpa, the lifeline of Bilaspur, runs parallel to the university campus.

The university is a residential cum affiliating institution. It covers almost the entire spectrum of the higher education requirements of the local people. The university is structured into the following academic divisions:

- Adult & Continuing Education
- Anthropology & Tribal Development
- Biotechnology
- Botany
- Chemistry
- Commerce
- Computer Science & IT
- Economics
- Education
- English
- Forestry Wild Life & Environment Sc.
- Hindi
- History
- Institute of Technology
- Journalism & Mass Communication
- Library & Information Science
- Management
- Pharmacy
- Physical Education
- Pure & Applied Mathematics
- Pure & Applied Physics
- Political Sc. & Public Administration
- Rural Technology
- Social Work
- Zoology

Welcome to the Department of Zoology

Present view of the Department

Proposed Building for the Department (Under Construction)

Department Profile

The Department of Zoology is one of the first departments to be established by the Guru Ghasidas Vishwavidyalaya after becoming Central University in 2009. Only in four years the department has made its identity in the frontier areas of Life Sciences and now it has developed into a full- fledged center of teaching and research in modern biology. The vision of the department is to teach and research in all branches of Zoology and to produce students who are relevant to their Society and the international Community.

The Department of Zoology offers 5 years integrated UG/PG, 2 years PG and Ph.D. degrees. The undergraduate program is designed in such a way so as to provide exit point after B. Sc. (Hon.) degree and also integrate it with P.G. program making it M. Sc. (Integrated) program in Zoology. Selections are done through an all India Vishwavidyalaya Entrance Test (VET).

The course structure and content delivery modes will have enough opportunities for interactive learning and exposure towards research. Many innovative teaching practices are the highlights of the program.

Students are assessed and evaluated throughout the semester by a continuous system of tests, seminars, assignments, mid and end-semester examinations.

The Department has been giving focus on developing experimental skills through live experimental designs, both by UG & PG students.

The Department has developed a teaching programme which stresses on the uniformity principals of molecular and cellular mechanisms in all living systems which are very close to the human being and complete understanding of these mechanisms could help to the basic zoologists towards the various fields of clinical science as well as in the Medical Sciences.

At present the department has 09 teaching faculty members who are actively engaged in their respective field of research specializations. The thrust area of research includes Neuroendocrinology, Fish and Fisheries, Reproductive biology, Biochemistry and Molecular Biology, Entomology and Environmental Science.

The department laboratory contains all necessary instruments and equipments to carry out theory and practical classes as per the syllabus. Instrument rooms with all the necessary sophisticated instruments required for the research work are available in the Department.

The departmental library consists of large number of books on different disciplines on Zoology. Books and journals especially in thrust areas have been purchased and catalogued separately for use. Apart from this, a central library is available in the campus premises also.

The museum is well stocked with various specimens belonging to all the animal phyla which are used for teaching Invertebrate and Vertebrates divisions.

The Zoological Sciences in India

Zoological science is central to our understanding of the world. Zoologists seek to discover the fundamental principles that predicate animal life focusing on the diversity, function and evolution of animals. It provides the scientific basis for our knowledge both of the organisms with whom we share our biosphere and of ourselves.

India is now growing up to become an international player in the zoological sciences, powered by its recent economic growth.

Keeping the importance of zoological science in mind for the development of the country, the Indian government is expanding as well as starting several new biological research institutes. These institutes will definitely open many new positions for life science researchers.

The modern zoological research came into being much later in India. Until the 1960s, biological research was largely directed toward pragmatic applications in agriculture, nutrition, and public health. Initially the Indian Institute if Science (IISc), Bangalore started laboratory groups involved in fermentation, pharmacology, and silkworm biology in 1941. The first truly modern “molecular biology research unit” began in 1962 as a branch of the Tata Institute of Fundamental Research (TIFR) in Mumbai. Similarly, new biological research units formed within traditional physical science institutes in other locations. G.N. Ramachandran, inventor of the “Ramachandran plot” widely used in protein structural studies, founded the Molecular Biophysics Unit at the IISc in 1970. The Center for Cellular and Molecular Biology (CCMB) in Hyderabad also began as a semi-autonomous branch of a regional Indian Institute of Chemical Technology in 1977 and became a National Laboratory in 1981. The National Institute of Immunology (NII)

began in 1986 with the focused goal of developing vaccines. But now it is conducting a wide range of basic biological research. The Center for Biochemical Technology began as a producer of biochemical reagents for India in 1977 but later its name was changed as Institute of Genomics and Integrative Biology in 2002. The National Center for Cell Science (NCCS), Pune was started in 1988 as a repository and distribution center for tissue culture cell lines. At that time it was known as the National Facility for Animal Tissue and Cell Culture but later in 1995 became a broad, basic biological science institute with a new name of National Center for Cell Science (NCCS).

National Centre for Biological Sciences (NCBS) in Bangalore, Karnataka, established in 1992, is a research center specializing in biological research. It is a part of the Tata Institute of Fundamental Research (TIFR) under the Department of Atomic Energy of the Government of India. The mandate of NCBS is basic research in the frontier areas of biology. It is one of the important institutions in India where stem cell research is being conducted.

India is one among the seventeen mega-diversity countries in the world. The country embraces more than 91,307 animal species (over 7.35% of world´s known species). The Zoological Survey of India, the only taxonomic organization in the country involved in the study of all kinds of animals from Protozoa to Mammalia, occurring in all possible habitats from deepest depth of the ocean to the peaks of Himalaya, was established on 1st July, 1916 to promote survey, exploration and research leading to the advancement in our knowledge of the various aspects of the exceptionally rich animal life

The conservation of biological diversity through the establishment and management of national parks and sanctuaries is now globally recognized. Wildlife Institute of India was set up in 1982 as a nodal national agency to meet the urgent capacity building needs for scientific planning, management and research in the field of wildlife conservation.

Biology also has come to the Indian Institutes of Technology. Many IITs have started life science departments. The Indian government also has launched five Indian Institutes for Science Education and Research (called IISERs), which are new campuses devoted to undergraduate/master's science education and research.

Currently, there are more than 350 Indian Universities; most are operated by State governments along with a smaller number of Central. The Universities are primarily dedicated to graduate training, post graduate training and PhD in various fields including zoological science.

In India times are changing rapidly for the zoological sciences. Funds are becoming easily available for state-of-the-art equipment on the basis of which India is becoming an increasingly viable location to conduct zoological research. With high ambition and better resources our country will definitely going to become competitive internationally in this field.

Zoology as a Carrier:

Zoology is a wide field offering many career opportunities for research and teaching. Zoologists are life scientists also known as animal scientists or animal biologists who study animals both in the laboratory settings as well as in natural habitat. They study the different aspects of animal like their origin and development, their habits, behaviors, interactions and many more. Here is a brief summary of some of the main careers available in this field.

- Researchers conduct research in university departments as well as in colleges, where they can also get the chance to teach students and develop their teaching ability.
- Due to various anthropogenic factors many animal species are becoming threatened day to day. Those who are having interest in conservation of animals can work as a conservationist with various national and international conservation agencies, reporting on the factors responsible for their decreasing population.
- Zoological parks are established for ex-situ conservation of animals. Students from zoology background can work in these parks as Zookeepers as well as Zoo Curators. Zookeepers are mainly involved in proper management of animal enclosures. Zoo curators play major role in acquiring animals for zoos, either through breeding programs, through purchase or exchange from other zoos, or very rarely from the wild after proper approval from the concerned government agencies.
- Zoologists can work as Animal and Wildlife Educators in various public venues such as Zoological parks, Wild life Sanctuaries and Museums where they can educate visitors to understand the wild life with the help of wide range of materials.
- Those who are having interest in studying animal behaviour can build their carrier as an ethologist and can educate people regarding interactions with animals.
- Wildlife Rehabilitators care for ill, injured or orphaned wild animals that have been damaged by natural disasters or man-made activities.

Faculty Profile

Dr. (Mrs.) Seema Rai

Designation- Professor

Research Interests: Molecular Reproductive and Metabolic Endocrinology, Endocrine Disruption, Clock Gene Regulation

Publications:

- Research Papers: 53
- Books: 01
- Book Chapter: 5

Email - seemarai.72@ggu.ac.in

Contact No.- 09406211523

Dr. (Mrs.) Monika Bhadauria

Designation- Professor

Research Interests: Hepatoprotection, Nephro and neuroprotection, Metal Toxicity, Silicosis

Publications:

- Research Papers: 55
- Books Chapter: 06

Email: monikabhadauria@rediffmail.com

Contact No.-09407567647

Prof. L.V.K.S. Bhaskar

Designation-Professor

Research Interests: Genetic basis of complex diseases

Publications:

- Research Papers: 201
- Books: 2
- Book Chapter:14

Email - bhaskar.lvks@ggu.ac.in

Dr. Rohit Seth

Designation- Associate Professor
Research Interests: Cell & Cancer Biology, Neuroscience Data Analytics
Publications:

- Research Papers: 22
- Books Chapter: 2

Email - rohitseth123@gmail.com
Contact No.- 96305-87045

Dr. Sushant Kumar Verma

DesignationAssistantProfessor
Research Interests: Environmental Toxicology, Biodiversity
Publications:

- Research Papers: 18
- Books: 01
- Book Chapter: 01

Email: vermasushant2008@gmail.com
Contact No.-07587300084

Dr. Santosh Singh

Designation- Assistant Professor
Research Interests: : Biochemistry and Molecular Biology (Neurochemistry of metabolic encephalopathy)
Publications:

- Research Papers: 13

Email: santoshbhu@gmail.com
Contact No.-09406296914

Dr. Manish Kumar Tripathi

Designation- Assistant Professor
Research Interests: Immunology and Endocrinology
Publications:

- Research Papers: 18
- Book: 1

Email: manish10aug@gmail.com
Contact No.- 9026068226

Dr. Neha Jain

Designation- Assistant Professor
Research Interests: Ichthyology, Environmental Toxicology
Publications:

- Research Papers: 07

Email - drnehajain2016@gmail.com
Contact No.- 9977960173

Dr. Geeta Mishra

Designation- Assistant Professor
Research Interests: Toxicology and Pharmacology, Hepatic-renal protection
Publications:

- Research Papers: 11

Email - gitamishra007@gmail.com
Contact No.- 9993711637

Technical and Supportive Staff

Mr. Sushil Kumar Sharma
UDC (II)
Contact Number: 09300321425

Mr. Bechan Singh Paikra
Technical Assistant
Contact Number: 09907902468

Mr. Balram Khairwar
MTS
Contact Number: 09165725099

Departmental Facilities

Library

The departmental library serves as an important resource for students as well for faculty of the department. It is well equipped with modern facilities and has a substantial collection of more than 1200 books. The department provides following facilities for the students:

- Reading room
- Open access of all books
- Internet facility
- Dissertation reports of students for reference
- Scientific journals

Computational Facility

The department provides computing facilities to students, staff and faculty. The computers are provided with various educational software's with internet facility.

Museum

The Museum of Zoology is home to a huge variety of preserved animals which are significant for our knowledge on the faunal diversity of the biosphere.
Various models related to evolution, embryology and of various other fields are used for the purpose of academic study by students and teachers.




Library Resources

Indian Journals

- Current Science
- Indian journal of Experimental Biology
- Biochemical and Cellular Archive
- Journal of Bioscience
- Journal of Genetics

International Journals

- Science
- Nature
- Blood
- Biology and Reproduction
- Neuroendocrinology

E- Resources (Journal) Available

UGC-Infonet URLs (Full Text Resources)

S. No.	Resource Name	Resource URL
1.	Cambridge University Press	http://journals.cambridge.org/
2.	Springer Link	http://www.springerlink.com
3.	Taylor & Francis	http://www.informaworld.com/
4.	Wiley-Blackwell	http://onlinelibrary.wiley.com/
5.	Science Direct: http://www.sciencedirect.com/ Subject Covered:(i) Agricultural and Biological Sciences, (ii) Biochemistry, Genetics and Molecular Biology, (iii) Chemistry, (iv) Immunology and Microbiology	
Bibliographic Database		
6.	JCCC	http://www.jccc-ugcinfonet.in
7.	ISD	http://isid.org.in
INDEST Consortium (Full Text)		
8.	IEL Online	http://www.ieee.org/ieeexplore
Full Text (Vishwavidyalaya Resources)		
9.	Business Source Elite-EBSCO News Paper Source Plus-EBSCO	http://search.ebscohost.com/

10.	Indiastat.com	http://www.indiastat.com

Research Facilities

Instruments Available:

- Automatic Microplate Reader with on-board Shaker
- Centrifuge Machine
- Co_2 Incubator
- Cryostat Microtome Automatic
- Fluorescence Microscope
- Hybridization Oven
- Leica 2125 Rts-Manual Rotatory Microtome
- Leica CM 1100 Bench Top Cryostat
- Mini 48 Wells Per Socket Thermal Cycler
- Orbital Shaking Incubator
- Refrigerated Cooling Centrifuge
- Spectrophotometer
- Stereo Zoom Research Microscope,
- Thermo Forma Vertical Ultra Freezer -80
- Water Purification System
- Autoclave
- Blood Cell Counter
- Blood Pressure Apparatus
- CO_2 cylinder With Regulator And Gas
- Deep Freezer -20ºC
- Digital Camera SLR
- Digital pH Meter
- Digital Rota Rod Apparatus
- Dissecting Microscope
- Glucometer Accu Check Active
- Glucometer Accu Check Integra
- Haemocytometer
- Horizontal Electrophoresis Set-Up (Nucleic Acid)
- Hot Plate
- Inclined Binocular Microscope
- Laminar Airflow Cabinet
- Magnetic Stirrer
- Magnetic Stirrer With Hot Plate
- Micro Pipette Adjustable Vol. 0.5-10µl
- Micro Pipette Adjustable Vol. 100-1000µl
- Micro Pipette Adjustable Vol. 20-200µl
- Micro Pipette Adjustable Vol. 2-20µl
- Electrophoretic apparatus
- Morris Water Maize
- Pre Filtration Unit
- Primo Vert Microscope
- Protein Vertical Gel Electrophoresis
- Rotary Microtome Open Type
- Single And Double Water Steel Distillation Unit
- Single Pan Balance
- Sonicator
- Stethoscope Standard
- Student Monocular Microscope
- Trinocular Research Microscope
- Vortex Mixture
- Water Bath
- Weiber Orbital Incubator Shaker
- Weighing Balance

Co_2 Incubator

Cooling Centrifuge

Flow Cytometer

UV Visible Spectrophotomete

Serological Water Bath

Remi Centrifuge

Fluorescence Microscope

Stereozoom Microscope

Inverted Microscope

Orbital Shaker

Table Top Cryostat

Table Top Cryostat

Cryostat microtome

Table Top Cryostat

Thermo cycler

Rotatory Microtome

Microtome

Hybridization Oven

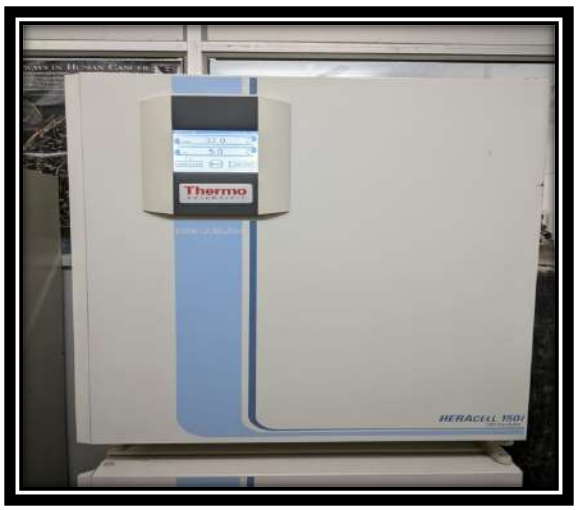
Soxholet Apparatus

Microplate Reader

Nano Fluorimeter

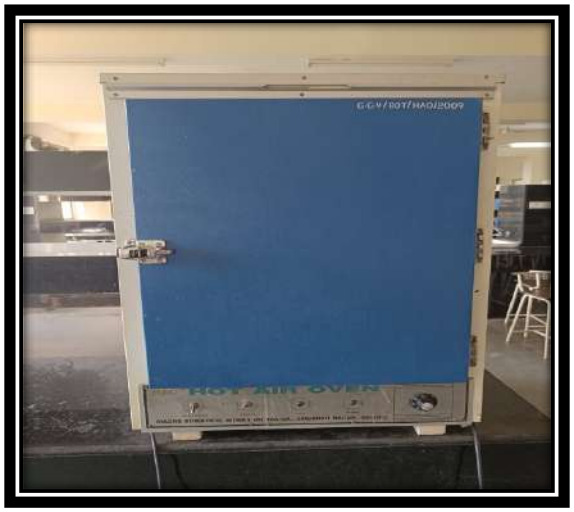
Vertical Ultra Freezer (-80 & -20)

Incubator



Incubator

Water Bath



Hot Air Oven

Laminar flow

Micro centrifuge

Phase Contrast Microscope

Automatic Staining Apparatus

Central Instrumentation Facility

Atomic Absorption Spectrophotometer

LC-MSMS

Gel Documentation System

Ongoing Research Projects

S. No.	Faculty	Title of the Project	Funding Agency	Total Grant received (in Lacs)
1.	Prof. LVKS Bhaskar	'Evaluating the interrelationship between miRNA expression and SNPs in miRNA-Target genes in sickle cell disease".	CSIR	32.16
2.	Prof. LVKS Bhaskar	"Association of apelin with the vaso occlusive pain crisis and pain measures in sickle cell disease."	ICMR	25

Student's Achievements

Ms. Nikita Zachariah:

- Selected for **IAS Summer Research Fellowship** for Teachers and Students: To do research on "Effect of LPS and Cisplatin on hematopoietic mechanism of Drosophila".
- Selected for integrated Ph.D.at **IISER Pune**
- Selected for integrated Ph.D. (Invited to Join as Junior Scholar) TIFR: (Deemed University) (under Dept. of Atomic Energy) to work on research proposal "Effect of Alprazolam on Neuroanatomical and pharmacological distribution of c-Fos in Amygdala and Hippocampus"
- Cleared written test at NCBS: (branch of TIFR) (under Dept. of Atomic Energy)
- Cleared written exam for Ph.D. at IISc Bangalore: (under MHRD) and subsequently called for interview after written test.

Ms. Khuleswari Kurrey:

- Qualified GATE-XL 2013

Ms. Honey Nikita Lovett:

- Worked as project fellow with Dr. Seema Rai under UGC funded project, got selected to pursue Ph.D. at University of Texas, U.S.A. following her high score in GRE and TOEFL examinations.

Courses Offered

- **3 Years (6 Semesters) UG program in Zoology**
- **2 Years (4 Semesters) Course in M.Sc. Zoology**
- **Ph.D. in Zoology**

SCHEME AND SYLLABUS

FOR

Learning Outcomes based Curriculum Framework

(LOCF)

For

ZOOLOGY HONOURS

DEPARTMENT OF ZOOLOGY

SCHOOL OF LIFE SCIENCES

GURU GHASIDAS VISHWAVIDYALAYA, BILASPUR

(CG)

2021-2022

1. Introduction

Zoology deals with the study of animal kingdom specially the structural diversity, biology, embryology, evolution, habits and distribution of animals, both living and extinct. As it covers a fascinating range of topics, the modern zoologists need to have insight into many disciplines. The learning outcomes-based curriculum framework for a B.Sc. degree in Zoology is designed to cater to the needs of students in view of the evolving nature of animal science as a subject. The framework is expected to assist in the maintenance of the standard of Zoology degrees/programmes across the country by reviewing and revising a broad framework of agreed expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The framework, however, does not seek to bring about uniformity in syllabi for a programme of study in Zoology, or in teachinglearning process and learning assessment procedures. Instead, the framework is intended to allow for flexibility and innovation in programme design and syllabi development, teachinglearning process, assessment of student learning levels.

2. Learning Outcomes based approach to Curriculum Planning

The courses should be delivered in terms of concepts, mechanisms, biological designs & functions and evolutionary significance cutting across organisms at B.Sc. level. These courses should be studied by students of all branches of biology. Both chalk and board, and PowerPoint presentations can be used for teaching the course. The students should do the dissertation/ project work under practical of different courses, wherever possible.

The students are expected to learn the courses with excitements of biology along with the universal molecular mechanisms of biological designs and their functions. They should be able to 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 contributions from research and innovation have made the subjects modern, interdisciplinary and applied and laid the foundations of Zoology, Animal Sciences, Life Sciences, Molecular Biology and Biotechnology. These courses and their practical exercises will help the students to apply their knowledge in future course of their career development in higher education and research. In addition, they may get interested to look for engagements in industry and commercial activities employing Life Sciences, Molecular Biology and Biotechnology. They may also be interested in entrepreneurship and start some small business based on their interest and experience.

2.1 Nature and extent of the B.Sc. degree Programme in Zoology

B.Sc. Zoology course will help to understand the behaviour, structure and evolution of animals. Zoologists use a wide range of approaches to do this, from genetics to molecular and cellular biology, as well as physiological processes and anatomy, whole animals, populations, and their ecology. The scope of Zoology as a subject is very broad. The intention is to understand the subject of Zoology in the evolving biological paradigm in modern times; where, living beings need to be understood at the level of atomic interactions; and comparative systems of organisms need to be studied through the prism of integrated chemical, physical, mathematical and molecular entities to appreciate the inner working of different organisms at morphological, cellular, molecular, interactive and evolutionary levels. The key areas of study within the disciplinary/subject area of Zoology comprise: animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied zoology, behaviour, immunology, reproductive biology, and insect, vectors and diseases. B.Sc. degree programme in Zoology also deals with skill enhancement courses such as apiculture, aquarium fish keeping, medical diagnostics, sericulture etc. The depth and breadth of study of individual topics dealt with would vary with the nature of specific Zoology programmes. As a part of the efforts to enhance the interest and employability of graduates of Zoology programmes, the curricula for these programmes are expected to include learning experiences that offer opportunities for higher studies and research at reputed laboratories.

2.2 Aims of Bachelor's degree programme in Zoology

Zoology is the study of all animal life; from primitive microscopic malaria-causing protozoa to large advanced mammals, across all environmental spheres from red deer in mountain forests to dolphins in deep oceans, and from underground burrowing voles to golden eagles in the skies. Some of these animals are useful to us and we nurture them as pets or livestock; some are serious pests or disease-causing; and some are simply splendid and awe-inspiring. No matter what our relation with the animals is, we need to understand their behaviour, population dynamics, physiology and the way they interact with other species and their environments. It provides students with the knowledge and skill base that would enable them to undertake further studies in Zoology and related areas or in multidisciplinary areas that involve advanced or modern biology and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

The modern era requires a classical zoologist with a modern approach to master many subjects of Zoology. There is a need for the students to compete with the globe, therefore, the main focus of this curriculum is to enable the student to be professionally competent and successful in a career. Having Zoology as backbone of the curriculum, this course, with the department centric electives will enhance the skills required to perform research in laboratory and experimental research. The students can choose to focus on a "whole animal" or a "bits of animals" approach. The "whole animal" pathway makes the students proficient in the identification and study of animals while the latter approach provides the skills required to pursue laboratory and experimental work such as disease research, DNA technologies, wildlife forensics etc. The curriculum can be modified to such extent that a student at B.Sc. level can be a specialist in immunology, ornithology, animal behaviour or entomology. For such specializations, the curriculum needs to focus on special skills to maximise the students' employment probability; for example few skills needed by industry may include the species-specific monitoring for key species, handling of dangerous/ poisonous/ wild animals and the use of Geographic Information Systems (GIS) for data collection.

3. Graduate Attributes in Zoology

 Disciplinary knowledge and skills: Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in Zoology and its different subfields (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, and insect, vectors and diseases), and other related fields of study, including broader interdisciplinary subfields such as chemistry, physics and mathematics; (ii) ability to use modern instrumentation for advanced genomic and proteomic technology.

 Skilled communicator: Ability to impart complex technical knowledge relating to Zoology in a clear and concise manner in writing and oral skills.

 Critical thinker and problem solver: Ability to have critical thinking and efficient problem solving skills in the basic areas of Zoology (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, insect, vectors and diseases etc.).

 Sense of inquiry: Capability for asking relevant/appropriate questions relating to issues and problems in the field of Zoology, and planning, executing and reporting the results of an experiment or investigation.

 Team player/worker: Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.

 Skilled project manager: Capable of identifying/mobilizing appropriate resources required for a project, and manage a project to completion, while observing responsible and ethical scientific conduct; and safety and chemical hygiene regulations and practices.
 Digitally literate: Capable of using computers for Bioinformatics and computation and appropriate software for analysis of genomics and proteomics data, and employing modern bioinformatics search tools to locate, retrieve, and evaluate location and biological annotation genes of different species.
 Ethical awareness/reasoning: Capable of conducting their work with honesty and precision thus avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and appreciating environmental and sustainability issues. Research ethics committee expects them to declare any type of conflict of interest that may affect the research. Any plan to withhold information from researchers should be properly explained with justification in the application for ethical approval.
 Lifelong learners: Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling.

