

THREE/FOUR-YEAR DEGREE COURSE

(With Multiple Entry /Exit Option)

Based on NEP-2020



ZOOLOGY

(SINGLE MAJOR AND TWO MINORS)

(Effective from Session 2026-27)

(BATCH 2026-2030)



SAMBALPUR UNIVERSITY

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COURSE STRUCTURE

THREE-YEAR DEGREE COURSE WITH A SINGLE MAJOR AND TWO MINOR

SEMESTER	Core I	Core II	Core III	Multidisciplinary	AEC	SEC	VAC	Community Engagement and services/Field work/Internship	Total Minimum Credit
I	2x4=8	1x4=4		1x3=3	1x4=4 Odia		1x3=3 Env Studies and Disaster Management		22
II	2x4=8		1x4=4	1x3=3	1x4=4 English	1x3=3			22
*VOCATIONAL COURSE I (4 CREDIT)									44
III	3x4=12	1x4=4		1x3=3			1x3=3		22
IV	3x4=12		1x4=4					1x4=4	20
*VOCATIONAL COURSE II (4 CREDIT)									42
V	3x4=12	1x4=4				1x3=3	1x3=3		22
VI	2x4=8		1x4=4			1x3=3	1x3=3		18
									40
TOTAL	15x4=60	3x4=12	3x4=12	3x3=9	2x4=8	3x3=9	4x3=12	1x4=4	126

- ❖ In case a student opts for NCC and clears 'C' certificate, additional 16 credits shall be awarded and total credit shall be $126+16 = 142$ credit.
- ❖ One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester. One Credit will be generally equivalent to 15 hours of instructions.
- ❖ Each semester shall comprise of 15 weeks of academic activities with a minimum of 90 working days.

***Vocational Course:**

- ❖ Students may choose vocational courses after 2nd Semester and 4th Semester for Certificate Course or Diploma Course respectively with 4 credit each opt for exit.

FOUR YEAR DEGREE COURSE WITHOUT RESEARCH

Semester	Core-I	Core-II	Core-III	Multi-disciplinary	AEC	SEC	VAC	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	2X4=8	1X4=4		1X3=3	1X4=4 Odia		1x3=3 Environmental Studies and Disaster management		22
II	2X4=8		1X4=4	1X3=3	1X4=4 English	1X3=3			22
									44
III	3X4=12	1X4=4		1X3=3			1X3=3		22
IV	3X4=12		1X4=4					1x4=4	20
									42
V	3X4=12	1X4=4				1x3=3	1x3=3		22
VI	2X4=8		1X4=4			1x3=3	1x3=3		18
									40
VII	4x4=16	1x4=4							20
VIII	4x4=16	1x4=4							20
									40
Total	23x4=92	5x4=20	3x4=12	3x3=9	2x4=8	3x3=9	4x3=12	1x4=4	166

FOUR YEAR DEGREE COURSE WITH RESEARCH

Semester	Core-I	Core-II	Core-III	Multi-disciplinary	AEC	SEC	VAC	Community Engagement & Services/ Field work /Internship	Total Minimum Credit
I	2X4=8	1X4=4		1X3=3	1X4=4 Odia		1x3=3 Environment al Studies and Disaster management		22
II	2X4=8		1X4=4	1X3=3	1X4=4 English	1X3=3			22
									44
III	3X4=12	1X4=4		1X3=3			1X3=3		22
IV	3X4=12		1X4=4					1x4=4	20
									42
V	3X4=12	1X4=4				1x3=3	1x3=3		22
VI	2X4=8		1X4=4			1x3=3	1x3=3		18
									40
VII	3x4=12	2x4=8							20
VIII	2x4=8							Research 12	20
									40
Total	20x4=80	5x4=20	3x4=12	3x3=9	2x4=8	3x3=9	4x3=12	16	166

