

Syllabus for Undergraduate Program in Zoology



DEPARTMENT OF ZOOLOGY

**COTTON UNIVERSITY,
GUWAHATI-781001, ASSAM**

COTTON UNIVERSITY
CBCS CURRICULUM OF B. SC. IN ZOOLOGY (HONOURS)
EFFECTIVE FROM AUGUST 2018

Program Learning Outcomes (PLOs)

PLO1. Students pursuing a B.Sc. (Major) in Zoology will study and gain a thorough understanding of discipline as well as associated biological sciences. They should have skills at the end of their graduation that will provide them a competitive advantage in pursuing higher education in India or overseas, as well as careers in academia, research, or industry.

PLO2. Based on the morphological, anatomical, and systemic arrangement of chordates and non-chordates, students will be able to identify, classify, and distinguish various life forms on earth. They will be able to explain the economic, ecological, and medical importance of different animals in human life. This will pique their interest and encourage them to learn more about animal diversity and pursue wild life photography or expedition as a career option. Students would get professional benefits in teaching, research, and taxonomist careers in various government organizations, such as the Zoological Survey of India and National Parks/Sanctuaries, thanks to their procedural expertise of identifying and classifying animals.

PLO3. Biotechnology, biostatistics, bioinformatics, and molecular biology practical abilities can be applied to a job as a scientist in the drug development industry in India or overseas. Our students will learn basic experimental skills in genetics, molecular biology, biotechnology, qualitative and quantitative microscopy, enzymology, and analytical biochemistry, among other topics. These techniques will give our students who want to pursue further education an advantage. Students will be able to critically analyse the way evolution has shaped these traits in the human body if they have a thorough understanding of comparative anatomy and developmental biology of various biological systems, as well as learning about the organization, functions, strengths, and weaknesses of various systems.

PLO4. Students enrolled in skill enhancement courses such as aquaculture, sericulture, and apiculture will learn how to grow fish, bees, and silk moths, which will prepare them to start their own businesses and generate self-employment, allowing them to become successful entrepreneurs. They will be able to work in diagnostic or research laboratories after learning diagnostic testing, haematological, histopathology, staining processes, and other skills utilised in clinical and research laboratories. A thorough understanding of the various physiological systems and methods available for measuring vital physiological parameters and comprehending the mechanism behind the occurrence of various life-threatening diseases via laboratory examination, assessment of basic physiological functions by interpreting physiological charts will aid in determining their career options.

PLO5. Students that take wild life management courses will learn how to identify essential aspects in the management of wild animals as well as different approaches for estimating, remote sensing, and global positioning. Students will be inspired to pursue a career in animal conservation and management after taking this course.

Matrix showing Program Outcomes of different types of courses for B.Sc. Zoology

Program Outcomes	Core Course													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Core competency	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Critical thinking	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Research-skills	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Teamwork	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑

Discipline Specific Elective Courses (DSE)

Program Outcomes	DSE1	DSE2	DSE3	DSE4
Additional Academic Knowledge	☑	☑	☑	☑
Problemsolving	☑	☑	☑	☑
Additional Analytical skills	☑	☑	☑	☑
Additional Research skills	☑	☑	☑	☑

Generic Elective Courses (GE)

Program Outcomes	GE1	GE2	GE3	GE4
Additional Academic Knowledge	☑	☑	☑	☑
Exposure beyond discipline	☑	☑	☑	☑
Problemsolving	☑	☑	☑	☑
Analytical reasoning	☑	☑	☑	☑

Skill Enhancement Course (SEC)

Program Outcomes	SEC1	SEC2
Additional Knowledge enhancement	☑	☑
Exposure beyond discipline	☑	☑
Analytical reasoning	☑	☑
Digital Literacy	☑	☑
Moral and ethical awareness	☑	☑

TOTALNUMBER OF COURSES IN UG LEVEL- CBCS (B. SC. - ZOOLOGY HONOURS)

Type of courses	Core Course (C)	Discipline Specific Elective Course (DSE)	Generic Elective Course (GE)	Ability Enhancement Compulsory Course (AE)	Skill Enhancement Course (SE)	Total No. of Courses& Credit
No. Of courses	14	4	4	2	2	30
Credit per course	6	6	6	2	2	140

Semester	Course code	Course detail	Credits
I	ZOO –101C	Introductory Animal Biology ,Systematics& Animal Diversity (I):Non Chordates (uptoPseudocoelomates)	4
	Practical	Introductory Animal Biology, Systematics &Non Chordata(Pseudocoelomates) LAB	2
	ZOO-102C	Animal Diversity (II): Coelomates & Perspectives in Ecology.	4
	Practical	Non Chordata (Coelomates) & Ecology (LAB)	2
II	ZOO-201C	Animal Diversity (III) : Protochordates to Chordates	4
	Practical	Animal Diversity (III) : Protochordates to Chordates (LAB)	2
	ZOO-202C	Cell Biology	4

	Practical	Cell Biology (LAB)	2
III	ZOO-301C	Histology & Comparative Anatomy of Vertebrates	4
	Practical	Histology & Comparative Anatomy of Vertebrates (LAB)	2
	ZOO-302C	Physiology & Endocrinology	4
	Practical	Physiology & Endocrinology (LAB)	2
	ZOO-303C	Genetics (Classical Applied Genetics)	4
	Practical	Genetics (LAB)	2
IV	ZOO-401C	Fundamentals of Biochemistry and Metabolism	4
	Practical	Fundamentals of Biochemistry and Metabolism(LAB)	2
	ZOO-402C	Information Biology(Bioinformatics), & Biostatistics, Instrumentation	4
	Practical	Bioinformatics, Biostatistics& Instrumentation (LAB)	2
	ZOO-403C	Evolutionary & Adaptive Biology	4
	Practical	Evolutionary & Adaptive Biology (LAB)	2
V	ZOO-501C	Molecular Biology & Animal Biotechnology	4
	Practical	Molecular Biology & Animal Biotechnology (LAB)	2
	ZOO-502C	Economic & Applied Zoology	4
	Practical	Economic & Applied Zoology (LAB)	2
VI	ZOO-601C	Developmental Biology & Immunology	4
	Practical	Developmental Biology & Immunology (LAB)	2
	ZOO-602C	Animal Behaviour& Wildlife Biology/Environmental Science	4
	Practical	Animal Behaviour& Wildlife Biology/Environmental Science (Field visit,LAB)	2

SYLLABUS STRUCTURE OF B. SC. HONOURS IN ZOOLOGY UNDER CBCS SYSTEM

DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE) – FOUR COURSES OFFERED TO BE OPTED FOR IN SEMESTER V & VI

SEMESTER V		SEMESTER VI	
ZOO-503DSE1	ZOO-504DSE2	ZOO-603DSE3	ZOO-604DSE4
Biology of Insects	Parasitology	Aquatic biology	Reproductive Biology

GENERIC ELECTIVE COURSES (GE) – COURSES (MODULAR) OFFERED TO STUDENTS OF OTHER DEPARTMENTS.

Semester I	Semester II	Semester III	Semester IV
ZOO-103GE 1	ZOO-203GE 2	ZOO-304GE 3	ZOO-404GE 4
Animal diversity	Environment and Public Health	Food nutrition and Health	Human Physiology

ABILITY ENHANCEMENT COMPULSORY COURSES (AEC) - COMPULSORY COURSES

Semester I	Semester II
Environmental Science	English / MIL

SKILL ENHANCEMENT COURSES (SEC)

Semester III	Semester IV
ZOO-001SEC	ZOO-002SEC
Vermicomposting and Bio fertiliser	Medical Diagnostics

TABLE-1: DETAILS OF COURSES & CREDIT OF B.SC. ZOOLOGY(HONOURS) UNDER CBCS

S. No.	Particulars of Courses	Credit points
1	Core Course:14 papers	Lecture +Tutorial+ Practical (L+T+P)
1A	Core Course: Theory (14 Papers)	14×4=56
1B	Core Course(practical/tutorial**)(14 papers)	14×2=28
2	Elective Courses:8 papers	
2A	A. Discipline Specific Elective(DSE) (4 papers)	4×4=16
2B	DSE(practical)(4 papers)	4×2=8
2C	B.General Elective(GE) (Interdisciplinary) (4 Papers)	4×4=16
2D	GE (practical) (4 Papers)	4×2=8
3	Ability Enhancement Courses	
3A	AEC,ENVS,EnglishCommunication/MIL	2×2=4
3B	Skill Enhancement Course (SE)	2×2=4
Total credit		140

**Practical class can be conducted in the scheduled time of tutorial class.

TABLE-2: SEMESTER-WISE DISTRIBUTION OF COURSE & CREDITS IN B.SC. ZOOLOGY HONOURS

Credit per courses	SEM -I	SEM -II	SEM -III	SEM -IV	SEM -V	SEM -VI	Total no. of Courses	Total
C (6)	2	2	3	3	2	2	14	14× 6=84
DSE(6)	-	-	-	-	2	2	4	4×6=24
GE(6)	1	1	1	1	-	-	4	4×6=24
AEC (2)	1	1	-	-	-	-	2	2×2=4
SEC(2)	-	-	1	1	-	-	2	2×2=4
Total no. of Course/SEM	4	4	5	5	4	4	26	-
Total Credit/ SEM	20	20	26	26	24	24	-	140

COTTON UNIVERSITY
COURSE STRUCTURE: UG(ZOOLOGY HONOURS) CBCS CURRICULUM

Semester I			
Course code	Course Details	Course wise lecture (h)	Credits
ZOO-101C	Introductory to Animal Biology, Systematics & Animal Diversity (I) : Non Chordates (upto Pseudocoelomates)	Core (64L)	4
Practical	Introductory to Animal Biology, Systematics & Non Chordata (Pseudocoelomates) LAB	Core (32P)	2
ZOO-102C	Animal Diversity (II): Coelomates & Perspectives in Ecology	Core (64L)	4
Practical	Non Chordata (Coelomates) & Ecology (LAB)	Core (32P)	2
ZOO-103GE	Animal diversity	General Elective (64L)	4(3L+1T)
Practical	Animal diversity (LAB)	General Elective (16P)	2
ZOO-H-AE-101	Environmental Science	Ability Enhancement Compulsory (32L)	2
Total four(4) courses			20

Semester II			
Course Name	Course Detail	Course wise lecture (h)	Credits
ZOO-201C	Animal Diversity (III) : Protochordates to Chordates	Core (64L)	4
Practical	Animal Diversity (III) : Chordate Practical	Core (32P)	2
ZOO-202C	Cell Biology	Core (64L)	4
Practical	Cell Biology(LAB)	Core (32P)	2
ZOO-203M (GE)	Environment and Public Health	General Elective(64L)	4(3L+1T)
Practical	Environment and Public Health(LAB)	General Elective(32P)	2
ZOO-H-AE-202	English / MIL	Ability Enhancement Compulsory (32L)	2
Total Four (4) Courses			20

SemesterIV

Semester III			
Course code	Course Details	Course wise lecture (h)	Credits
ZOO-301C	Histology & Comparative Anatomy of Vertebrates	Core (64L)	4
Practical	Histology & Comparative Anatomy of Vertebrates (LAB)	Core (32P)	2
ZOO-302C	Physiology & Endocrinology	Core (64L)	4
Practical	Physiology & Endocrinology(LAB)	Core (32P)	2
ZOO-303C	Genetics (Classical &Applied Genetics)	Core (64L)	4
Practical	Genetics(LAB)	Core (32P)	2
ZOO-001S	Vermicomposting and Biofertilizer	Skill Enhancement (32L)	2
ZOO-304GE	Food nutrition and Health	General Elective (64L)	4(3L + 1T)
Practical	Food nutrition and Health(LAB)	General Elective (32P)	2
Total Four (4) Courses			26
Course code	Course Details	Course wise lecture (h)	Credits
ZOO-401C	Fundamentals of Biochemistry and Metabolism	Core (64L)	4
Practical	Fundamentals of Biochemistry and Metabolism (LAB)	Core (32P)	2
ZOO-402C	Information Biology &Biostatistics(Bioinformatics)	Core (64L)	4
Practical	Bioinformatics & Biostatistics (LAB)	Core (32P)	2
ZOO-403C	Evolutionary & Adaptive Biology	Core (64L)	4
Practical	Evolutionary & Adaptive Biology(LAB)	Core (32P)	2
ZOO-002S	Medical Diagnostics	Skill Enhancement (32L)	2
ZOO-404GE	Human Physiology	General Elective (64L)	4(3L + 1T)
Practical	Human Physiology LAB	General Elective (32P)	2
Total five(5) courses			26

SemesterV

Course code	Course Details	Course wise lecture (h)	Credits
ZOO-501C	Molecular Biology & Animal Biotechnology	Core (64L)	4
Practical	Molecular Biology & Animal Biotechnology (LAB)	Core(32P)	2
ZOO-502C	Economic & Applied Zoology	Core(64L)	4
Practical	Economic & Applied Zoology (LAB)	Core(32P)	2
ZOO-503DSE	Biology of Insects	DSE(64L)	4
Practical	Biology of Insecta/ Fish and fisheries (LAB)	DSE(32P)	2
ZOO-504DSE-L	Parasitology	DSE (64L)	4
Practical	Parasitology (LAB)	DSE (32P)	2
Total four(4) courses			24

SemesterVI			
Course code	Course Details	Course wise lecture (h)	Credits
ZOO-601C	Developmental Biology & Immunology	Core (64L)	4
Practical	Developmental Biology & Immunology (LAB)	Core (32P)	2
ZOO-602C	Animal Behaviour & Wildlife Biology/Environmental Science	Core (64L)	4
Practical	Animal Behaviour & Wildlife Biology/Environmental Science (Field visit, LAB)	Core (32P)	2
ZOO-603DSE	Aquatic Biology/ Biotechnology	DSE(64L)	4
Practical	Aquatic Biology (LAB)/Biotechnology (LAB)	DSE(32P)	2
ZOO-604DSE	Reproductive Biology	DSE (64L)	4
Practical	Reproductive Biology (LAB)	DSE (32P)	2
Total four(4) courses			24

ZOO-101C

INTRODUCTORY ANIMAL BIOLOGY, SYSTEMATICS AND ANIMAL DIVERSITY(I): NON-CHORDATES (UPTO PSEUDOCOELOMATE)

Credit 4

Total no of lectures-64

Learning Objectives:

1. The course would provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life.
2. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their evolutionary relationships, structural and functional affinities.
3. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Learning Outcomes:

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

- LO1.** Learn about the importance of systematics, taxonomy and structural organization of animals.
- LO2.** Appreciate the diversity of non-chordates living in varied habit and habitats.
- LO3.** Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- LO4.** Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representative of various animal phyla.
- LO5.** Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- LO6.** Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions, assignments and projects.