4. Qualification Descriptors for a Bachelor's Degree programme in Zoology

The qualification descriptors for a Bachelor's Degree programme in Zoology may include the following:
 Demonstrate (i) a fundamental/systematic or coherent understanding of the academic field of Zoology, its different learning areas and applications, and its linkages with related disciplinary areas/subjects; (ii) procedural knowledge that creates different types of professionals related to Zoology area of study, including research and development, teaching and government and public service; (iii) skills in areas related to specialization area relating the subfields and current developments in the academic field of Zoology.
 Use knowledge, understanding and skills required for identifying problems and issues relating to Zoology. A keen interest in research and the study of living organisms.
 Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s);
 Meet one's own learning needs, drawing on a range of current research and development work and professional materials;
 Apply one's subject knowledge and transferable skills to new/unfamiliar contexts to identify and analyse problems and issues and solve complex problems with welldefined solutions.
 Demonstrate subject-related and transferable skills that are relevant to Zoologyrelated job trades and employment opportunities
 Good observation skills
 Able to work precisely
 A logical approach to problem-solving
 Good oral and written communication abilities
 Able to work independently or with team members

5. Learning Outcomes in Bachelor's Degree programme in Zoology

5.1 Knowledge and Understanding •

Demonstrate (i) in-depth knowledge and understanding about the fundamental concepts, principles and processes underlying the academic field of Zoology and its different subfields (animal diversity, principles of ecology, comparative anatomy and developmental biology of vertebrates, physiology and biochemistry, genetics and evolutionary biology, animal biotechnology, applied Zoology, aquatic biology, immunology, reproductive biology, and insect, vectors and diseases, apiculture, aquarium fish keeping, medical diagnostics, and sericulture) (ii) procedural knowledge that creates different types of professionals in the field of Zoology and related fields such as, apiculture, aquarium fish keeping, medical diagnostics, and sericulture, etc.(iii) skills related to specialization areas within Zoology as well as within subfields of Zoology, including broader interdisciplinary subfields.

 Over the years, Zoologists were able to find many differences within the same breed of an animal species. As a Zoology professional one can study extinct animals by specializing in Paleozoology, on the different types of birds in Ornitholog; opt for studying
 Herpetology and Arachnology, the branches dealing with the study of snakes and spiders, respectively or
 Appreciate the complexity of life processes, their molecular, cellular and physiological processes, their genetics, evolution and behaviour and their interrelationships with the environment.
 Study concepts, principles and theories related with animal behaviour and welfare.
 Understand and interpret data to reach a conclusion
 Design and conduct experiments to test a hypothesis.
 Understand scientific principles underlying animal health, management and welfare.
 Accept the legal restrictions & ethical considerations placed for animal welfare.
 Understand fundamental aspects of animal science relating to management of animals.
 Assess problems and identify constraints in management of livestock.

5.2 Subject Specific Intellectual and Practical Skills

The students will be able to
 Understand how organisms are classified and full and identified
 Demonstrate knowledge of basic zoological principles
 Use appropriate information with a critical understanding
 Learn basic laboratory and analytical skills
 Use effective methods for modifying animal behaviour
 Participate in animal management programmes in an effective manner
 Work safely and effectively in the field, in laboratories and in animal facilities
 Demonstrate competence in handling and statistical analysis of data gained from practical
 Learn communication and IT skills, including the collation and statistical analysis of data, citing & referencing work appropriately, communicating using a range of formats

In course learning outcomes, the student will attain subject knowledge in terms of individual course as well as holistically. The example related to core courses and their linkage with each other is stated below:
The core courses would fortify the students with in-depth subject knowledge concurrently; the discipline specific electives will add additional knowledge about applied aspects of the program as well as its applicability in both academia and industry.

Generic electives will introduce integration among various interdisciplinary courses.
The skill enhancement courses would further add additional skills related to the subject as well as other than subject. In brief, the students graduated with this type of curriculum would be able to disseminate subject knowledge along with necessary skills to suffice their capabilities for academia, entrepreneurship and Industry.

For each syllabus, the course content has been divided into four units with a breakup of the topics to be covered to provide the students better understanding of the main theme represented in the title of each unit. Such type of design is to indicate the breadth of content to be taught thus ensuring more or less uniform coverage of information on a certain theme. The teacher has to take up the contents in such a manner by asking questions and answering them that the whole process appears to be an interesting narrative with topics falling in line rather than appearing as unrelated complex terms. Learning will be more enjoyable and imbibing if appropriate examples are cited from our daily lives.

6. Course Structure for Bachelor's Programme in Zoology with details

6.1 Core Courses
These courses provide an in depth understanding of relevant theories, concepts, and principles of zoology besides having an insight into the philosophy of the subject. The students are likely to have a strong foundation in Zoology.

6.2 Discipline Specific Elective Courses
With the course content largely subject specific, the first aim of these courses is to engage all students in enriching, enjoyable and intellectually stimulating learning experiences. Methods are designed to support independent learning. The courses are likely to help students acquire subject-specific, cognitive and transferable skills to solve complex problems.

6.3 Generic Elective Courses
These courses enable the students to apply knowledge and understanding to address not only the core issues but also the issues of general importance where the knowledge of Zoology can be an added advantage. The courses will facilitate the students to develop all-round knowledge and skills on the integrated subjects in life sciences.

6.4 Ability Enhancement Courses
These courses will mainly enhance the ability and personal skills of the students and help in personality development besides making them aware about the latest happenings or trends and facilitating effective communication with correct usage of technical language in order to present complex concepts and information. The students will learn to express in competitive and professional environments, orally and in writing in a clear and concise manner.

6.5 Skill Enhancement Courses
These courses will encourage and enhance the investigative and analytical skills of students resulting in their ability to formulate problems clearly, identify key issues and reach the solution with logical arguments. The classroom sessions are aimed to provide industry-standard skills and can be helpful in fetching jobs.

7. Assessment and Evaluation

7.1 Assessment methods
Students' performance in core, discipline electives, generic electives and skill enhancement courses are to be assessed in various ways viz.,
- The oral and written scheduled or surprise tests,
- Problem-solving exercises,
- Closed-book and open-book tests,
- Practical skills and laboratory reports,
- Individual and group project reports,
- Seminar presentations,
- Group discussions
- Viva voce examinations.
- The computerized learning, literature surveys and evaluations, peers and self-assessment can be the additional methods used.
- Regular reading habits in the students need to be inculcated through continuous monitoring and observation about weaker aspect of the students.

7.2 List of Topics Suggested for Seminar and Group Discussion

1. Origin of life
2. Molecular systematics vs traditional taxonomy
3. Molecular system of classification
4. Living fossils
5. Animal connecting links
6. Reliability of taxonomic characters
7. Scope of evo-devo (Evolutionary developmental biology)
8. Mass extinction phenomenon
9. Pleuripotency and its relevance
10. Latest trends in developmental biology
11. Evolution of major animal lineages
12. Relevance of Palaentology in current scenario
13. Parthenogenesis in animals
14. Polymorphism
15. Parasitic adaptations
16. Metamorphosis
17. Freshwater sponges
18. Molluscs of industrial value
19. Coral reefs and their role in ecosystem generation
20. Biochemical pathways, their evolutionary background and regulation
21. Water regulation in marine animals
22. Were dinosauers warm blooded?
23. Evolution of terrestrial animals
24. Blood groups and their importance
25. Role of DNA sequencing in evolutionary history.
26. Genetic control of sex determination.
27. Bone marrow transplant
28. Recent advances in tissue culture and engineering.
29. Somatic hybridization
30. Neurodegenerative disorders
31. Popular cell lines and their importance
32. Apoptosis
33. Mutations and cancer
34. Epithelial tissue and its importance
35. Genome modification/ editing
36. Recent advances in gene cloning
37. Epigenetic disorders in humans
38. Diseases due to chromosomal anomalies
39. Stem cell technology
40. Genetic counseling
41. RNA interference
42. DNA barcoding
43. Stem cells & IPS cells
44. Current trends in DNA sequencing
45. DNA markers and Genetic diversity
46. Comparative genomics in understanding of gene function
47. Biodiversity and climate change
48. Biotechnology: Past, present and Future.
49. Molecular Taxonomy, New Classification systems
50. Tree of Life.

51. Marine zooplanktons and their ecological importance including oxygen evolution
52. Bioprospecting and Biopiracy
53. Molecular systematics vs. traditional taxonomy
54. Biochemical Pathways and their evolutionary background, Regulation
55. Biodiversity Hotspots.
56. Biotechnology; Past present and Future
57. Climate change: threat to food security
58. Stratospheric Ozone depletion and marine productivity
59. Good ozone vs. bad ozone
60. Air pollution and climate change
61. Biodiversity under climate changing scenario
62. Preparing healthy/ fit animal stock for tomorrow ; Conventional Breeding
63. Hybrids or transgenic animals
64. Vital body enzymes
65. Hormonal disorders
66. The process of Transcription
67. Advances in DNA hybridization
68. Essential and non essential amino acids
69. Important body lipids
70. Parental care in animals
71. Learning in birds
72. Instinctive behaviour invertebrates
73. Social behaviour in primates
74. Application of animal behaviour studies
75. Behaviour in captivity
76. Circadian rhythm
77. Environmental ethics
78. Biodiversity hotspots
79. Biodiversity mapping
80. Population explosion
81. Ecological indices
82. Niche segregation
83. Carrying capacity
84. Eukaryotic genome
85. Regulation of gene expression
86. RNA editing and splicing
87. DNA damage and repair
88. Central dogma of molecular biology
89. Molecular cloning
90. Monoclonal and polyclonal antibodies production techniques
91. Immunological techniques in disease diagnosis
92. Basic principles of light microscopy
93. Using SEM and TEM
94. Principles of Florescence and confocal microscopes
95. Applications of calorimetry and spectrophotometry
96. Techniques involving separation of biomolecules.
97. Diseases caused by viruses
98. Common bacterial diseases
99. Autoimmune diseases
100. Hybridoma technology and its applications
101. Zoonotic diseases

102. Helminth infections in humans
103. Concept of Immunity
104. Graphical representation of biological results
105. Statistical methods of hypothesis testing
106. Information technology in data acquisition and retrieval
107. Database management
108. Use of bioinformatics in biological research
109. Basics of information technology
110. Fish culture
111. Dairy management
112. Cattle diseases and their management
113. Apiculture and Sericulture
114. Pearl culture industry
115. Vermiculture
116. Prawn culture, a good source of revenue generation
117. In vitro fertilization techniques
118. Phenoplasticity and its relevance

7.3 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.

8. Distribution of different types of courses with their credits for B.Sc. Zoology (Honors)

Semester	Core Course	AEC	SEC	DSE	GEC	Intern-ship	Seminar	Disserta-tion	Credits /hour load
1	CC-I CC-II	AEC-I	SEC-I		GEC-I				19/27

2	**CC-III CC-IV**	**AEC-II**	**SEC-II**		**GEC-II**				**19/27**
3	**CC-V CC-VI CC-VI**	**AEC-III**			**GEC-III**				**22/31**
4	**CC-VII CC-IX CC-X**	**AEC-IV**			**GEC-IV**				**22/31**
Summer vacation						√			**6**
5	**CC-XI CC-XII**	**AEC-V**		**DSE-1 DES-II**					**22/31**
6	**CC-XIII CC-XIV**			**DSE-III**			√	√	**23/37**
Credits	**42 (T) + 28 (P) =84**	**5 (T) + 5 (P)**	**5 (T) + 5 (P)**	**9 (T)+ 6 (P) =24**	**16 (T) + 8 (P) =24**	**6**	**2**	**6**	**133**
% Course	**56.80**	**5.40**	**5.40**	**16.20**	**16.20**		**13.5**		**100**

Core Courses (CC): ZOUATT1 and ZOUALT1

Semester	Core Course	Course Title	Credits
I	CC-I	Systematic and Diversity of Life- Protists to Chordates	Theory: 03 Practical: 02

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

UNIT I: Origin of Life on Earth, Products of evolutionary process 13 Lectures

Origin of life on Earth: Arrival of simple form from primordial chemicals. Multicellularity: from simple collections of poorly differentiated cells to complex body plans. Biological diversity. Systematics and taxonomy. Species concept, clades. Nomenclature and utility of scientific names. Classification: morphological and evolutionary (molecular). Relationship of taxa: phylogenetics and cladistics.

UNIT II: Diversity in Protists and acoelomate Metazoa 13 Lectures

Structure and diversity in Protists. Origin of Metazoans: Diploblastic and triploblastic organization; symmetries; body cavities; protostomes and deuterostomes. Special features and structural diversity in sponges. Cnidarians: Special features; transition of third germ layer; polymorphism and division of labour; coral reef forming Cnidarians. The Bilateria: Basic characteristics. The acoelomates: Basic organization and adaptive radiations in flatworms.

UNIT III: Diversity in pseudocoelomate and coelomate Non chordates 13 Lectures

The Ecdysozoa: characteristics of the representative taxa. Pseudo coelomates; Basic organization and adaptive radiations in roundworms. The coelomates: Basic organization and adaptive radiations in Arthropods- Ancestors/ fossil arthropods. Adaptive radiations in Crustaceans, Insects, etc. Basic organization and diversity in Annelids. Basic organization and diversity in Molluscs. Disruption of bilateral symmetry and its significance. Basic organization of Echinoderms; their affinity to Chordates.

UNIT IV: Diversity in Protochordates and Chordates 13 Lectures

Chordates– Primitive Chordates and their affinities. Hemichordates, Urochordates and Cephalochordates. Advent of vertebrates: Cyclostomes, their evolutionary status and affinities. Basic organization and diversity of fishes, their evolutionary transitions. From Water to Land invasion - Early Tetrapodes. Amphibians diversity and adaptability to dual mode of life. Amniotes: the amniotic egg, adaptive radiations in reptiles; the avian ancestors. Birds: Adaptation from terrestrial to aerial mode of life. Origin of Mammals-Special features of Monotremes and Marsupials. Characteristics of other mammalian groups with special reference to primates

Recommended readings

1. Barnes, R. S. K.; Calow, P.; Olive, P. J. W.; Golding, D. W.; Spicer, J. I. (2002) The Invertebrates: a Synthesis, Blackwell Publishing.
2. Hickman, C.; Roberts, L.S.; Keen, S.L.; Larson, A. and Eisenhour, D. (2018) Animal Diversity, McGraw-Hill.
3. Holland, P. (2011) The Animal Kingdom: A Very Short Introduction, Oxford University Press.
4. Kardong, K.V. (2006) Vertebrates: Comparative Anatomy, Function, Evolution (4th edition), McGraw-Hill.
5. Barrington, E.J.W. (1979) Invertebrate Structure and Functions. II Edition. E.L.B.S. and Nelson.
6. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
7. Bushbaum, R. (1964) Animals without Backbones. University of Chicago Press.

Practical

1. Study of animals through slides and museum specimens in the laboratory with details on their classification, biogeography and diagnostic features (record book).
2. Study of animals in nature during a survey of a National Park or Forest area.
3. Collection of five species (preferably invertebrates, insects) belonging to a clade. A project work 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.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUATT2 and ZOUALT2

Semester	Core Course	Course Title	Credits
I	CC-II	Developmental Biology and Evolution	Theory: 03 Practical: 02

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 the 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

UNIT I: How does reproduction start, commence and modify in living system? 13 Lectures

Reproduction: a basis of species sustenance. Asexual and sexual reproduction and their relevance in corresponding environments. How are germ cells "special"? Gamete formation, types, external and internal fertilization; causes of Infertility. Structural and biochemical changes in gametes during and after fertilization, block to polyspermy. Establishment of the major embryonic axes, polarity, morphogen gradients and their interpretation. Fate maps, their relevance. In vitro fertilization; Amniocentesis; Artificial insemination (AI); Test tube baby.

UNIT II: How does development affect organization of phenotypes & their variation? 12 Lectures

Developmental commitment. 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. Induction and recruitment. Organogenesis: formation of heart and kidney. Concept of competence, determination and differentiation and growth, molecular mechanism involved. Pleuropotency. Stem cell biology and tissue repair

UNIT III: Tracing the evolutionary biology of development 12 Lectures

Role of extra embryonic membranes in development, Placenta: types, structure and functions. Metamorphosis in insect and frog. Regeneration: epimorphosis, morphollaxis and compensatory regeneration. Development, ageing and apoptosis. Developmental mechanisms of evolutionary change

(Evo-devo). Developmental biology in understanding of disorders. Teratogenesis; wound healing, birth defects, developmental brain disorders. Neurodegeneration. Endocrine Disruptors & Cancer.

UNIT IV: Understanding evolution through natural selection, adaptation and optimal models tradeoffs **15 Lectures**

Early life on Earth and its indirect evidences, direct evidence of early life; great oxygenation and its relationship with life. Evolution and radiation of metazoans, major evolutionary transitions, Mass extinctions, Anthropocene and its uniqueness. Evidences of evolution: Hardy-Weinberg Equilibrium, Selection, Migration. Nonrandom mating, Cost/ benefit of sex, Sexual conflict, Evolution in asexual systems Life-history adaptations, Number and size of offspring; Parent-offspring conflict. Genetic drift, Neutral evolution; Theories of evolution. Sources of variation: mutation, recombination, epigenetic variation. Evolution of mutation rates. Phenotypic plasticity, Genome evolution: Mobile genetic elements; gene duplication. Evolution and Health: Evolution of antibiotic Resistance, Virulence, Evolutionary medicine.

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
4. Campbell, N. and Reece, J. (2014) Biology (10th edition). Benjamin Cummings
5. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing.
6. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007) Evolution. Cold Spring, Harbour Laboratory Press.
7. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett

Practical

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 up to 96 h.
5. Extra embryonic membranes of chick through permanent slides.
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.
10. Analogy and homology (wings of birds and insects, forelimbs of bat and rabbit).
11. Serial homology in appendages of Palaemon.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUBTT1 and ZOUBLT1

Semester	Core Course	Course Title	Credits
II	CC-III	Comparative Anatomy and Physiology of Non Chordates	Theory: 03 Practical: 02

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

UNIT I: Diversity of Tegument and Digestive system 13 Lectures

Basic affinities and differences between prokaryotes and eukaryotes; protists and the non-chordate animals. Symmetry, Coelom development and diversity. Cell membrane in protists and its derivatives. Tegument in non-chordates and its derivatives. Nutrition and feeding modes in protists. Digestive system & feeding mechanism in non-chordates): Process of digestion from food vacuoles to complex digestive organs.

UNIT II: Diversity of Locomotory, Respiratory, Circulatory and Excretory systems 13 Lectures

Locomotion and diversity of locomotory organs in protists and non-chordates, muscle and locomotion, Structure and diversity of skeletal elements in protists and non-chordates. Respiration: diversity of respiratory organs, modes of respiration. Respiratory pigments and oxygen consumption rates of different organisms. Circulation and the diversity of circulatory system. Excretion (protists): endocytosis, exocytosis; Excretion and diversity of excretory organs in non chordates.

UNIT III: Diversity of Nervous and Reproductive systems 13 Lectures

Nervous system with special reference to diversity in brain and nerve chord. Neuroendocrine systems, pheromones. Sense organs: Mechanoreceptors and their diversity in different taxa. Sense organs: photoreceptors, chemoreceptors, thigmoreceptors, rheoreceptors and proprioceptors in different taxa. Diversity of the reproductive organs and accessory sex organs; modes of reproduction- asexual and sexual reproduction. Metamorphosis. Diversity of larval forms in non-chordates

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

Organization and affinities in fossils (such as trilobites). Affinities of living fossils, Limulus and Peripatus. Polymorphism and colony formation. Parasitc adaptations and life cycle patterns in parasites belonging to different taxa. The parasites listed by World Health Organization under preventive programmes. Structure

and diversity of the pest organisms. Invertebrate model organisms and their importance. Taxa with special characteristics: Types of canal systems in sponges and their significance. Torsion and detorsion in Mollusca. Components of water vascular system in echinoderms.

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. Boradale, L.A. and Potts, E.A. (1961) Invertebrates: A Manual for the use of Students. Asia Publishing Home.
6. Marshall, A.J and Williams, W.D. (1995) Text book of Zoology-Invertebrates. VII Ed., Vol. I, A.L.T.B.S. Publishers.
7. http://abacus.bates.edu/acad/depts/biobook/AnimPhyl.pdf

Practical

1. Study of models, permanent slides and museum specimens representing different protists and non-chordate taxa.
2. Some additional slides/specimens of Protozoans of agricultural importance. Coral-reef forming Cnidarians Plant parasitic nematodes Nematodes used as models in experimental biological research
3. Dissection of Pheretima to expose circumpharyngeal ganglia
4. Dissection of Periplaneta to expose the digestive system and salivary glands
5. Dissection of Palaemon to expose appendages and statocyst
6. Dissection of Pila
7. Study of larval forms: Ephyra, Planula, Trochophore, Pluteus, Velliger, Zoea, Metazoea, Bipinnaria
8. Some videos to develop understanding on the animals of different taxa.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUBTT2 and ZOUBLT2

Semester	Core Course	Course Title	Credits
II	CC-IV	Cell Biology and Histology	Theory: 03 Practical: 02

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

UNIT-I: The structure and organelles of prokaryotic and eukaryotic cells. 13 Lectures

Cell biology, its scope in modern perspective. Cell theory and its modern version and interpretation. General structure of prokaryotes, bacteria, archaea and eukaryotes. Extra nuclear cell organelles: Ultrastructure and functions of endoplasmic reticulum, ribosome, Golgi apparatus, lysosome, peroxisomes. Mitochondria: Origin, structure, composition, genome organization and function. Cytoskeleton: composition and functions; microtubules and microfilaments. MT vs Actin - their organization, association with membrane. Nucleus: size, shape, structure and functions of interphase nucleus. Ultrastructure of nuclear membrane and pore complex. Nucleolus: general organization, chemical composition and functions, nuclear sap/ nuclear matrix, nucleo-cytoplasmic interactions.

UNIT-II: Cell membrane and transport mechanism 12 Lectures

Cell membrane organization: cell membrane: structure, composition, models and function. Fluid mosaic model. Lipid Composition, inner and outer leaflets. Structure and functions of membrane proteins: Integral, peripheral and lipid-anchored membrane proteins. Junctional complexes, membrane receptor modifications: microvilli, desmosomes and plasmodesmata. Receptor mobility and clustering in the lipid bilayer. Cell receptor function - cellular trafficking. Transport across membrane: diffusion and osmosis. Active and passive transport, endocytosis and exocytosis

UNIT-III: Cell cycle, cell signaling and cell culturing 14 Lectures

Cell cycle, cell division- mitosis and meiosis. Cell division check points and their regulation. Role of growth factors. Mutations in the genes that regulate cell cycle and division and their role in causing cancer. Programmed cell death (Apoptosis). Cell regulation and Cell signaling: Signaling molecules and their receptors. Functions of cell surface receptors. Regulation of signaling pathways. Cell culture: Types of cell culture- monolayer and suspension culture. Types of culture media. Sterilization methods for culture wares

and culture media. Maintenance of a cell line and storage of cells. Subcellular fractionation by differential centrifugation.

UNIT-IV: Structural and functional significance of animal tissues 13 Lectures

Introduction to tissues. Epithelial tissue: types, structure and characteristics. surface modifications. Basement membrane: structure and characteristics. Cell junctions. Exocrine and endocrine glands: types and structure. Connective tissue cells. Structure and function of loose, dense and adipose tissue. Cartilage and bone: classification, and fine structure. Structure and function of spleen. Membranes of the brain and spinal cord.

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.

Practical

1. Study of prokaryotic and eukaryotic cell types with the help of chart, slide and video.
2. Separation and isolation of cells by sedimentation velocity in unit gravity.
3. Disruption of cells, isolation and identification of subcellular components, isolation of nuclei.
4. Isolation of mitochondria by differential centrifugation and identification of succinic dehydrogenase in the mitochondrial pellet.
5. Chromosome segregation in mitosis and meiosis.
6. Preparation of chromosome squashes from grasshopper/cockroach testes for the observation of stages of meiosis.
7. Study of types of tissue through permanent slides: epithelial, connective, muscular, nervous etc.
8. Study of histology of tissues by preparing permanent stained slides through microtomy.
9. Isolation and estimation of DNA.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUCTT1 and ZOUCLT1

Semester	Core Course	Course Title	Credits
III	CC-V	Comparative Anatomy and Physiology of Chordates	Theory: 03 Practical: 02

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

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

Structure of integument from fishes to mammals with an account on epidermal and dermal derivatives and their functional significance. Anatomy and physiology of axial and appendicular skeleton. Comparative anatomy of pelvic and pectoral girdles from fishes (cartilaginous and bony) to mammals. Types of muscles, physical properties and ultrastructural organization of skeletal muscle fibres, muscle contraction.

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

Comparative anatomy of jaw suspension, oral cavity, teeth (dentition mammals). Structure and diversity of alimentary canal and digestive glands in chordates. Biological significance of nutrients- carbohydrates, proteins, fats, vitamins and minerals. Physiology of digestion with special reference to enzymes involved. 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 heart, cardiac cycle, cardiac output, Integration of cardiovascular function, electrocardiogram. Composition of blood, blood groups, Mechanism of blood coagulation. Types and functional significance of endocrine glands and hormones.

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

Aquatic and terrestrial respiration; transition from water to air breathing. Breathing and gas exchange, gas transport, Hb and O2 dissociation, BMR. Comparative anatomy and functional significance of lungs in amphibians, reptiles, birds and mammals. Types and development of kidneys and their ducts in anamniotes and amniotes. Nephron- structure, types and their function. Physiology of excretion in vertebrates; urine formation, counter current mechanism, Role of ADH and RAAS in excretion. Mechanisms of osmoregulation in fresh water and marine organisms, stenohalinity and euryhalinity.

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

Introduction to central and peripheral nervous systems. Structural and functional evolution of brain and spinal cord in various classes of chordates. Peripheral nervous system- functional significance of somatic and autonomic nervous systems. Structure and functions of neuron, ionic basis of resting and action potentials, nerve impulse and its transmission, synapse and synaptic transmission, Reflex action. Types of sense organs- vision, hearing, taste, smell and touch in chordates. Mechanism of thermoregulation in homeotherms and poikilotherms. Comparative details of testes and ovaries from fishes to mammals; modes of reproduction; estrous and menstrual cycle, implantation, gestation, parturition, lactation and birth control.

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).
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 edition) W.B. Saunders Co.
8. Withers, P.C. et al. (1992) Comparative Animal Physiology (1st edition) Brooks Cole.