THREE/ FOUR YEAR DEGREE COURSE WITH A SINGLE MAJOR AND TWO MINOR

UNDER NEP 2020
ACADEMIC SESSION: 2026-30

SUBJECT: ZOOLOGY

COURSE AT A GLANCE

Sl No	SEMESTER	PAPER	COURSE TITLE	TYPE OF PAPER (P/NP)	CREDIT HOUR (CH)	FULL MARK
CORE I/ MAJOR						
1	I	PAPER -I(Theory)	Invertebrates: Protista to Echinodermata	P	4	100
		PAPER -I(Practical)	Invertebrates: Protista to Echinodermata			
2		PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	P	4	100
		PAPER -II(Practical)	Diversity of Chordates: Protochordates to Mammalia			
3	II	PAPER -III(Theory)	Microbiology	P	4	100
		PAPER -III(Practical)	Microbiology			
4		PAPER -IV(Theory)	Cell Biology	P	4	100
		PAPER -IV(Practical)	Cell Biology			
5	III	PAPER -V(Theory)	Principles of Ecology	P	4	100
		PAPER -V(Practical)	Principles of Ecology			
6		PAPER -VI(Theory)	Physiology: Controlling and Coordinating Systems	P	4	100
		PAPER -VI(Practical)	Physiology: Controlling and Coordinating Systems			
7		PAPER -VII(Theory)	Fundamentals of Biochemistry	P	4	100
		PAPER -VII(Practical)	Fundamentals of Biochemistry			
8	IV	PAPER -VIII(Theory)	Endocrinology & Reproductive Biology	P	4	100
		PAPER -VIII(Practical)	Endocrinology & Reproductive Biology			
9		PAPER -IX(Theory)	Comparative Anatomy of Vertebrates	P	4	100
		PAPER -IX(Practical)	Comparative Anatomy of Vertebrates			
10		PAPER -X(Theory)	Physiology: Life Sustaining Systems	P	4	100
		PAPER -X(Practical)	Physiology: Life Sustaining Systems			
11	V	PAPER -XI(Theory)	Biochemistry of Metabolic Processes	P	4	100
		PAPER -XI(Practical)	Biochemistry of Metabolic Processes			
12		PAPER -XII(Theory)	Principles of Genetics	P	4	100
		PAPER -XII(Practical)	Principles of Genetics			
13		PAPER -XIII(Theory)	Molecular Biology	P	4	100

		PAPER -III(Practical)	Molecular Biology			
14	VI	PAPER -XIV(Theory)	Developmental Biology	P	4	100
		PAPER -XIV(Practical)	Developmental Biology			
15		PAPER -XV(Theory)	Taxonomy and Evolutionary Biology	P	4	100
		PAPER -XV(Practical)	Taxonomy and Evolutionary Biology			
			FOURTH YEAR HONS WITHOUT RESEARCH			
16	VII	Core XVI(Theory)	Instrumentation and Techniques	P	4	100
		Core XVI(Practical)	Instrumentation and Techniques			
17		Core XVII(Theory)	Biostatistics and Bioinformatics	P	4	100
		Core XVII(Practical)	Biostatistics and Bioinformatics			
18		Core XVIII(Theory)	Animal Biotechnology	P	4	100
		Core XVIII(Practical)	Animal Biotechnology			
19		Core XIX(Theory)	Immunology	P	4	100
		Core XIX(Practical)	Immunology			
20	VIII	Core XX(Theory)	Aquatic Biology and Toxicology	P	4	100
		Core XX(Practical)	Aquatic Biology and Toxicology			
21		Core XXI(Theory)	Wildlife and Conservation Biology	P	4	100
		Core XXI(Practical)	Wildlife and Conservation Biology			
22		Core XXII(Theory)	Chronobiology & Animal Behaviour	P	4	100
		Core XXII(Practical)	Chronobiology & Animal Behaviour			
23		Core XXIII	Research Project	P	4	100
			FOURTH YEAR HONS WITH RESEARCH			
24	VII	Core XVI(Theory)	Instrumentation and Techniques	P	4	100
		Core XVI(Practical)	Instrumentation and Techniques			
25		Core XVII(Theory)	Biostatistics and Bioinformatics	P	4	100
		Core XVII(Practical)	Biostatistics and Bioinformatics			
26		Core XVIII(Theory)	Animal Biotechnology	P	4	100
		Core XVIII(Practical)	Animal Biotechnology			
27	VIII	Core XIX(Theory)	Aquatic Biology and Toxicology	P	4	100
		Core XIX(Practical)	Aquatic Biology and Toxicology			
28		Core XX(Theory)	Wildlife and Conservation Biology	P	4	100
		Core XX(Practical)	Wildlife and Conservation Biology			
29		Core XXI	RESEARCH		12	
CORE II/ MINOR I: ZOOLOGY						
1	I	PAPER -I(Theory)	Invertebrates: Protista to Echinodermata	P	4	100
		PAPER -I(Practical)	Invertebrates: Protista to Echinodermata			
2	III	PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	P	4	100