Unit 1: Introductory Animal Biology

8L

Introduction to concept of Animal Biology, concept of ecology; Water and life, Properties of water and role of water in life; Properties and significance of carbon in life; Level of organization of Biomolecules in life; Prokaryotic and Eukaryotic cells.

Unit 2: Principles of Taxonomy and Systematics

18L

Introduction of Taxonomy, Definition of Taxonomy and relationship with Systematics, Application of taxonomy; Zoological Nomenclature: Binomial and Trinomial Nomenclature; Three kinds of classification: Components of Classification, Taxonomic hierarchy (Linnaean hierarchy), Taxonomic types; International Code of Zoological Nomenclature (ICZN): Origin, Components and Rules of Nomenclature; Elementary idea of Taxidermy and Museology.

Unit 3: Animal Diversity- Criteria for classification

6L

of multicellular organisms.	
Symmetry; Early development: Protostome and Deuterostome, Spiral and radial cleavage, Body cavities: Acoelomate, Pseudocoelomate, Coelomate and Enterocoelomate, Homology and Analogy.	
Unit 4: Animal Diversity–I (Protista to Ctenophora)	32L
4.1. Protozoa	12L
1. General characters and classification up to orders with examples, 2. Type study: Amoeba and Paramecium, 3. Life cycle and pathogenicity of Plasmodium vivax, 4. Nutrition, Locomotion and Reproduction in Protozoa.	
4.2. Metazoa	4L
1. Evolution of metazoan; 2. metamerism of metazoan and its significance.	
4.3. Porifera	4L
1. General characters and classification upto orders with examples 2. Canal system in Porifera (Sponges)	
4.4. Cnidaria	8L
1. General characters and classification upto orders with examples, 2. Type study: Obelia; polymorphism in Siphonophora, 3. Diversity of coral and coral reefs formations, conservation.	
4.5. Ctenophora	4L
1. General characteristics 2. Difference between Cnidaria and Ctenophora, evolutionary significance.	

Practical

Credit 2

List of practical:

1. Study and preparation of prokaryotic cells
2. Study of eukaryotic cells.
3. Taxonomic arrangement of animal species from random sized supplied museum specimens.
4. Identification of permanent whole mount preparation:
Amoeba, Euglena, Paramecium, Entamoeba, Opalina.
5. Study and classification of invertebrate specimen upto order (in museum): Grantia, Sycon, Spongilla, obelia, Physalia, Aurelia, Metridium, Pennatula, Gorgonia, Medusipora.
6. Identification upto order from museum and significance of adult *Fasciola hepatica*, *Taeniasolium* and *Ascaris lumbricoides* (male/female)
7. Study of: sponge spicules and gemmules from slide.
8. Permanent staining and mounting of any protozoa (Euglena/ Paramecium) and Obelia colony.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Books Recommended-

1. Dalela & Sharma: Animal Taxonomy and Museology (1976, Jai Prakash Nath).
2. Kapoor: Theory and Practicals of Animal Taxonomy (1988, Oxford & IBH).
3. Simpson: Principles of Animal Taxonomy (1962, Oxford).

4. Roymahoney: Laboratory Techniques in Zoology (1966, Butterworths).
5. Mayer & Ashlock: Principles of Systematic Zoology (1991, McGraw Hill).
6. Campbell & Reece: Biology (7thed 2005, Pearson).
7. Jordan. K. and P. S. Verma, Invertebrate Zoology, S Chand and Co. Ltd.
8. Modern text book of Zoology, Invertebrates, R. L. Kotpal, Rastogi Publications.
9. Nigam: Biology of Non-Chordates (1997, S Chand)
10. Villee, Walker & Barnes: General Zoology (5thed 1979, Saunders)
11. F. C. Majumuria-Invertebrate Zoology, Vol I.
12. Parker and Haswell: Text Book of Zoology, Vol I.

ZOO-102C

ANIMAL DIVERSITY (II): NON-CHORDATA (COELOMATES) & PERSPECTIVE IN ECOLOGY

Credit 4

Total no of lectures-64

Learning Objectives:

The course would provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their evolutionary relationships, structural and functional affinities. The course will also make the students aware about the characteristic morphological and anatomical features of diverse animals; economic, ecological and medical significance of various animals in human life; and will create interest among them to explore the animal diversity in nature.

Learning Outcomes:

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

- LO1.** Learn about the importance of systematics, taxonomy and structural organization of animals.
- LO2.** Appreciate the diversity of non-chordates living in varied habitats and habitats.
- LO3.** Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- LO4.** Critically analyse the organization, complexity and characteristic features of non-chordates making them familiarize with the morphology and anatomy of representatives of various animal phyla.
- LO5.** Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.
- LO6.** Enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions, assignments and projects.

Unit 1: Introduction to Coelomates & Evolution of Coelom and Metamerism	20L
1.1. Annelida	8L
1. General characters and classification upto orders with examples in Annelida; 2. Type Study of Leech; 3. Coelomoduct and Nephridia and their relationship (according to Goodrich).	
Unit 3: Animal Diversity- Criteria for classification of multicellular organisms.	6L

Symmetry; Early development: Protostome and Deuterostome, Spiral and radial cleavage, Body cavities: Acoelomate, Pseudocoelomate, Coelomate and Enterocoelomate, Homology and Analogy.

Unit 4: Animal Diversity–I (Protista to Ctenophora)	32L
4.1. Protozoa	12L
1. General characters and classification up to orders with examples, 2. Type study: Amoeba and Paramecium, 3. Life cycle and pathogenicity of Plasmodium vivax, 4. Nutrition, Locomotion and Reproduction in Protozoa.	
4.2. Metazoa	4L
1. Evolution of metazoan; 2. metamerism of metazoan and its significance.	
4.3. Porifera	4L
1. General characters and classification upto orders with examples 2. Canal system in Porifera (Sponges)	
4.4. Cnidaria	8L
1. General characters and classification upto orders with examples, 2. Type study: Obelia; polymorphism in Siphonophora, 3. Diversity of coral and coral reefs formations, conservation.	
4.5. Ctenophora	4L
1. General characteristics 2. Difference between Cnidaria and Ctenophora, evolutionary significance.	

Practical

Credit 2

List of practical:

1. Study and preparation of prokaryotic cells
2. Study of eukaryotic cells.
3. Taxonomic arrangement of animal species from random sized supplied museum specimens.
4. Identification of permanent whole mount preparation: Amoeba, Euglena, Paramecium, Entamoeba, Opalina.
5. Study and classification of invertebrate specimen upto order (in museum): Grantia, Sycon, Spongilla, obelia, Physalia, Aurelia, Metridium, Pennatula, Gorgonia, Medripora.
6. Identification upto order from museum and significance of adult *Fasciola hepatica*, *Taeniasolium* and *Ascaris lumbricoides* (male/ female)
7. Study of: sponge spicules and gemmules from slide.
8. Permanent staining and mounting of any protozoa (Euglena/ Paramecium) and Obelia colony.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

ZOO-102C: ANIMAL DIVERSITY (II): NON-CHORDATA (COELOMATES) & PERSPECTIVE IN ECOLOGY (Credit-4)
Total no of Lectures-64

Learning Objectives:

The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature. The study of Ecology imparts the knowledge about the judicious use of existing ecological resources for sustainable development. Ecology is the only branch of science which briefs us on the ways and means of living with nature for mutual benefit. Study of ecology will provide students opportunity to understand its practical aspects and help them to solve many contemporary ecological issues such as global warming, land degradation, habitat loss, desertification and pollution etc. The hands-on experiences of laboratory will also enable students to understand the ecosystem and ecology in a better way.

Learning outcomes:

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

- LO1. Demonstrate an understanding of key concepts in ecology with emphasis on historical perspective, role of physical factors and concept of limiting factors.
- LO2. Comprehend the population characteristics, dynamics, growth models and interactions.
- LO3. Understand the community characteristics, ecosystem development and climax theories.
- LO4. Know about the types of ecosystems, food chains, food webs, energy models, and ecological efficiencies.
- LO5. Apply the basic principles of ecology in wildlife conservation and management.
- LO6. Appreciate the diversity of non-chordates living in diverse habitats.
- LO7. Understand evolutionary history and relationships of different non-chordates through functional and structural affinities.
- LO8. Critically think about the organization, complexity and characteristic features of non-chordates.
- LO9. Comprehend the economic importance of non-chordates, their interaction with the environment and role in the ecosystem.

Unit 1: Introduction to Coelomates & Evolution of coelom and metamerism (20L)
1.1: Annelida 8L

1. General characters and classification upto orders with examples in Annelida; 2. Type Study of Leech; 3. Coelomoduct and Nephridia and their relationship (according to Goodrich).

1.2: Arthropoda **8L**

1. General characters and classification upto orders with examples in Arthropoda; 2. Type Study of Prawn; 3. Life history of mosquito, and its role as vector; 4. Respiration in Arthropoda; 5. Social life of Honey bees.

1.3: Onychophora **4L**

1. General Characters and evolutionary significance of Onychophora; 2. Structure (Anatomical peculiarities) and affinities of Onychophora (Peripatus).

Unit:2 Mollusca & Echinodermata **(16L)**

2.1: Mollusca **9L**

1. General characters and classification of Mollusca upto orders with examples, 2. Nervous system and Respiration in Mollusca, 3. Torsion and Detorsion in Gastropoda, 4. Larval forms of Mollusca and evolutionary significance (trochophore larva), 5. Foot modifications in Mollusca.

2.2: Echinodermata **7L**

1. General characters and classification of Echinodermata upto orders with examples, 2. Water Vascular System in Asteroidea, 3. Larval forms of Echinodermata, 4. Affinities of Echinodermata.

Unit:3 Perspectives in Ecology **(28L)**

3.1 : Introduction to Ecology **6L**

1. History of ecology, autecology, synecology, levels of organisation, abiotic factors and impact on animals, 2. Laws of Limiting factors (Leibigs law of minimum, Shelford's law of tolerance); 3. soil types and soil erosion.

3.2: Population **10L**

1. Unique and important attributes of population. (population characteristics density, natality, mortality, life tables, Fecundity tables, survivorship curve, age and sex ratio, Dispersion, 2. Population Growth- Geometric and Exponential logistic growth equation, R & K strategies, Population regulation: density dependent and independent factors, 3. Population interaction- Gausse's principle with laboratory and field examples, Malthusian equation, Lotka-Voltere equation for competition, predator-prey cycle.

3.3: Community **6L**

1. Community characteristics, spurs diversity, Abundance, Dominance, richness, vertical stratification, Ecotone and edge effect, 2. Ecological succession; 3. Theories pertaining to climax community.

3.4: Ecosystem

6L

1. Types of ecosystem with example, Food Chain- Detritus & Grazing food chain (Linear & Y shaped), Food Web; 2. Energy flow through ecosystem, Ecological pyramids & Ecological efficiency; 3. Biogeochemical cycles (Nitrogen cycle).

Practicals

Credit 2

Unit : I

1. Study of museum specimens:
 - a. Annelids- Aphrodite, Nereis, Heteronereis, Chaetopterus, Pheretima, Hirudinaria;
 - b. Arthropods- Limulus, Balanus, Cancer, Scolopendra, Julus, Queen termite, Stick insect, Lepisma, Praying mantis, Peripatus.
 - c. Molluscs- Chiton, Unio, Octopus, Loligo, Mytilus, Dentalium, Pinctada.
 - d. Echinoderms- Asterias, Echinus, Cucumaria, Ophiura, Clypeaster.
2. Study of digestive system, septal nephridia, pharyngeal nephridia of earthworm and digestive system of leech (demonstration).
3. Study of T.S. through pharynx, gizzard and typhlosolar intestine of earthworm through permanent slides.
4. Temporary mount of mouth parts, dissection of nervous system of cockroach; urinogenital system in leech (demonstration through chart/diagram/dissection/model).
5. Study of larval forms of Mollusca (Nauplius, Trochophore), Echinoderms (Bipinnaria, Ophiopluteus, Pluteus, Echinopluteus)

Unit:II

1. Study of population density in a natural/hypothetical community by quadrat method.
2. Study of an aquatic ecosystem: Phytoplankton and zooplankton.
3. Determination of temperature, turbidity, alkalinity, pH, dissolved oxygen content (Winkler's method) and free carbon dioxide with reference to aquatic ecosystem.
4. Determination of temperature, moisture content of soil.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Books Recommended -

1. E. L. Jordan and Dr. P. S. Verma, Invertebrate Zoology, S Chand and Co. Ltd.
2. Modern text book of Zoology, Invertebrates, R. L. Kotpal, Rastogi Publications.
3. Ruppert and Barnes. D. (2006), Invertebrate Zoology, 8th edition, Hault and Saunders Publications.
4. Invertebrates, A New Synthesis, 3rd edition, Blackwell Science.

5. P. S. Verma and V.K. Agarwal, Text book of Ecology
6. Ecology-Theories and Applications 2001,4th edition, Peter Styling.
7. Odum,E.P.,2008,Fundamentals of Ecology, Indian edition, Brooks/Cole.
8. Krebs,C.J.,2001,Ecology,VI edition, Benjamin Cummings.
9. Robert Leo Smith Ecology and field biology, Harper and Row publishers.

ZOO-201C: ANIMAL DIVERSITY III: PROTOCHORDATES TO CHORDATES
(Credits-4)

Total no of lectures-64

Learning Objectives

The course is designed with an aim to provide scope and historical background of chordates. It will impart knowledge regarding basic concepts of origin of chordates and make the students understand the characteristics and classification of animals with notochord. The exclusive phenomena in chordates like biting mechanism in snakes, flight adaptations in birds etc. will be explained. The adequate explanation to the students regarding various mechanisms involved in thriving survival of the animals within their geographic realms will create interest among students.