Practical

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. Mount of weberian ossicles of fish.
6. Study of axial and appendicular skeleton of vertebrates.
7. Qualitative analysis of nutrients: Carbohydrate, Proteins, Lipids.
8. Estimation of haemoglobin.
9. Counting of different types of blood cells using haemocytometer.
10. Study of action of salivary amylase.
11. Rate of oxygen uptake in fish.
12. Effect of temperature on opercular movement of fish.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUCTT2 and ZOUCLT2

Semester	Core Course	Course Title	Credits
III	CC-VI	Genetics	Theory: 03; Practical: 02

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

UNIT I: Concept of Genes and Genomics **13 Lectures**

Genetics: scope and importance. Elements of heredity and variation: Classical and Modern concept of Gene (Cistron, muton, recon), Alleles etc. Mendel's laws of inheritance, Chromosomal basis of inheritance and its applications. Exceptions to Mendelian Inheritance: Incomplete dominance, Codominance, Multiple allelism, Lethal alleles, Pleiotropy, Epistasis- Recessive, Double recessive and double dominant. Penetrance and expressivity, Phenocopy, Polygenic inheritance. Mendelian traits in man.

UNIT II: The recombination and interaction of Genes **13 Lectures**

Linkage and crossing over, cytological basis of crossing over. Organelle inheritance (Mitochondrial) Extra-nuclear inheritance, Maternal Inheritance, Sex Chromosomes and sexlinkage: XX/XO, XX/XY, ZZ/ZW and haploidy/diploidy types, Gene dosage Compensation, Epigenetics. Structural and numerical alterations of chromosomes, meiotic consequences in structural heterozygotes. Autosomal dominant and autosomal recessive, X-linked dominant, and X-linked recessive. Haplodiploidy. Genic balance theory, intersex, gynandromorphs.

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

Gene Expressions and regulation: One gene-one enzyme hypothesis /one polypeptide hypothesis. Concept of operon of bacteria and bacteriophages. Bacterial transposons. Vertical and horizontal gene transfer. Transformation, transfection and transduction. Genetic complementation. Genetic mapping. Genetic screens as a basis for functional genomics. Deficiencies, EMS & X-ray-based mutagenesis screens. RNA-inheritance.

UNIT IV: Human Population Genetics and Genetic Counselling **13 Lectures**

Human Genetics: Pedigree analysis; Karyotype, banding and nomenclature of chromosome subdivisions. Genetic disorders: chromosomal aneuploidy (Down, Turner and Klinefelter syndromes), chromosome translocation (Chronic Myeloid Leukemia) and deletion ("cry of cat" syndrome), gene mutation (sickle cell anemia). Genetic counseling. Polymerase Chain Reaction. DNA Sequencing; Southern, Western &

Northern Blots. In situ Hybridization, FISH, SNPs, RFLPs, ESTs, STS and Oligonucleotide arrays. Gene Cloning vs Animal Cloning, Nuclear transplantation, stem cells and IPS cells.

Recommended readings

1. Gardner, E.J. et al. (2006) Principles of Genetics (John Wiley).
2. Russell, P.J. (2010) Genetics (Benjamin Cummings).
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.
5. Klug, W.S., Cummings, M.R. and Spencer, C.A. (2012). Concepts of Genetics. (X edition) Benjamin Cummings.
6. 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.

Practical

1. Application of probability in the law of segregation with coin tossing
2. Frequency of the following genetic traits in human: widow's peak, attached ear lobe, dimple in chin, hypertrichosis, colour blindness, PTC tasting
3. Study of mode of inheritance of the following traits by pedigree charts – attached ear lobe, widow's peak
4. Familiarization with techniques of handling Drosophila, identifying males and females; observing wild type and mutant (white eye, wing less) flies, and setting up cultures
5. 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)
6. Demonstration of lethal alleles using Curly (Cy) mutant in Drosophila
7. Demonstration of multiple allelism by showing mutants of white eye series in Drosophila
8. Study of structural chromosome aberrations (dicentric, ring chromosomes and inversions in polytene chromosomes) from prepared slides/photographs
9. Study of human karyotypes and numerical alterations (Down syndrome, Klinefelter syndrome and Turner syndrome)
10. Extraction of Genomic DNA from bacteria.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUCTT3 and ZOUCLT3

Semester	Core Course	Course Title	Credits
III	CC-VII	Biochemistry	Theory: 03; Practical: 02

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

UNIT I: Introduction to Biochemistry, Carbohydrates 12 Lectures

Introduction, scope and importance of Biochemistry. Principle of bimolecular organization, configuration and conformation. Water as biological solvent. Carbohydrates: Structure and biological importance. Classification - Reducing and non-reducing sugars, monosaccharides, Oligosaccharides (Disaccharides), polysaccharides (peptidoglycans and glycosaminoglycans). Catabolism of carbohydrates and ATP production, Glycolysis, Krebs cycle, Electron transport chain and ATP synthesis Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

UNIT II: Lipids: Structure and Biological significance 13 Lectures

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

UNIT III: Protein structure and metabolism 16 Lectures

Proteins: Composition and Biological significance. Amino acids -Structure, classification and properties, Ionization, titration curve, pK and pI. Physiological importance of essential and non-essential amino acids. Catabolism of amino acids: Transamination, Deamination, Urea cycle. Enzymes: Nomenclature and classification, general properties, specificity, cofactors, isozymes. Mechanism of enzyme action (ES complex and lowering of activation energy, chemical catalysis). Kinetics (determination of Km and Vmax using Michaelis-Menten and Lineweaver-Burk plots). Regulation of enzyme activity, inhibition, allosteric regulation, role of covalent modifications, ribozymes and concept of abzymes.

UNIT IV: Nucleic acids and mechanisms of replication, transcription and translation 11 Lectures

Structure -Bases, nucleosides and nucleotides. DNA structure: Conformation (A, B and Z), DNA double helix (Watson and Crick model). DNA and RNA as genetic material. Organization of nucleosomes and higher order structure. DNA replication: Machinery and Basic mechanism (Prokaryotes). Transcriptional unit and basic mechanism of transcription (Prokaryotes). Genetic code and basic mechanism of translation (Prokaryotes).

Recommended readings

1. Nelson, D.L. & Cox, M.M. (2017) Lehninger 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.

Practical

1. Preparation of models of amino acids and dipeptides.
2. Ninhydrin test for α-amino acids.
3. Determination of pK and pI values of glycine.
4. Benedict's test for reducing sugars.
5. Iodine test for starch.
6. Determination of acid value of oil.
7. Preparation of models of nitrogenous bases, nucleosides and nucleotides.
8. Qualitative test for DNA & RNA.
9. Determination of the activity of enzyme (Urease).

9.1. Effect of [S] and determination of Km and Vmax.
9.2. Effect of temperature.
9.3. Effect of time.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUDTT1 and ZOUDLT1

Semester	Core Course	Course Title	Credits
IV	CC-VIII	Behaviour and Chronobiology	Theory: 03 Practical: 02

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 geneenvironment 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

UNIT I: Behaviour and the response invoking stimuli 12 Lectures

Animal behaviour. Scope and importance of study. Proximate and ultimate causes of behavior and the evolutionary approach to studying behaviour. Methods and recording of a behavior Types of stimuli invoking response: internal and external cues. Patterns of behaviour: Kinds of behaviour: foraging behaviour, Territorial behaviour. Mate selection and courtship behaviour. Parental care, defensive behaviour. Allelomimetic and maladaptive (abnormal) behaviour. Stereotyped Behaviours (Orientation, Reflexes); Innate/ Instinct behaviour. vs. Learnt Behaviour.

UNIT II: Communication and regulation of behaviour 13 Lectures

Social organization (e.g., Honey bee, Termites etc.). Communication in living in groups. Evolution of sociality, eusocial organisation. Genetic basis of behaviour. Regulation of behaviour: Neural control: kineses, taxes, simple reflexes. Sensory processing: toad prey capture, sound localization (owls), echolocation (bats). Hormonal control. Biological clocks: Advantages of biological rhythms. Circadian and circannual rhythms. Photoperiodism, tidal, solar and lunar rhythms, entrainments. Biological oscillation: the concept of Average, amplitude, phase and period, Role of melatonin. Applications of Chronobiology. Chronopharmacology, Chronomedicine, Chronotherapy. Migratory behaviour in birds and fishes.

UNIT III: Innate behaviour; Evolution of reproductive behaviour 13 Lectures

Innate behaviour: communication (primates, bees and ants). Decision making. Motor Output: leech swimming/crawling, escape behavior, cricket vocalizations. Sensorimotor integration: electric fish, bird song instinct and motivation. territorial behaviour, schooling behaviour. Displacement activities, Ritualization, Habitat selection, food selection and foraging behaviour in African ungulates. Mimicry and colouration. Evolution of reproductive behavior, mating systems and parental care. Asymmetry in sex, sexual dimorphism.

Unit IV: Learning behaviour; conditioning; socio-biology 14 Lectures

Learning (Learnt behaviour): habituation, imprinting, conditioned reflex, trial and error learning, latent learning, insight learning. Types of learning -Habituation, Imprinting and types of imprinting -filial and sexual, Classical conditioning, Instrumental learning and insight learning. Social behaviour: Social and cultural transmission of Behaviour; aggregation, group selection, kin selection, altruism. Social organization (e.g., Honeybee, Naked Mole Rat and Monkey). Elements of Socio-biology: Selfishness, cooperation, altruism, kinship and inclusive fitness

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., Massachusetts, 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. Kumar, V. (2002). Biological Rhythms: Narosa Publishing House, Delhi/ Springer Verlag, Germany.

Practical

1. Orientation of an animal to light.
2. Constructing an ethogram.
3. Chemical communication in ants.
4. Selective predation of coloured prey items.
5. Predatory behaviour of a carnivorous animal.
6. Nests and nesting habits of the birds and social insects
7. To study the behavioural responses of wood lice to dry and humid conditions.
8. To study geotaxis behaviour in earthworm.
9. To study the phototaxis behaviour in insect larvae.
10. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
11. Visit to Forest/ Wild life Sanctuary/Biodiversity Park/Zoological Park to study behavioural activities of animals and prepare a short report.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUDTT2 and ZOUDLT2

Semester	Core Course	Course Title	Credits
IV	CC-IX	Ecology	Theory: 03; Practical: 02

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

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

Introduction and scope of Ecology. Structure and function of ecosystem; Abiotic factors affecting survival and sustenance of organisms e.g., water, temperature, light, pH and salinity. Role of limiting factors in survival of biotic components. Major ecosystems of the world: Ecological features, limiting factors, zonation and classification of organisms of fresh water and marine ecosystems. Introduction to Biome: Ecological features of Tundra, Desert, Savannah and Tropical Rain forest Biomes.Energy flow in ecosystem, food chain and food web. Productivity. Mineralization and recycling of nutrients: C, N, P & S.

UNIT II: Population ecology; Human population growth **13 Lectures**

Ecology of populations. Unique and group attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal. Factors regulating population dispersal and growth: Exponential and logistic growth. Population regulation: density-dependent and independent factors; r and K strategies. Ecological efficiencies. Human population growth: Impacts on environment, carrying capacity, human health and welfare.

UNIT III: Biotic community, characteristics and attributes **13 Lectures**

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

UNIT IV: Environmental degradation; Environmental movement etc. **13 Lectures**

Environmental ethics; Pollution: Air, water and noise pollution and their control; Natural resources: Mineral, water and forest, their significance and conservation; Types of biodiversity, Hotspots; Biodiversity: status, monitoring and documentation; major drivers of biodiversity change; Biodiversity mapping using GPS, GIS and remote sensing. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value; Threats of biodiversity. Application of ecology in management and Conservation programmes.

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.

Practical

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 and collecting organisms from a given area.
4. Preparing and clearly present an essay based on the evaluation of 4-7 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.
7. Investigation of volatile inhibitory substances produced through decomposition of plant debris and root exudates.
8. Estimation of the ratio of the producers and consumers.
9. Studying insect diversity in a habitat.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUDTT3 and ZOUDLT2

Semester	Core Course	Course Title	Credits
IV	CC-X	Molecular Biology	Theory: 03; Practical: 02

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

Unit I: Central dogma; detailed information on nucleic acids **13 Lectures**

Introduction to Molecular Biology, Central Dogma of Molecular Biology. Structure and Function of DNA, DNA forms: Plasmid DNA, Genomic DNA and Repetitive DNA. Conformation, Structure and Topology of DNA. DNA-Protein interaction, DNA polymorphisms. Structure and Function of RNA, Ribosomal RNA (rRNA), Transfer RNA (tRNA), Messenger RNA (mRNA), Noncoding RNA.

Unit II: Chromosomes; DNA replication, recombination, repair etc. **13 Lectures**

Chromosomes, Chromatin, Histones, Histone-modifications. Chromatin remodeling. DNA modifications, DNA methylation DNA Replication, plasmid DNA replication and genomic DNA replication. DNA polymerases, other regulatory proteins, centromeric and telomeric DNA replication. DNA-damaging agents. DNA repair, mismatch repair, single strand- and double strand DNA repair

Unit III: RNA transcription, processing, editing, splicing etc. **13 Lectures**

Transcription, RNA polymerase I, II, III, transcription factors, Regulation of gene expression in prokaryotes and eukaryotes. RNA processing, splicing of hnRNA into mRNA, 5'-capping and 3'-polyadenylation of mRNA, rRNA and tRNA modifications and processing. RNA editing, alternative splicing, transsplicing, miRNA, siRNA, piRNA, lncRNA, RNA-protein complex.

Unit IV: Ribosomes: Role in cell sustenance. **13 Lectures**

Ribosomes, Genetic Code, triplet codons, Wobble base, synonymous codons, degeneracy of codons, missense-, nonsense- and frame shift mutations. Translation, protein synthesis in E. coli and eukaryotic cells. Aminoacylation of tRNA, initiation, elongation, peptide bond formation, translocation, termination, recycling of ribosome, regulation of protein synthesis and codon bias. Post-translational modifications and processing of proteins.

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.

Practical

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. Preparation of LB-agar plates (with and without 100 microgram/ml Ampicillin and 10 microgram/ml Tetracycline), streaking of E. coli DH5alpha strain (normal) and transformed with plasmids [Ampicillin-resistant (pBluescript) and Tetracyclineresistant (pBR322)].
4. Isolation of the plasmid DNA from the E. coli culture by alkaline lysis method.
5. Agarose gel electrophoresis of the plasmid DNA and the genomic DNA.
6. Staining of β-galactosidase activity in the DH5alpha cells with pBluescript plasmid by IPTG+X-Gal as an example of induction of gene expression.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUETT1 and ZOUELT1

Semester	Core Course	Course Title	Credits
V	CC-XI	Biotechniques	Theory: 03; Practical: 02

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

After successfully completing this course, the students will 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

UNIT I : Microscopy and Microtomy **13 Lectures**

Microscopy: Introduction to Microscopy. Definitions-Resolving Power, Limit of Resolution and Magnification, Numerical Aperture. Types of microscopes. bright field, dark-field, phase contrast. Basic principles of Light, Electron, Fluorescence and Confocal Microscopy. Measurements, Drawings and photomicrography. Microtomy: Tissue preparation, fixation, block preparation, sectioning, staining, dehydration and mounting. Type of microtome, type of blade, ultra-microtome and rotary microtome.

UNIT II : Tools and techniques in Biochemistry and Physiology **13 Lectures**

Biochemistry and Physiology: Physiological Salines, Buffers and the use of pH meter. Extraction of Tissue Glycogen, Proteins, Lipids and Nucleic Acids by Graaf's Method. Subcellular Fractionation by Differential Centrifugation. Basic Principle and Application of Colorimetry and Spectrophotometry, SOS, Beer-Lambert's Law. Principle and applications of Electrophoresis: Separation of Biomolecules by Native PAGE, 2D PAGE. Agarose gel electrophoresis. Principle and Applications of Paper chromatography, Thin layer chromatography, Gel-filtration chromatography.

UNIT III : Tools and Techniques in Endocrinology and immunology **13 Lectures**

Raising Polyclonal and Monoclonal Antibodies. Antigen-Antibody Interactions- Immunodiffusion, Ouchterlony's Double Immunodiffusion, Counter-Current, Immunoelectrophoresis, Western Blotting, ELISA, RIA. Application of Immunological techniques in disease diagnosis. Tracer techniques: Principle and Applications.

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

Cell Culture and Laboratory Animals: Cell culture and its basic requirements. Culture mediaNutrient and Non-nutrient, commonly used media for human cell lines. Sterilization of culture wares and Media, laminar flow. Types of animal cell culture, cell viability testing. cryopreservation. Lymphocyte culture. Cell

harvesting and Storage Methods. In Vitro culture of Entamoeba histolytica, Coenorhabditis elegans. Maintenance and Handling of laboratory rats and rabbits. Bioethics.

Recommended readings

1. Boyer, R. (2000) Modern Experimental Biochemistry (3rd edition) Benjamin-Cummings.
2. Pearse, A.G.E. (1980-1993) Histochemistry - Theoretical and applied, Volume I-III, Churchill-Livingstones.
3. Plummer, D. (2017) An Introduction to Practical Biochemistry (3rd edition) McGraw Hill.
4. Wilson, K. and Walker, J. (2010) Experimental Biochemistry, Cambridge.

Practical

1. Preparation of buffer and determination of pH.
2. Identification of amino acids in the mixture using paper chromatography.
3. Verification of laws of spectrophotometry.
4. Separation of proteins using SDS-PAGE.
5. Tissue fixation, paraffin block preparation, sectioning.
6. Preparation of permanent slides of microscopic organisms/ small insects.
7. Demonstration of bright field, phase contrast, fluorescence, confocal and electron microscopes.

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUETT2 and ZOUELT2

Semester	Core Course	Course Title	Credits
V	CC-XII	Microbiology, Parasitology and Immunology	Theory: 03 Practical: 02

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

After successfully completing this course, the students will 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

UNIT: Microbiology: A brief account of pathogenic bacteria and viruses. 13 Lectures

Brief history of microbiology- germ theory of disease, discovery of penicillin. Diversity of microbes- viruses and bacteria. Host pathogen interaction: invasion, antigenic heterogeneity, toxins and enzymes secretions. Kinetics of bacterial growth and staining techniques. Viral diseases: polio, rabies, hepatitis, influenza, dengue, AIDS, chicken pox, swine flu with emphasis on their causative agents, pathogenesis, diagnosis, prophylaxis. Bacterial diseases caused by Streptococcus pneumoniae, Salmonella typhi, Escherichia coli, Helicobacter pylori, Mycobacterium tuberculosis, Vibrio cholerae. Fungal diseases: Ringworm infection, aspergillosis, candidiasis.

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

Introduction to parasites and parasitic diseases. Mode of transmission, portal of entry and implications of parasitism. Parasitic adaptations. Concept of zoonotic diseases. Protozoan diseases of medical importance: amoebiasis, giardiasis, malaria, trypanosomiasis, leshmaniasis and toxoplasmosis. Helminthic diseases of medical importance: Schistosomiasis, taeniasis, ascariasis and filariasis.

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

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

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

Acquired immunity: Humoral and cell mediated immune response. Role of B and T cell in immunity. Receptors, activation and differentiation of B and T cells. Cytokines: Properties and function. MHC complex and molecules with classification and function. Graft rejection. Antigen processing and their presentation. Hypersensitivity. Autoimmune disorders. Hybridoma technology, monoclonal antibodies, immunotoxins.

Recommended readings

1. Jawetz, M. and Adelberg (2015) Medical Microbiology (27th edition)
2. Chatterjee, K.D (2015) Parasitology (13th edition)
3. Goldsby, R.A.; Kindt, T.J. and Kuby, J. (2006) Immunology (6th edition).
4. Roitt, I.; Brostoff, J. and Male, D. (2012) Immunology (8th edition).

Practical

1. Study of permanent slides and specimens of parasitic protozoans and helminthes.
2. Pathological examination of sputum, blood, urine and stool.
3. Blood: Erythrocyte Sedimentation Rate (ESR), Haematocrit.
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 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.

Group discussion or Seminar presentation on one or two related topics to those provided in the list.

Core Courses (CC): ZOUFTT1 and ZOUFLT1

Semester	Core Course	Course Title	Credits
VI	CC-XIII	Biostatistics and Bioinformatics	Theory: 03 Practical: 02

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

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

 Know the theory behind fundamental bioinformatics analysis methods. 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

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

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

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

Correlation: Types of correlation, Calculation of correlation in continuous data and ordinal data. Regression: Linear regression, regression coefficient. Analysis of variance (ANOVA): One way, post-hoc tests. Hypothesis testing: Parametric tests (Paired and unpaired t-test, z-test, F-test) & Non Parametric tests (Chi-square test, Mann-Whitney U-test)

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

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

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

Basic features and management systems of following: Nucleic acid sequences databases, Genome databases, Protein sequence, structures and interacting proteins databases, Literature databases, Biodiversity and ecosystem based databases. Introduction to data retrieval systems, Search engines, Entrez, sequence retrieval system (SRS) and protein identification resource (PIR). Introduction to molecular sequence analysis software packages and tools, Prediction of motifs, folds and domains, Sequence alignments (BLAST and Clustal W) and phylogenetic trees (PHYLIP). Applications of bioinformatics: Clinical informatics, Cheminformatic resources and pharmacoinformatics

Recommended readings

1. Daniel, W.W. (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. Barnes, M.R. and Gray, I.C. (2003) Bioinformatics for geneticists, Wiley.
5. Mount, D.W. (2006) Bioinformatics (2nd edition) CBS.

Practical

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

Group discussion or Seminar presentation on one or two related topics from the list.

Core Courses (CC): ZOUFTT2 and ZOUFLT2

Semester	Core Course	Course Title	Credits
VI	CC-XIV	Applied Zoology	Theory: 03;Practical: 02

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

After successfully completing this course, the students will 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

UNIT I: Aquaculture **13 Lectures**

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

UNIT II: Apiculture, Lac culture and Sericulture **13 Lectures**

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

UNIT III: Dairy management and poultry farming **13 Lectures**

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

UNIT IV: Vermiculture; Maintenance of reared animals **13 Lectures**

Vermiculture: Biology of Eisenia foetida. Rearing of earthworms, Equipments , devices used in vermiculture, Vermicompost Technology. Methods and products, Vermiwash Collection, Composition and use. Introduction and importance. Health care and maintenance of reared animals. Methods for analysis of blood. Methods for analysis of urine. Infectious diseases. Non-infectious diseases

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.

Practical

1. Morphological characterization of common fish species.
2. Identification of two major carps – Labeo rohita and Catla catla and their life cycles.
3. Mounting of the sting apparatus.
4. Castes (through charts/specimens) study of bees
5. Worker honey bee with emphasis on leg modifications (through specimens/charts) and whole mount preparation of the 3 pairs of legs.
6. Life cycle of mulberry silkworm, Bombyx mori (model/chart/specimens) and life cycle of tasar silkworm, Antheraea mylitta.
7. External morphology and nomenclature of dairy animals. Determination of the specific gravity of milk by using a mercury lactometer.
8. Test for good quality eggs (Floating test, cracking test) and for fertilized and unfertilized eggs (Light test, Cracking test).
9. External morphology of poultry birds (model).
10. Project report on visit to dairy farm and visit to Poultry farm (Poultry management and Poultry breeds).

Group discussion or Seminar presentation on one or two related topics from the list.

Discipline Specific Elective Courses (DSE): ZOUETD1 and ZOUELD1

Semester	Core Course	Course Title	Credits
V	DSE-I	Mammalian Physiology	Theory: 03; Practical: 02

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 hemoglobin content, blood groups and blood pressure.

Theory

Unit-I: An overview of respiration and circulation in mammals 12 Lectures
Respiration: Mechanism and regulation of breathing; Transport of oxygen and carbon dioxide; Respiratory quotient. Circulation: Blood buffers, blood groups, blood cells, cardiac cycle, Haemopoiesis, homeostasis.

Unit-II: An overview of digestion and excretion in mammals 10 Lectures
Nutrition and Digestion: Balanced diet; Digestion and absorption of carbohydrates, proteins and fats; Gastrointestinal hormones: role in digestion. 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
Nervous System: Organization, neuron and glial cells- types and structure; Synapses – types and transmission, resting membrane potential: genesis; Action potential: initiation and conduction. Vision: Structure of eye, retinal components, and photoreceptors: ionic basis of potential generation. Hearing: Structure of ear, mechanoreceptor: ionic basis of potential generation.

Unit-IV: An overview of Muscular system and muscle contraction in mammals 11 Lectures
Muscles: Types, Ultra structure of skeletal, smooth and cardiac muscles, muscle proteins; Neuromuscular junction; Molecular and chemical basis of muscle contraction; Characteristics of muscle twitch, tetanus and fatigue, isotonic and isometric contractions.

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.

Practical

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. Determination of oxygen consumption (cockroach)
8. Preparation of casein from milk
9. Recording of simple muscle twitch with electrical stimulation (or Virtual)
10. Demonstration of reflex action
11. Study of permanent histological sections of mammalian oesophagus, stomach, duodenum, rectum, lung, kidney and brain cells

Group discussion or Seminar presentation on one or two related topics from the list.

Discipline Specific Elective Courses (DSE): ZOUETD2 and ZOUELD2

Semester	Core Course	Course Title	Credits
V	DSE-II	Endocrinology	Theory: 03; Practical: 02

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.

Learning outcomes

- Understand neurohormones and neurosecretions.
- Learn about hypothalamo and hypapophysial axis.
- Understand about different endocrine glands and their disorders.
- Understand the mechanism of hormone action.

Theory

Unit-I: The chemical messangers **07 Lectures**

Definition and classification of hormores. Endocrine, paracrine and autocrine modes of hormone delivery, Feedback mechanism, Types of hormones, protein and steroid hormone.

Unit II: Hypothalamo-hypophysial Axis **10 Lectures**

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

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

Structure, Hormones, Functions, Systhesis and Regulation of Thyroid gland; Parathyroid and Adrenal glands; Pancreas; Ovary and Testis; Hormones in homeostasis; Disorders of endocrine glands.

Unit-III: Evolution of reproductive mechanism and regulation **05 Lectures**

Evolution of human reproductive strategy; Evolutionary impact on behaviour; Sexuality hormonal effects on maternal-infant bonding; Parturition; Stress, anorexia, steroids in the environment; Endocrine disrupting chemicals.