		PAPER -II(Practical)	Diversity of Chordates: Protochordates to Mammalia			
3	V	PAPER -III(Theory)	Microbiology	P	4	100
		PAPER -III(Practical)	Microbiology			
CORE III/ MINOR II: ZOOLOGY						
1	II	PAPER -I(Theory)	Invertebrates: Protista to Echinodermata	P	4	100
		PAPER -I(Practical)	Invertebrates: Protista to Echinodermata			
2	IV	PAPER -II(Theory)	Diversity of Chordates: Protochordates to Mammalia	P	4	100
		PAPER -II(Practical)	Diversity of Chordates: Protochordates to Mammalia			
3	VI	PAPER -III(Theory)	Microbiology	P	4	100
		PAPER -III(Practical)	Microbiology			
CORE II/ MINOR I: ZOOLOGY (FOURTH YEAR HONS WITHOUT RESEARCH) (Wef 24-25 session)						
	VII	PAPER -IV(Theory)	Cell Biology	P	4	100
		PAPER -IV(Practical)	Cell Biology			
	VIII	PAPER -V(Theory)	Principles of Ecology	P	4	100
		PAPER -V(Practical)	Principles of Ecology			
CORE II/ MINOR I: ZOOLOGY (FOURTH YEAR HONS WITH RESEARCH) (Wef 24-25 session)						
	VII	PAPER -IV(Theory)	Cell Biology	P	4	100
		PAPER -IV(Practical)	Cell Biology			
		PAPER -V(Theory)	Principles of Ecology	P	4	100
		PAPER -V(Practical)	Principles of Ecology			

NB: P- Practical, NP-Non Practical

OTHER COURSES

MULTIDISCIPLINARY COURSES (MDC) UNDER NEP-2020

Three courses to be chosen from **baskets of Multidisciplinary courses** for Semester-I/II/III with 3 credits each. Students are advised to choose one course/ Semester from the basket provided. Students are advised to opt for courses outside their discipline. No repetition of courses allowed.

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)

Sl No	Paper	Dept to teach the Course	Course title	Credit	Full mark
SEMESTER-I					
1	I	Chemistry	Environmental Chemistry	3	100
2		Botany	Gardening and Vermicomposting	3	100
3		Economics	Economics in Everyday Life	3	100
4		History	History of Education in Modern India	3	100
5		Odia	Tulanatmak Sahitya	3	100
6		Pol Sc	Political Process in India	3	100
7		English	Ethical Literature	3	100
8		Commerce	Financial Literacy	3	100
9		Education	Educational Psychology	3	100
SEMESTER-II					
1	II	Statistics	Survival Analysis and Biostatistics	3	100
2		Zoology	Apiculture	3	100
3		Education	Gender and Education	3	100
4		Geography/Geology	Climatology	3	100
5		Philosophy	Vedic Culture	3	100
6		Hindi	Vigyapan Avadharana Aur Prayojanmulak Aayam	3	100
7		Home Science	Food Science and Nutrition	3	100
8		Commerce	Fundamentals of Entrepreneurship and E- Commerce	3	100
9		Economics	Demography	3	100
SEMESTER-III					
1	III	Mathematics/Computer sc	Programming in C++	3	100
2		Physics	Introduction to Spectroscopy	3	100
3		History/Sanskrit	Indian Knowledge System	3	100
4		Pol Sc	Human Rights	3	100
5		Sociology	Environmental Issues and Challenges	3	100
6		Commerce	Entrepreneurship Development and Start-up	3	100
7		Psychology	Health psychology	3	100
8		Sanskrit	Philosophy of Bhagavad Gita	3	100
9		Botany	Herbarium Preparation	3	100

NB: All courses are Non Practical papers.

ABILITY ENHANCEMENT COURSE(AEC) UNDER NEP-2020

Sl No	Semester	Course	Credit hour (CH)	Full Mark
1	I	Odia/Hindi/Sanskrit/Urdu	4	100
2	II	English	4	100

SKILL ENHANCEMENT COURSES (SEC) UNDER NEP-2020

Three courses to be chosen from the **baskets of SEC** for Semester-II/V/VI, respectively with 3 credits each. Student can opt any one of SEC courses in a particular semester from the basket without repetition.

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)

Sl No	Semester	Paper	Course title	Credit hour (CH)	Marks
1	II	PAPER I	Personality Development Or Election studies and public opinion Or Quantitative and Logical Thinking Or Analytical Thinking and Logical Reasoning Or Renewable Energy & Energy Harvesting Or Vermicomposting	3	100
2	V	PAPER II	Yoga in Everyday Life Or Basics of Museum and Achieves Or Working with Communities Or Fundamentals of data science and data management Or Quantitative and Logical Thinking Or Programming With Mathematica	3	100
2	VI	PAPER III	Life Skill Education Or Quantitative and Logical Thinking Or Income Tax E-return Filing Or Organic Farming Or Biofertilizer Or Type Setting in Latex	3	100

NB: All courses are Non Practical (NP) papers.