Learning Outcomes:

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

- LO1.** Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.
- LO2.** Study about diversity in animals making students understand about their distinguishing features.
- LO3.** Appreciate similarities and differences in life functions among various groups of animals in Phylum Chordata.
- LO4.** Comprehend the circulatory, nervous and skeletal system of chordates.
- LO5.** Know about the habitat and habitat of chordates in marine, freshwater and terrestrial ecosystems.

Unit 1: Introduction to chordates (12L)

- 1. General characteristics, and outline classification of Chordata. **5L**
- 2. Origin of Chordata-Dipleurula concept and the Echinoderm theory of origin of chordates; 3. Advanced features of vertebrates over protochordates

Protochordata 7L

- 1. General characteristics and classification of sub-phylum Hemichordate, Urochordata and Cephalochordata up to Classes; 2. Salient features and affinities of Balanoglossus; 3. Retrogressive metamorphosis in urochordata (Ascidia); 4. Affinities of Amphioxus

Unit 2: Agnatha and Pisces (16L)

2.1: Agnatha:

6L

- 1. General characters and classification of cyclostomes up to order with examples; 2. Ammocoete larva and its evolutionary significance; 3. Distinction between Petromyzon and Myxine.

2.2: Pisces :10L

1. General characters and classification of Chondrichthyes and Osteichthyes up to subclass/order with examples; 2. Accessory respiratory organ, osmoregulation in fishes; 3. Migration and parental care in fishes.

Unit 3 Amphibia and Reptilia (18L)

3.1: Amphibia: 10L

1. General characters and classification up to living Orders with examples; 2. Respiration and parental care in Amphibia 3. Neoteny and paedogenesis; 3. Origin of tetrapoda (evolution of terrestrial ectotherms)

3.2: Reptilia: 8L

1. General characters and classification up to living Orders with examples; 2. Poisonous and non-poisonous snakes; 3. Poison apparatus and Biting mechanism in Snake; 4. Affinities of Sphenodon

Unit 4: Aves and Mammalia (18L)

4.1: Aves :6L

1. General characters and classification up to living orders with examples; 2. Migration in Birds; 3. Archaeopteryx - a connecting link; 4. Flight adaptation and flight mechanism.

4.2: Mammals: 12L

1. General characters and classification up to living orders with examples; 2. Affinities of Prototheria and Marsupialia; 3. Adaptive radiation w.r.t. locomotory appendages; 4. Echolocation in chiropterans.

Practical (Credits-2)

1. Dissections/ models:

a) Scoliodon – Afferent branchial system, Efferent branchial system, V, VII, IX, and X cranial nerves (demonstration through already dissected specimen).

b) Weberian ossicle of Mystus/Rohu/Catla.

c) Mice: Arterial & Reproductive system (demonstration).

2. Temporary mounting: Placoid, Cycloid, Ctenoid scales, Squamous and Ciliated Epithelium, Striated and non-striated muscles.

3. Study of Museum specimens: Identification and classification up to order. (Generic name should be given)

Balanoglossus, Herdmania, Amphioxus, Petromyzon, Myxine, Pristis, Torpedo, Hippocampus, Monopterus, Notopterus, Rohu, Cyprinus, Hypophthalmichthys, Ctenopharyngodon, Clarius, Mystus, Necturus, Axoltol larva, Salamander, Hyla, Alytes, Chelone, Draco, Chameleon, Naja, Hydrophis, Viper, Krait, House sparrow, Owl, Hedgehog, Manis, Bat, Monkey.

****Lab note book, with drawing and labelling; methods where applicable.**

Recommended books:

1. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
2. Pough H. Vertebrate life, VIII Edition, Pearson International.
3. Parker, T. J. & Haswell, W. (1972). Text Book of Zoology , Volume II: Marshall and Willam (Eds.) 7th Ed. Macmillan Press, London.
4. Kardong, K. V. (2002). Vertebrates: Comparative anatomy, function evolution. Tata McGraw Hill. McGraw Hill.
5. Romer, A. S. & Parsons, T. S. (1986). The vertebrate body. 6th Ed. Saunders College Publishing.
6. Jordan, E.L. & Verma, P.S. (2003). Chordate Zoology. S. Chand & Company Ltd. New Delhi.
7. Sinha, K. S., Adhikari, S., Ganguly, B. B. & Bharati Goswami, B. D. (2001). Biology of Animals. Vol. II. New Central Book Agency (p) Ltd.
8. Futuyama, D. (1997). Evolutionary Biology. 3rd Ed. Sinauer Associates, INC. Note: Classifications for Protochordata, Agnatha, Reptilia, Aves and Mammalia to be followed from
9. Young (1981), for Pisces to be followed from Romer (1959), for Amphibia to be followed from Duellman and Trueb (1986).

Learning Objectives:

The objective of the course is to help the students to learn and develop an understanding of a cell as a basic unit of life. This course is designed to enable them to understand the functions of cellular organelles and how a cell carries out and regulates cellular functions.

Learning Outcomes:

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

LO1. Understand fundamental principles of cell biology.

LO2. Explain structure and functions of cell organelles involved in diverse cellular processes.

LO3. Appreciate how cells grow, divide, survive, die and regulate these important processes.

LO4. Comprehend the process of cell signalling and its role in cellular functions.

LO5.

Have an insight of how defects in functioning of cell organelles and regulation of cellular processes can develop into diseases.

LO6. Learn the advances made in the field of cell biology and their applications.

Unit 1:**(16L)****1.1: Overview of Cells****6L**

1. Introduction to Cell Theory
2. Basic structure of Prokaryotic and Eukaryotic cells and their comparison, viruses
3. Elementary idea of microscopy and cell fraction.

1.2: Organization of cell-I:**10L**

1. Ultra structure and composition of Plasma membrane: Various models; 2. Function of plasma membrane: permeability, osmosis, transport across membrane (active and passive), facilitated transport; 3. Elementary knowledge of cell communication and cell junctions.

Unit 2: Organization of the cell-II**(22L)****2.1: Cytoplasmic organelles I:****10L**

1. Structure and Functions: Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Ribosomes;
2. Protein sorting and mechanisms of vesicular transport

2.2: Cytoplasmic organelles II:**6L**

1. Mitochondria: Structure and function; 2. Mitochondrial Respiratory Chain and electron transport, Chemi-osmotic hypothesis; biogenesis of mitochondria; 3. Peroxisome: structure and function.

2.3: Nuclear organization **6L**

1. Structure of nucleus (nuclear envelope, nuclear pore complex, nucleolus) and function, biogenesis of ribosome, 2. Interface chromatin and its compaction into metaphase chromosome, euchromatin and heterochromatin.

Unit 3: Cytoskeleton and cell reproduction **(14L)**

3.1: Cytoskeleton **5L**

1. Types of cytoskeleton and their role in cell movement; 2. Structure and function of microtubules, microfilament and intermediate filament.

3.2: Cell Reproduction **9L**

1. Basic features of cell cycle, regulation of cell cycle progression; 2. Events of mitosis, mitotic spindle and chromosome movement; 3. Events and phases of meiosis and its significance.

Unit 4: Multiplicative cell division and cell signaling **12L**

1. Elementary knowledge of cancer: its development, types and causes; 2. Concept of tumor viruses, oncogenes and tumor suppressor genes with special reference to p53. 3. Cell signalling transduction pathways; Types of signaling molecules and receptors; 4. GPCR and Role of second messenger (cAMP); 5. Apoptosis and Necrosis/cell death and cell renewal: programmed cell death and necrosis.

Practical– Cell Biology Lab: **(Credits 2)**

1. Familiarization with the student's light microscope and stereobinocular microscope.
2. Diversity of eukaryotic cells – methylene blue staining of buccal epithelium, striated muscle cells; Leishman staining of mammalian blood cells
3. Permeability of plasma membrane – effect of isotonic, hypotonic and hypertonic solutions on mammalian RBC.
4. Staining of nucleus and nucleolus from any given sample.
5. Staining of mitochondria from buccal epithelium.
6. Staining of Golgi complex.
7. Study various stages of mitosis from the temporary squash preparation of onion root tip/tadpole tail.
8. Study of meiosis from the temporary squash preparation in grasshopper/grylotalpa testes.
9. Demonstration of preparation of polytene chromosomes from salivary glands of Chironomous larva.

****Lab note book, with drawing and labelling; methods where applicable.**

Reference Books-

1. Lewin's Cells – 3rd Edition – Cassimeris/Lingappa/Plopper – Johns & Bartlett Publishers (2013).
2. Biology of Cancer by Robert. A. Weinberg. 2nd edition., Garland Science (2013).

3. The Cell: A Molecular Approach. V Edition. Cooper, G.M. and Hausman, R.E. (2009),ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York, Bruce Albert, Bray Dennis, Lewis Julian, Raff Martin, Roberts Keith and Watson James (2008).
5. Karp G. 2010, Cell and Molecular Biology, John Wiley Publication, 6thEdn. John Wiley and Sons.
6. De Robertis, E.D.P. and De Robertis, E.M.F. (2006) Cell and Molecular Biology 8thEdn. Lippincott and Williams and Wilkins, Philadelphia.
7. Lodish et al. 2008: Molecular Cell Biology (Freeman)
8. Becker W.M. et al. 2009: The World of the Cell, 7thEdn. Pearson Benjamin Cummings Publishing, San Francisco.

ZOO-301C: COMPARATIVE ANATOMY OF VERTREBRATES AND HISTOLOGY (Credit 4)

Total no of lectures:64L

Learning Objectives:

This course aims to provide the undergraduate students a thorough knowledge of structural details and comparative account of the different organ systems of the body from lower to higher vertebrates, and protochordates, thus enabling them to appreciate the incredible vertebrate diversity. The course furnishes an understanding of evolutionary basis of morphological and anatomical differences as well as similarities that occur among vertebrates. It helps students propose possible homology between structures, and understand how they evolved as the vertebrates dwelled different habitats. The structural modifications of digestive, circulatory, respiratory and skeletal system relates to the distribution of animals in their different comfort zones of habitat and ecological niches. The understanding of anatomical details of organ systems of mammals like rat and mice aims to give the basic information for their use in experimental and research studies in different branches of Zoology like Immunology, Medical Zoology and Reproductive Biology etc.

Learning Outcomes:

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

LO1. Explain comparative account of the different vertebrate systems

LO2. Understand the pattern of vertebrate evolution, organisation and functions of various systems.

LO3. Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.

LO4. Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates; and digestive system and its anatomical specializations with respect to different diets and feeding habits.

LO5. Learn the evolution of brain, sense organs and excretory organs to a complex, highly evolved form in mammals;

LO6. Learn to analyze and critically evaluate the structure and functions of vertebrate systems, which helps them to discern the developmental, functional and evolutionary history of vertebrate species.

LO7. Understand the importance of comparative vertebrate anatomy to discriminate human biology.

A. Comparative Anatomy

Unit 1: Comparative Account of Integumentary to Respiratory system (14L)

1.1: Integumentary system: 3L

1. Comparative structure, 2. function and derivatives of integument in amphibian, 3. birds and mammals.

1.2: Skeletal system: 4L

1. Jaw suspension; structure of branchial and visceral arches; 2. Comparative account of the axial and appendicular skeleton.

1.3: Digestive System	3L
1. Comparative account of feeding mechanism; 2. Alimentary canal and associated glands; 3. Comparison of dentition in vertebrates	
1.4: Respiratory system	4L
1. Comparative account of respiration through buccopharynx, skin, gills, lungs; 2. Accessory respiratory organs	
Unit 2: Circulatory system to sense organs in vertebrates	(15L)
2.1: Circulatory system	4L
1. General plan of circulation in vertebrates; 2. Comparative account of heart and aortic arches in vertebrates	
2.2: Nervous system	6L
1. Comparative account of brain; 2. Cranial nerves in vertebrates; 3. Cranial nerves in mammals	
2.3: Urigenital system	6L
1. Succession of kidney in vertebrates 2. Evolution of urinogenital ducts 3. Types of mammalian uteri	
2.4: Sense organs	5L
1. Types of receptors in vertebrates; 2. Brief account of visual and auditory receptors in vertebrates	
B. Histology	(35L)
Unit 1: Differentiation and tissues	(9L)
1.1: Differentiation:	3L
1. Types of differentiation; 2. Mechanism of cellular differentiation and organization of tissue	
1.2: Animal tissue:	6L
1. Types, structure and their functions; 2. Epithelial; 3. Muscular; 4. Connective; 5. Nervous tissues	
Unit 2: Histological structure of organs	12L
Histology of 1. GI tract, 2. Liver, 3. pancreas, 4. spleen, 5. lung, 6. kidney of mammal.	
Unit 3: Fixation and staining of tissues	5L
1: Basic principles of fixation and staining, classification, composition and properties of dye, use of mordants and metachromatic dyes; 2: Microtomy technique	

Practical :**(Credit-2)**

1. Study of disarticulated skeleton of Toad, Pigeon and Guineapig.
3. Comparative study of skull in vertebrates.
4. Circulatory system, brain, pituitary, urinogenital system in *Channa punctatus* (Demonstration).
5. Study of histological slide: T.S. of skin, stomach, intestine, liver, pancreas, kidney testis, ovary of mammals through permanent slides.
6. Study of blood cells in vertebrates.
7. Preparation of permanent slides of any five mammalian tissues- Microtomy technique.

****Lab note book, with drawing and labelling; methods where applicable.****Reference Books:**

1. Chordate Zoology, E.L. Jordan and P.S. Verma, S. Chand Publication
2. Kardong K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
3. Kent, G.C. and Carr R. K. (2000). Comparative Anatomy of Vertebrates. IX Edition, The McGraw-Hill Companies
4. Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons
5. Walter, H.E. and Sayles, L.P. Biology of Vertebrates, Khosla Publishing House

ZOO-302C: PHYSIOLOGY AND ENDOCRINOLOGY**(Credits 4)****Total no of lectures-64****Learning Objectives:**

Physiology is the study of life, specifically, how cells, tissues and organ function. It is a core and fundamental scientific discipline that defines the health and well-being of living organisms. Besides satisfying a natural curiosity about how our body systems function, it gives us knowledge about the functions of all the parts and systems of the body. It is also of central importance in medicine and health sciences. The course has been designed to apply the theoretical concept to the laboratory exercises for acquiring skills. The fundamental or coherent understanding of the subject will be extended to related disciplinary areas/subjects through understanding of normal body functions, enabling effective treatment of abnormal or diseased states. The students will be equipped with skill-based knowledge to help them undertake further studies in physiology and related areas as well as in multidisciplinary subjects.