Unit-IV: Regulation of Hormone Action **10 Lectures**

Hormone action at Cellular level: Hormone receptors; Membrane and intracellular receptors, Transduction and regulation of Hormone action at Molecular level; Molecular mediators; Genetic control of hormone action.

Recommended 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. Hadley, M.E. and Levine J.E. (2007) Endocrinology (6th edition) Pearson Prentice-Hall, New Jersey. 4. David, O.N. (2013) Vertebrate Endocrinology.

Practical

1. Dissection and demonstration of Endocrine glands in laboratory bred rat*.
2. Study of the permanent slides of all the endocrine glands.
3. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat*.

4. Demonstration of Castration/ ovariectomy in laboratory bred rat*.
5. Estimation of plasma level of any hormone using ELISA.
6. Designing of primers of any hormone.

Group discussion or Seminar presentation on one or two related topics from the list

Discipline Specific Elective Courses (DSE): ZOUFTD1 and ZOUFLD1

Semester	Core Course	Course Title	Credits
VI	DSE-III	Neuroscience	Theory: 03; Practical: 02

About the course

This course will start from the basics of the nervous system of invertebrates and will gradually move towards a more complex vertebrate nervous system. The students will also be taught about the types of synapse, neurotransmitters and their receptors besides other related aspects.

Learning outcomes

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

- Understand the structure of brain and improved methods to study it.
- Develop treatments for neurodegenerative diseases (such as Alzheimer's and Parkinson's diseases) and mental illnesses.
- Understand the structure of different lobes of the brain and their corresponding functions.
- Understand intricacies of nerve impulse conduction.

Theory

Unit-I: Brain and spinal cord: Diversity in animals **12 Lectures**

General organization of nervous system: Invertebrate Nervous system: Organization of neurons in brain and ganglia of invertebrates nerve net, nerve plexus and ganglionated nervous system (hydra, starfish and earthworm); Functional organization of the human central nervous system, subdivisions of the CNS – spinal cord, medulla, pons, cerebellum, midbrain, diencephalon and cerebral hemispheres; Various lobes of the brain- fore brain, mid brain and hind brain and their functional familiarization; Limbic System and its related functions.

Unit-II: Nerve cells and action potential **12 Lectures**

Types of cells: neuronal, glial, ependymal and Schwann cells; Chemical basis of neural transmission- ionic basis of resting membrane potential: Donann's equilibrium experiments, Nernst's potential, Goldman's equation, sodium-potassium pump; Action Potential & propagation- Hodgkin and Huxley's model, voltage clamp experiment and the derivation and propagation of action potential.

Unit-III: Synaptic potential, neurotransmission etc. **14 Lectures**

Neuromuscular junctions, synapse and synaptic transmission. Synaptic potential and synaptic integration [Electrical and Chemical Synaptic Potential], Excitatory Post Synaptic Potential (EPSP), Inhibitory Post Synaptic Potential (IPSP). Neurotransmitters–Different types– catecholamines, amino acidergic and peptidergic neurotransmitters and their biosynthesis. Physiological role and pharmacological significance of neurotransmitters. Agonist and antagonist for neurotransmitters: Acetylcholine, Dopamine, GABA and Glutamate, Neuropeptide (Endorphin and Enkephalin). Neurotransmitter receptors: (a) Ionotropic receptors (nicotinic receptors of acetylcholine) (b) Metabotropic receptors like G-protein coupled receptors (D1 and D2 of dopamine and muscarinic receptors of acetylcholine).

Unit-IV: Neuropharmacology and molecular pathogenesis **14 Lectures**

Relationship of functional properties of neural systems with perception and behaviour; sensory systems, molecular basis of behaviour including learning and memory. Neuropharmacology: Introduction and its branches. Behavioural neuropharmacology: Effects of drug dependence and addiction. Roles of neurotransmitters, neuropeptides, neurohormones and neuromodulators in neuropharmacology. Molecular pathogenesis of pain and neurodegenerative diseases such as Parkinson's, Alzheimer's, psychological disorders, addiction, etc.

Recommended readings

1. Baer, M.F. and Connors B.W. (2015) Neuroscience: Exploring the brain.
2. Byrne, J.H.; Heidelberg, R. and Waxham, M.N. (2014) From Molecules to Networks: An Introduction to Cellular and Molecular Neuroscience.
3. Kandel, E.R.; Schwartz, J.H. and Jessell, T.M. (2000) Principles of Neural Science (4th edition) McGraw Hill Companies
4. Simmons, J. and Young, D. (2003) Nerve Cells and Animal Behaviour (2nd edition) Peter. CUP.
5. Stahl, S.M. (2000) Essential Psychopharamacology- Neuroscientific Basis and Practical Applications (2nd edition) CUP
6. Vilayanur, S.R. and Blakeslee S. (1998) Phantoms in the Brain. Probing the Mysteries of the Human Mind.

Practical

1. Dissection of chicken brain.
2. Questionnaire based exercise- Alcohol screening (MAST), alcohol used disorder test (AUDIT)
3. Dissection of goat brain
4. Study of neurons and/ or myelin by Nissl, Giemsa or Luxol Fast Blue staining.
5. Study of olfaction in Drosophila.
6. Study of novelty, anxiety and spatial learning in mice.
7. Development of nervous system in zebra fish.

Group discussion or Seminar presentation on one or two related topics from the list

Discipline Specific Elective Courses (DSE): ZOUFTD1 and ZOUFLD1

Semester	Core Course	Course Title	Credits
VI	DSE-III	Wildlife Conservation and Management	Theory: 03 Practical: 02

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

Unit-I: Value of wildlife and need for its conservation **13 Lectures**

Definition, value and importance of wildlife; Causes of depletion of wildlife; Factors responsible for the extinction of animals; Types of protected areas and the concept of zoning within the protected areas; Wildlife Sanctuaries and National Parks in India: general strategies and issues; Theories of population dispersal; Animal movement, concept of home range and territory; Tracking movement by remote sensing and GIS.

Unit-II: Population and prey-predator dynamics **13 Lectures**

Impact of habitat destruction and fragmentation on wildlife; Biological parameters such as food, cover, forage and their impact on wild life; Population attributes; concepts of exponential and logistic growth rates of wildlife; Density dependent and independent population regulation; Impact of introduced species on preexisting flora and fauna of wildlife; Identification and estimation of wild animals by fecal sample analysis, hair identification, pug marks and census methods. Predator-prey models and impact of predation.

Unit-III: Wildlife Conservation **13 Lectures**

Wildlife conservation objectives- strategies and issues; Captive breeding techniques and translocation and reintroduction; Inviolate area and critical habitats and their impact on wildlife; Restoration of degraded habitat; Damage caused by wildlife in India and its mitigation; Sick animal refuges in protected areas.

Unit-IV: Rehabilitation and management **13 Lectures**

Type of wildlife management-manipulative, custodial; Management of over abundant wild animal populations causing damages to nearby inhabitants and their crops and animals; Tools

and techniques to control the menace of wild animals; Management of exotic and invasive wetland species in India. Habitat manipulation– control and regulation of grazing. Weed eradication; Major diseases of domestic and wild animals and their control and impact of wild life tourism.

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 edition) 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.

Practical

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna.
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 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 for flora and fauna.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).

Group discussion or Seminar presentation on one or two related topics from the list.

Generic Elective Courses (GEC): ZOUATG1 and ZOUALG1

Semester	Core Course	Course Title	Credits
I	GEC-I	Exploring the Brain: Structure and Function	Theory: 03 Practical: 02

About the course

The course provides an insight into the structure of brain, its associated functions, its gradual evolution with increased cranial capacity, mechanism of neurotransmission and the associated neurodegenerative disorders.

Learning outcomes

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

- The early and current status of neuroscience.
- The structure of brain cells and their circuit.
- Evolution and adaptation of brain.
- Brain development, aging and imaging.
- Neurotransmitters and their action.
- The process of learning and memory.
- Different type of brain disorders.

Theory

UNIT I: Scope of Neuroscience. Brain structure **11 Lectures**

Introduction to Neuroscience and its scope. Classical views and latest advances in Neuroscience. Brain cells, types: Neurons – types and structure; Glia- types and structure; Neuronal circuit.

UNIT II: Evolution and development of brain **12 Lectures**

Evolution and Adaptation of Brain: Theories of brain evolution. Evolution of brain in vertebrates and associated behavioral adaptation. Organization and development of brain in human. Divisions of the brain. Structure-function relationship. Neuroimaging- CT and MRI.

UNIT III: Neurotransmitters and mechanism of neurotransmission **13 Lectures**

Neurotransmitters and neurotransmission: Noradrenergic, serotonergic, dopaminergic and cholinergic system. Mechanism of neurotransmission and drug action. Learning and memory. Types, mechanism, disorders.

UNIT IV: Managing brain health **16 Lectures**

Brain aging: Structural and chemical changes. Functional changes. Maintenance of healthy brain. Brain disorders: Neurodegenerative diseases- Epilepsy, Stroke, Alzheimer's, Parkinsons. Neuropsychiatric disorders- Anxiety, Depression, Mood disorders, Schizophrenia.

Recommended readings

1. Squire, L. et al. (2003) Fundamental Neuroscience, Academic Press.
2. Kandel, E. (2000) Principles of Neural Science, McGraw Hill

Practical

1. Dissection and study of chicken brain.
2. Observation and quantization of Drosophila behavior in response to food.

3. Experiments based on the course contents.

Group discussion or Seminar presentation on one or two related topics from the list.

Generic Elective Courses (GEC): ZOUBTG1 and ZOUBLG1

Semester	Core Course	Course Title	Credits
II	GEC-II	Vectors, Diseases and Management	Theory: 03 Practical: 02

About the course

The course provides an insight into the common vector-borne diseases, their etiology, role of vectors in their spread, host- parasite relationship and finally the strategies to manage these vectors.

Learning outcomes

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

 Develop awareness about the causative agents and control measures of many commonly occurring diseases.

 Develop understanding about the favourable breeding conditions for the vectors.

 Devise strategies to manage the vectors population below threshold levels, public health importance.

 Undertake measures or start awareness programmes for maintenance of hygienic conditions, avoidance of contact from vector, destruction of breeding spots in the vicinity of houses and cattle shed by public health education campaign.

Theory

Unit I: Vector and vector bionomics **13 Lectures**

Brief introduction, types and morphological peculiarities of vectors such as mosquitoes, flies, fleas, lice, bugs, ticks and mites. Host-vector relationship. Primary and secondary vector concept. Vectorial capacity. Vector bionomics-larval habitats and host biting preferences, human and animal biting indices. Evolution of vector bionomics and its effect on disease transmission. Vector incrimination. Human practices and the occurrence of pests

Unit II: Disease vectors and the causes of disease outbreaks **13 Lectures**

Salient features of the vectors belonging to Diptera, Siphonaptera, Siphunculata, Hemiptera, Arachnida, Blattaria, Acarina (families Ixodidae and Argasidae) etc. Role of non-blood sucking flies in myiasis; of blood sucking flies in transmission of plague and typhus; of lice (body, head, pubic) in transmission of typhus, relapsing and trench fevers, Vagabond's disease and Phthiriasis; of bugs in transmission of Chaga's disease of. Brief account of mites and the associated diseases. Population biology, Factors affecting abundance, Density dependence and independence, How do people cause outbreak?

Unit III: Vector management strategies **13 Lectures**

Control of vector flies by screening, fly traps, electrocution, poison baits and outdoor residual sprays; biological control by natural parasites and predators. Chemical control. Efficacy of synthetic pyrethroids, residual spray of insecticides, treated bed nets/curtains and fumigations. Biological control of mosquitoes by the use of viruses, bacteria, fungi, parasites, nematodes and larvivorous fishes. Sterile insect technique, Eradication, Other genetic approaches, Pheromones/allelochemicals, Attract-and –kill, Mating disruptors, alarm pheromones and oviposition disruptors

Unit IV: Emerging concepts and approaches to vector management **13 Lectures**

Legislation and regulation, Methods of sampling and monitoring, sampling plan, Allocation of sampling units. Exclusion and routes of entry. Controlled atmosphere, Risk assessment, The integrated control/ IPM approach, Damage thresholds estimation, Forecasting, Increasing agroecosystem resistance, Pesticide selection, Eradication versus control, Up to what limits IPM should be adopted. Decision support

Recommended readings

1. Imms, A.D. (1977). A General Text Book of Entomology. Chapman & Hall, UK.
2. Chapman, R.F. (1998). The Insects: Structure and Function.IV Edition, Cambridge University Press, UK.
3. Mathews, G. (2011). Integrated Vector Management: Controlling Vectors of Malaria and other Insect Vector borne Diseass.Wiley-Blackwell.
4. Belding, D.L. (1942). Textbook of Clinical Parasitology. Appleton-Century Co., Inc., New York.
5. Roy, D.N. and Brown, A.W.A. (2004). Entomology. Biotech Books, Delhi

Practical

1. Study of mouth parts of different insects.
2. Study of permanent slides of the following insect vectors: Aedes, Culex, Anopheles, Pediculus humanus corporis, Pediculus humanus capitis, Phithirus pubis, Xenopsylla cheopis, , Musca domestica, Cimex lectularius, Phlebotomus argentipes through permanent slides/ videos.
3. State the diseases transmitted by above insect vectors.
4. Project report submission on any one of the insect vectors and the disease transmitted.

Group discussion or Seminar presentation on one or two related topics from the list.

Generic Elective Courses (GEC): ZOUCTG1 and ZOUCLG1

Semester	Core Course	Course Title	Credits
III	GEC-III	Food, Nutrition and Health	Theory: 03; Practical: 02

About the course

The course covers the basic concepts of balanced diet for people of different ages besides focusing on the consequences of malnutrition and the deficiency diseases and the diseases caused due to poor hygiene.

Learning outcomes

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

 Understand the role of food and nutrients in health and disease.

 Provide culturally competent nutrition services for diverse individuals.

 Implement strategies for food access, procurement, preparation, and safety that are relevant for the culture, age, literacy level, and socio-economic status of clients and groups.

 Perform food system management and leadership functions that consider sustainability in business, healthcare, community, and institutional arenas.

Theory

Unit 1: Nutrition and dietary nutrients **12 Lectures**

Basic concept of Food: Components and nutrients. Concept of balanced diet, nutrient requirements and dietary pattern for different groups viz., adults, pregnant and nursing mothers, infants, school children, adolescents and elderly people.

Unit II: Macro nutrients and micronutrients **12 Lectures**

Nutritional Biochemistry: Macronutrients. Carbohydrates, Lipids, Proteins- Definition, Classification, their dietary source and role. Micronutrients. Vitamins- Water-soluble and Fat-soluble vitamins- their sources and importance. Important minerals viz., Iron, Calcium, Phosphorus, Iodine, Selenium and Zinc: their biological functions.

Unit III: Malnutrition and nutrient deficiency diseases **15 Lectures**

Definition and concept of health: Common nutritional deficiency diseases- Protein Malnutrition (e.g., Kwashiorkor and Marasmus), Vitamin A deficiency, Iron deficiency and Iodine deficiency disorders- their symptoms, treatment, prevention and government initiatives, if any. Life style dependent diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention. Social health problems- smoking, alcoholism, narcotics. Acquired Immuno Deficiency Syndrome (AIDS): causes, treatment and prevention. Other ailments viz., cold, cough, and fever, their causes and treatment.

Unit IV: Diseases caused by microorganisms **13 Lectures**

Food hygiene: Potable water- sources and methods of purification at domestic level. Food and Water-borne infections: Bacterial diseases: cholera, dysentery; typhoid fever, viral diseases: Hepatitis, Poliomyelitis etc., Protozoan diseases: amoebiasis, giardiasis; Parasitic diseases: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention. Causes of food spoilage and its prevention.

Recommended reading

1. Mudambi, S.R. and Rajagopal, M.V. (2007). Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed;; New Age International Publishers
2. Srilakshmi, B. (2002). Nutrition Science; New Age International (P) Ltd.
3. Srilakshmi, B. (2007). Food Science; Fourth Ed; New Age International (P) Ltd.

4. Swaminathan, M. (1986). Handbook of Foods and Nutrition; Fifth Ed; BAPPCO.
5. Bamji, M.S.; Rao, N.P. and Reddy, V. (2009). Text Book of Human Nutrition; Oxford & IBH Publishing Co. Pvt Ltd.
6. Wardlaw, G.M. and Hampl, J.S. (2007). Perspectives in Nutrition; Seventh Ed; McGraw Hill.
7. Lakra, P. and Singh M.D. (2008). Textbook of Nutrition and Health; First Ed; Academic Excellence.
8. Manay, M.S. and Shadaksharaswamy, M. (1998). Food-Facts and Principles; New AgeInternational (P) Ltd.
9. Gibney, M.J. et al. (2004). Public Health Nutrition; Blackwell Publishing.

Practical

1. Detecting adulteration in
    a) Ghee b) Sugars c) Tea leaves and d) Turmeric.
3. Estimation of Lactose in milk.
4. Titrimetric method for Ascorbic acid estimation.
5. Estimation of Calcium in foods by titrimetry.
6. Study of the stored grain pests from slides/ photograph (*Sitophilus oryzae, Trogoderma granarium, Callosobruchus chinensis* and *Tribolium castaneum*): their identification, habitat and food sources, damage caused and control. Preparation of temporary mounts of the above stored grain pests.
7. Project- Computer aided diet analysis and nutrition counselling for different age groups.

Group discussion or Seminar presentation on one or two related topics from the list

Generic Elective Courses (GEC): ZOUDTG1 and ZOUDLG1

Semester	Core Course	Course Title	Credits
IV	GEC-IV	Global Environmental Issues	Theory: 03; Practical: 02

About the course

This course focuses on the diversity of living forms particularly animals with a detailed inference on the loss of species due to various reasons and the need of their conservation.

Learning outcomes

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

- Understand the fundamental issues of environment.
- Analyze different sources of environmental problems and methods of measurement of pollution.
- Examine economic growth and quality of life.
- Examine the microbiology of waste water treatment and its various schemes.

Theory

Unit I: Environment and Environmental Problems **13 Lectures**

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, Fisheries depletion, Eutrophication, their impact and biotechnological approaches for management.

Unit II: Environmental Pollution **11 Lectures**

Environmental pollution - types of pollution, Air, water and land pollution. sources of pollution, measurement of pollution, fate of pollutants in the environment, Ocean acidification, Bioconcentration, bio/geomagnification.

Unit III: Environmental Economics **12 Lectures**

Environmental Economics : Basic concept; methods of evaluation; Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit ratio and cost effectiveness analysis.

Unit IV: Use of Microbes in Waste Water Treatment **15 Lectures**

Aerobic decomposition process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic decomposition process - anaerobic filters, up- flow anaerobic sludge blanket reactors. Treatment schemes for sewage from dairy, distillery, tannery, sugar and pharma industries.

Recommended readings

1. Frances, H. (2012). Global Environmental Issues (2nd edition) Willey-Blackwell
2. Mahesh, R. (2007) Environmental Issues in India: A Reader. Pearson-Longman.

Practical

There are no structured class lab experiments involved. However the students are expected to visit various sites on the web, make teams for group-discussion indulge in debates, collect justifiable information from various sources, make historical report on major global environmental issues:

1. Atmosphere Management: Pollution, global warming/climate change, Stratospheric ozone depletion its impact and possible solutions.

2. Fresh water Management: Pollution, reasons, severity of problem, impact for the present and the future, its impact and possible solutions.
3. Marine Ecosystem: Pollution of marine ecosystem, its impact and possible solutions.
4. Soil degradation and Desertification
5. Solid Waste Management

Ability Enhancement Course (AEC): A1

Semester	Core Course	Course Title	Credits
I-V	AEC-I	Human Health and Sex Education	Theory: 01, Practical: 01

About the course

The course is designed to address problems associated with health and sex thereby, promoting fitness and well being.

Learning outcomes

After the completion of this course, the students will be able to:

- understand the importance of good health.
- observe clean sexual habits thereby warding off sexually transmitted diseases.

Theory

Unit I: Health: Physical and spiritual

Health as a state of wellbeing, health awareness, Physical health, immunization and vaccination, healthy food, balanced diet, food supplements, proper sleep, exercise and keeping away from stress, pathogens and pollution. Reproductive health, adolescence, senescence. Prevention from mental illness and disabilities, alcoholism, tobacco addiction, de-addiction, lifestyle diseases. Spiritual health, yoga and meditation.

Unit II: Human reproductive and developmental cycle

Human reproductive system: structural details of male reproductive system, semen, hormonal control. Female reproductive system- structure of ovary, puberty, reproductive cycles and hormonal control, gestation period, hysterectomy, menopause. Events of human reproduction: Gametogenesis-spermatogenesis and oogenesis, ovulation, fertilization, embryonic development, parturition.

Unit III: Infertility and assisted reproductive techniques

Human intervention in reproduction: Contraception and birth control-barrier method, hormonal methods, natural methods, sterilization, termination of pregnancy. Infertility-male and female infertility, causes and treatment for infertility. Advanced Reproductive Technologies- IVF, GIFT, ZIFT, Donor Insemination (DI). Sperm transfer techniques. Surrogacy.

Unit IV: Sex education and prevention from Sexually transmitted diseases

Sexually transmitted diseases: Syphilis, chlamydia, trichomoniasis, gonorrhea, AIDS, Sex education: Adolescent sexual activity, teenage pregnancy, sexual harassment, sexual awareness and policies (legal aspects), lesbian and gay sex, bisexual, transgender youth, adolescent stress management

Recommended readings

1. Kothari P. (1994) Common sexual problems and solutions by, UBS Publishers and Distributors Ltd.
2. Hadley, Mac. E.. (2004) Endocrinology. (5th edition) Pearson Education, Singapore.
3. Taylor, D.J., Green, N.P.O., Stout G. W. (2005) Biological Science. (Editor R. Soper) 3rd Edition, Cambridge University Press.
4. The Complete Manual of Fitness and Well-being. The Reader's Digest Association, Inc. Pleasantville, New York / Montreal.
5. Guyton, A.C. and Hall, J.E..Textbook of Medical Physiology.

Ability Enhancement Course (AEC): A2

Semester	Core Course	Course Title	Credits
I-V	AEC-II	Human Nutrition	Theory: 01, Practical: 01

About the course

The course deals with the importance of nutrition in maintaining health; the essential nutrients, balanced diet, the calories associated with different food items and the factors affecting the fitness in humans, food sanitation and hygiene.

Learning outcomes

After the completion of this course, the students will be able to:

- Know about essential nutrients and required macro and micro nutrients
- Cultivate proper feeding habits. Know caloric value of the food items
- Learn the proper and scientific value of different food items.

Theory

Unit I: Carbohydrate and protein as important food sources

Carbohydrates: Functions, classification, food sources, storage in body. Brief outline of metabolism: glycogenesis & glycogenolysis (in brief), glycolysis, citric acid cycle.

Proteins: Functions, classification, food sources, composition, essential & nonessential amino acids, protein deficiency. Metabolism: Transformation, Decarboxylation, Ammonia formation & transport, Urea cycle.

Unit II: Fat as a source of energy

Fats & oils: Function of fats, classification, food sources, composition, saturated and unsaturated fatty acids, biomedical importance, essential fatty acids. Brief out line of metabolism: Beta oxidation of fatty acids, Ketosis, Cholesterol. **Vitamins and Minerals:** sources and functions, deficiency status. Bioavailability and deficiency of Calcium, Iron, Iodine, Sodium & Potassium. **Water:** importance as a nutrient, function, sources, requirement, water balance & effect of deficiency.

Unit III: Nutritional requirements and calories of a balanced diet

Basal metabolic rate, energy requirements of man, women, infants and children. Nutritional value of foods-cereals, fruits, milk, egg, meat, fish. Balanced diet, Nutrition requirements as per physiological stages of pregnancy, food selection, complication of pregnancy. Nutrition requirements during lactation and during infant growth and development, breast feeding, infant formula, Supplementary diet.

Unit IV: Malnutrition and health requirements

Nutritional requirement and growth in preschool children growth, Nutritional requirement of school children, importance of snacks, school lunch. Nutritional needs and feeding pattern during adolescence and adulthood. Geriatric nutrition: Factors affecting food intake and nutrition related problems. Foods of nutritional value, Balanced diet, Malnutrition, Use of food in body. Role of fibres in human nutrition; Effect of cooking and heat processing on the nutritive value of foods; Processed supplementary foods; Food sanitation in hygiene.

Recommended readings

1. Gopalan, C., Ramasastri, B.S. & Balasubramanian, S.C. (1971). Nutritive value of Indian foods. National Institute of Nutrition, Hyderabad.
2. Gopalan, D. & Vijayaraghavan, K. (1971). Nutrition atlas of India, ICMR, New Delhi.
3. Ghosh, S. (1981). The feeding care of infants and young children, UNICEF, New Delhi.

4. Mudambi, S.R. (1995). Fundamentals of food and nutrition. New age international, New Delhi.
5. Swaminathan, M. (1989). Handbook of food and nutrition. Bappco, Bangalore.
6. Swaminathan, M. (1974). Essentials of food and nutrition. Vol I & II, Ganesh and Co. Madras.

Ability Enhancement Course (AEC): A3

Semester	Core Course	Course Title	Credits
I-V	AEC-III	History of Indian Science	Theory: 01, Practical: 01

About the course
The course provides an insight into the status of science in ancient India, its gradual development, innovations and the pioneers in the field of science, reputed research institutions in India and cutting edge research in science.

Learning outcomes
On completion of this course, the students will be able to
- Develop understanding of various branches of science during different eras
- Analyze the role played by different Indian organizations in science
- Appraise the contribution of different Indian Scientists.

Unit I: Science in Ancient and Medieval India
History of development in astronomy, mathematics, engineering and medicine subjects in Ancient India, Use of copper, bronze and iron in Ancient India, The geography in literature of Ancient India. Influence of the Islamic world and Europe on developments in the fields of mathematics, chemistry, astronomy and medicine, innovations in the field of agriculture-new crop introduced new techniques of irrigation.

Unit II: Indian Science in before and after Independence
Introduction of different surveyors, zoologists and doctors as early scientist in Colonial India, Indian perception and adoption for new scientific knowledge in Modern India, Establishment of premier research organizations like CSIR, DRDO and ICAR and ICMR, IIT's, Establishment of Atomic Energy Commission, Launching of the space satellites, ISRO's accomplishments. Zoological survey of India.

Unit III: Prominent Indian scientists
Eminent scholars in mathematics and astronomy: Baudhayana, Aryabhatta, Brahmgupta, Bhaskaracharya, Varahamihira, and Nagarjuna, Medical science of Ancient India (Ayurveda and Yoga): Susruta, Charak. Scientists of Modern India: Srinivas Ramanujan, C.V. Raman, Jagdish Chandra Bose, Homi Jehangir Bhabha,Vikram Sarabhai etc.

Unit IV: Prominent research in Animal Sciences in Republic of India
History of animal tissue culture with context to India; green, white and pink revolutions in India: causes, details, and outcomes. The pioneers associated with. First gene cloning, First genome sequencing from India. Premier Research institutes and current eminent scientists in India, GM organisms.

Recommended readings
1. Kuppuram, G. (1990) History of Science and Technology in India, South Asia Books.
2. Handa, O.C. (2014) Reflections on the history of Indian Science and Technology, Pentagon Press.
3. Basu, A. (2006) Chemical Science in Colonial India: The Science in Social History, K.P. Bagchi & Co.
4. Habib, I. (2016) A people's history of India 20: Technology in Medieval India, 5th Edition, Tulika Books.
5. Rahman, A. et al (1982) Science and Technology in Medieval India – A Bibliography of Source Materials in Sanskrit, Arabic and Persian, New Delhi: Indian National Science Academy.
6. Subbarayappa, B.V. & Sarma, K.V. (1985), Indian Astronomy -– A Source Book, Bombay.
7. Srinivasan, S., Ranganathan, S. (2013) Minerals and Metals heritage of India, National Institute of Advanced Studies.

8. Srinivasiengar, C.N. (1967) The History of Ancient Indian Mathematics, World Press Private Ltd. Calcutta.
9. Bhardwaj, H.C. (2000) Metallurgy in Indian Archaeology. Tara Book Agency

Ability Enhancement Course (AEC): A4

Semester	Core Course	Course Title	Credits
I-V	AEC-IV	Personality Development	Theory: 01, Practical: 01

About the course
The course includes diverse aspects of personality development including the principles and methods to achieve success by enhancing psychological skills and time management abilities. The course also deals with ways of human resource improvement by enhancing creativity and thinking skills.

Learning outcomes
After the completion of this course, the students will be able to:
 Develop understanding of the concepts and principles of basic psychological skills
 Apply techniques and methods to enhance productivity and time management
 Develop critical thinking and managerial skills
 Organize human resources with improved leadership qualities

Unit I: Basic Psychology Skills
Mental Heuristics and Priming, Cialdini's six psychological principles, Self Awareness and Self Development: Self appraisal, thoughtful and responsible approach, value and belief system, perception and attitude. Charisma and charisma enhancements, facing interviews.

Unit II: Productivity and Time Management
Eisenhower Matrix, Pomodoro Technique, Dealing with Procrastination, Journaling methods, Checklists, to-do lists and scheduling the events. Swot analysis. Identifying one's strength and failures. Knowing

Unit III: Dealing Negativity
Work-life balance, stress management, coping with failures and depression. Interpersonal skills and communication skills, learning about commitment and how to move things forward, making key decisions

Unit IV: Critical Thinking and Human resources
Logical fallacies, Cognitive biases, Mental Models, Critical Thinking. Evaluation and improvement; Leadership qualities. Leading by example, effective feedback, ethical reasoning.

Recommended readings
1. Bast, F. (2016) Crux of time management for students. Available at: https://www.ias.ac.in/article/fulltext/reso/021/01/0071-0088
2. Cialdini, R.B. (2001) Influence: The Psychology of Persuasion, Revised Edition. Harper Collius.
3. Green, C.J. (2015) Leadership and soft skills for students: Empowered to succeed in High School, College and beyond. Dog Ear Publishing.
4. Velayudhan, A. and Amudhadevi, N. V. (2012) Personality Development for College Students. LAP Lambert Academic Publishing.

Skill Enhancement Course (AEC): L1

Semester	Core Course	Course Title	Credits
I-II	SEC-I	Aquaculture	Theory: 01, Practical: 01

About the course

This course will give the students an understanding of the principles of aquaculture, including production systems, water quality, nutrition, spawning, larval culture and culture methodologies with special reference to fish, and prawn. The course will include an opportunity to conduct hands-on activities related to culture and husbandry of animals

Learning outcomes

After completing this course the learners will be able to

- understand the aquaculture systems
- Understand conditioning factors and how they can be manipulated
- Describe water depuration mechanisms
- Understand the environmental impacts of aquaculture

Theory

Unit I: Freshwater aquaculture systems

Aquaculture concept, Culture systems: Freshwater prawn culture, fish culture in paddy fields, Brackish water culture, Mariculture: Oyster culture, Crab culture, Lobster culture, mussel culture, culture of Eels, Culture of aquatic weeds. Composite fish culture: Definition and various patterns. Mixed fish farming in India. Techniques of composite culture. Culture of buffalo fish ..Culture of Catfishes. Culture of miscellaneous fishes. Cray fish culture.

Unit II: Preparation and management of fish culture ponds

Nursery ponds. Predatory and Weed fishes and their control. Fish toxicants. Fertilization. Aquatic insects and their control. Fish food organisms and their production. Supplementary feeding. Transport of fish seed and Brood fish. Causes of mortality in transport. Methods for packaging and transport. Open systems. Closed systems. Use of chemicals in live fish transport. Anesthetic drugs. Antiseptics and Antibiotics.

Unit III: Fish pathology

Parasitic infections. Fungus infections. Protozoan diseases.suryodata; Worm diseases. Non parasitic diseases. Rearing ponds, Stocking ponds. Fish breeding: Natural and artificial. Harvesting: Fishing techniques, preservation & processing of fish. Fresh water prawn culture. Introduction. Breeding characteristics. Juvenile prawn migration. Seasonal & regional distribution of seeds. Identification of juveniles. Controlled breeding. Culture: Ponds, Monoculture. Mixed culture.

Unit IV: Technologies in Fisheries development

Role of hard water in culture of Macrobrachium species. Fertilization & feeds. Pearl culture: Introduction, Pearl producing mollusks, pearl formation, collection of oysters, Rearing of oysters, insertion of nucleus, harvesting of pearls, composition & quality of pearl. Recirculation technology, Geographic Information System (GIS) technology, passive Acoustics in fisheries, Use of Information Communication Technology (lCT) in fishes: production aspects, marketing aspects.

Recommended readings

I. Jingran, V. G. (1983) Fish and fisheries of India , Hindustan pub. corp. New Delhi.
2. Hute, M. and Kahn, H. (2000) Textbook of fish culture, Blackwell Scientific Publication, Australia.

3. Srinivasulu, M., Reddy, K.R.S., Rao, S. (1999) Text book of Aquaculture, Discovery Publishing House New Delhi.
4. Yawn Mehta, Fisheries & Aquaculture Biotechnology (2011) Campus Books International, Prahalad street, Ansari Road, Durga Ganj, New Delhi.

Skill Enhancement Course (AEC): L2

Semester	Core Course	Course Title	Credits
I-II	SEC-II	Sericulture	Theory: 01, Practical: 01

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, the student 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, and
- To provide field exposure

Theory

Unit I: Silkworm distribution and races

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

Unit II: Biology of silkworm

Mulberry and non-mulberry Sericulture. Biology of silkworm. Selection of mulberry variety and establishment of mulberry garden, Rearing house and rearing appliances. Silkworm rearing technology: Early age and Late age rearing Selection of silkworm races/breeds for rearing. Incubation- definition, requirement of environmental conditions, incubation devices; identification of stages of development; black boxing and its importance.

Unit III: Diseases of silk worm and prevention and control

Diseases of silkworm. Disinfectants: Formalin, bleaching powder RKO. Types of mountages, Spinning, harvesting and storage of cocoons. Introduction; classification of silkworm diseases. Protozoan disease: symptomatology due to Nosema bombycis infection, source, mode of infection and transmission, cross infectivity, prevention and control. Bacterial, Viral, Fungal diseases: causative agents, symptoms, transmission prevention and control.

Unit IV: Prospects of Sericulture in India

Sericulture Types- natural and synthetic fibres- types of silk produced in India; Importance of mulberry silk. Silk industry in different states, employment, potential in mulberry and nonmulberry sericulture. Employment generation in sericulture: Role of women in sericulture. Sericultural practices in rain-fed and irrigated conditions; traditional and non-traditional areas. 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.

Skill Enhancement Course (AEC): L3

Semester	Core Course	Course Title	Credits
I-II	SEC-II	Toxicology	Theory: 01, Practical: 01

About the course

This course is focused on theoretical and applied knowledge on the effects of chemical substances on human health. The students will also get introduced to the toxicological analysis and the signs and symptoms of important toxic syndromes. The students will also study the basic toxicokinetic principles and metabolic systems to elucidate mechanisms of toxicity induced by xenobiotic compounds.

Learning outcomes

After completing this course the students will be able to

 learn basic principles of signaling pathways and mechanisms of cell death
 understand gene-environment interactions
 examine the application how xenobiotics disrupt normal cellular processes of genomics, proteomics, and metabolomics data
 understand mechanisms of systemic and organ toxicity induced by xenobiotics; and learn how to analyze and interpret complex data sets in toxicological research and deliver a scientific presentation.
 use clinical and laboratory findings in the treatment of acute toxic exposures

Unit I: Basic Concept of Toxicology

Introduction of toxicology, history of toxicology, definition of toxicology, definition of poison, definition of toxicity and classification of toxicants. Mode of action of toxic agents.

Unit II: Xenobiotics

Introduction, Important of xenobiotics concerned to Human health, absorption of xenobiotics, distribution of xenobiotics, accumulation of xenobiotics, elimination, biotransformation and excretion. Adverse effects of xenobiotics through Biological Magnification and Biotransformation, mechanism of Xenobiotic Translocation, Membrane permeability and mechanism of chemical transfer,

Unit III: Pesticides and Heavy Metal Toxicity

Pesticides and their toxicological effects. Classification of Pesticides, Insecticides, Mode of action of Insecticide. Heavy Metal Toxicity: Introduction, dispersion, general principal of metal toxicity, sources, toxic metals and their toxicity. Arsenic, Alumunium, Cadmium (ItaiItai disaster), Chromium Lead, Mercury, Manganese, Zinc and Nickel.

Unit IV: Evaluation of toxicity

Acute subAcute and chronic assays LD50, LC50, NOEL. Maintenance and general handling of animals for toxicological laboratory. Ecotoxicology, clinical toxicology, occupational and nanotoxicology.

Recommended readings

1. Williams, P.L.; James, R. C. Roberts, S.M. (2003) Principles of Toxicology: Environmental and Industrial Applications, John Wiley & Sons, Inc.
2. Klaassen, C. (2007) Casarett and Doull's Toxicology The basic science of poisons – McGraw-Hill.
3. Duffs, J. and Worth, H. (2006) Fundamental Toxicology, RSC Publishing.

Skill Enhancement Course (AEC): L4

Semester	Core Course	Course Title	Credits
I-II	SEC-II	Reproductive Technologies	Theory: 01, Practical: 01

About the course
The course is designed for the students to make them aware of the induced release of gametes, multiple ovulation, super ovulation, in vitro oocyte maturation and cryopreservation of gametes and embryos. It will also explain the causes of infertility and the techniques for intra fallopian and intrauterine transfer and in vitro fertilization.

Learning outcomes
At the end of the course the students will be able to
 identify structures and function of reproductive anatomy in the male and female
 identify hormones, their production site, physiology impacts and how to manipulate specific hormones to control reproduction either positively or negatively.
 summarize critical components of reproductive technologies involved in breeding, semen collection, gamete biology and embryonic development.
 communicate via oral, written, podcast, and website modalities.
 recognize how differences based on cultural and ethnicity impact individuals.

Unit I: Assisted reproductive technologies
Scope of reproductive technologies; Induced release of gametes and its significance; Biochemistry of semen composition and formation; Assessment of sperm functions; Role of assisted reproductive technologies in infertile human and animals; Constraints in assisted reproductive technologies; Culture techniques for farm animals' embryos.

Unit II: Ovulation and implantation
Fertilization and implantation. Infertility in male and female individuals: causes, diagnosis and management; Multiple ovulation, superovulation; In vitro oocyte maturation; Cryopreservation of gametes and embryos.

Unit III: Intrafallopian transfer
Intracytoplasmic sperm injection; In vitro fertilization of gametes; Intrafallopian transfer (GIFT) of gamete; Intrafallopian transfer (ZIFT) of zygote; Intrauterine transfer (IUT) of embryo; Transgenic animals and their uses.

Unit IV: Contraceptive technologies
Introduction to contraceptive technologies; Immunocontraception. Antibody mediated infertility; Surgical methods; Oral contraceptives; Injectables; Implants; Intrauterine uterine device (IUD); Physical and chemical barrier methods; Demographic terminology used in family planning.

Recommended readings
1. Jones, R. E. and Lopez, K. H. (2013) Human Reproductive Biology (3rd edition)

Scheme and Syllabus

For

M. Sc. Zoology (CBCS)

Applicable from Session 2021-2022 to onwards

Department of Zoology

School of Life Sciences

Guru Ghasidas Vishwavidyalaya, Bilaspur (CG)

Post Graduate Program: M. Sc. Zoology (CBCS)
Offered by the Department of Zoology, School of Life Sciences

1. Name of the Program : Master of Science in Zoology

2. Specializations available : Biochemistry and Molecular Biology, Fish Biology, Mammalian Reproductive Physiology and Endocrinology, and Toxicology.

3. Program Specifications
   School of studies: School of Life Sciences
   Department: Department of Zoology
   Program: M.Sc. in Zoology
   Date of approval in Board of Studies: 24/12/2021

4. Mode of study: Full time (semester system)
   Class room teaching; experiential learning; tutorials; project assignments and dissertation work.

Purpose of the Program:
The Master of Science degree program in Zoology provides students the opportunity to enhance their knowledge and competence in the diverse field of animal science and encourages students to get indulges in the subject. Another focus of this program is to motivate students towards research. Students are encouraged to get involved in dissertation projects under the guidance of faculty mentors that address topics related to animal health, environment, nutrition, physiology, production, and behavior. The attainment of a master's degree also qualifies students to pursue further specialized training and gain entrance to professional schools, or to pursue a doctorate.

Learning outcomes:
- Students will be able to identify the major groups of organisms with an emphasis on animals and be able to classify them within a phylogenetic framework.
- Students will be able to compare and contrast the characteristics of animals that differentiate them from other forms of life.
- Students will be able to use the evidence of comparative biology to explain how the theory of evolution offers the only scientific explanation for the unity and diversity of life on earth.
- Students will able to understand the concepts of physiology, nutrition, health and economics with reference to animals.
- Students will be able to explain the mechanisms and role of reproductive physiology, Immunology, toxicology & neurobiology in health & disease
- Students will be able to apply the scientific method to questions in biology by formulating testable hypotheses, gathering data that address these hypotheses, and analyzing those data and will be able to demonstrate critical thinking and problem solving skills in Biostatistics course.

- Students will be able to explain how organisms function at the level of the gene, genome, cell, tissue, organ and organ-system.
- Students will be able to demonstrate proficiency in the experimental techniques and methods of analysis appropriate for their area of specialization within biology.

Semester-wise Theory Papers/ Practical
Masters of Science in Zoology (CBCS)
Department of Zoology, School of Life Science

Course Opted	Course Code	Name of the Course	T-L-D /Week	Credits	CCA	ESE	Total
		Semester – Ist					
CC 1	**ZOPATT1**	Comparative Anatomy of Vertebrates	T-3	3	40	60	100
CC 1	**ZOPALT1**	Comparative Anatomy of Vertebrates	L-4	2	20	30	50
CC 2	**ZOPATT2**	Cell Biology	T-3	3	40	60	100
CC 2	**ZOPALT2**	Cell Biology	L-4	2	20	30	50
CC 3	**ZOPATT3**	Endocrinology	T-3	3	40	60	100
CC 3	**ZOPALT3**	Endocrinology	L-4	2	20	30	50
OE 1	**ZOPATO1**	To be drawn from the pool of OE	T-3	3	40	60	100
OE 1	**ZOPALO1**	To be drawn from the pool of OE	L-4	2	20	30	50
	***Certificate**	**UACE, VAC, CC, OCC and others offered by university**					
			28H/W	**20**	**240**	**360**	**600**
		Semester IInd					
CC 4	**ZOPBTT1**	Biochemistry and Molecular Biology	T-3	3	40	60	100
CC 4	**ZOPBLT1**	Biochemistry and Molecular Biology	L-4	2	20	30	50
CC 5	**ZOPBTT2**	Basic Mammalian Physiology	T-3	3	40	60	100
CC 5	**ZOPBLT2**	Basic Mammalian Physiology	L-4	2	20	30	50
CC 6	**ZOPBTT3**	Animal behavior	T-3	3	40	60	100
CC 6	**ZOPBLT3**	Animal behavior	L-4	2	20	30	50
DSE: 1	**ZOPBTD1**	Molecular Genetics	T-3	3	40	60	100
DSE: 1	**ZOPBLD1**	Molecular Genetics	L-4	2	20	30	50
RM	**ZOPBTA1**	Research Methodology	T-2	2	40	60	100
	***Certificate**	**UACE, VAC, CC, OCC and others offered by university**					
			30H/W	**22**	**280**	**420**	**700**
		Semester IIIrd					
CC 7	**ZOPCTT1**	Developmental Biology	T-3	3	40	60	100
CC 7	**ZOPCLT1**	Developmental Biology	L-4	2	20	30	50
CC 8	**ZOPCTT2**	Regulatory Mammalian Physiology	T-3	3	40	60	100
CC 8	**ZOPCLT2**	Regulatory Mammalian Physiology	L-4	2	20	30	50
CC 9	**ZOPCTT3**	Evolution, Environmental Biology and Sustainable Development	T-3	3	40	60	100
CC 9	**ZOPCLT3**	Evolution, Environmental Biology and Sustainable Development	L-4	2	20	30	50
DSE: 2	**ZOPCTD1**	Brain function and Mental Awareness	T-3	3	40	60	100
DSE: 2	**ZOPCLD1**	Brain function and Mental Awareness	L-4	2	20	30	50

	***Certificate**	**UACE, VAC, CC, OCC and others offered by university**					
			28H/W	**20**	**240**	**360**	**600**
Semester IVth							
CC 10	**ZOPDTT1**	Biotechniques	T-3	3	40	60	100
CC 10	**ZOPDLT1**	Biotechniques	L-4	2	20	30	50
DSE: A	**ZOPDTD1**	Biochemistry of Intermediary Metabolism and Enzymology	T-3	3	40	60	100
DSE: A	**ZOPDLD1**	Biochemistry of Intermediary Metabolism and Enzymology	L-4	2	20	30	50
DSE: A	**ZOPDTD2**	Molecular Biology of Information Pathway: Nucleic Acids	T-3	3	40	60	100
DSE: A	**ZOPDLD2**	Molecular Biology of Information Pathway: Nucleic Acids	L-4	2	20	30	50
DSE: B	**ZOPDTD3**	Neuroendocrinology, Non-Classical Hormones and Signaling	T-3	3	40	60	100
DSE: B	**ZOPDLD3**	Neuroendocrinology, Non-Classical Hormones and Signaling	L-4	2	20	30	50
DSE: B	**ZOPDTD4**	Mammalian Reproduction, Fertility and Sterility	T-3	3	40	60	100
DSE: B	**ZOPDLD4**	Mammalian Reproduction, Fertility and Sterility	L-4	2	20	30	50
DSE: C	**ZOPDTD5**	Fish Anatomy, Physiology and Biotechnology	T-3	3	40	60	100
DSE: C	**ZOPDLD5**	Fish Anatomy, Physiology and Biotechnology	L-4	2	20	30	50
DSE: C	**ZOPDTD6**	Fish Culture, Capture Fishery and Fish Pathology	T-3	3	40	60	100
DSE: C	**ZOPDLD6**	Fish Culture, Capture Fishery and Fish Pathology	L-4	2	20	30	50
DSE: D	**ZOPDTD7**	Mechanism of Toxicity	T-3	3	40	60	100
DSE: D	**ZOPDLD7**	Mechanism of Toxicity	L-4	2	20	30	50
DSE: D	**ZOPDTD8**	Reactive Metabolites and Defense System in Biology	T-3	3	40	60	100
DSE: D	**ZOPDLD8**	Reactive Metabolites and Defense System in Biology	L-4	2	20	30	50
Dissert-ation	**ZOPDDD1**	Based on DSE Elected (I/II/III/IV)	D-14	7	80	120	200
	***Certificate**	**UACE, VAC, CC, OCC and others offered by university**					
			35H/W	**22**	**260**	**390**	**650**

1. Discipline Specific Electives (DSE) in forth semester for each session will be offered to students on the basis of availability of faculty and infrastructure.
2. Offering of DSE in any particular session will be decided after a formal meeting of all faculty members of Department of Zoology.
3. Each student may study any one out of the given electives (A, B, C and D). Elective papers will be distributed among the students on the basis of merit/choice.
4. The project work/dissertation will be carried out in the field of respective elective papers opted by the students.
5. Open Elective Courses will be offered by department in first semester is fundamental of public health / Applied Zoology.

Abbreviations:

CC= Core Course
OE= Open Elective
DSE= Discipline Specific Electives
DSE: I= Biochemistry and Molecular Biology
DSE: II = Mammalian Reproductive Physiology and Endocrinology
DSE: III= Fish Biology
DSE: IV= Toxicology
CCA= Continuous Comprehensive Assessment
ESE= End-Semester Examinations
UACE= University Additional Credit Electives,
VAC=: Value Added Course
CC= Certificate Courses,
OCC=: Online certificate Courses

SEMESTER I
CORE 1

ZOPATT1: COMPARATIVE ANATOMY OF VERTEBRATES

Unit I: Origin, integument and skeletal system: Origin of chordates and vertebrates; Development, structure and function of vertebrate integument and its derivatives (gland, scale, feathers and hair); Axial and appendicular skeleton of vertebrates and their modifications; Comparative account of jaw suspensorium and vertebral column.

Unit II: Digestive system: General structure of digestive system in vertebrates; Modifications in relation to feeding habit, Length and surface area, internal folds, supplementary diverticulae; Accessory digestive glands; Comparative anatomy of alimentary canal in vertebrates, Dentition.

Unit III: Respiratory and Circulatory system: Characters of respiratory tissue; Comparative account of respiratory organs in vertebrates; Evolution of heart, aortic arches and portal systems in vertebrates; Blood and its circulation in different vertebrate groups.

Unit IV: Urogenital system: Types and evolution of kidney tubules in different vertebrate groups; Urinary duct and bladder; General plan of gonads; Accessory reproductive organs in different group of vertebrates.

Unit V: Nervous system: Comparative account of the brain in relation to its functions in vertebrates; Comparative anatomy of spinal cord, peripheral and autonomous nervous system in vertebrates; Evolution and anatomy of electroreception and lateral line system.

Books Recommended

1. Hildebrand (1995) Analysis of Vertebrate Structure, John Wiley.
2. Kotpal (2003) Modern Text Book of Zoology Vertebrates, Rastogi Publications.
3. Nigam (1983) Biology of Chordates, S Chand.
4. Romerand Parsons (1986)TheVertebrate Body, 6thEd. Saunders.
5. Saxena S and Saxena RK (2008) Comparative Anatomy of Vertebrates, 2nd Ed.
6. Kent GK and Carr RK (2015) Comparative Anatomy of Vertebrates, 9th Ed.
7. Kardong K (1995) Vertebrate Comparative Anatomy Function Evolution, 4th Ed.
8. Singh S (2013) A Text Book of Comparative Anatomy of Vertebrates

Percent Change From Previous Syllabus: 10.0 %

SEMESTER I
CORE 1

ZOPALT1: COMPARATIVE ANATOMY OF VERTEBRATES

1. Identification, Classification and study of distinguish features of the representative examples of different classes of vertebrates.
2. Study of permanent slides showing whole mount of vertebrate scales.
3. Comparative study of histological slides of skin in different group of vertebrates.
4. Study of available permanent slides of different vertebrate organs.
5. Demonstration of brain and heart of different vertebrates through alternative methods of dissection.
6. Comparative study of vertebra, limbs and girdles of different vertebrate groups.
7. Study of afferent and efferent arteries of fish.
8. Study of cranial nerves of fish.

Course Objectives:
To learn the basic of vertebrates anatomy to understand how different anatomies function have evolved and develop.
Be familiar with new development in the field of comparative vertebrate anatomy.
To indicate the contribution that comparative anatomy of vertebrates can make to the overall discussion of evolution.
Help student skin a knowledge base for understanding vertebrate anatomy and evolution by explaining to them the basic structures and organization of anatomical system there development and function and their modification in the major transitions in vertebrate evolution.

Course Outcomes:
Describe the major architectural features of the integumentary skeletal nervous muscular digestive respiratory circulatory excretory and reproductive systems.
Develop an understanding of the application of comparative anatomy in current scientific method /literature.

Percent Change From Previous Syllabus: 10.0 %

SEMESTER I
CORE 2

ZOPATT2: CELL BIOLOGY

Unit 1: Basic structure of prokaryotic and eukaryotic cell: Ultrastructure of cell membrane (Fluid mosaic model), membrane proteins and lipids, mitochondria, assemblies of respiratory chain and F0 F1–ATPase, golgi complex, endoplasmic reticulum and lysosome; structure and functions of centrosome; Cell junctions: Tight and gap junctions, Desmosomes.