Learning Outcomes:

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

- LO1.** Have a clear knowledge of basic fundamentals and understanding of advanced concepts so as to develop a strong foundation that will help them to acquire skills and knowledge to pursue advanced degree courses.
 - LO2.** Comprehend and analyse problem-based questions on physiological aspects.
 - LO3.** Recognize and explain how all physiological systems work in unison to maintain homeostasis in the body; and use of feedback loops to control the same.
 - LO4.** Learn an integrative approach to understand the interactions of various organ systems resulting in the complex overall functioning of the body.
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A. Physiology (39L)

Unit 1: Life sustaining systems (25L)

1.1 Physiology of digestion: 4L

1. Structural organisation and functions of Gastrointestinal tract; 2. Mechanical and chemical digestion of food; 3. Absorptions of carbohydrates, lipids, proteins, water, minerals, vitamins.

1.2 Physiology of Respiration: 6L

1. Mechanism of Respiration; 2. transport of Oxygen and Carbon dioxide in blood; 3. Dissociation curves and the factors influencing it; 4. respiratory pigments; 5. Carbon monoxide poisoning.

1.3 Physiology of Circulation: 6L

1. Components of Blood and their functions; Structure and functions of haemoglobin; 2. Haemostasis: coagulation of blood; 3. Haemopoiesis: mechanism and regulation; 4. Blood groups; ABO and Rh factor.

1.4 Physiology of heart: 4L

1. Structure of mammalian heart; 2. Coronary Circulation, Origin and conduction of cardiac impulses; 3. Cardiac Cycle and cardiac output; 4. Blood pressure and its regulation; 5. Autonomic control and chemical regulation of heart rate

1.5 Thermoregulation & Osmoregulation: **5L**
1. Physiological classification based on thermal biology; 2. Thermal biology of endotherms; 3. Osmoregulation in aquatic vertebrates; 4. Extra renal osmoregulatory organs in vertebrates.

Unit 2: Control and coordinating systems **(14L)**

2.1: Nervous System **8L**
1. Structure of neuron, resting membrane potential; 2. Propagation of nerve impulse; 3. Types of synapse, Synaptic transmission and Neuromuscular junction; 4. Reflex action and its types.

2.2: Muscular system **3L**
1. Ultra structure of muscles; 2. Molecular and chemical basis of muscle contraction.

2.3 Renal Physiology :3L
1. Renal blood supply; 2. Mechanism of urine formation; 3. Regulation of acid-base balance.

B. Endocrinology **(25L)**

Unit 1: Introduction to Endocrinology **5L**
1. brief account of structural features & function of endocrine glands; 2. Classification, Characteristic and Transport of Hormones.

Unit 2: Epiphysis, Hypothalamo-hypophysial Axis & peripheral endocrine glands **(12L)**

2.1. Epiphysis, Hypothalamo-hypophysial Axis: **7L**
1. Structure of pineal gland, Secretions & their functions in biological rhythms & reproduction; 2. Regulation of neuroendocrine glands, Feedback mechanisms; 3. Structure of pituitary gland, its hormones and functions, Hypothalamo-hypophysial portal system.

2.2 Structure and function of peripheral endocrine glands: **5L**
1. Thyroid; 2. Parathyroid; 3. Adrenal; 4. Endocrine pancreas; 5. Testis; 6. Ovary

Unit 3: Regulation of Hormone Action & Hormonal dysfunctions **(8L)**

3.1 Regulation of Hormone Action **6L**
1. Bioassays of hormones using RIA & ELISA; 2. Estrous cycle in rat and menstrual cycle in human; 3. Multifaceted role of Vasopressin & Oxytocin; 4. Effects of abnormal secretions of hormones

3.2 Hormonal dysfunctions and diseases **2L**
1. Dwarfism and acromegaly; 2. Goiter; 3. Addison's disease; 4. Diabetes mellitus.

Practical **(Credit-2)**

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood (total count) cells using haemocytometer
3. Estimation of haemoglobin using Sahli's haemoglobinometer
4. Preparation of haemin and haemochromogen crystals from mammal/fish blood.
5. Recording of blood pressure using a sphygmomanometer

6. Determination of pulse rate at rest and after exercise.
7. Differential count of WBC
8. To demonstrate the activity of salivary amylase and effect of acid & heat(temp) on its activity.
11. Study of permanent slides of different endocrine glands invertebrates (pituitary, thyroid, testis, ovary)

****Lab note book, with drawing and labelling; methods where applicable.**

Recommended books:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Harcourt Asia PTE Ltd. W.B. Saunders Company.
2. Eckert Animal Physiology: Mechanisms and adaptations Randall, Berggren and French.
3. Vander A, Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.
4. Balinsky: An Introduction to Embryology.
5. Turner and Bagnara: General Endocrinology, 6th ed. 1984, Saunder.
6. Vertebrate Endocrinology by David O. Norris.
7. Hadley: Endocrinology (5th ed., 2000, Prentice Hall)

ZOO-303C: GENETICS (CLASSICAL & APPLIED GENETICS) (Credit 4)

Total no. of Lectures-64

Learning Objectives:

Unknown to them, human beings had been applying the principles of genetics by engaging in selective breeding of domesticated animals for many centuries. However, it was only with the work of Mendel and advent of 20th century, that basic principles of the science of genetics were formulated. In about a century of its existence, this field has generated tremendous amount of knowledge through observational and experimental research. The information amassed in the last century has laid the foundation for more discoveries in this important field of life science. This course aims to provide an overview of genetics starting from the work of Mendel to the current understanding of various phenomena like recombination, transposition, sex determination and mutations. The course will help in building sound fundamental knowledge of the principles of genetics, to be used as a stepping stone for higher studies and research in this field.

Learning Outcomes:

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

- LO1. Have a deeper understanding of the varied branches of the biological sciences like microbiology, evolutionary biology, genomics and metagenomics.
 - LO2. Gain knowledge of the basic principles of inheritance.
 - LO3. Analyze pedigree leading to development of analytical skills and critical thinking enabling the student to present the conclusion of their findings in a scientific manner.
 - LO4. Know the mechanisms of mutations, the causative agents and the harmful impact of various chemicals and drugs being used in day-to-day life.
 - LO5. Find out the effects of indiscriminate use of various chemicals, drugs or insecticides in nature by studying their effect on various bacterial species in soil and water samples from different industrial or polluted areas.
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Unit 1: Mendelism

16L

Genetics and its Extension -

1. Mendel and his experiments; 2. Principles of segregation and independent assortment and their chromosomal basis; 3. Test cross; 4. Application of laws of probability to Mendelian inheritance; 5. Principles of inheritance, Incomplete dominance and co-dominance, Epistasis, Multiple alleles, Lethal alleles, Pleiotropy; 6. Sex-linked, sex-influenced and sex-limited inheritance, Polygenic Inheritance.

Unit 2: Linkage, Crossing Over, Chromosomal Mapping and mutations

16L

1. Linkage and Crossing Over, molecular basis of crossing over, Cytological aspects of crossing over in *Drosophila*; 2. Measuring Recombination frequency and linkage intensity using three factor crosses, Interference and coincidence. 3. Types of gene mutations; 4. Types of chromosomal aberrations, Non-disjunction and variation in chromosome number; 5. Molecular basis of mutations in relation to UV light and chemical mutagens.

Unit 3: Sex Determination and Human Genetics

16L 1. Mechanisms of sex determination in *Drosophila*; 2. Sex determination in mammals;

3. Dosage compensation in *Drosophila* & Human; 3. Karyotype, banding, nomenclature of chromosome subdivisions and genetic map; 4. Genetic disorders, Chromosomal aneuploidy (Down, Turner and Klinefelter syndromes); 5. Chromosome translocation (chronic myeloid leukemia) and deletion ("cry of cat" syndrome); 6. Gene mutation (cystic fibrosis); 7. Genetic counselling.

Unit 4: Applications of genetic engineering and applied Genetics

16L

1. Molecular diagnosis of genetic disorders and gene therapy; 2. Crop and livestock improvement; 3. Extra-chromosomal Inheritance- Criteria for extra chromosomal inheritance, Kappa particle in *Paramecium*; 4. Recombination in Bacteria and Viruses Conjugation, Transformation, Transduction, Complementation test in Bacteriophage; 5. Transposable Genetic Elements Transposons in bacteria, P elements in *Drosophila*.

Practical

Credit 2

1. Pedigree analysis of some human inherited traits.
2. Human blood grouping, Genotypic frequency of Human ABO blood group.
3. Analysis of Hardy-Weinberg's equilibrium by citing any example.
4. Preparation and Mounting of sex chromatin (bar bodies) from the buccal epithelium.
5. Study of human karyotypes and numerical alterations (Down syndrome, Klinefelter syndrome and Turner syndrome) through charts.
6. Study of mutant varieties of *Drosophila*.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be maintained.**

Books Recommended –

1. Brooker: Genetics : Analysis and Principles (1999, Addison-Wesley,)
2. Gardner et al: Principles of Genetics (1991, John Wiley)
3. Griffith et al: An Introduction to Genetic Analysis (2005, Freeman)
4. Hartl & Jones: Essential Genetics: A Genomic Perspective (2002, Jones & Bartlett)
5. Russell: Genetics (2002, Benjamin Cummings)
6. Snustad & Simmons: Principles of Genetics (2006, John Wiley)
7. Lewin: Genes IX (2008, Jones & Bartlett).
8. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings.
9. Bhamrah, H.S., Text Book of Genetics, Amazon Co.

ZOO-401C: FUNDAMENTALS OF BIOCHEMISTRY

(Credit-4)

Total no. of lectures –64

Learning Objectives:

The program is designed to enable a student acquire sound knowledge of biochemistry and its practicable applicability. Effort has been made to make the study relevant, interesting and encouraging to the students to join the industry or to prepare them for higher studies including research. The new and updated syllabus is based on a basic and applied approach to ensure that students develop problem solving skills, laboratory skills, chemistry communication skills, team skills as well as ethics.

Learning Outcomes

Upon completion of the course, students will be able to

LO1. Gain knowledge and skill in the interactions and interdependence of physiological and biomolecules

LO2. Understand essential of the metabolic pathways along with their regulation.

LO3. Know the principles, instrumentation and application of bioanalytical techniques.

LO4. Get exposure to various processes used in industries.

LO5. Become aware about classical laboratory techniques, use modern instrumentation, design and conduct scientific experiments and analyze the resulting data.

LO6. Be knowledgeable in proper procedures and regulations in handling and disposal of chemicals

UNIT 1-Introduction to Biochemistry (8L)

1.1. Chemistry of living system: 4L

1. Chemistry of living system-Scope and importance; 2. Chemical bonds and energy; 3. Properties of water as biological solvent.

1.2. Biomolecules- 4L

1. Definition of biomolecules and its Configuration, Conformation, Organization of biomolecules.

UNIT 2-Carbohydrates and proteins: their metabolism (18L)

2.1. Carbohydrate metabolism 9L

1. Structure, functional and classification of carbohydrates; 2. carbohydrate metabolism: gluconeogenesis, citric acid cycle, fermentation, pentose phosphate pathway, shuttle systems (malate aspartate shuttle, glycerol -3- phosphate shuttle, and Cori cycle); 3. Glycogen metabolism (glycolysis, glycogenolysis, glycogenesis)

2.2. Protein metabolism 9L

1. General properties of amino acids; essential and non-essential amino acids; 2. Classification and general properties of proteins; 3. Structural organization and functional significance of proteins; 4. Protein metabolism (catabolism of amino acids: transamination, deamination and ornithine cycle, fate of glucogenic and ketogenic-amino acids with examples of serine and leucine)

UNIT3–Lipids and metabolism, intermediary metabolism and oxidative phosphorylation (18L)

3.1. Lipid metabolism 8L

1. Classification, properties and functional significance of lipids; 2. Functional significance of fatty acids, triglycerides and steroids; 3. Types and properties of lipoproteins; 4. Formation of lipid bi-layer; 5. Lipid metabolism (β -oxidation of saturated fatty acids, Ketogenesis),

3.2. Intermediary pathway 4L

Interconversion pathway and inter relationship between carbohydrates, proteins and fats metabolism.

3.3. Oxidative phosphorylation 6L

1. Oxidative phosphorylation in mitochondria; 2. ATP synthesis and Respiratory complexes; 3. Inhibitors and uncouplers.

UNIT 4 –Enzymes and the laws of thermodynamics and Nucleic Acids (20L)

4.1. Enzymes 9L

1. Introduction, properties and classification of major types of enzymes; 2. Factors of enzyme activity, Biological significance of enzymes; 3. Mechanism of enzyme action, enzyme kinetics (Michaelis–Menten hypothesis) and Inhibition; 4. Allosterism.

4.2. Thermodynamics 3L

Laws of Thermodynamics and its biological application

4.3. Nucleic Acids and protein synthesis 8L

1. Types of Nucleic Acid (DNA and RNA) and their function and differences; 2. Structure of DNA (Watson and Crick Model of DNA); 3. Different types of RNA and its functional significance; 4. Protein synthesis: transcription and translation.

Practical (Credit -2)

1. Qualitative detection of carbohydrates (Benedict test for reducing sugars and Iodine test for starch), lipids and proteins.
2. Study of enzymatic activity of trypsin/ pepsin, lipase and their inactivation by heat.
3. Detection of ninhydrin test for amino acids through paper chromatography.
4. Quantitative estimation of protein by Lowry's method.
5. Quantitative estimation of lipid.
6. Estimation of Alkaline Phosphatase and LDH from serum/tissue.
7. Preparation of models of nitrogenous bases, nucleosides, nucleotides, amino acids, dipeptides.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended books–

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H Freeman and Co.
3. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry, XXVIII Edition. Lange Medical Books/McGraw-Hill.
4. Concept of biochemistry, L.M. Srivastava, third edition
5. Lehninger Principles of Biochemistry, Indian edition, English, Hardcover, David L. Nelson, Michael Cox).