Unit 2: Nucleic acids: Chemical and Physical structure; Chromatin/Chromosome: Nucleosome and higher order structure (Solenoid to Metaphase chromatid); Nucleolus: Structure and biogenesis of ribosomes.

Unit 3: Cytoskeleton: Organization of microtubules, microfilaments and intermediary filaments; Protein sorting and mechanisms of vesicular transport: Signal peptide and SRP dependent targeting of translational complex; targeting to plasma membrane and lysosome; targeting of nuclear and mitochondrial proteins.

Unit 4: Transport across the cell membrane: Channels and transporters, diffusion, osmosis and measurement of osmotic pressure; Active transport: mechanism and related calculations; Cell signaling molecules and receptors, Signal transduction pathways (DAG and cAMP); Cell interactions: Apoptosis and necrosis.

Unit 5: Cell cycle and cancer: Mitotic and Meiotic cell divisions and their significance, spindle apparatus and synaptonemal complex, cell cycle and its regulation, labeling index and cell cycle duration measurement, cell synchronization and cell cycle inhibitors; Cancer (Concept of oncogenes and tumor suppressor genes with special referencetop53, Retinoblastoma and Ras and APC).

Books Recommended

1. Alberts et al. (2008) Molecular Biology of the Cell, 5th Ed. Garland Publishing House.
2. Cooper GM (2004) The Cell, 3rdEd. ASM Press.
3. Hardin et al. (2012) Becker's World of the Cell, 8th Ed. Pearson Benjamin Cummings.
4. Karp (2008) Cell and Molecular Biology-Concepts and Application, 5th Ed. John Wiley.
5. Lewin B (2008) Genes IX, Jones and Bartlett Publishers.
6. Lodishet al (2016) Molecular Cell Biology. 8th Ed. W.H. Freeman.
7. Tamarin RH (2004) Principles of Genetics. Tata McGraw-Hill Publishing Comp. Ltd.
8. Watson et al. (2007) Molecular Biology of the Gene. 6th Ed. Benjamin Cummings.

Percent Change From Previous Syllabus: 10.0 %

SEMESTER I
CORE 2

ZOPALT2: CELL BIOLOGY

1. Preparation of permanent slide to demonstrate DNA by Feulgen reaction
2. Preparation of permanent slide to demonstrate DNA and RNA by MGP
3. Preparation of permanent slide to demonstrate muco-polysaccharides by PAS reaction
4. Preparation of permanent slide to demonstrate proteins by mercuro-bromophenol blue/Fast green
5. Study of mitosis in onion root tip
6. Study of meiosis in grasshopper testis
7. Study of permanent slides: Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.
8. Study of permanent slides: Prophase, Metaphase, Anaphase and Telophase; Barr body.

Course Objective:
To study the structure and function of different component of prokaryotic and eukaryotic cell.
To study basics of cancer, tumor processing and cell communication.

Course Outcomes:
Students will develop ability to understand how a cell works in molecular level.
Develop in-depth knowledge of components of cell and their working.
Students will develop understanding about how different components pass through the plasma membrane differently.

Percent Change From Previous Syllabus: 05 %

SEMESTER I
CORE COURSE 3

ZOPATT3: ENDOCRINOLOGY

Unit 1: Introduction to Endocrine System: Classes of hormones; Mechanism of hormone action: Protein hormones, membrane receptors, G-proteins, cyclic AMP signaling cascade, PKC signaling pathway, steroid hormones (genomic and nongenomic pathways)

Unit 2: Hypothalamo-hypophysial System: General organization; Neurohypophysial hormones: oxytocin and vasopressin; Neural control of adenohypophysis: Hypophysiotropic hormones and actions; Adenohypophysial hormones: Chemistry and physiological roles of somatotropin and prolactin; Glycoprotein hormones: FSH, LH and TSH and Pro-opiomelanocortin: ACTH, MSH.

Unit 3: Thyroid hormones: Biosynthesis, control of secretion and physiological role of thyroid hormones; Parathyroid: Parathormone, calcitonin and vitamin D in calcium homeostasis; Endocrine pancreas: biosynthesis and physiological actions of insulin and glucagon.

Unit 4: Gonadal hormones: Structure of mammalian testis and ovary; Spermatogenesis and structure of sperm; Physiological role of androgens; Oogenesis and structure of egg; Steroid hormone biosynthetic pathways; Ovary: organization and physiological role of estrogen, progesterone, relaxin and inhibin; Estrous and menstrual cycle; Hormones of pregnancy; Parturition; Hormonal control of lactation.

Unit 5: Adrenal cortex: Organization mineralocorticoid and glucocorticoid hormone: control of secretion, rennin-angiotensin system; Adrenal medulla: catecholamine biosynthesis, release and physiological role.

Books Recommended

1. Bentley (1998) Comparative Vertebrate Endocrinology, Cambridge University Press.
2. Norris (2007) Vertebrate Endocrinology, 4th Ed. Academic Press.
3. Hadley (2007) Endocrinology, 6th Ed. Prentice Hall.
4. Brooks and Marshall (1995) Essentials of Endocrinology, Blackwell Science.
5. Turner and Bagnara (1984) General Endocrinology, Saunders.
6. Larson (2002) Williams Textbook of Endocrinology, 10th Ed.Saunders.

Percent Change From Previous Syllabus: 20.0 %

SEMESTER I
CORE COURSE 3

ZOPALT3: ENDOCRINOLOGY

1. Handling, sexing, numbering and maintenance of rat
2. General survey of endocrine glands in rat
3. Study of vaginal smear preparation in rat
4. Study of the following using permanent slides:
   a. Endocrine glands and reproductive organs of rat
   b. Gonads (testis and ovary from fish to birds)
   c. Thyroid of fish (pharyngeal and ectopic) and reptile
   d. Adrenal homologues (interrenal and chromaffin tissues) in fish and reptile
   e. Cell types pituitary
   f. Hypothalamo-neurohypophsial system
5. Demonstration of frog metamorphosis by models and charts
6. Demonstration of ELISA-based hormone assay

Course Objective:
To explain new hormones are synthesized, secreted and different from other physiological secretion. Their role in regulation of homeostasis of all physiological process via autocrine, paracrine, and endocrine modes of delivery, following negative and positive feedback mechanism. It also explains molecular mechanism of hormonal action based on the types of receptor.

Course Outcomes:
It will explain various endocrinological principle which helps in determination of pathophysiological basis and consequences of specific endocrine disorder**.**

Percent Change From Previous Syllabus: 20.0 %

SEMESTER I
OPEN ELECTIVE 1

ZOPATO1: FUNDAMENTALS OF PUBLIC HEALTH

Unit 1: Concepts of Health: Concepts of Health & Disease; Dimensions of Health: Physical dimension, Mental dimension, Social dimension, Spiritual dimension, Emotional dimension, Vocational dimension; Outbreaks, epidemics and pandemics; History of public health; Determinants of Health; Indicators of Health.

Unit 2: Measuring Health and disease: Causation of diseases; Risk measurement, Measurement of morbidity and mortality: Incidence, Prevalence, Age-adjustment and survival analysis, use of morbidity and mortality; Comparing disease occurrence: Risk difference, Attributable fraction, Population attributable risk, Relative risk, Attributable risk.

Unit 3: Epidemiology of infectious diseases: Infectious diseases; agent biology, epidemiology, pathogenesis and pathology, clinical presentation and management; public health strategies and mechanisms.

Unit 4: Inequalities and Disparities in Health: Poverty, discrimination, vulnerability, income inequality and impact on health outcome, measuring poverty, measuring health inequalities.

Unit 5: National Health Programs: National Rural Health Mission, National Vector Borne Disease Control Program, Malaria eradication program, Reproductive and Child Health Program, National AIDS Control Program, Revised National Tuberculosis Control Program, National Leprosy Eradication Program, National Program for Control of Blindness, National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke, Integrated Management of Neonatal and Childhood Illness**.**

Books Recommended

1. Berkman LF, Kawachi I & Glymour MM. Social Epidemiology. New York: Oxford University Press, 2014.
2. Nambiar Devaki, Arundati Muralidharan The social determinants of health in India: concepts, processes, and indicators. Springer Publication. New Delhi. 2017
3. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
4. Nelson K E: Infectious disease epidemiology: theory and practice
5. Griesecke J: Modern infectious disease epidemiology
6. Green J, Thorogood J, Qualitative methods for Health research, Sage Pub, 2004
7. Catherine Pope, Nicholas Mays, Qualitative Research in Health Care, John Wiley & Sons, 2008
8. Collins, C., Green, A., 2014. Valuing Health Systems: A Framework for Low and Middle-Income Countries. SAGE Publications.
9. Gupta, R.P., 2016. Health Care Reforms in India: Making Up for the Lost Decades. Elsevier India.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER I
OPEN ELECTIVE 1

ZOPALO1: FUNDAMENTALS OF PUBLIC HEALTH

1. Questionnaire design for epidemiological studies
2. The Michigan Alcohol Screening Test (MAST)
3. AUDIT questionnaire: screen for alcohol misuse
4. Calculation of risk ratio
5. Estimation of disease prevalence
6. Calculation of incidence
7. Calculating the sample size for surveys
8. Analysis and interpretation of epidemiological data

Course Objectives:
Students will be introduced to the field of public health. To provide an overview of prevention and health promotion methods. To comprehend the causes and consequences of disease and health-related states. To comprehend the state of health and disease on a global and national level.

Course Outcomes:
Students will gain sufficient knowledge and skills in a variety of public health topics. Develop a workforce to take on public health responsibilities in specific geographic areas. Develop a comprehensive understanding of the epidemiological transitions of programs specific to each region of the country in order to prioritize public health challenges for policymaking.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER I
OPEN ELECTIVE 2

ZOPATO2: APPLIED ZOOLOGY

Unit 1: Introduction to Host-parasite Relationship: Host, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis.

Unit 2: Parasitic Protozoa & Helminthes: Life history and pathogenicity of *Entamoeba histolytica*, *Plasmodium vivax* and *Trypanosoma gambiense.* Parasitic life history and pathogenicity of *Ancylostoma duodenale* and *Wuchereria bancrofti*.

Unit 3: Insects of Economic Importance: Biology, damage and control caused by *Helicoverpa armigera*, *Pyrilla perpusilla* and *Papilio demoleus*, *Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum.*

Unit 4: Insects of Medical Importance: Medical importance and control of *Pediculus* (head louse), Anopheles, Culex and Aedes mosquitoes, *Xenopsylla cheopis*.

Unit 5: Poultry farming and Fish technology: Principles of poultry breeding, Management of breeding stock and broilers, Processing and preservation of eggs; Major and minor carps of economic importance; Induced breeding and transportation of fish seed.

Books Recommended

1. Park, K. Preventive and Social Medicine. XVI Edition. B.B Publishers. (2007)
2. Arora, D. R and Arora, B. Medical Parasitology. II Edition. CBS Publications and Distributors. (2001)
3. Kumar, Robbins & Cotran. Pathologic Basis of Disease. Elsevier; 9th edition. (2014)
4. Atwal, A.S. Agricultural Pests of India and South East Asia, Kalyani Publishers. (1986)
5. Dennis, H. Agricultural Entomology. Timber Press (OR). (2009)
6. Dunham R.A. Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K. (2004)
7. Pedigo, L.P. Entomology and Pest Management, Prentice Hall. (2002)
8. Shukla and Upadhyay. Economic Zoology. Rastogi Publication (2016)
9. Jhingran. V.G. Fish and fisheries of India. Hindustan Publishing Corporation (1997)
10. Khanna. S.S, An introduction to fish biology and fisheries. Surjeet Publication (2019)
11. K.P. Shrivastava, G.S. Dhaliwal. A textbook of Applied Entomology. Kalyani Publication (2013)

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER I
OPEN ELECTIVE 2

ZOPALO2: APPLIED ZOOLOGY

1. Study of *Plasmodium vivax*, *Entamoeba histolytica*, *Trypanosoma gambiense*, *Ancylostoma duodenale* and *Wuchereria bancrofti* and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: Pediculus, Culex, Anopheles, Aedes and *Xenopsylla*.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs.
4. Identifying feature and economic importance of *Helicoverpa* (Heliothis) *armigera*, *Papilio demoleus*, *Pyrilla perpusilla*, *Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum.*
5. Visit to a poultry farm. Submission of visit report

Course Objectives:

To introduce the methodology and perspectives of applied branches of zoology with a view of educating youngsters on the possibilities of self-employment.

Course Outcomes:

To get a basic understanding of human health and parasite biology & insects of economic importance and learn the basic principles involved in the culture and breeding of common poultry and fish species.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER II
CORE COURSE 4

ZOPBTT1: BIOCHEMISTRY AND MOLECULAR BIOLOGY

Unit 1: Laws of thermodynamics and their applications: Concept of free energy and calculations based on free energy change; Metabolism: Concept of metabolic pathways; Energy transduction: glucose and fatty-acids as energy source; Glycolysis and Krebs cycle; Feeder pathway of glycolysis; Mechanism and chemiosmotic concept of ATP synthesis, bioenergetics of ATP and other high energy phosphate compounds; Digestion, mobilization, and transport of fats; β-oxidation; NADPH producing pathway: Pentose phosphate pathway.

Unit 2: Protein: Primary structure, peptide bond, Secondary structure, α-helix, β-pleated sheet and bends, prediction of secondary structure, Ramachandran plot, tertiary structure, forces stabilizing tertiary structure, Domains and motifs-Quaternary structure.

Unit 3: Enzymes: Enzyme kinetics, lowering of activation energy, derivation of Michaelis-Menten equation, related calculations and Michaelis-Menten and Lineweaver-Burk plots; Mechanism of action, active site, substrate binding, transition state analogues and abzyme: Acid-base and covalent catalysis; Concepts of regulation of enzyme activity.

Unit 4: Nucleic acids: Structure, folding motifs, conformational flexibility and supercoiling; Mechanism of DNA replication: DNA polymerases, origin of replication and formation of primosome, replication fork and replisome, termination of replication; DNA damage and repairing mechanism.

Unit 5: Mechanism of transcription: RNA polymerases, formation of pre-initiation complex at RNA *pol* II promoter: Processing of hnRNA: Capping, Poly(A) tailing, splicing; Genetic code and mechanism of translation: Role of ribosomes and tRNAs, formation of initiation complex; Elongation and termination: Post translational modification.

Books Recommended

1. Nelson et al (2004) Lehninger: Principles of Biochemistry, 3rd Ed. Pearson.
2. Zubay et al (1995) Principles in Biochemistry, 2nd Ed. WCB.
3. Strayer (2002) Biochemistry, 5th Ed.
4. Lodish et al (2007) Molecular Cell Biology, 6thEd.Freeman and Company.
5. Voet and Voet (2004) Biochemistry, John Wiley.
6. Alberts et al. (2008) Molecular Biology of the Cell, 5th Ed. Garland Publishing House.
7. Cooper GM (2004) The Cell, 3rdEd. ASM Press.
8. Price and Stevens (1988) Fundamentals of Enzymology, 2nd Ed. Oxford University Press.

Percent Change From Previous Syllabus: 05.00 %

SEMESTER II
CORE COURSE 4

ZOPBLT1: BIOCHEMISTRY AND MOLECULAR BIOLOGY

1. Preparation of extract for enzyme assay (alkaline phosphatase)
2. Study of alkaline phosphatase activity
3. Standard curve preparation
4. Effect of enzyme concentration and determination of total and specific activity
5. Effect of temperature on enzyme activity
6. Effect of time on enzyme activity
7. Effect of substrate concentration on enzyme activity
8. Determination of Km and Vmax by Michaelis-Menten and Lineweaver-Burk Plot
9. DNA isolation
10. RNA isolation
11. Reverse transcriptase polymerase chain reaction
12. Western blotting
13. Northen blotting

Course Objective:
To build comprehensive working knowledge of biomolecules and their role in specific molecular transformations. To enable the students to develop an integrated approach for understanding the various life science problem at the molecular level.

Course Outcomes:
Students will recognize and interpret the structural and functional aspects of molecules and their interactions that give rise to the supramolecular complexes such as organelles and cells. Students will have the ability to perform laboratory techniques used in molecular biology and biochemistry.

Percent Change From Previous Syllabus: 05.00 %

SEMESTER II

CORE COURSE 5

ZOPBTT2: BASIC MAMMALIAN PHYSIOLOGY

Unit 1: Integumentory system: Cell junction: tight junctions, adherens junctions, desmosomes, hemidesmosomes and gap junctions; Epithelial and connective tissue; Structure, type and function of skin, accessory structure of skin, aging.

Unit 2: Digestion: Anatomy of gastrointestinal tract; Digestive glands (salivary, gastric, liver and gall bladder, pancreatic and intestinal gland); Digestion of fat, protein and carbohydrate, nucleic acid; absorption of nutrients, regulation of digestion and absorption; balanced diet, vitamins.

Unit 3: Respiration: Anatomy of respiratory system, pulmonary ventilation, respiration, gaseous exchange, lung volume and capacity, control of respiration, basal metabolic rate, respiratory quotient; Respiratory disorders: hypoxia, dyspnoea.

Unit 4: Cardiovascular: Function, properties and component of blood, formation of blood cell, hemostasis, blood group; Structure and function of heart, origin and conduction of cardiac impulse, cardiac cycle and ECG, myocardial infarction, circulatory routes, hemodynamic.

Unit 5: Excretion: Structure and function of kidney, glomerular filtration, tubular reabsorption and secretion, urine formation, transportation, storage and elimination; Kidney function tests, buffer system.

Recommended

1. Ganong (2005) Review of Medical Physiology, 22nd Ed. Lang Medical Publications.
2. Guyton and Hall (2006) Text Book of Medical Physiology, 11th Ed. W.B. Saunders.
3. Keel et al (1989) Samson Wright's Applied Physiology, 13th Ed. Oxford Press.
4. Murray et al (1989) Harper's Illustrated Biochemistry, 27th Ed. Appleton and Lange.
5. Tortora GJ and Derrikson B (2012) Principles of Anatomy and Physiology, Volume I-II, 13th Ed. John Wiley & Sons, Inc.
6. Chaterjee CC (2018) Human Physiology, Volume I-II, 12th Ed. CBS Publication.
7. Walker R (2014) Mammalian Physiology
8. Verma et al (2000) Animal Physiology, Chand (S.) & Co Ltd, India

Percent Change From Previous Syllabus: 05.00 %

SEMESTER II
CORE COURSE 5

ZOPBLT2: BASIC MAMMALIAN PHYSIOLOGY

1. Study of histological slides: Salivary gland, Liver, Pancreas, Stomach and Intestine.
2. Glucose estimation
3. Amylase assay in the given sample
4. Determination of blood groups (ABO and Rh factor)
5. Erythrocyte counting
6. Total leucocytes counting in blood
7. Study of histological slides: Kidney, Heart and Lungs
8. Study of Kidney, Heart and Lungs with models/PPT
9. Assessment of kidney function test

Course Objective:
To study morphological, structural, functional and metabolic aspects of mammals.
To create awareness among students about their health.

Course Outcomes:
Students will understand the physiochemical basis of how each system operates and build also they will understand the functioning of each system. The knowledge can be applied to the understanding of everyday activities of human body.

Percent Change From Previous Syllabus: 05.00 %

SEMESTER II
CORE COURSE 6

ZOPBTT3: ANIMAL BEHAVIOUR

Unit 1: Introduction to animal behavior: History of the study of animal behavior; Patterns of behavior; Genetic basis of behavior: Development of bird song; Learned behavior and types of learning.

Unit 2: Specific behavior pattern: Habitat selection and foraging behavior; Animal signals and communication; Social dominance and concept of territoriality; Fixed action pattern-characteristics and evolutionary features; Mimicry: mimetic releaser and code breakers.

Unit 3: Control of behavior (a): Neural control: Control of hippocampal pyramidal cell discharges; Perceptual mechanisms: Behavioral and cellular responses to novel and repeated stimuli; Motivational systems: Neural mechanisms involved in a cat's attack on a rat; Hypothalamic mechanisms for motivational and species-Typical behavior; Behavior of hippocampal neurons during conditioning.

Unit 4: Control of behavior (b): Hormonal control: Hormones classes: Peptides or proteins, steroids, monoamines and lipid based hormones. Hormonal control of social behavior; Hormonal control of behavior in a lizard; Pheromonal regulations and biological rhythms.

Unit 5: Parental care, mating and courtship behavior, altruism: Parental care; Sexual selection: intra sexual selection (male rivalry); inter-sexual selection (female choice); sperm competition; mate guarding; consequences of mate choice for female fitness; monogamous verses polygamous sexual conflict; Reciprocal altruism; group selection; kin selection and inclusive fitness; Sociality in animal systems; Social organization in honey bees.

Books recommended:

1. Alcock (2009) Animal Behavior: An Evolutionary Approach, 9th Ed, Sinauer Asso.
2. Kaushik M P (2015) Animal Behavior, Kalyani Publication.
3. Mathur R (2005) Animal Behavior, Rastogi Publications.
4. Richard et al (2013) Thompson: The Neural Control of Behavior, Academic Press.
5. Manning A and Dawkins MS (2012) An Introduction to Animal Behavior, 6thEd. Cambridge University Press.
6. Drickamer and Vessey (1986) Animal Behavior – Concepts, Processes and Methods, 2nd Ed. Wadsworth.
7. Shukla et al (2011) Economic Zoology, Biostatistics and Animal Behavior, Rastogi Publication.
8. Mandal FB (2015) Text book of Animal Behavior, 3rd Ed. PHI Learning.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER II
CORE COURSE 6

ZOPBLT3: ANIMAL BEHAVIOUR

1. Study of individual and social behavioral patterns of a troop of monkeys.
2. Courtship behavior in the fruit fly.
3. Study the different behavior of laboratory rats.
4. Nest making behavior of birds.
5. Habitat preference behavior in insects.
6. Habituation in earthworms/mosquito larvae.
7. Locomotory behavior of dipteran larvae (fruit fly): Locomotion on different types of substrata (writing paper, plastic sheet and sand paper) & Effects of light intensity and light quality on the rate of locomotion.
8. Study of interspecific association between cattle and egrets.
9. Territorial behavior in stray dogs.

Course Objective:
Ethology focuses on behavior under natural conditions, and viewing behavior as an evolutionarily adaptive trait. Understanding how genes and the environment come together to shape animal behavior is also an important underpinning of the field. Genes capture the evolutionary responses of prior populations to selection on behavior.

Course Outcomes:
Students will understand the ways how animal interact with other organisms and the physical environment.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER II
DSE 1

ZOPBTD1: MOLECULAR GENETICE

Unit 1: Classical genetics: Properties and evolution of genetic material flow of genetic information; Mendel's laws and their chromosomal basis of inheritance; Extensions of Mendelian principles: Dominance relationships, epistasis, pleiotropy, expressivity and penetrance; Linkage and crossing over; Sex linked, sex-limited and sex influenced character; Sex determination; dosage compensation in *Drosophila.*

Unit 2: Modern gene concept: Concepts of transcriptome and proteome, gene duplication– gene families, interrupted gene, pseudogenes and transposable genetic element; Regulation of gene activity in *lac* and *trp*operons of *E. coli*; Introduction to gene regulation in eukaryotes; Organization of a typical eukaryotic gene.

Unit 3: Gene mutation: Types and molecular basis, manipulation of genes, site-specific mutagenesis, reporter genes expression, genomic expression profiling; Methods for detection of induced mutations; Methods of gene mapping: 2 and 3- point test cross in *Drosophila,* Gene mapping in human by linkage analysis in pedigrees, ordered and unordered tetrad analysis.

Unit 4: RNA interference: siRNA, shRNA, miRNA; Therapeutic use of RNA interference. Detection of sickle cell anemia, thalassemia, cystic fibrosis, haemophilia, muscular dystrophy; Gene therapy: *Ex vivo* and *in vivo* therapy, strategies and delivery.

Unit 5: Applications and implications of genetic engineering: Restriction enzymes, cloning vectors; production of recombinant DNA molecules; Preparation and screening of cDNA library; DNA sequencing: PCR and RT PCR; Gene transfer and transfection methods, transgenic animal production-DNA integration; Use of cre/loxp in transgenic animal production; Somatic cloning.

Books Recommended

1. Brown (2006) Genomes, 3rdEd. Garland Science.
2. Gardner et al (2006) Principles of Genetics, John Wiley.
3. Griffith et al (2008) Modern Genetic Analysis,Freeman.
4. Karp (2010) Cell and Molecular Biology, John Wiley and Sons.
5. Krebs et al (2011) Lewin's Genes X, Jones and Barlett.
6. Lewin (2010) Genes X, Jones andBartlett.
7. Lodish et al (2008) Molecular Cell Biology,Freeman.
8. Pierce (2012) Genetics – A Conceptual Approach,Freeman.

Percent Change From Previous Syllabus: 05.0 %

SEMESTER II
DSE 1

ZOPBLD1: MOLECULAR GENETICE

Genetics

1. Basic principle of experimental animal handling and ethical issues and bio safety for molecular biology work.
2. Identification of different embryonic stages of *Drosophila.*
3. Extraction of DNA from animal tissue/blood.
4. Extraction of RNA from animal tissue.
5. Study of sex chromatin in human female from buccal epithelial and hair bud cells
6. Examination of wild type (males and females) and mutants of *Drosophila*
7. Sex linked inheritance in *Drosophila melanogaster*
8. Separation of protein on native and /denaturation gel (PAGE) / western blotting
9. Temporary squash preparation of polytene chromosomes from salivary glands of *Drosophila* larvae

Course Objective:
To study the Mendelian genetics, linkage analysis, genetic engineering, methods of cloning and their use, analysis of pedigree.

Course Outcomes:
Students will understand the basis of genetics through Mendelian genetics.
Develop in-depth knowledge of how genes are arranged in a chromosome, develop understanding about pedigree analysis, cloning techniques and lethal genetic disorder.
Students will develop understanding about how we can produce an organism with desired genome.

Percent Change From Previous Syllabus: 05.0 %

SEMESTER II
COMPULSORY PAPER

ZOPBTA1: RESEARCH METHODOLOGY

Unit 1: Introduction to research
Meaning of research, objectives of research, research process, criteria of good research, defining the research problem, basic principles of research design, developing a research pla

Unit 2: Basics of scientific communication
Types of scientific communication: research papers, review, letter to editor; Constituents of research paper: title, running title, authorships, abstracts, keywords, introduction, materials and methods, results, discussion, acknowledgements, referees, figures, table components, communication with the editors, handling referees comments, galley proofs; Plagiarism.

Unit 3: Research ethics involving human participants or laboratory animals
Ethics and biomedical research: General principles on ethical considerations involving human subjects. Institutional ethics committee: its organization and functions, general ethical issues. Ethical guidelines for experimental animals: Sources of experimental animals, anesthesia and euthanasia, laboratory animal ethics, animal ethics committee, its organization and functions, ethical guidelines for use of animals for scientific research, CPCSEA guidelines.

Unit 4: Data analysis for statistics
Methods of data collection; Graphical representation of data; Measurement of central tendency: Definition, characteristics, types, merits and demerits; Measurement of dispersion: Range, Mean deviation, Standard deviation, Standard error.

Unit 5: Statistical analysis
Variance, Coefficient of variation, Correlation and Regression and their coefficients; Test of significance: Student t- test, Chi-squire test; ANOVA; Elementary idea of probability.

Suggested readings

1. National Ethical Guidelines for Biomedical and Health Research involving human participants ICMR, New Delhi 2017.
2. Guidelines for care and use of animals in scientific research. Indian National Science Academy, New Delhi.
3. Research Methodology, methods and techniques by C.R. Kothari (2009).
4. Biostatistics: A foundation for analysis in health sciences, 9th Ed. Wayne W Daniel (2008).
5. Computer fundamentals, Pradip K Singha and Priti Singha (BPB Publication).

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER III
CORE COURSE 7

ZOPCTT1: DEVELOPMENTAL BIOLOGY

Unit 1: Fertilization and development: Biochemical aspect of fertilization; penetration and activation of egg and early development; Fate maps; embryonic induction and differentiation; Hormonal control of metamorphosis in amphibians; Neuro endocrine control of insect metamorphosis; Biochemistry and mechanism of action of hormones during metamorphosis.

Unit 2: Early embryonic development: Origin of anterior and posterior polarity; Generation of dorso-ventral polarity; Maternal effects of genes; the homeotic selector genes for segmental identity-bithorax and antennapedia complex.

Unit 3: Organogenesis: Development of vertebrate limb; Development of heart and kidney; Organizer, inductive tissue interactions in developments, Primary embryonic induction, Regional specificity in induction; Differentiation of Vertebrate lens.

Unit 4: Genetic errors of human development: Nature of human syndromes-pleiotropy, genetic heterogeneity, phenotypic variability, gene expression and human disease-inborn errors of nuclear RNA processing, inborn errors of translation; teratogenesis-environmental assaults on human development- teratogenic agents like alcohol, retinoic acid etc.

Unit 5: Regeneration: Epimorphic regeneration of reptile (salamander) limb; Morphollaxis regeneration in hydra; embryonic stem cells and their applications. Programmed cell death: apoptosis, autophagy and necrosis.

Reference Books:

1. Balinsky BI An Introduction to Embryology, W B Saunders Co., Philadelphia (Latest edition).
2. Karp G and Berrill NJ. Development, McGraw Hill, New York (Latest edition).
3. Saunders JW. Developmental Biology, MacMillan Co., London (Latest edition).
4. Gilbert SF Developmental Biology, Sinamer Associates Inc. USA (Latest edition).
5. Oppenheimer SB Introduction to Embryonic Development, Allyn and Bacon (Latest edition).
6. Regeneration in vertebrates by C S thornton. The University of Chicago press.

Percent Change From Previous Syllabus: 30.0 %

SEMESTER III
CORE COURSE 7

ZOPCLT1: DEVELOPMENTAL BIOLOGY

1. Study of frog embryonic development through models
2. Collection of frog spawns and observation of different developmental stages
3. Study of spiral cleavage in eggs of snail
4. Effect of vitamin A in tadpole tail regeneration
5. Study of embryonic development in chick through slides
6. Window preparation to study chick embryo development
7. Study of expression of developmental genes in larval imaginal discs
8. Preparation of Sperm slide.

Course Objective:
Major objective is to provide student with a sound coverage of mammalian reproductive biology with in framework of human biology. Study will be achieved by learning fundamental of structure and function of male and female reproductive tract, gametogenesis, fertilization early embryonic fetal development till birth of young one.

Course Outcomes:
It will provide important function to consider sexual differentiation and development, infertility and current reproductive technology**.**

Percent Change From Previous Syllabus: 10.0 %

SEMESTER III
CORE COURSE 8

ZOPCTT2: REGULATORY MAMMALIAN PHYSIOLOGY

Unit 1: Skeletal system: Structure and function of bone, bone formation; Axial skeletal: skull and vertebral column; Appendicular skeletal: pectoral and pelvic girdle, limbs, joints. **Muscular system:** Type function and properties of muscles, skeletal muscle tissue; Contraction and relaxation, control of muscle tension, muscle proteins.

Unit 2: Nervous system: Type of nervous tissue: neuron and glia; Structure of brain, cerebrospinal fluid, neural network, cranial nerves, blood brain barrier, spinal cord anatomy, spinal nerves.

Unit 3: Electrical signal in neurons: Axonal and synaptic transmission: Membrane potential and action potential; Types of synapses and synaptic knobs; Excitatory and inhibitory post-synaptic potential; Chemical transmission; Neurotransmitters (acetylcholine, catecholamines, serotonin and GABA), neuropeptides.

Unit 4: Lymphatic system and immunity: Lymphatic system: structure and function; Immunity: innate and adaptive immunity, Immune cells: types and production, Immune tolerance; Humoral immunity: Antigen and hapten, primary and secondary response, Immunoglobulins: types, structure and functions, Generation of antibody diversity, Class switching, somatic hypermutation, Concept of clonal selection.

Unit 5: Cell mediated immunity: T cell receptor, T helper cell and lymphocyte activation, role of cytotoxic T cell, perforin and granzymes; Regulation of immune responses and Hypersensitivity; Major histocompatibility complex (MHC), Complement system; Antigen: processing and presentation, concept of vaccination; Autoimmunity.

Books Recommended

1. Ganong (2005) Review of Medical Physiology, 22nd Ed. Lang Medical Publications.
2. Guyton and Hall (2006) Text Book of Medical Physiology, 11th Ed. W.B. Saunders.
3. Keel et al (1989) Samson Wright's Applied Physiology, 13th Ed. Oxford Press.
4. Murray et al (1989) Harper's Illustrated Biochemistry, 27th Ed. Appleton and Lange.
5. Tortora GJ and Derrikson B (2012) Principles of Anatomy and Physiology, Volume I-II, 13th Ed. John Wiley & Sons, Inc.

Percent Change From Previous Syllabus: 10.00 %

SEMESTER III
CORE COURSE 8

ZOPCLT2: REGULATORY MAMMALIAN PHYSIOLOGY

1. Study of skin with the help of chart and models
2. Study of muscle with the help of chart and models
3. Study of appendicular skeleton system with the help of model
4. Study of axial skeleton system with the help of model
5. Total and differential leucocytes counting in blood
6. Study of histological slides
7. Study of brain by model/chart
8. To study functioning of brain by rotarod
9. To study functioning of brain by light and dark chamber

Course Objective:
To study physiological and metabolic aspects of systems and their regulations.
To study the interaction between immune systems and their components with various systems of the body.

Course Objective:
To explain new hormones are synthesized, secreted and different from other physiological secretion. Their role in regulation of homeostasis of all physiological process via autocrine, paracrine, and endocrine modes of delivery, following negative and positive feedback mechanism. It also explains molecular mechanism of hormonal action based on the types of receptor.

Course Outcomes:
It will explain various endocrinological principle which helps in determination of pathophysiological basis and consequences of specific endocrine disorder**.**

Course Outcomes:
Students acquire knowledge about how immune system communicates with different systems of the body. Different sensory systems works and how they affect behavior.

Percent Change From Previous Syllabus: 10.00 %

SEMESTER III
CORE COURSE 9

ZOPCTT3: EVOLUTION, ENVIRONMENTAL BIOLOGY AND SUSTAINABLE DEVELOPMENT

Unit 1: Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; An overview of evolutionary thoughts: Lamarckism, Darwinism and Neo Darwinism; Modern synthetic theory; Evolution of horse, Geological time scale, Sources of variations: Heritable variations and the its role in evolution. Neutral theory, Molecular clock, Phylogenetic trees, Convergent and divergent evolution.

Unit 2: Population genetics: Hardy-Weinberg equilibrium (statement and derivation of equation); Evolutionary forces upsetting H-W equilibrium: Mutation, Natural selection. Genetic Drift mechanism, Role of Migration and Mutation in changing allele frequencies. Isolating mechanisms: Concepts of species and models of speciation, Adaptive radiation/macroevolution (exemplified by Galapagos finches).

Unit 3: Ecosystem dynamics: Ecological hierarchy in nature, Biotic and abiotic factors of environment, Ecosystem functioning-concept of trophic level, food chain, food web, ecological pyramids, energy flow in ecosystem, ecological efficiency.

Unit 4: Population ecology: Population dynamics, Population growth form, r- and k- selections and carrying capacity, Biological communities and species interactions, Types of interactions between two species, Interspecific competition.

Unit 5: Human impact on the environment and sustainable development: Concept of sustainable development, Environmental degradation (habitat destruction, fragmentation, biological invasions) and management, Forest, water and mineral resources, Biodiversity conservation and concept of ecosystem services, Global environmental changes (ozone depletion, acid deposition, greenhouse gas emissions and global warming), Environmental impact assessment.

Books Recommended

1. Bergstorm CT and Dujatkin LA (2012) Evolution 1st Ed. WW Norton and Co.
2. Freeman S and Herron JC (2016) Evolutionary Analysis.Pearson Education Ltd, India.
3. Futuyma DJ (1997) Evolutionary Biology, 3rd Ed. Sinauer Associates.
4. Gillespie JH (1998) Population Genetics: a Concise Guide, John Hopkins Univ Press.
5. Hall BK and Hallgrimson B (2008) Stirckberger's Evolution, 4th Ed. Jones and Barlett.
6. Page RDM and Holmes EC (1998) Molecular Evolution: A Phylogenetic Approach. Blackwell Sc.
7. Kardong K (2004) An Introduction to Biological Evolution, McGraw Hill.
8. Smith JM (1998) Evolutionary Genetics 2nd Ed. Oxford University Press.

Percent Change From Previous Syllabus: 05.00 %

SEMESTER III
CORE COURSE 9

ZOPCLT3: EVOLUTION, ENVIRONMENTAL BIOLOGY AND SUSTAINABLE DEVELOPMENT

1. Study of quantitative inheritance in *Drosophila*: sternopleural bristle phenotypes in *D. melanogaster*
2. Demonstration of natural selection under laboratory conditions by making competition between red eyed and white eyed *D. melanogaster*
3. Demonstration of Hardy-Weinberg equilibrium in human populations by taking examples of MN and ABO blood group systems
4. Study of inversion polymorphism in *Drosophila*
5. Study of sexual isolation between two closely related and sympatric species of *Drosophila*: *D. bipectinata and D. malerkotliana.*
6. Study of Zoo and Phytoplanktons in pond water
7. Preparation of temporary slides of Zooplanktons
8. Calculation of biodiversity indices
9. Physiochemical analysis of water
10. Estimation of aquatic: primary productivity using dark and light bottles
11. Study of species interactions

Course Objective:
To study how evolution progresses and affects population in individual level.

Course Outcomes:
Students will develop understanding about how evolution affects natural selection.
Students will develop understanding about how speciation occurs due to evolution.
Students will develop understanding about population genetics.

Percent Change From Previous Syllabus: 05.00 %

SEMESTER III
DISCIPLINE SPECIFIC ELECTIVE: 1

ZOPCTD1: BRAIN FUNCTION AND MENTAL AWAREMESS

Unit 1: Early embryonic development & Evolution of the nervous system: Major events in early embryonic development, cleavage, formation of blastula and gastrula; Embryonic origin of the nervous system.

Unit 2: Anatomy of the Brain: Organization of the nervous system; Subdivisions of the nervous system; The scalp, skull and meninges; Cerebrospinal fluid; Central, autonomic and peripheral nervous system.

Unit 3: Neuron: An overview of the nervous system, anatomy of the neuron, classification and type of the neurons; structure and function of dendrite & axon; ultrastructure and properties of the synapse.

Unit 4: Biological Imperatives – The Hypothalamus: Regulation of Biological rhythm, sleep, temperature, thirst and drinking, hunger and feeding.

Unit 5: Mental Awareness: Advances and challenges in neuroscience: Advances: Parkinson's disease; Pain; Epilepsy; Major Depression; Manic-Depressive Illness. Challenges: Addiction; Alzheimer's Disease; Learning Disorders; Stroke; Neurological Trauma; Anxiety Disorders; Schizophrenia; Neurological AIDS; Multiple Sclerosis; Down Syndrome; Huntington's Disease; Tourette Syndrome; Brain Tumors; Amyotrophic Lateral Sclerosis.

Books Recommended

1. Gilbert, Developmental Biology (7th Edition) Sinnaur Publication, 2006
2. Sanes, Development of the Nervous System (2nd Edition), Academic Press, 2006
3. Siegel, Basic Neurochemistry (7th Edition) Academic Press, 2006
4. Kendel, Principles of Neural Science (4th edition), McGraw Hill, 2000
5. Richard F. Thompson: The Brain – A Neuroscience Primer (2nd Ed. 1993, W. H. Freeman & Company)
6. Squire, Fundamental Neuroscience (3rd Edition), Elsevier, 2008
7. Bear, Neuroscience-Exploring the Brain, Lippincott, 2007

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER III
DISCIPLINE SPECIFIC ELECTIVE: 1

ZOPCLD1: BRAIN FUNCTION AND MENTAL AWAREMESS

1. Comparative study of brain of lower and higher vertebrates.
2. Dissection of Chicken Brain
3. Dissection of Goat Brain
4. Histology and sectioning of major areas in the brain.
5. Brief introduction of the staining techniques and stains used in brain Histology.
6. Anatomical mapping of major hypothalamic centers.
7. Study of pituitary and pineal cell types through prepared slides.
8. Hands on training in Electrophysiology: Understanding of electrophysiological techniques from microelectrodes to devices and from recording modes to data analysis; Brain slice electrophysiology (field recordings and patch clamp).
9. Some important behavioural techniques in neuroscience:
   (a). Rotarod (b). Morris water maze (c). 8 Arm radial maze or T – Maze
10. Study of MRI and CT-SCAN images for diagnosis of various neurological conditions

Course Objectives:

This hands-on laboratory exercises is designed to engage the students in common techniques used in neuroscience research. Chicken and Goat brain dissections will be done to explore the anatomy of the brain, enabling students to understand the brain circuitry. Students will learn histological techniques as well. Neurophysiological experiments will be done to study brain function and behavior.

Course Outcomes:

Students will understand anatomical parts of the brain and relate structure with the functioning of the brain. Students will develop a deep knowledge of behavioral neuroscience through lectures, laboratory exercises, and readings on numerous and diverse behavioral neuroscience topics. They will also develop an understanding of various neurological defects by reading MRI and CT-SCAN from normal and persons suffering from neurological defects.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
CORE COURSE 10

ZOPDTT1: BIOTECHNIQUES

Unit 1: Microscopy: Property of light, image formation, types of objectives, numerical aperture, limit of resolution, magnification; Structure, function and application of light (Bright-field and dark field) microscope, phase contrast microscope, fluorescence microscope, confocal microscope, transmission and scanning electron microscope.

Unit 2: Spectroscopy: Principle, structure, functioning and applications of colorimetry, UV-visible spectrophotometry, fluorimetry and atomic absorption spectrophotometry; ELISA.

Unit 3: Centrifugation: Principle of centrifugation, types of centrifuges and their applications, types and caring of rotors; determination of centrifugal force, sedimentation of cellular organelles.

Unit 4: Electrophoresis and Chromatography: Electrophoresis**:** Principle, types of electrophoresis, factors affecting migration, isoelectric focusing of proteins; PAGE and agarose gel electrophoresis; Blot techniques: Southern, Northern and Western.
Chromatography: Basic principle and application; Planar chromatography, Gas chromatography, High performance liquid chromatography, Ion exchange and affinity chromatography.

Unit 5: Microtomy: Basic principle of fixation, types and chemistry of fixation; Tissue processing: Dehydration, clearing, embedding and block preparation; Types of microtome; Histological stains: hematoxylin and eosin.

Books Recommended

1 Bancroft and Stevens (2002) Theory and Practice of Histological Techniques, Churchill-Livingstone.
2 Boyer (1993) Modern Experimental Biochemistry and Molecular Biology, 2nd Ed. Benjamin/Cumin.
3 Karp (2007) Cell and Molecular Biology, Wiley.
4 Lodish et al (2007) Molecular Cell Biology, Freeman.
5 Plummer (1990)An Introduction to Practical Biochemistry, 3rd Ed. Tata-McGrawHill.
6 Pollard andEarnshaw (2002) Cell Biology, Saunders.
7 Ruthman (1970) Methods in Cell Research, Bell and Sons.
8 Wilson and Walker (2006) Principles of Biochemical and Molecular Biological Techniques, 6th Ed. Cambridge University Press.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
CORE COURSE 10

ZOPDLT1: BIOTECHNIQUES

Biotechniques

1. Principle and working of centrifuges using yeast cells.
2. Principle and working of paper chromatography
3. Principle and working of spectrophotometer
4. Cell counting using hemocytometer (by using suitable stain)
5. Demonstration of agarose gel electrophoresis for DNA.
6. Fixation, block preparation, staining and identification of given samples.
7. Demonstration of ELISA for hormonal assay
8. Study and interpretation of electron micrographs/ photographs showing
   a) DNA replication
   b) Transcription
   c) Split genes

Course Objective:
The aim of this course is to provide an advanced understanding of standard methodologies in biology that are commonly used in life science research.

Course Outcomes:
Student will get acquired with common laboratory techniques and can comfortably handle the instruments. Biotechniques are in high demand in academics, research and industry and play prominent role in biomedical and clinical research.

Percent Change From Previous Syllabus: 40.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE: A
Biochemistry and Molecular Biology

ZOPDTD1: BIOCHEMISTRY OF INTERMEDIARY METABOLISM AND ENZYMOLOGY

Unit 1: Overview of Metabolism: Concept of metabolism, ATP as "Energy Currency of cell"; coupled reaction; Use of reducing equivalents and cofactors; Intermediary metabolism and regulatory mechanism: Transcriptome, Proteome and Metabolome

Unit 2: Metabolism of Carbohydrates and Lipids: Glycogenesis Vs glycogenolysis; Glycolysis Vs gluconeogenesis; Krebs cycle; Pentose phosphate pathway; Glyoxylate pathway; Fatty acid: biosynthesis and degradation; Cholesterol: biosynthesis and degradation; Eicosanoids: classification, biosynthesis and functions.

Unit 3: Amino acids and Protein: Structure and classification of **a**mino acids; Protein structure**:** Determination of primary structure: Amino acid composition, N- and C- terminal determination, Amino acid sequence determination; Forces and interactions involved in structural organization of fibrous and globular proteins; Structure function relationship; Protein denaturation; Molecular chaperones and protein folding.

Unit 4: Overview of Enzymology: Nomenclature and classification; Mechanism of enzyme action: Enzyme substrate binding, Binding energy, entropy change; Enzyme distribution, diversity and evolution.

Unit 5: Enzyme Kinetics: Single substrate reactions: steady state and equilibrium kinetics; Michaelis-Menten equation and plot; Linear kinetic plots: Lineweaver-Burk, Edie-Hofstee, Cornish-Bowden; Multi-substrate reactions**:** Random sequential, Ordered, Theorel-Chance mechanism, Ping-pong (double reciprocal) mechanism.

Unit 6: Enzyme inhibition and regulation: Competitive; non-competitive; un-competitive and mixed inhibitions; Determination of nature of inhibition and Ki by L-B and Dixon plots; Regulation: allosterism and covalent modifications**;** Multi-enzyme complex and multifunctional enzymes

Books Recommended

1. Nelson et al: Lehninger Principles of Biochemistry (7th ed, 2018 MacMillan Worth)
2. Berg et al: Biochemistry (5th ed2002, Freeman)
3. Mathews et al: Biochemistry (3rd ed 2004, Pearson)
4. Zubay et al: Principles in Biochemistry (2nd ed 1995, WCB)
5. Rawn: Biochemistry (1989, Neil Patterson)
6. Bender: Amino acid metabolism (1985, John Wiley)
7. Voet & Voet: Biochemistry Vol I & II (4rth ed 2011, Wiley)
8. Rafi MD: Biochemistry 2nd ed (2014 University Press)

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV

DISCIPLINE SPECIFIC ELECTIVE: A

Biochemistry and Molecular Biology

ZOPDLD1: BIOCHEMISTRY OF INTERMEDIARY METABOLISM AND ENZYMOLOGY

1. Estimation of blood glucose level using glucose oxidase method
2. Estimation of total cholesterol, HDL-cholesterol and triacyl glycerol
3. Estimation of amino acid concentration
4. Studies on quantitation of proteins by various methods: Biuret, Lowry, Bradford, Bromocresol and UV spectrophotometry
5. Studies on the expression of protein by western blotting
6. Tissue collection, storage and processing and preparation of enzyme extract
7. Standardization of the assay procedure
8. Determination of total enzyme activity and specific activity
9. Tissue distribution and sub-cellular distribution of enzyme activity.
10. Kinetic studies

Course Objective:

The course aims to provide an advanced understanding of the core principles and topics of protein structure and function. Emphasis is given to chemical structural and functional relationship of proteins and enzyme kinetics and its regulation.

Course Outcomes:

The principles of globular protein structure, as well as the techniques used for elucidation of structures and approaches to their prediction from sequence.The behavior of proteins in solution and the principles of molecular recognition.Intermediates in enzyme-catalyzed reactions and their investigations.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE: A
Biochemistry and Molecular Biology

ZOPDTD2: MOLECULAR BIOLOGY OF INFORMATION PATHWAY: NUCLEIC ACIDS

Unit 1: Eukaryotic genome: Introduction to structural and functional genomics, Denaturation and renaturation of DNA, unique and repetitive DNA, sequences (LINEs, SINEs), Chromatin organization, Nucleosomes and higher order structures, Histones and non-histone chromosomal proteins, Telomere, Chromatin modifications; Human genome: mapping, characteristics and implications.

Unit 2: DNA replication, repair and recombination: DNA polymerases, ARS and initiation in yeast, Eukaryotic chromatin replication and regulation; DNA repair: Multiple DNA repair system: Mismatch repair, Base excision repair, Nucleotide excision repair, Direct repair; DNA recombination: Homologous genetic recombination, site-specific recombination.

Unit 3: Transcription and its regulation: RNA polymerases in eukaryotes, Transcription factors: general and specific, Assembly of pre-initiation complex and initiation. Elongation and elongation factors, Enhanceosomes, Transcriptome, Promoter analysis and characterization, Expression system: transient and stable, Deletion mapping, S1/RNase mapping, Chromatin immunoprecipitation (ChIP), Electrophoretic mobility shift assay, DNase I foot printing.

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Unit 4: Post transcriptional processing and regulation: Introns: types and mechanisms of splicing, RNA editing, Post transcriptional gene silencing (RNA interference); Catalytic RNA and its role.

Unit 5: Genetic engineering: Tools: Restriction enzymes and other enzymes for DNA manipulation, Vector types: cloning and expression, Probes; Cloning strategies: cDNA and genomic libraries, Positional cloning,; Screening of clones: Preparation of probes, Hybridization: Southern, Northern (colony/plaque), immuno-screening; Characterization of clones: Sequencing, Microarray; PCR and its applications, Application: transgenic organisms and genetically modified organisms (GMOs), animal cloning, site-directed mutagenesis, generation of knock-out animals, gene therapy, DNA drugs; Ethical and social issues.

Books Recommended

1. Malacinski: Freifelder's Essentials of Molecular Biology (4th Ed 2005, Narosa)
2. Lewin: Genes IX (2008, Jones and Bartlett)
3. Brown: Genomes (3rd ed 2006, Garland Science)
4. Brown: Gene Cloning and DNA Analysis (2001, Blackwell)
5. Sambrook & Russell: Molecular Cloning (2001, Cold spring Harbor)
6. Primrose: Principles of Gene Manipulation (2001, Blackwell)
7. Asubel et al: Current Protocol in Molecular Biology (1994, Wiley)
8. Lodish et al: Molecular Cell Biology (6th ed 2007, Freeman)
9. Goldsby et al: Kubey Biochemistry (2001, Freeman)
10. Gesteland et al: RNA World (2nd ed 1999, Cold Spring Harbor)

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE: A
Biochemistry and Molecular Biology

ZOPDLD2: MOLECULAR BIOLOGY OF INFORMATION PATHWAY: NUCLEIC ACIDS

1. Sterilization techniques, media preparation and agar plate preparation
2. Measurement of growth curve of *E. coli*., calculation of its generation time and viable cell counting
3. Induction of β-galactosidase in *E. coli*
4. Rapid isolation of plasmid DNA (mini prep. alkaline lysis method)
5. Restriction digestion of plasmid and analysis by agarose gel electrophoresis, determination of insert size
6. Cloning of a DNA fragment
7. Preparation of competent cells, transformation and screening of colonies (blue-white selection)
8. Demonstration: Southern hybridization, PCR

Course Objective: The course intends to give basic knowledge about the population genetics as well as the importance of genetic, environmental and social determinants of origin of non-communicable and infectious diseases.