**ZOO-402C: BIOINSTRUMENTATION, INFORMATIONAL BIOLOGY,
BIOINFORMATICS AND BIostatISTICS**

(Credit 4)

Total no. of lectures-64

Learning Objectives:

This course offers an overview of fundamental concepts of Bioinformatics and Biostatistics. An interdisciplinary program, it emphasizes integration of Computer Science with Biology and introduces the student to various computational methods and software tools for understanding biological databases, gene sequence alignments, gene annotation, protein structure predictions, drug discovery, molecular phylogeny, metagenomics, etc. The broad aim of this course is to make students get basic hands-on training and develop skill-sets required for computational analysis of biological data. Recently many interest groups, such as governments, universities, research institutes and industries find Bioinformatics as a crucial area of research and development due to generation of large-scale genome sequencing data. In view of above, this course is designed to motivate the undergraduate students to pursue postgraduate program in Bioinformatics and Biostatistics.

Learning Outcomes:

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

- LO1. Explain the basic concepts of Bioinformatics and Biostatistics and its various applications in different fields of biological sciences
 - LO2. Describe theoretical sources of biological data, and list various biological databases – nucleic acids, protein sequence, metabolic pathways and small molecule
 - LO3. Identify various file formats of sequenced data and tools for submission of data in database as well as retrieval of gene and protein data from databases
 - LO4. Annotate gene sequence and protein structure prediction
 - LO5. Perform and explain the underlying mechanisms of pairwise and multiple sequence alignments and determine phylogenetic relationships
 - LO6. Describe various computational tools and methodologies and their application in structural bioinformatics, functional genomics and *in silico* drug discovery
 - LO7. Measure variability (standard deviation, standard error, coefficient of variance) and hypothesis testing (Z-test, t-Test, chi-square test)
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Unit 1: Bioinstrumentation: Biological techniques.

(20L)

1.1 Analytical technique:

Principle and application of Analytical instrument- pH meter, colorimeter and spectrometer, Centrifuge and Ultracentrifuge.

1.2 Microscopical technique:

1. Working principle of Light microscope, Electron microscope, Phase contrast and Fluorescence microscope.

1.3 Separation technique:

Chromatographic separation and their types with application, Principle and application of electrophoresis

1.4 Preservation technique:

Preparation and application of cryopreservation, Cryobank

Unit 2: Informational Biology/ Bioinformatics

25L

1.1 Introduction to Bioinformatics

Definition, aim and branches, scope and application of bioinformatics

1.2 Database in bioinformatics

1 Types of biological database, Data formatting and its types; 2. Biological database retrieval system (SRS, Entrez), 3. National Centre for Biotechnological Information (NCBI), Tools and databases NCBI, 4. Database Retrieval tool, sequence submission tool, nucleotide, protein and Gene expression database; 5. Nucleotide database EMBL, DDBJ, Protein information Resource (PIR) and Swissprot.

Unit 3 : Computer in biology

7L

1. Application of computer in biology; 2. Data processing in computer; 3. Basic knowledge of computer language: Basic, C++/COBALT, Citran, etc.

Unit 4 : Statistics in biology

12L

1. Application of statistics in biology; 2. Measures of central tendency: Mean, Median, Mode and their uses; 3. Standard Deviation in data analysis and Standard error and their calculation; 4. Regression and Correlation; Application of computer programs and softwares, their uses in biological data analysis.

Practical

(Credit 2)

1. Preparation of buffer and determination of pH.
2. Centrifuge
3. Demonstration of functioning spectrophotometer and colorimeter
4. Identification of amino acid in mixture using ninhydrin through paper chromatography
5. Familiarity with tissue culture lab (Lab visit).
6. Assessing of different information biological database, nucleic acid and protein databases
7. Retrieval of Nucleotide and protein sequence from databases
8. Performance of pairwise (Blast) and multiple sequence alignment
9. Construction of phylogenetic tree and interpretation
10. To perform standard deviation and two sample t-test for a set data collected from vicinity of garden of any organism.
11. To learn graphical representation in given statistical data with help of computer (MS-EXCEL)

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

1. Biostatistics in Brief Made Easy: K Visweswar.
2. Categorical Data Analysis by Alan Agresti.

3. Campbell, A. M. and Heyer L P., Discovering genomics, proteomics and Bioinformatics, II Edition, Benjamin Cummings.
4. Ghosh, Z., and Bibekananda M, Bio informatics: Principles and Applications, Oxford University Press.
5. Pevsner, S. Bio-informatics and Functional genomics, Wiley-Black well.
6. Statistics by Murray R Spiegel, Larry J Stephens.

ZOO-403C: EVOLUTIONARY & ADAPTIVE BIOLOGY

(Credit -4)

Total no of lectures-64

Learning Objectives:

The study of evolutionary biology is essential for anyone who seeks to obtain an understanding of life and natural world. It is a unifying thread which joins all organisms from prokaryotes to highest of eukaryotes. This course emphasizes on the development of evolutionary thought by dealing in general with the process and pattern of biological evolution. On one hand, it offers a chance to students to learn about deciphering evidences ranging from fossil records to molecular data and arranges them to establish phylogenetic relationships of species, while, on the other, it provides a platform to understand various forces which bring about variations among populations of species and cause them to diversify into new species.

Learning Outcomes:

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

- LO1. Acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.
 - LO2. Apply knowledge gained, on populations in real time, while studying speciation, behavioural susceptibility to diseases.
 - LO3. Gain knowledge about the relationship of the evolution of various species and the environment they live in.
 - LO4. Get motivated to work towards mitigating climate changes so that well adapted species do not face extinction as a result of sudden drastic changes in environment.
 - LO5. Use knowledge gained from study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
 - LO6. Predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
 - LO7. Use various software to generate interest towards the field of bioinformatics and coding used in programming language
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Unit I: Evolution

23L

1. Organic evolution-Meaning, Morphological and anatomical, Embryological: Paleontological, biochemical and molecular evidences of organic evolution; 2. Theories of Evolution-Lamarckism, Neo-Lamarckism, Darwinism, DeVries mutation theory, Present or modern concept of evolution; 3. Evolution of Horse; 4. Evolution of Man.

Unit II: Zoogeography

17L

1. Definition, Biogeographical realms-Discontinuous, Restricted distribution, factors influencing animal distribution; 2. Genetic Drift, Species concept, Speciation, Genetic and Geographical, Reproductive Isolating mechanisms, Natural selection in action (industrial melanism, antibiotic and DDT resistance);

Unit III: Fossils

9L

1. Fossils: definition, fossilization and significance, dating of fossils; 2. Geological Time Scale;
3. Extinction and mass extinction- Causes, impact.

Unit IV: Adaptive Biology

15L

1. Adaptation-Definition, Significance, Principles of adaptation, Types of adaptation – Aquatic, terrestrial and Volant adaptation; 2. Strategies of Adaptation in Animals-Migration, Camouflage (Cryptic Appearance), Mimicry, Warning colouration, Hibernation and Aestivation, Adaptation to water scarcity and cold, Bioluminescence; 3. Adaptive radiation in mammals.

Practical

(Credit-2)

List of practical-

1. Demonstration of geological scale through chart.
2. Study of homologous and analogous organs through suitable museum specimen (wings of birds & insect, forelimbs of bat & rabbit)
3. Study of lung fishes (Dipnoi- from museum) and their evolutionary significance.
4. Study of animals (from museum specimens) as an evolutionary connecting link and its significance (Peripatus, Neoplinea, Protopterus, Balanoglossus, Archeopteryx, Duck billed Platypus).
5. Study of Embryological evidences of evolution (through charts and models) (mammalian embryos).
6. Graphical representation and interpretation of data of height/ weight from human samples in relation to their age and sex.
9. Study of adaptive modification in feet and mouth parts of birds and mouth parts of insects (from slides).
10. Construction of phylogenetic trees and its interpretation (silico study through anyone software- clustalX/W, PhylipNI).

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books -

1. Rastogi: Organic Evolution (1988, Kedarnath & Ramnath)
2. Campbell, N.A. and Reece J.B (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
3. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
4. iGeneics: A Molecular Approach. 3rd edition. Peter.J. Russell.
5. Ridley. M, Evolution, Blackwell Publishing.
6. Barton, N. H., et.al. Evolution Cold Spring Harbon Laboratory Press.
7. Hal, B. K. et al. Evolution Jones and Barlett Publishers.
8. Lemurs, Ecology and adaptation, (Development in Primatology: Progress and Prospects) Edited by L Gould M L Seuther.
9. Parker G., Adaptation and Ecology.
10. Rose E., Animal adaptation for survival; The Rosen Publishing Group.
11. Moody: Introduction to Evolution (1978, Kalyani).

Z00-501C: MOLECULAR BIOLOGY, MICROBIOLOGY AND BIOTECHNOLOGY

(Credit - 4)

Total no of lectures-64

Learning Objectives:

The course aims to provide students with an introduction of the underlying molecular mechanisms of various biological processes in cells and organisms. The study primarily involves learning about structure and synthesis of deoxyribo- and ribo-nucleic acids, formation of proteins, and regulation of gene expression. The course aims to develop basic understanding of structure-function relationships of nucleic acids and proteins. Biotechnology is the advanced branch of biological sciences which mostly deals with technological application on biological systems. It is basically the management of biological processes for industrial and other human welfare purposes. The present paper on biotechnology attempts to give a wholesome idea of biotechnology at a basic level. It provides a toolkit in the form of a number of various techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine.

Learning Outcomes:

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

- LO1. Describe the basic structure and chemistry of nucleic acids, DNA and RNA;
 - LO2. Compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes.
 - LO3. Elucidate the molecular machinery and mechanism of information transfer processes—transcription and translation—in prokaryotes and eukaryotes;
 - LO4. Explain post-transcriptional modification mechanisms for the processing of eukaryotic RNAs;
 - LO5. Discuss general principles of transcription regulation in prokaryotes by exploring the structure and function of lactose and tryptophan metabolism operons;
 - LO6. Give an overview of gene expression regulation in eukaryotes;
 - LO7. Explain the significance of DNA repair mechanisms in controlling DNA damage;
 - LO8. Use or demonstrate the basic techniques of biotechnology like DNA isolation, PCR, transformation, restriction digestion etc.
 - LO9. Make a strategy to manipulate genetic structure of an organism for the improvement in any trait or its well-being based on the techniques learned during this course.
 - LO10. Understand better the ethical and social issues regarding GMOs.
 - LO11. Use the knowledge for designing a project for research and execute it.
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Unit 1. Molecular Biology

18L

1. Salient features of DNA and RNA; 2. DNA as a genetic material; 3. Mechanism of DNA replication in Prokaryotes, semi conservation, bidirectional and discontinuous replication; 4. Replication of telomers. 5. RNA polymerase and transcription unit; 6. Mechanism of transcription in prokaryotes and Eukaryotes, synthesis of rRNA and mRNA, transcription factors;

7. Genetic code and Protein synthesis in prokaryotes; 8. Ribosomes structure and assembly in prokaryotes; 9. Proteins involved in initiation, elongation and termination of polypeptide chain; 10. Inhibitors of protein synthesis;

Unit II. Post Transcriptional Modification, Gene regulation and DNA repair **15L**

1. Structure of globin mRNA, Split genes, concept of introns and exons, Splicing Mechanism, RNA editing; 2. Transcription regulation in prokaryotes, Principles of transcription regulation from lac operon, trp operon, Gene silencing, Genetic imprinting; 3. Types of DNA repair mechanism, Pyrimidine dimerization and mismatch repair, nucleotide and base excision repair, SOS repair.

Unit III. Microbiology **15L**

1. Types of microbes and their protective role; 2. Gram –positive and Gram –negative bacteria; 3. General morphology and characters of protista and economic importance; 4. Viruses- Structure, Genome, epidemiology of infectious disease with reference to human host. Bacterial (Tuberculosis), Viral (Hepatitis), Protozoan (Amoebiasis) disease; 5. Microbe interactions and immune responses, Antibiotics and their chemotherapeutic agents.

Unit IV. Biotechnology **16L**

1. Concept and scope of biotechnology, animal cell culture, essential factors and applications; 2. PCR, Western and southern blot, northern blot, Sanger DNA sequencing; 3. Cloning vectors: plasmids, cosmids, lambda bacteriophage; 4. Restriction enzymes: types and functions; 5. Production of cloned and transgenic animals, Nuclear transplantation, Retroviral method, application of transgenic animals; 6. Application of recombinant DNA in medicine, Recombinant insulin and human growth hormone, Gene therapy.

Practical: Z00-501C **(Credit-2)**

Molecular Biology-

1. Isolation and quantification of genomic DNA using spectrophotometer (A260 measurement) either by Instrument or by demonstration/virtual lab/dry lab;
2. Agarose gel electrophoresis for DNA either by Instrument or by demonstration through instrument.
3. Preparation of solid culture medium (LB) and growth of E. coli by spreading and streaking;

Microbiology-

1. Simple staining and Gram's staining of bacteria.
2. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria.
3. Biochemical test for characterization: Catalase, Nitrate-reduction, Indole production, Methyl Red and Voges-Proskauer Test.
4. Sugar fermentation test.

Biotechnology-

1. Preparation of animal culture media.

2. Demonstration of Preparation of genomic DNA from E. coli/animals/ human.
3. Demonstration of PCR

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

1. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter: Molecular Biology of the Cell, IV Edition.
3. Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
5. Lewin B. (2008). Gene XI, Jones and Bartlett
6. McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.
7. Alexander, M. (1977). Introduction to Soil Microbiology. John Wiley and Sons, New York.
8. Atlas, R. M. and Bartha, R. (1997). Microbial Ecology: Fundamentals and Applications, 4th ed., Benjamin/ Cummings.
9. Black, J. G. (2011). Microbiology: Principles and Explorations. 8th ed. John Wiley and Sons, New York.
10. Campbell, R. (1983). Microbial Ecology. 2nd ed. Oxford, Blackwell.
11. P.K. Gupta: Biotechnology and Genomics, Rastogi publishers (2003).
12. B.D. Singh: Biotechnology, Kalyani publishers, 1998 (Reprint 2001).
13. T.A. Brown: Gene cloning and DNA analysis: An Introduction, Blackwell Science (2001).
14. Bernard R. Click & Jack J. Pasternak: Molecular Biotechnology, ASM Press, Washington (1998).

ZOO-502C: ECONOMIC & APPLIED ZOOLOGY

(Credit-4)
Total no of lectures-64

Learning Objectives:

The course aims to provide students with an introduction of the application and economic importance of non-chordates with special reference to entomology, fishery science. Further, this course will help student to understand the fundamental importance of amphibian, avian and mammalian fauna in different fields of natural science as well as measure economic benefits in terms of monetary value.