Course Outcome: On completion of the course, the students know and are able to use basic genetic concepts and identify Mendelian inheritance patterns. Further students become familiar with different genetic and environmental factors that are important for the origin of both communicable and noncommunicable diseases.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE B
Mammalian Reproductive Physiology and Endocrinology

ZOPDTD3: NEUROENDOCRINOLOGY, NON-CLASSICAL HORMONES AND SIGNALING

Unit 1: Neuroendocrinology - Hypophysiotropic hormones: Localization, secretion and mechanism of action, TRH, GnRH, CRH, GHRH and PACAP, Somatostatin, Monoamines; Pineal gland- Pinealocytes and Synthesis of Melatonin, biological clock and calendar**,** Melatonin and photoperiodic measurement.

Unit 2: Non-classical hormones: Growth factors: cellular origin, secretion and functions**,** Epidermal growth factor family**,** Transforming growth factor family, Platelet-derived growth factor, Insulin family (IGF-1 and IGF-II), Nerve growth factor family, Hematopoietic growth factors, Eicosanoids (prostaglandins, thromboxanes and leukotrines), Leptin.

Unit 3: Control of hormone secretion: Synthesis, processing, and sorting of preprohormone Precursor, Sequential stages of the regulated secretory pathway, Dense-cored granule Exocytosis, Regulation of exocytosis by calcium and protein kinase C.

Unit 4: Receptors: Nuclear receptors, Structure, Families (glucocorticoid, thyroid and estrogen), Activation and recycling; Membrane receptors, Enzyme-linked receptors, Cytokine receptors, G-Protein coupled receptors, Ligand-gated ion channels; Hormone signaling- Receptor tyrosine kinase pathway, Cytokine receptors pathway, Cyclic AMP pathway.

Unit 5: Phospholipid/calcium- protein kinase C pathway, Nitric oxide signaling pathway, MAP kinase pathway; Molecular basis of hormone synergism and antagonism**,** Glycogen metabolism**,** Smooth muscle contraction, Termination of hormone action Pathophysiology of hormone receptors, hormone analogues as drug and xeno-estrogens

Books Recommended

1. Bolander: Molecular Endocrinology (Latest Edition)
2. DeGroot and Jameson: Endocrinology (Latest Edition)
3. Larson Williams Textbook of Endocrinology (Latest Edition)
4. Norman and Litwack. Hormones (Latest Edition)
5. Henson and Castracane: Leptin and Reproduction (Latest Edition)
6. Norris and Lopez: Vertebrate Endocrinology (Latest Edition)
7. Brooks and Marshall: Essentials of Endocrinology (Latest Edition)

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE B
Mammalian Reproductive Physiology and Endocrinology

ZOPDLD3: NEUROENDOCRINOLOGY, NON-CLASSICAL HORMONES AND SIGNALING

1. *In situ* study of pituitary (portal circulation) and pineal (associated epithalamic complex) gland.
2. Study of pituitary and pineal cell types through prepared slides and charts.
3. Anatomical mapping of hypothalamic centres (SON, PVN, AR, VMO, mammillary nucleus, median eminence).
4. Ascorbic acid depletion bioassay for LH.
5. ELISA/RIA of TSH or gonadotropins.
6. Biochemical estimation of fructose and alkaline and acid phosphatases in seminal vesicle and prostate.
7. Preparation of the sperm slide and study of structure of the sperm.

Course Objective:
Objective is to note about the classification of hormones and chemical signaling mechanisms, hormone synthesis, secretion and transport. Hormone receptors and signal transduction processes interactions between the endocrine, nervous and immune systems. To study about the effect of hormones at distant cells and target tissues / organs by binding to specific receptor proteins in the target cell, resulting in a change in cell function.

Course Outcomes:
To enhance knowledge about functions of different hormones, development and growth; maintenance of the internal environment; and regulation of metabolism and nutrient supply. Students will gather the idea and knowledge about the hormone binds to the receptor, it results in the activation of a signal transduction pathway that typically activates gene transcription, resulting in increased expression of target proteins; non-genomic effects are more rapid, and can be synergistic with genomic.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE B
Mammalian Reproductive Physiology and Endocrinology

ZOPDTD4: MAMMALIAN REPRODUCTION FERTILITY AND STERILITY

Unit 1: Gonadotropins and Reproductive cycles: Structure, secretion and regulation of gonadotropins, Estrous and Menstrual cycle, Sexual/Gonadal and brain differentiation and behavior; Hormones of sexual behavior, Sites of action of sex hormones Primer pheromones; Estrous cycle disruption, male induction of estrus (whitten effect), male induced pregnancy block (bruce effect), human reproductive pheromones.

Unit 2: Regulation of gonadal function: Testicular function Spermatogenesis and hormonal regulation, Sertoli cell, Leydig cell, Cell– cell interactions; Epididymis: organization and function, male accessory sex glands: structural organization and endocrine regulation of prostate, functions of accessory sex glands; Ovarian function Follicular development and selection, oocyte maturation, mechanism of ovulation, hormonal and molecular changes during periovulatory period, factors involved in follicular rupture, follicular atresia, regulation of steroidogenesis.

Unit 3: Fertilization and Implantation: Hormonal control of gamete interaction, role of zona proteins, **g**amete activation, sperm-egg fusion; Hormonal control of puberty and pregnancy. Biology of implantation-Cellular aspects, molecular aspects, markers of developing embryo, cross-talk between embryo and uterus

Unit 4: Control of male and female fertility (Chemical interference): Suppression of spermatogenesis, Suppression of hypophysial activity by steroid hormones, Chemicals acting directly on the testis, Prevention of sperm maturation in epididymis, Surgical interference with reference to vasectomy; Inhibition of ovulation with reference to oral contraceptives, mechanical methods with reference to intrauterine devices, interferences and approaches.

Unit 5: Male and female sterility: Parameters of male sterility, origin and cause of male sterility, azoospermia, oligozoospermia, varicocoele, cryptorchidism; Tubal factors, premature ovarian failure, polycystic ovarian syndrome, luteal insufficiency, endometriosis.

Books Recommended

1. Leung and Adashi (2004)The Ovary, Raven Press.
2. Adashi et al. (1996) Reproductive Endocrinology, Surgery and Technology, Lippincott Raven Publishers.
3. Findlay (1994) Molecular Biology of the Female Reproductive System, Academic Press.
4. Knobil and Neill (1994) The Physiology of Reproduction, Vol. I-II, Raven Press.
5. Knobiland Neill (1998) Encyclopedia of Reproduction, Vol. 1-4, Academic Press.
6. Lamming (1984) Marshall's Physiology of Reproduction, Longman.
7. Hadley ME (2003) Endocrinology
8. Yadav BN (2011) Mammalian Endorinology, Vishal Publishing Group.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE B
Mammalian Reproductive Physiology and Endocrinology

ZOPDLD4: MAMMALIAN REPRODUCTION FERTILITY AND STERILITY

1. Demonstration of growth factors in ovary/testis.
2. Preparation and study of permanent slides of male and female reproductive organs.
3. Study of stages of spermatogenesis and spermeogenesis using histological slides of testis.
4. Biochemical estimation of 3β-hydroxysteroiddehydogenase.
5. Study of sperm motility, sperm morphology, and sperm count in rat.
6. Effect of cadmium chloride treatment on testis*in vitro*.
7. Biochemical estimation of succinate dehydrogenase and catalase activity.
8. Study of rat oestrous cycle using vaginal smear preparations.
9. Demonstration of implantation sites by pontamine blue (blue dye reaction) in mouse.
10. Demonstration of vesoctomy, tubectomy, hysterectomy, super ovulation & PCOS in rats.
11. Demonstration of antral follicle, corpus luteum, egg isolation, granulose and theca cells.

Course Objective:
To study the various causes and factor important for the fertility. It also deals about the reproductive pathophysiology of sterility.

Course Outcomes:
The study of such subject may be helpful in establishing the best clinical practices required for a counseling framework to such couple who are close to or facing the problems of sterility.
The knowledge will also be helpful in providing the different diagnostic techniques used in the fertility clinics and IVF centers.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE C
Fish and Fisheries

ZOPDTD5: FISH ANATOMY, PHYSIOLOGY AND BIOTECHNOLOGY

Unit 1: Integumentary and Digestive system: Integument: General organization of epidermis and dermis and their derivatives; Digestion: Alimentary canal; Digestion and absorption of lipid, protein and carbohydrate.

Unit 2: Respiratory and Circulatory system: Respiration: Gill structure; Physiology of gill respiration; Accessory respiratory organs; Structure and function of swim bladder; Circulation: Heart and aortic arches; Regulation of cardiac activity, Hemodynamics; Components of fish blood.

Unit 3: Excretory and Endocrine system: Excretion and osmoregulation: Excretion of nitrogenous wastes; Water and ion balance; Endocrine glands and tissues: Structure and functions: Pituitary, Thyroid, Pancreas, Adrenal (chromaffin and inter-renal tissues), Corpuscles of stannius, Urophysis, Ultimobranchial and pineal gland.

Unit 4: Nervous system: Brain and cranial nerves, Receptors; Eye: structure, photoreception, Acoustico-lateralis system: Membranous labyrinth, lateral line organs; Chemoreceptors; Electroreceptors.

Unit 5: Fish reproduction and Biotechnology: Teleostean gonad; Reproductive cycle; Types and modes of reproduction; Hypothalamo-hypophyseal gonadal axis, Role of environmental factors on gonadal maturation and spawning; Induced breeding; Chromosomal manipulation-Gynogenesis, Androgenesis, Cryo-preservation of gametes and embryo, Transgenic fish.

Books Recommended

1. **Brown ME (1957) The Physiology of Fishes Vol. I-II, Academic Press.**
2. **Evans DH (1998) The Physiology of Fishes, CRC Press.**
3. Gopakumar et al. (2000) Fifty Years of Fisheries Research in India, Fisheries Division Indian Council of Agricultural Research
4. **Gorbman et al (1962) Comparative Endocrinology, John Wiley and Sons, New York, Chicheester, Brisbane.**
5. **Hoar WS and Randall DJ (1971) Fish Physiology Vol. I - XIV, Academic Press.**
6. **Hughes GM (1967) Comparative Physiology of Vertebrate Respiration, Heinemann Educational Books Ltd.**
7. **Nilsson S and Holmgren S (1968) Fish Physiology Recent Advances, Croom Helm, London.**
8. **Norris DO (2020) Vertebrate Endocrinology, 6th Ed. Academic Press.**

9. Jhingran VG (1985) Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE C
Fish and Fisheries

ZOPDLD5: FISH ANATOMY, PHYSIOLOGY AND BIOTECHNOLOGY

1. General anatomical observations of a bony fish.
2. Display of afferent and efferent branchial vessels.
3. Study of available histological slides of different structures/organs.
4. Study of haematological parameters- blood corpuscles, T.C, D.C and Hb content
5. Determination and comparison of hemoglobin content of water-breathing and air breathing fish.
6. Study of ventilation rate and surfacing activity of fish under different experimental conditions.
7. Determination of feeding habit of carps and catfishes by analyses of their gut contents
8. Preparation of permanent stained slides of different endocrine glands and kidney of a teleost.

Course Objectives:
To know about the vital systems in fishes and its physiology.
To know about the food and feeding activity of the fishes.
To get knowledge about the hormones related with reproduction like FSH, LH, etc.
To get knowledge about induced breeding like hypophysation and stripping.
To use various fish biotechnologies to improve the quality and quantity of fishes like gyanogenesis and androgenesis.
To know about the techniques used in cryopreservation of gametes and embryo for the further use.
To get knowledge about the transgenic fishes.

Course Outcomes:
This course work will provide the knowledge about complete biology of fishes. Generally, the carps do not breed in stagnant water; therefore artificial breeding is carried out. This course will provide basic knowledge of induced breeding in fishes. The course will also through light on the biotechniques like cryopreservation and production of transgenic fishes.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE C
Fish and Fisheries

ZOPDTD6: FISH CULTURE, CAPTURE FISHERY AND FISH PATHOLOGY

Unit 1: Fish culture systems and Pond management: Pond culture, pen culture, cage culture, running water culture; Different ponds of a fish farm; Formulation and operation of different types of hatcheries; Composite fish farming; Fish culture in paddy fields; Sewage-fed fisheries; Physico-chemical properties of pond water and their maintenance; Manuring and liming; Larvivorous fishes; Weed fishes and their eradication; Aquatic vegetation and its control.

Unit 2: Fishery resources of India and Fishing methods: Inland fisheries- Lakesterine fishery; Riverine fishery; Marine fishery; Estuarine Fishery; Types of fishing gears, Fishing crafts; Modern techniques and equipments for finding and capturing fishes.

Unit 3: Fish nutrition: Food and feeding habits of freshwater fishes; Nutrients requirement for various growth stages of freshwater carps and their bioenergetics; Supplementary feed; Anti-nutritional factors.

Unit 4: Fish by-products, Fish spoilage and preservation: Fish by products: Liver oils, Fish meal, Fish silage, Fish protein, Shark fins and fin rays, Fish roes, Isinglass, Fish skin, Pearl essence; Ornamental fishes; Fish aquarium: Preparation and maintenance; Bacterial, chemical and enzymatic spoilage, Fish preservation: Drying, Salting, Smoking and Canning; Additives and Preservatives.

Unit 5:Fish pathology: Main causes of disease in farmed fish; Preventing diseases through proper management; Common disease symptoms in fish; Symptoms, treatment and control: common diseases caused by viruses, bacteria, fungi, protozoa and crustaceans in fishes; Nutritional diseases in fishes.

Books Recommended

1. **Chakroff M (2015) Freshwater Fish Pond Culture and Management, Sci. Publishers.**
2. **Davis HS (1956) Culture and Diseases of Game Fishes, University of California Press.**
3. **Duijn CV (1967) Diseases of Fishes, London Iliffe Books Ltd.**
4. Datta-Munshi and Hughes(1992) Air-breathing fishes of India, Oxford and IBH.
5. **Hall CB (1994) Ponds and Fish Culture, Agro Botanical Publishers.**
6. **Hora SL and Pillay TVR (1962) Handbook on Fish Culture in the Indo-Pacific Region, Fisheries Division, Biology Branch, FAO.**
7. **Jhingran VG (1991) Fish and Fisheries of India. Hindustan Pub.Corporation, New Delhi.**
8. **Khanna SS and Singh HR (2003) A Textbook of Fish Biology and Fisheries, Narendra Publishing House.**

9. Kreuzer R (1974) Fishery products, FAO, Fishing News (Books) Ltd., England.
10. Lagler et al. (2003) Ichthyology, John Wiley.
11. Ribelin WE and Migaki G (1975) The Pathology of Fishes, The Univ. of Wisconsin Press.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE C
Fish and Fisheries

ZOPDLD6: FISH CULTURE, CAPTURE FISHERY AND FISH PATHOLOGY

1. Analysis of some important physical and chemical properties of water
2. Collection and identification of plankton, weeds and aquatic plants.
3. Study of weeds and aquatic plants.
4. Study of ornamental, exotic and larvicidal fishes.
5. Study of major carps.
6. Study on modern techniques of fishing.
7. Study of various types of fishing gears.
8. Visit to fish market/fish pond/fish farm/breeding centers.

Course Objectives:
To know about the basic types of fish culture systems.
To know about the pond management for fish culture, optimum conditions required for fish culture and modern techniques of culture and capture fisheries.
To know about the common fish diseases and its control measures.
To get the knowledge of fishery resources of India like freshwater, marine and brackish.
To know about indigenous and improved fishing gears and crafts
To get the basic idea of fish nutrition and supplementary food for fishes.
To know about the nutritional and anti-nutritional factors of the fishes
To get knowledge about additives and preservatives used to keep food items preserve for long time
To get idea about various fish byproducts used by human beings

Course Outcomes:
Students will be aware about the various fishery resources of India, from which we obtain fishes by culture and capture fishery. The fishes use many kinds of food. If scarcity of food is there then, artificial food is given. Students will also be familiar about nutrition and anti-nutritional factors present in the supplementary food provided to the fishes. This course will provide the knowledge about the additives and preservatives used in the food, and also about fish byproducts.
Since fish are the best source of our food, therefore we should increase their production by using improved techniques. The course will also highlight on the selection of species of fishes to get maximum benefit. The students will also get knowledge about the various diseases.

Percent Change From Previous Syllabus: 50.0 %

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE D
Toxicology

ZOPDTD7: MECHANISM OF TOXICITY

Unit 1: Introduction to toxicology: History and scope of toxicology; Different areas of modern toxicology; Classification of toxic substance; various definitions of toxicological significance.

Unit 2: Exposure and response to toxicants: Types and characteristics of exposure; routes and site, dose, duration and frequency; Dose–response relationship; LD_{50}, LC_{50}, TD_{50} and therapeutic index, Variation in toxic responses; Aquatic toxicology: Bioaccumulation and biomagnification.

Unit 3: Modes of chemically induced cyto-toxicity: General response patterns and morphological aspects for cytopathology; Mechanisms of apoptosis, autosis and necrosis; Atrophy, Hypertrophy, Hyperplasia and Regeneration.

Unit 4: Hepatic toxicity: Introduction to the liver and its response to toxicants; Overview of hepatic parenchymal and nonparenchyal cells; Evaluation of hepatotoxicity: Physiological, biochemical and pathological response to toxic injury; Hepatic defence against toxicity; Mechanism of action of hepatotoxicant (CCl_4 /Acetaminophen/ Alcohol)

Unit 5: Renal toxicity: Susceptibility of kidney to toxic insult, Clinical aspect of renal injury; Acute and chronic renal failure; Mechanism of glomerulus injury; Biochemical mechanisms of proximal tubules cellular death; Renal toxicity of heavy metals (Hg/ As).

Unit 6: Xenobiotic-Receptor mediated toxicity: Ligand–selective activation, receptor mediated toxicity, Species and tissue specific differences in nuclear receptor activity, Estrogen-receptor mediated toxicity, structure and modulation of gene expression, PPAR-α mediated toxicity.

Books Recommended

1. Karen S and Brown TM (2006) Principles of Toxicology, 2nd Ed. CRC press.
2. McQueen CA (2018) Com. Toxicology-Vol 1: General principle 3rd Ed. Elsevier.
3. McQueen CA (2018) Com. Toxicology-Vol 8: Cellular and Molecular Toxicology 3rd Ed. Elsevier.
4. McQueen CA (2018) Com. Toxicology-Vol 9: Toxicology Testings and Evaluation 3rd Ed. Elsevier.
5. McQueen CA (2018) Com. Toxicology-Vol 10: Biotransformation 3rd Ed. Elsevier.
6. Stanley E. Manahan (2003) Toxicological Chemistry and Biochemistry, 3rd Edition, Lewis Publishers, CRC Press Company
7. Barlie FA (2008) Principles of Toxicology Testing, CRC Press, Taylor and Francis.
8. Somasundaram SG (2016) Natural Product Interactions on Genome, CRC Press

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE D
Toxicology

ZOPDLD7: MECHANISM OF TOXICITY

1. To study the structure and function of toxins.
2. Quantitative identification of functional groups in given sample.
3. Qualitative identification of functional groups in given sample.
4. Training on different routes of drug administration (Oral, I.M., I.P, SC.)
5. Calculation of LD_{50}/LC_{50} by given data.
6. Calculation of therapeutic index by given data.
7. Collection of blood samples from rats/mice.
8. Collection of urine and feces samples from rats/mice.
9. To study excretory ability of liver (Kit method).
10. To study synthesis ability of liver (Kit method).
11. Demonstration of choleretic activity of xenobiotics (virtual lab).
12. Assessment of Liver function tests (Kit method).
13. Assessment of Kidney function tests (Kit method).

Course Objective:
To study few molecular mechanisms involved in chemically induced toxicity and methods to evaluate general toxicity in laboratory.

Course Outcomes:
Students will gain appreciable knowledge and critical thinking to correlate mechanism of chemically induced toxicity in intact body at molecular level.Students will also gain understanding regarding methods to identify toxic responses in various testing models.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE D
Toxicology

ZOPDTD8: REACTIVE METABOLITES AND DEFENSE SYSTEM IN BIOLOGY

Unit 1: Free radical reactions and reactive metabolites: Nature of free radicals; Initiation, propagation and termination of radical reactions; Formation of free radicals in lipids and lipid peroxidation in membranes.

Unit 2: **Reactive metabolites:** Introduction to reactive metabolites: Reactive oxygen species and reactive nitrogen species; Nature and stability of reactive metabolites, Fate of reactive metabolites, Factors affecting toxicity of reactive metabolites. Biological sources of reactive oxygen species: the key role of superoxide anion radical, hydrogen peroxide and hydroxyl radicals.

Unit 3: **Oxidative stress and antioxidant defense:** Definition of oxidative stress; toxicological consequences of oxidative stress on proteins, DNA, lipids and signal transduction. Antioxidant defense mechanism: Enzymatic and Non enzymatic antioxidants; superoxide dismutases, catalases and glutathione peroxidases, glutathione, tocopherols and β- carotene as antioxidants.

Unit 4: Metal toxicity: Metal- Ligand interactions in biological fluids, interactions between metal ions and macromolecules: metal - protein interaction, metal - nucleic acid interactions; Induction of heat shock proteins, cytoskeletal effects, heamporphyrin metabolism, metallothionein and its biological functions.

Unit 5: Fate of xenobiotics in animal body: Absorption, Distribution, Metabolism (Phase I metabolism: CYP multigene family; Phase II metabolism: Conjugation–Deconjugation reactions; Cofactor supply) and Excretion of xenobiotics.

Books Recommended

1. Klassen CD (2008) Cassarett and Doull's Toxicology: The Basic Science of The Poisons, 7th Ed. McGraw Hill Publisher.
2. Timbrell J (2000) Principles of Biochemical Toxicology, 3rd Ed. Taylor and Francis.
3. Klaassen and Whatkins (2010) Cassarett and Doull's "Essentials of Toxicology" 2nd Ed. McGraw Hill Publisher.
4. Karen S and Brown TM (2006) Principles of Toxicology, 2nd Ed. CRC press.
5. Manahan SE (2003) Toxicology, Chemistry and Biochemistry, 3rd Ed. CRC Press LLC
6. Pillay VV (2013) Modern MedicalToxicology4th Ed. Jaypee Brothers Medical Publishers
7. Hohgson E (2010) A Textbook of Modern Toxicology, 4th Ed. John Wiley and Sons, Inc., Publication.
8. McQueen CA (2018) Comprehensive Toxicology-Vol 2: Hepatic Toxicology 3rd Ed. Elsevier Publications.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV
DISCIPLINE SPECIFIC ELECTIVE D
Toxicology

ZOPDLD8: REACTIVE METABOLITES AND DEFENSE SYSTEM IN BIOLOGY

1. Handling of laboratory animals.
2. Demonstration of toxic effects of given xenobiotic using computer simulation programs/virtual labs.
3. Assessment of antioxidant potential in given sample.
4. To study the structure and function of metal-ligand complexes.
5. Assessment of chelating effect of molecules against selected metals.
6. Assessment of metal induced hematotoxicity.
7. Biochemical assessment of glutathione.
8. Assessment of oxidative stress
9. Histopathological effects of metals on tissues
10. To observe toxic effects on cellular level using electron micrographs of tissues

Course Objective:
To be acquainted with the history and scope of toxicology, metal toxicity and occupational health hazards so that student may develop reasoning behind the effect of environment.

Course Outcomes:
Student will be able to understand toxicology and its scope in life, to identify different types of toxicants and create understanding about effects of toxic agents present in environment.

Percent Change From Previous Syllabus: 100 % (Newly introduced)

SEMESTER IV

ZOPDDD1: DISSERTATION

Topic will be based on the major elective opted by students. Project will include laboratory/field based work followed by submission of report and an open presentation.

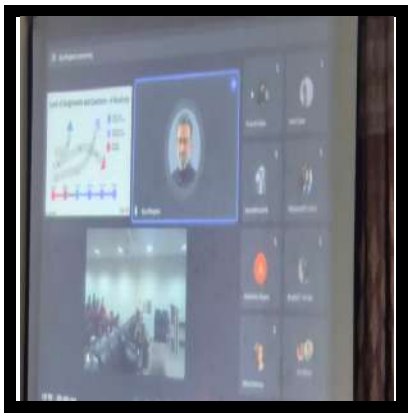
Useful Contact Numbers

Sl. No.	Designation	Name	Contact No.
01	Vice Chancellor	Professor Alok Kumar Chakrawal	260283, 260353
02	Registrar (Acting)	Prof. Manish Shrivastava	260209
03	Dean Student Welfare	Prof. M. N. Tripathi	260204
04	OSD		260159
05	Controller of Exam (Acting)	Prof. R. K. Sharma	260044
06	Finance Officer (In Charge)		260036
07	Dean, School of Life Sciences	Prof. Seema Rai	9406211523
09	HOD	Prof LVKS Bhasker	8224979600
10	Deputy Registrar (Stores)		260381
11	Deputy Registrar (Administration)		260036
12	Assistant Registrar (Development and Engineering Section)		260207
13	Assistant Registrar (Administration and RTI Cell)		260017
14	Assistant Registrar (Examination)		260000
15	Cultural Co-ordinator		2600037
16	Computer Centre		260356
17	University Guest House		260024
18	Health Centre		202317
19	Police Station, Koni	-	260039
20	Post Office. Koni	-	260032

“One Day Brainstorming Symposium on National Education Policy-2020 in Transformational Reforms of Curriculum Mapping” (17 December 2022)





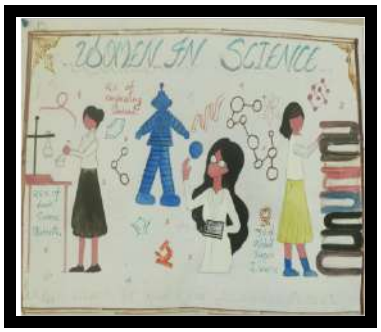
Best Paper Awards (2020, 2021, 2022)

Best Teacher Award (2021, 2022)

Departmental Activities

National Science Day (28 February 2020)



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