Learning Outcomes:

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

LO1. Take up various entrepreneurship project for self-sustenance.

LO2. Culture, rear and propagate economically important fauna for business as well as for conservation.

LO3. Connect theoretical knowledge with the practical application.

LO4. Expose themselves into the world of various academia-industry interface.

Unit 1: Economic importance of non-chordates **6L**

1. Soil protozoa and their role in agriculture; 2. Sponge culture and its importance in industry and commerce; 3. Earthworm and soil improvement; 4. Prawn culture, 5. Pearl culture.

Unit 2: Applied Entomology: **(26L)**

2.1 Apiculture- **6L**

1. Life history of honey bee, colony, nest, caste distinction, 2. Economics of bee keeping.

2.2 Lac culture- **9L**

1. Enemies of lac, uses of lac; 2. Insect control: Mechanical, Physical, Cultural and Biological control of Pests; 3. Integrated Pest management.

2.2 Sericulture **11L**

1. Types of silkworms; 2. Life cycle of Bombyx mori; 3. Structure of silk gland and secretion of silk; 4. Silkworm rearing technology: Early age and Late age rearing, Spinning, harvesting and storage of cocoons; 5. Pests of silkworm: Uzi fly, dermestid beetles and vertebrates; 6. Pathogenesis of silkworm diseases: Protozoan, viral, fungal and bacterial.

Unit 3: Fish industry & Economic significance of Amphibia and Reptilia **(17L)**

3.1 Fish industry and economy **13L**

1. Inland Fisheries; Marine Fisheries; 2. Pen and cage culture; Polyculture; Composite fish culture; Induced breeding of fish; 3. Fish diseases: Bacterial, viral and parasitic; 4. Preservation and processing of harvested fish, Fishery by-products; 5. Indigenous ornamental fishes.

3.2. Economic importance of Amphibia and Reptilia **4L**

1. Amphibia as a biological control agent; 2. Snake venom and its uses; 3. Antivenin production.

Unit 4: Economic utility of Aves and Mammalia

15L

1. Birds: in pollination, poultry; 2. Mammals: Basic knowledge about dairy and livestock breeding; 3. Animal husbandry: piggery; 4. Human's role in social welfare-mitigation of infertility problems, organ culture and transplantation.

Practical: ZOO-502C

(Credit-2)

1. Study of permanent slides of protozoan, helminthes and arthropod vectors.
2. Study of some important pests of Paddy, Jute, Tea, Cane sugar, vegetables and stored grain pest.
3. Study of the lifecycle of silk worms (Eri, Muga and Mulberry), life history of honey bee.
4. Dissection of mouth parts of Honey bee, Sting gland of honey bee.
5. Identification of commercially important (10 spp.) and ornamental fishes (5 spp.).
8. Identification of Exotic fishes.
8. In vivo demonstration of pituitary gland from commonly found fishes.
9. Maintenance of fresh water aquarium.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated. Field Visit may be organised if necessary.**

Recommended Books -

1. EkambaranathAyar: A manual of Zoology, Part I – Invertebrata & Vertebrata (1973, S. Vishwanathan)
2. Kotpal, Agarwal and Khetrapal: Modern Textbook of Zoology: Invertebrates & Vertebrates (Rastogi)
3. Marshall: Parker and Haswell Textbook of Zoology, Vol. I & Vol. II (7th ed. 1972, Macmillan)
4. Nigam: Biology of Non-chordates & Chordates (1985, S. Chand)
5. Jordon and Verma: Invertebrate & Vertebrate Zoology, Vol I and II (1995, S. Chand)

ZOO-601C: DEVELOPMENTAL BIOLOGY & IMMUNOLOGY (Credit-4)

Total no of lectures-64

Learning Objectives:

The aim of the course in immunology is to apprise the student with the working of the immune system in normal health and how it fights the disease and may sometimes contribute to disease. The immune system is incredibly complex. This course is hence designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications.

Learning Outcomes:

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

- LO1.** Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity.
- LO2.** Define the cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of Major Histocompatibility Complex
- LO3.** Explain the cellular and molecular aspects of lymphocyte activation, homeostasis, differentiation, and memory
- LO4.** Understand the molecular basis of complex, humoral (Cytokines and Complement) and cellular processes involved in inflammation and immunity, in states of health and disease
- LO5.** Describe basic and state-of-the-art experimental methods and technologies
- LO6.** Integrate knowledge of each subsystem to see their contribution to the functioning of higher-level systems in health and disease including basis of vaccination, autoimmunity, immunodeficiency, hypersensitivity and tolerance
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Unit 1: Early and Late embryonic development

22L

1. Types of eggs, Egg membranes; 2. Fertilization (External and Internal), Fertilization Mechanism: Changes in gametes, sperm egg interactions, Activation of egg, Gamete fusion in sea urchin; Blocks to polyspermy; 3. Planes and patterns of cleavage, Comparison of cleavage in different animals (sea urchin, frog and chick); 4. Types of Blastula and Gastrulation; Fate maps 5. Embryonic induction and organizers; 6. Parthenogenesis. 7. Fate of Germ Layers; 8. Extra-embryonic membranes in birds and mammals; 9. Placenta: Structure, types and functions. 10.

Unit II: Post embryonic development and Implications of Developmental Biology

15L

1. Development of brain and heart in Vertebrates; 2. Metamorphic development in insect and amphibian; 3. Regeneration: Modes of regeneration in invertebrates and vertebrates, epimorphosis and morphallaxis; 4. Teratogenesis: Teratogenic agents, causes and their effects on embryonic development; 5. Introduction to In vitro fertilization, 6. Introduction to Stem cells (ESC); 7. Amniocentesis.

Unit III: Introduction to immunity and organs of immune system:

13L

1. Basic concepts of immunity; 2. Innate Immunity-Anatomical barriers, Inflammation, Cells involved in innate immunity; 3. Mechanism of Immunity; 4. Cells and organs of immune system,

Types of immune cells:lymphoid and myeloid; 5. Structure and function of Primary and secondary lymphoid organs.

Unit IV: Adaptive Immunity and Immunological disorders

14L

1. Humoral Immunity:Antigens,Immunoglobulins: types, structure and function; 2.Cell mediated immunity: Types, properties and functions of cytokines; 2. Antigen processing and presentation; 3. Functions of T-cells; 3. Introduction to immunological disorders: Autoimmune diseases- Types, symptoms and causes (Rheumatoid arthritis, Psoriasis, Alopecia)

Practical:ZOO-601C

(Credit-2)

Developmental Biology:

1. Study of different types of eggs in invertebrates and vertebrates.
2. Study of developmental stages of chick: Primitive streak and different hours of incubation- 13 18 , 24,32,42- 48,60- 72, and 84-120 hours through permanent slides (w.m.)
3. Study of developmental stages of amphibia - whole mounts and sections through permanent slides-egg, cleavage(2,4,8, 16 celled stages),blastula&gastrula -early, mid, late stages, neural fold and neurula, tail bud stage, tadpole of amphibian(frog)(4mm to 8mm size)
4. Isolation and preparation of permanent slides of different hours of incubation of chick embryo(24-28, 48,72 hours) .
5. Window preparation on hen's egg(Demonstration of chick embryonic development making window preparation of fertilized egg).

Immunology-:

1. Demonstration of lymphoid organs (primary & secondary) from rat/mouse through dissection and display.
2. Study of antigen –antibody reactions with ABO blood grouping.
3. Demonstration of ELISA test through charts.
4. Study of the macrophages in blood and cell counting.
5. Study of histological structure of lymphoid organs through permanent slides.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommendedbooks -

1. Alberts et al: Molecular Biology of the Cell (2008, Garland)
2. Balinsky: An Introduction to Embryology (1981, CBS)
3. Gilbert: Developmental Biology (8th ed., 2006, Sinauer)
4. Wolpert: Principles of Development (3rd ed. 2007, Oxford)
5. Sku Robert A., Embryology, Epigenesis and Evolution. Cambridge University press.
6. Stone L S., Foundations of Embryology.
7. Carlson B and Grawn Mc., .Foundations of Embryology.
8. Merrill P Bradely., Foundations of Embryology.

9. Abbas et al: Cellular and Molecular Immunology (2001, Saunders)
10. Alberts et al: Molecular Biology of the Cell (5th ed. 2008, Garland)
11. Kuby: Immunology (2003, Freeman)
12. Roitt and Delvis: Roitt's Essential Immunology (6th ed. 2006, Blackwell)

**ZOO-602C: ANIMAL BEHAVIOR, WILDLIFE BIOLOGY AND POLLUTION
BIOLOGY**

(Credit 4)

Total no. of lectures-64

Learning Objectives:

This course aims to provide an overview of animal behaviour and chronobiology starting from historical perspectives to types of behaviours and their evolutionary significance. The course also highlights types, mechanisms and importance of the biological rhythms and biological clocks operating in the living organisms. This course will help the learners to understand and appreciate different types of animal behaviours, their adaptive, evolutionary and practical significance.

Learning Outcomes:

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

LO1. Understand types of animal behaviour and their importance to the organisms.

LO2.

Enhance their observation, analysis, interpretation and documentation skills by taking short projects pertaining to Animal behaviour and chronobiology.

LO3.

Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetic basis of the behaviour.

LO4. Understand various processes of chronobiology in their daily lives such as jet lag.

LO5.

Learn about the biological rhythm and their application in pharmacology and modern medicine.

LO6.

Realize, appreciate and develop passion to biodiversity; and will respect the nature and environment.

A.: Animal Behavior

(32L)

Unit 1: Introduction to Animal Behavior

16L

1. Introduction, Scope and methods of Ethology; 2. Behavior equipment – Sign, Stimuli, Stimulus filtering; 3. Innate behavior; 4. Learned behavior and types of learning; 5. Instinct v/s Learning; 6. Genetic basis of Behavior

Unit II: Sociobiology and Circadian Chronobiology

16L

1. Animal Communication, Dance Language in honey bees; 2. Eusocial organization- honey bees and ants, 3. Social organization in primates; 4. Types and characteristics of biological rhythms, 5. Photic and non-photoc zeitgeber, 6. Photoperiod and regulation seasonal reproduction of vertebrates.

B. Wildlife Biology

32L

Unit III: Introduction to Wildlife and Wildlife Protection

24L

1. Definition of Wildlife; 2. Strategies for Wildlife Conservation & Management; 3. IUCN Red list, 2. Wild life (protection) Act of 1972 and 1991 amendment; 4. Wildlife Sanctuaries, National Parks, Biosphere Reserves of N E India; 5. Rare and Endangered mammalian species of N E India.

Unit IV. Pollution Biology

8L

1. Sources and impact of environmental pollutants– air, water and soil; 2 Pollution Control

Practical: ZOO-602

(Credit 2)

1. Study of different types of nest in birds.
2. Demonstration of social behavior in honey bees.
3. Study of geotaxis behaviour in earthworm.
4. Study of the phototaxis behaviour in insect larvae.
5. Determination of biological chemical demand
7. Estimation of soil temperature
8. Visit to Wild life Sanctuary/Biodiversity Park/Zoological Park/Captive Breeding Center to study behavioral activities of animals and submission of report.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

Discipline Specific Elective Courses (DSE)-

ZOO-503DSE 1: BIOLOGY OF INSECTA

(Credits-4)

Total no of lectures-64

Learning Objectives:

Insects form over 70% of the faunal population on the earth. They have inhabited the earth for over 450 million years. They are the most diverse group of organisms occupying nearly all niches except for the deep sea. Learning of Morphology and Physiology of the Insects gives an overview of one of the best body designs which have survived on the earth.

Learning Outcomes:

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

LO1. Appreciate the diversity of insects.

LO2. Understand the physiology of Insects which has made them the most successful animals in terms of numbers and variety of species.

LO3. Get a glimpse of the highly organized social life of insects.

Unit I: Introduction to insect and Insect Taxonomy

10L

General Features of Insects, Distribution and Success of Insects on the Earth. Basis of insect classification; Classification of insects up to orders.

Unit II: General Morphology of Insects

16L

External Features; Head – Eyes, Types of antennae, mouth parts w.r.t. feeding habits; Thorax: Wings and wing articulation, Types of legs adapted to diverse habitat; abdominal appendages and genitalia.

Unit III: Physiology of Insects

18L

Structure and physiology of Insect body systems - Integumentary, digestive, excretory, circulatory, respiratory, endocrine, reproductive, and nervous system, sensory receptors; growth and metamorphosis.

Unit IV: Society, insect plant interaction and insects as vectors

20L

Group of social insects and their social life; Social organization and social behavior, Theory of co-evolution, role of allelochemicals in host plant mediation; Host-plant selection by phytophagous insects, Insects as plant pests. Insects as mechanical and Biological vectors, Brief discussion on houseflies and mosquitoes as important insect vectors.

Practical

(credit 2)

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects through temporary mount.
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.
5. Methodology of collection, preservation and identification of insects.

6. Study of any three insect pests and their damages
7. Study of any three beneficial insects and their products

Field study of insects and submission of a project report on the insect diversity

Recommended Books-

1. A general text book of entomology, Imms , A. D., Chapman & Hall, UK
2. The Insects: Structure and function, Chapman, R. F., Cambridge University Press, UK
3. Principles of Insect Morphology, Snodgrass, R. E., Cornell Univ. Press, USA
4. Introduction to the study of insects, Borror, D. J., Triplehorn, C. A., and Johnson, N. F., M
Sunders College Publication, USA
5. The Insect Societies, Wilson, E. O., Harward Univ. Press, UK
6. Host Selection by
Phytophagous insects, Bernays, E. A., and Chapman, R. F., Chapman and Hall, New York, USA
7. Physiological system in Insects, Klowden, M. J., Academic Press, USA
8. The Insects, An outline of Entomology, Gullan, P. J. , and Cranston, P. S., Wiley Blackwell,
UK
9. Insect Physiology and Biochemistry, Nation, J. L., CRC Press, USA

ZOO-504DSE 2:PARASITOLOGY

(Credits –4)
Total no. of lectures-64

Learning Objectives:

Parasitology will enable us diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as bio control agents. Parasitology; especially the study of life cycles of parasites; has helped in defying the stigmas and religious taboos for many societies making free many of the people from superstition and ill health. Developing countries like our country where majority of the people are engaged in agricultural activities and living in poor conditions have advantages to be harvested from the study of parasitology. The course shall surely skill the student to see, appreciate and understand the diversities of parasites in the whole spectrum of the study of life. The course shall also make the students aware about the possible scopes of the subject which include research and applied aspects including entrepreneurial works.

Learning Outcomes:

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

- LO1. Understand the variation amongst parasites, parasitic invasion in both plants and animal s; applicable to medical and agriculture aspects.
 - LO2. Help to know the stages of the life cycles of the parasites and the respective infective stages.
 - LO3. Develop ecological model, know population dynamics of parasite, establishment of parasite population in host body, adaptive radiations and methods adopted by parasite to combat with the host immune system
 - LO4. Develop skills and realize significance of diagnosis of parasitic attack and treatment of patient or host.
 - LO5. Learn important case studies to highlight interesting researches, serendipities towards head advancement and enrichment of knowledge in the field of Parasitology.
-

Unit 1: Introduction to Parasitology

16L

1. Brief introduction of Parasitism, parasite, parasitoid and Vectors (mechanical and biological vector); 2. Host parasite relationship; 3. Blood-sucking bugs; Chagas disease, bed bugs as mechanical vectors, control and prevention measures; 4. SARS

Unit 2: Non-chordates Parasites 1

(22L)

2.1 Parasitic Protists

11L

1. Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment/control measure of: *Entamoeba histolytica*, *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani*, *Plasmodium vivax*

2.2 Parasitic Platyhelminthes

11L

1. Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of: *Fasciolopsis buski*, *Taenia solium*, *Schistosoma haematobium*.

Unit 3 Non chordate Parasites II

(20L)

3.1 Parasitic Nematodes

12L

1. Study of Morphology, Life Cycle, Prevalence, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of : *Ascaris lumbricoides*, *Ancylostomaduodenale*, *Wuchereriabancrofti*, *Trichinella spiralis*; 2. Study of structure, life cycle and importance of *Meloidogyne* (root knot nematode), *Pratylenus* (lesion nematode)

3.2 Parasitic Arthropods

8L

1. Biology, importance and control of : ticks (soft tick *Ornithodoros*, hard tick *Ixodes*), mites (*Sarcoptes*), Lice (*Pediculus*), Flea (*Xenopsylla*); 2. Study of mosquito-borne diseases – Dengue, Chikungunya, Viral encephalitis

Unit 4: Parasite Vertebrates

6L

Brief account of parasitic vertebrates: Cookicutter shark, hood mockingbird and vampire bat

Practical

(Credits-2)

1. Study of life stages of any one: *Giardia intestinalis*, *Trypanosoma gambiense*, *Leishmania donovani* and *Plasmodium vivax* through permanent slides/micro photographs
2. Study of adult and life stages of any one: *Schistosoma haematobium*, *Taenia saginata* through permanent slides/micro photographs
3. Study of adult and life stages of any one: *Ascaris lumbricoides*, *Ancylostomaduodenale*, *Wuchereriabancrofti* and *Trichinella spiralis* through permanent slides/micro photographs.
4. Study of monogenea from the gills of fresh/marine fish
5. Study of nematode/cestode parasites from the intestines of Poultry bird.

****Lab notebook with labelled diagrams, methods and results.**

Recommended Books

1. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications and Distributors.
2. E.R. Noble and G.A. Noble (1982) Parasitology: The biology of animal parasites. V Edition, Lea & Febiger.
3. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and Francis Group.

4. Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributors, Medical Books Publishers, Chennai, Delhi.
5. Rattan Lal Ichhpujani and Rajesh Bhatia. Medical Parasitology, III Edition, Jaypee Brothers Medical Publishers (P) Ltd., New Delhi.
6. Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers.
7. K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBS Publishers & Distributors (P) Ltd.

ZOO-603DSE 3: AQUATIC BIOLOGY

(Credits-4)

Total no of lectures-64

Learning Objectives:

This course helps students to study about aquatic life and equip students with skills that can later lead into a profession in aquatic biology. Aquatic biology at undergraduate level works as an entry point for future aquatic biologist. Two major aspects of Aquatic biology are study of the organisms in the freshwater (Limnology) and saline waters (Marine biology). This paper focuses on research and explains processes, structures and pathways in most aquatic and wet ecosystems. Geographically, aquatic ecosystems in temperate, tropical and arctic regions, and both basic and applied science will be covered.

Learning Outcomes:

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

- LO1. Know the physico-chemical environment, and its role in an aquatic ecosystem.
 - LO2. Learn about adaptations exhibited by organisms to survive in these typical conditions.
 - LO3. Realize how human activities influence the physicochemical environment of water bodies, and devastating impact it has on aquatic organisms.
 - LO4. Learn about the laws governing the use of freshwater systems, as well as the local, state, federal, and international agencies that enforce these laws to protect endangered and vulnerable species.
 - LO5. Understand and apply relevant scientific principles in the area of aquatic biology and educate others or work to conserve our natural resources.
-

UNIT 1: Aquatic Biomes

10L

Brief introduction of the aquatic biomes: Freshwater ecosystem (lakes, wetlands, streams and rivers), estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.

UNIT 2: Freshwater Biology

24L

Lakes: Origin and classification, Lake as an Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous.

Streams: Different stages of stream development, Physico-chemical environment, Adaptation of hill-stream fishes

UNIT 3: Marine Biology

14L

Salinity and density of Sea water, Continental shelf, Adaptations of deep sea organisms, Coral reefs, Sea weeds.

UNIT 4: Management of Aquatic Resources

16L

Causes of pollution: Agricultural, Industrial, Sewage, Thermal and Oil spills, Eutrophication, Management and conservation (legislations), Sewage treatment, Water quality assessment- BOD

Practical

(Credit 2)

1. Determination of area of a wetland using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplanktons and zooplanktons present in an aquatic ecosystem.
3. Determination of the amount of Turbidity/transparency, Dissolved Oxygen, and Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a nearby lake / water body.
4. Instruments used in limnology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, PONAR grab sampler) and their significance.
5. A project report on a visit to a Sewage treatment plant or wetland (report to be submitted).

****Lab notebook with labelled diagrams, methods and results.**

Recommended Books-

1. Anathakrishnan: Bioresources Ecology 3rd Edition
2. Goldman: Limnology, 2nd Edition
3. Odum and Barrett: Fundamentals of Ecology, 5th Edition
4. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition
5. Wetzel: Limnology, 3rd edition
6. Trivedi and Goyal : Chemical and biological methods for water pollution studies
7. Welch: Limnology Vols. I-II

ZOO-604DSE 4: REPRODUCTIVE BIOLOGY

(Credit-4)

Total no of lectures-64

Learning Objectives:

This course is meant for making the students learn about the various aspects of reproduction in humans. It includes a detailed study of the male and female reproductive systems as well as factors that are important in maintaining reproductive health. The students are also made aware of new technologies in assisted reproduction as well as contraceptive methods. They are taught about social and public health issues related to family planning.

Learning Outcomes:

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

LO1. Get in-

depth understanding of morphology, anatomy and histology of male and female reproductive organs.

LO2. Know different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition and lactation.

LO3. Compare estrous and menstrual cycles and their hormonal regulation.

LO4. Comprehend the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.

LO5. Know about the diagnosis and management of infertility, including latest methods, technologies and infrastructure in assisted reproduction.

LO6. Practically understand the modern methods in contraception and their use in family planning strategies.

LO7. Translate their understanding into development of products like non-hormonal contraceptives; contribute to drug discovery programmes as well as neonatal and maternal health programmes and work with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

Unit1: Reproductive Endocrinology

(20L)

1.1: Gonadal hormones:

14L

1. Definition of gonadal hormones, types and mechanism of hormone action; 2. Steroids, glycoprotein hormones and prostaglandins; 3. Hypothalamo – hypophyseal – gonadal axis; 4. Regulation of gonadotrophin secretion in male and female

1.2: Reproductive System:

3L

1. Development and differentiation of gonads; 2. Genital ducts, External genitalia	
1.3: Sex differentiation.	3L
1. Definition of sex differentiation; 2. Mechanism of Sex differentiation	
Unit2: Functional anatomy of male reproductive system	(14L)
2.1: Outlines of reproductive system (male):	7L
1. Brief introduction of male reproductive system; 2. Structure and functions of testis, Cellular testicular functions; 3. System of testicular cell renewal	
2.2: Spermatogenesis:	7L
1. Mechanism of spermatogenesis; 2. Hormonal regulation; 3. Androgen synthesis and metabolism; 4. Epididymal function and sperm maturation; 5. Accessory glands functions	
Unit3: Functional anatomy of female reproduction	(20L)
3.1: Outlines of reproductive system (female):	8L
1. Brief introduction of female reproductive system; 2. Structure and functions of ovary; 3. Folliculogenesis; 4. Ovulation; 5. Corpus luteum formation and regression; 6. Steroidogenesis and secretion of ovarian hormones	
3.2: Reproductive cycles:	5L
1. Brief account of reproductive cycles of rat and human; 2. Regulation; 3. Changes in the male and female tract; 4. Ovum transport in the fallopian tubes; 5. Sperm transport in the female tract	
3.3: Fertilization:	1L
Mechanism of fertilization	
3.4: Hormonal control of reproduction:	6L
1. Hormonal control of embryo implantation 2. Hormonal regulation of gestation, 3. Pregnancy diagnosis 4. Foeto – maternal relationship 5. Mechanism of parturition and its hormonal regulation 6. Lactation and its regulation	
Unit4: Reproductive Health	(10L)
4.1: Infertilty problems:	3L
1. Types of infertility in male and female; 2. Causes; 3. Diagnosis and management;	
4.2: Assisted Reproductive Technology:	7L
1. Definition of Assisted Reproductive Technology; 2. Sex selection, Sperm banks and Frozen embryos; 3. In vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; 4. Modern contraceptive technologies, STDs.	

Practical**(Credits-2)**

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Study of estrous cycle through examining vaginal smear of rats/ any live animal.
3. Surgical techniques: principles of surgery in endocrinology;Ovarectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis and ovary
5. Sperm count and sperm motility, viability in rat epididymis
6. A visit to any city based Human reproductive centre/ to the reproductive centre of veterinary sciences.

**Lab notebook with labelled diagrams, methods and results.

Recommended Books-

1. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press.
2. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company.
3. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd.
4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme.

SKILL ENHANCEMENT COURSES (SE)-

ZOO-001S:VERMICOMPOSTING AND BIOFERTILIZER (Credit-2)

Total no. of 32L

Learning Objectives:

This course aims to provide hands on skills in preparing vermicompost and biofertilizers which is the need of the present situation considering waste managements as a major goal. The money earning skills like vermicomposting has greater significance in the academic curriculum bridging between knowledge and application.

Learning Outcomes:

- LO1.** Take up various entrepreneurship project for self-sustenance.
 - LO2.** Establish small scale industry for business as well as for waste management initiatives.
 - LO3.** Connect theoretical knowledge with the practical application.
 - LO4.** Expose themselves into the world of various academia-industry interface.
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Unit 1: Vermicomposting I

5L

Vermiculture- Definition, scope and importance, common species for culture, Environmental parameters; Vermicomposting of wastes in field pits, tank method, roof shed method, bin method, harvesting of compost, storage, vermiwash-preparation and application.

Unit II: Vermicomposting II

5L

Application of vermicomposting, earthworms for management of municipal, biomedical wastes; future perspective of vermicomposting, constraints for vermiculture in India. Marketing the product of vermiculture, market research, visit to relevant labs /field visits.

Unit III: Biofertilizer I

11L

Biofertilizers - Introduction, scope. A general account of Biofertilizer organisms, Cyanobacteria (BGA), Bacteria and Mycorrhizae, Cyanobacteria (BGA) as biofertilizers, Masscultivation of *Azolla*, Symbiotic association of Cyanobacteria, Field application of Cyanobacterial inoculants, Preparation of biofertilizers from wastes (banana peels, cow dung, vegetable wastes, egg peels)

Unit IV: Biofertilizer II

11L

Bacterial biofertilizers: General account of bacterial biofertilizer organisms. *Azospirillum*, *Azotobacter*, *Frankia*, *Phosphobacteria* and *Rhizobium*, Mechanism of nitrogen fixation (free-living and symbiotic), Mycorrhizal biofertilizers: A general account of Ecto, Endo and Arbuscular mycorrhizae; Application methods for different biofertilizers and its importance; National and Regional Biofertilizers Production and Development Centres.

ZOO-002S: MEDICAL DIAGNOSTICS

(Credit -2)

Total no. Lectures 32

Learning Objectives:

This course aims to aware and give hands on skills on medical diagnostics which is very important form the subject of zoology perspective. The detailed knowledge about various common diseases and their diagnostics are important and a skill-based subject that enable student to work in various medical laboratories.

Learning Outcomes:

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

LO1. Help medical practitioner/laboratory personnel in conducting tests.

LO2. Establish first aid helping center.

LO3. Aware people about various diagnostic facilities meant for different diseases.

Unit 1: Common diagnostics methods for Analysis of Blood

14L

Introduction to medical diagnostics and its importance, Blood composition (separation of serum from blood cells), Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's/Wrights/Gymsus stain, Platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.), Calculation of RBC related indices (MCV, MCH, MCHC) from P.C.V haemoglobin and total count of RBCs.

Unit II: Common Diagnostic techniques for Urine Sample Analysis

4L

Urine Analysis: Examination of Physical characteristics; Abnormal constituents (albumin, blood, sugar, uric acid).

Unit III: Non-infectious and Infectious Diseases

6L

Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Testing of blood glucose using Glucometer/Kit; Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis.

Unit IV: Tumours

8L

Types (Benign/Malignant), Detection of the stage-1, stage-2 and stage-3 metastasis; Biopsy examination of tumour sample through microtomy and visit to a clinical laboratory or cancer institute for Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan /using photographs.

Recommended Books-

1. Park, K. (2007), Preventive and Social Medicine, B.B. Publishers.
2. Godkar P.B. and Godkar D.P. Textbook of Medical Laboratory Technology, II Edition, Bhalani Publishing House.
3. Guyton A.C. and Hall J.E. Textbook of Medical Physiology, Saunders.
4. Robbins and Cortan, Pathologic Basis of Disease, VIII Edition, Saunders.
5. Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

GENERIC ELECTIVE COURSES-

ZOO-103GE 1: ANIMAL DIVERSITY

(Credits-4)

Total no. of lectures -64

Learning Objectives:

Zoology is the scientific study of animal life. Animals are the most diverse creatures on this planet. This course gives a framework for understanding the diversity within different groups, and interrelationship among different species and genera within each group. The aim of this course is to understand the importance of animal kingdom in context to hierarchy, body plan and their role in ecological development. This course provides an overview of the invertebrate and vertebrate animals, including sponges, cnidarians, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals. This paper comprises of 15 units. First nine units provide knowledge of coelom formation, different level of organization, different modes of living, evolutionary changes of Non-chordates and their salient features. Whereas, remaining units will impart knowledge on different classes of chordates. After completion of this course, the learners will have a framework for understanding all of the different types of animals, and the characteristics of each.

Learning Outcomes:

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

- LO1.** Distinguish between major phyla of animals through a demonstrated understanding of their taxonomic classification and diversity.
 - LO2.** Describe the distinguishing characteristics of all major phyla.
 - LO3.** Understand the fundamental differences among animal body plans and relate them to function, taxonomic classification, and evolutionary relationships among phyla.
 - LO4.** Illustrate life cycles, structure, function and reasons for importance of few representative organisms from different groups of animals.
 - LO5.** Identify anatomical structures from prepared tissues.
 - LO6.** Observe living animals in the environment and relate observations to theory from the course.
 - LO7.** Recognize major animal phyla and animals on the basis of their external characteristics
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Protista :General characters of Protozoa; Life cycle of Plasmodium	4L
Porifera : General characters and canal system in Porifera	4L
Radiata : General characters of Cnidarians and polymorphism	4L
Aceolomates : General characters of Helminthes; Life cycle of <i>Taeniasolium</i>	4L
Pseudocoelomates : General characters of <i>Nemethelminthes</i> ; Parasitic adaptations	4L
Coelomate Protostomes : General characters of Annelida ;Metamerism.	4L
Arthropoda : General characters. Social life in insects.	4L
Mollusca : General characters of Mollusca; Pearl Formation	4L
Coelomate Deuterostomes : General characters of Echinodermata, Water Vascular system in Starfish.	6L
Protochordata : Salient features	4L
Pisces : Osmoregulation, Migration of Fishes	4L
Amphibia : General characters, Adaptations for terrestrial life, parental care in Amphibia.	6L
Reptilia : Amniotes; Origin of reptiles, Terrestrial adaptations in reptiles.	4L
Aves : The origin of birds; Flight adaptations	4L
Mammalia : Early evolution of mammals, Primates, Dentition in mammals.	4L

Practical

(Credits- 2)

1. Study of following specimens: Non Chordates: Euglena, Noctiluca, Paramecium, Sycon, Physalia, Metridium, Taenia, Ascaris, Nereis, Aphrodite, Leech, Peripatus, Limulus, , Hermitcrab, Millipede, Centipede, Beetle, Chiton, Dentalium, Octopus, Asterias, and Antedon. Chordates: Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Ichthyophis, Salamander, Draco, Uromastix, Naja, Viper, model of Archaeopteryx, Owl, Squirrel and Bat.

2. Study of following Permanent Slides: Cross section of Sycon, Sea anemone and Ascaris(male and female). T. S. of Earthworm passing through pharynx, gizzard, and typhlosolar intestine. Bipinnaria and Pluteus larva.

3. Temporary mounts of mounts of Placoid ,cycloid and ctenoid scales.

4. Demonstration of Digestive and nervous system of Cockroach.

**Lab notebook with labelled diagrams, methods and results

Recommended Books-

1. Modern Text Book of Zoology, Invertebrates, Vol I & Vertebrates Vol II, R L Kotpal, Rastogi Publications.
2. E. L. Jordan and Dr. P. S. Verma, Invertebrate Zoology & Vertebrate Zoology, S Chand and Co. Ltd.
3. Barnes, R.D. (1992). Invertebrate Zoology. Saunders College Pub. USA.
4. Ruppert, Fox and Barnes (2006) Invertebrate Zoology. A functional Evolutionary Approach 7th Edition, Thomson Books/Cole
5. Campbell & Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
6. Kardong, K. V. (2002). Vertebrates Comparative Anatomy. Function and Evolution. Tata McGraw Hill Publishing Company. New Delhi.
7. Raven, P. H. and Johnson, G. B. (2004). Biology, 6th edition, Tata McGraw Hill Publications. New Delhi.

ZOO-203GE 2:ENVIRONMENT AND PUBLIC HEALTH

(Credits- 4)

Total no. of Lecture-64

Learning Objectives:

Health is wealth but this wealth is directly affected by the environment. Environmental issue that affects human health is the most important trigger that has led to the urgency of conservation of environment. All the aspects of human health, including quality of life are determined by physical, chemical, biological, social and psychological factors in environment. The sustenance of environment is the key to development of future of mankind. This course aims to create awareness among students about the necessity conservation of Mother Nature. The main objective of the syllabus is to assess, correct, control and prevent those factors that can adversely affect environment and hence health of present and future generation.

Learning Outcomes:

Upon completion of course, students will be able to:

LO1. Get familiarized with various aspects of environmental risks and hazards.

LO2. Recognize the climate change due to human activities.

LO3. Be aware about the various impacts of environmental degradation on human health through case studies and how it can be prevented.

LO4.

Learn about the nuclear and chemical disaster; and their after effects through case studies.

LO5. Know various waste management technologies and their utility.

LO6. Understand the diagnostic methods of various diseases and ways to prevent them.

LO7.

Realize the importance of nature conservation for betterment of human race and all living beings.

UNIT I: Introduction

9L

Sources of Environmental hazards, hazard identification and accounting, fate of toxic and persistent substances in the environment, dose Response Evaluation, exposure Assessment.

UNIT II: Climate Change and Pollution

20L

Greenhouse gases and global warming, Acid rain, Ozone layer destruction, Effect of climate change on public health; Air, water, noise pollution; sources and effects, Pollution control.

Unit III: Waste Management Technologies **26L**

Sources of waste, types and characteristics, Sewage disposal and its management, Solid waste disposal, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants, Case histories on Bhopal gas tragedy, Chernobyl disaster, Seveso disaster and Three Mile Island accident and their aftermath.

Unit IV: Diseases **9L**

Causes, symptoms and control of tuberculosis, Asthma, Cholera, Minamata disease, typhoid

Practical: ZOO-203GE **(Credits- 2)**

Determination of pH, Cl, SO₄, NO₃ in soil and water samples from different locations.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

1. Cutter, S.L., Environmental Risk and Hazards, Prentice-Hall of India Pvt. Ltd., New Delhi, 1999.
2. Kolluru Rao, Bartell Steven, Pitblado R and Stricoff —Risk Assessment and Management Handbook, McGraw Hill Inc., New York, 1996.
3. Kofi Asante Duah —Risk Assessment in Environmental management, John Wiley and sons, Singapore, 1998.
4. Kasperson, J.X. and Kasperson, R.E. and Kasperson, R.E., Global Environmental Risks, V.N. University Press, New York, 2003.
5. Joseph F Louvar and B Diane Louver Health and Environmental Risk Analysis fundamentals with applications, Prentice Hall, New Jersey 1997.

ZOO-304GE 3: FOOD, NUTRITION AND HEALTH(Credits-4)

Total no. of lecture 64

Learning Objectives:

The prime focus is to provide the students with a basic understanding of the relationship between food, nutrition and health. It is imperative that focus should be on realistic issues faced by people with respect to nourishment at all stages of life. Unhealthy eating habits particularly the shift from fresh food consumption to packaged foods with added salts and preservatives have contributed to the obesity epidemic in nearly all parts of the world. It is important to understand this link and change eating habits in accordance to one's age, pregnancy, lactation and physical activity. By taking steps to eat healthy, one can obtain the nutrients required by the body to stay healthy, active, and strong. Mental health is also affected largely by our lifestyle. Apart from physical activity, the intake of the required vitamins, minerals and antioxidants also nourish the brain. Malnutrition is the main cause of impairment of growth in young children and infants and leads to diseases like Marasmus. Moreover, food hygiene including food and water borne infections along with food spoilage has also been covered in this course.

Learning Outcomes:

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

LO1. Have a better understanding of the association of food and nutrition in promoting healthy living.

LO2. Think more holistically about the relationship between nutrition science, social and health issues.

LO3. Move on to do post-graduation studies and can apply for jobs as food safety officers, food analysts, food inspectors, food safety commissioners or controllers for jobs in organizations like FSSAI

LO4. Specialize in various fields of nutrition.

Unit 1: Basic concept of food and nutrition

10L

Food Components and food-nutrients; Concept of a balanced diet, nutrient needs and dietary pattern for various groups- adults, pregnant and nursing mothers, infants, school children, adolescents and elderly.

Unit II: Nutritional Biochemistry **12L**

Carbohydrates, Lipids, Proteins- Definition, Classification, their dietary source and role; Vitamins-Vitamins- Fat-soluble and Water-soluble vitamins- their dietary source and importance Minerals-- Iron, calcium, phosphorus, iodine, selenium and zinc: their biological functions.

Unit III: Health Introduction to health **22L**

Definition and concept of health, Major nutritional Deficiency diseases- Protein Energy Malnutrition (kwashiorkor and marasmus), Vitamin A deficiency disorders, Iron deficiency disorders, Iodine deficiency disorders- their causes, symptoms, treatment, prevention and government programmes, if any; Life style related diseases- hypertension, diabetes mellitus, and obesity- their causes and prevention through dietary and lifestyle changing; Problems of smoking, alcoholism, drug dependence and Acquired Immuno Deficiency Syndrome (AIDS): their causes, treatment and prevention.

Unit IV: Food hygiene: **20L**

Food and Water borne infections: Bacterial infection, Cholera, typhoid fever, dysentery; Viral infection: Hepatitis, Poliomyelitis; Protozoan infection: amoebiasis, giardiasis; Parasitic infection: taeniasis and ascariasis their transmission, causative agent, sources of infection, symptoms and prevention; Brief account of food spoilage: Causes of food spoilage and their preventive measures.

Practical :ZOO-304GE: **(Credits 2)**

1. To detect adulteration in Ghee, Sugars, Tea leaves and Turmeric
2. Estimation of Lactose in milk
3. Ascorbic acid estimation in food by titrimetry

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

1. Mudambi, SR and Rajagopal, MV. Fundamentals of Foods, Nutrition and Diet Therapy; Fifth Ed; 2007; New Age International Publishers
2. Srilakshmi B. Nutrition Science; 2002; New Age International (P) Ltd. □ Srilakshmi B. Food Science; Fourth Ed; 2007; New Age International (P) Ltd.
3. Swaminathan M. Handbook of Foods and Nutrition; Fifth Ed; 1986; BAPPCO.
4. Bamji MS, Rao NP, and Reddy V. Text Book of Human Nutrition; 2009; Oxford & IBH Publishing Co. Pvt Ltd.

5. Wardlaw GM, Hampl JS. Perspectives in Nutrition; Seventh Ed; 2007; McGraw Hill.
6. Lakra P, Singh MD. Textbook of Nutrition and Health; First Ed; 2008; Academic Excellence.
7. Manay MS, Shadaksharaswamy. Food-Facts and Principles; 1998; New Age International (P) Ltd.
8. Gibney et al. Public Health Nutrition; 2004; Blackwell Publishing.

ZOO-404GE 4: HUMAN PHYSIOLOGY

(Credits-4)
Total no. of Lecture-64

Learning Objectives:

The students will be introduced to the principles of normal biological function in human body. Basic human physiology will be outlined and correlated with histological structures. Students will be exposed to the concept of how animals maintain an internal homeostatic state in response to changes in their external environment. Hands-on practical skills useful in routine life will be inculcated among students. Students will be encouraged for subsequent biological courses that require an understanding of the physiology of organisms.

Learning Outcomes:

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

LO1. Know the principles of normal biological function in human body.

LO3. Outline basic human physiology and correlate with histological structures.

LO3. Understand how animals maintain an internal homeostatic state in response to changes in their external environment.

Unit 1: Digestion and Absorption of Food

10L

Structure and function of digestive glands; digestion and absorption of carbohydrates, fats and proteins; nervous and hormonal control of digestion (in brief)

Unit 2: Functioning of Excitable Tissue (Nerve and Muscle)

16L

Structure of neuron, Propagation of nerve impulse (myelinated and non-myelinated nerve fibre); Structure of skeletal muscle, mechanism of muscle contraction (Sliding filament theory), neuromuscular junction

Unit 3: Respiratory and Renal Physiology

18L Ventilation, external and internal respiration, transport of oxygen and carbon dioxide in blood, Factors affecting transport of gases; Functional anatomy of kidney, mechanism and regulation of urine formation, Nitrogenous wastes.

Unit 5: Cardiovascular, Endocrine and Reproductive Physiology

20L

Structure of heart, Coordination of heartbeat, Cardiac cycle, ECG; Structure and function of endocrine glands (pituitary, thyroid, parathyroid, pancreas, adrenal, ovaries, and testes), brief account of spermatogenesis and oogenesis, menstrual cycle.

Practical:ZOO-404GE

(Credits- 2)

1. Preparation of temporary mounts: Neurons and Blood film.
2. Preparation of haemin crystals.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Study of permanent histological slides of mammalian oesophagus, stomach, duodenum, lung, kidney, thyroid, pancreas, adrenal, testis, ovary.
5. Preparation of temporary mounts of squamous epithelium, striated and non-striated muscles.
6. DLC of blood.

**** Lab notebook with labelled diagrams, methods (wherever applicable) and results must be incorporated.**

Recommended Books-

1. Prakash, G. (2012). Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Company Ltd.
 2. Kesar, S. and Vashisht, N. (2007). Experimental Physiology, Heritage Publishers.
 3. Tortora, G.J. and Derrickson, B.H. (2009). Principles of Anatomy and Physiology, XII Edition, John Wiley and Sons, Inc.
 4. Widmaier, E.P., Raff, H. and Strang, K.T. (2008). Vander's Human Physiology, XI Edition, McGraw Hill.
 5. Guyton, A.C. and Hall, J.E. (2011). Textbook of Medical Physiology, XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
 6. Marieb, E. (1998). Human Anatomy and Physiology, IV Edition, Addison-Wesley.
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