VALUE AIDED COURSES (VAC) UNDER NEP – 2020

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)

Sl No	Semester	Paper	Course title	Credit	Marks
1	I	PAPER I	Environmental Studies and Disaster Management	3	100
2	III	PAPER II	Ethics & Values	3	100
3	V	PAPER III	Understanding Odisha	3	100
4	VI	PAPER IV	Creative Writing	3	100

COMMUNITY ENGAGEMENT AND SERVICES/FIELD WORK/INTERNSHIP UNDER NEP-2020

(Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)

Sl No	Semester	Course Description	Credit	Marks
1	IV	Community Engagement and Services/ Field work/ Internship: The curricular component of 'community engagement and services will involve activities that would expose students to the socio-economic issues in society so that the theoretical learning can be supplemented by actual life experiences to generate solutions to real-life problems. In 4 th semester the students have to be engaged in Internship/community engagement/Field work for 120hrs. related to major. The programme will be conducted following guidelines of Sambalpur University vide letter No-1372/Acd-I Dated 16.03.2026.	4	100

SUMMER VOCATIONAL COURSE UNDER NEP – 2020

(Students who want to exit after the second semester / Fourth Semester shall pursue a vocational course from the basket to get a certificate. Ref: University Letter No-3177/Acd. – I, Dated: 15. 07. 2025)

Sl No	Course Title	Credit	Marks
1	Social Impact Assessment study	4	100
2	Nursery Management	4	100
3	Fundamentals of Horticulture	4	100
4	Education in Early Childhood	4	100
5	Environmental Conservation	4	100

Process of Multiple Entry and Exit:

11.1 A student after completion of 1st academic Session with completion of 42 Credits and an additional 04 Credits in vocational stream can exit with a certificate issued by the HEI/University concerned. Such student can re –enter to the UG programme into the 3rd semester within two years from award of his certificate.

11.2 A student after completion of 2nd year with 84 and an additional **4 credit** in Vocational Stream can exit with a diploma. Such students can re-enter to UG programme in 5th semester within two years from award of this diploma.

11.3 Student who desires to undergo a 3-year degree programme will be allowed to exit after completion of 3rd year with minimum of 126/150 credits with a degree.

11.4 However, the total duration for completing the UG program shall not exceed 7 years from the admission into the 1st year Academic Session.

11.5 Students may acquire additional credit under Value-added / Multi-Disciplinary / Swayam etc. The additional credit shall not be taken into account for Division/ Grade/ Rank etc. They shall not count for admission into higher program.

EVALUATION

Distribution of Marks in Semester End and Continuous Evaluation: (Irrespective of credit in a course/Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continuous Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	100	60	20	20	----	--
With Practical	100	50	10	10	20	10

Distribution of Sessional Marks

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz	Assignment/Presentation
Without Practical	40	20	Above 95%- 5 Marks	10	05
With Practical	30	(Theory 10 + Practical 10)=20	85%-94%- 4 Marks	05	Nil
			75%-84%- 3 Marks		

Examination Question Pattern of Term End Examination

The term end theory examination shall be for 100 marks of three hour's duration, the weightage shall be 50 with practical and 60 without practical.

Question Pattern		With Practical	Without Practical
Part-I –Objective	Answer in MCQ /One word /Sentence. (All are Compulsory)	1x10=10	1x10=10
Part-II- Very Short Type	Answer maximum 50 words (All are Compulsory)	2x9=18	2x9=18
Part-III- Short Type	Answer maximum 250 words Answer any 8 out of 10 questions	5x8=40	5x8=40
Part-IV- Long Type	Answer maximum 800 words Answer any 4 out of 5 questions	8x4=32	8x4=32
Total		100	100
For Practical Paper		One Major Experiment-10 Record- 05 Viva voce-05	

Grading System

Qualification	Grade	Mark Secured from 100	Grade Point	CGPA	Classification for Hons. (Applicable to 4yr Course only)	Classification for Pass
Outstanding	‘O’	90-100	10	≥ 9.5	First Class Hons.	Pass
Excellent	‘A+’	80-89	9	≥ 8.5 - < 9.5		
Very Good	‘A’	70-79	8	≥ 7.5 - < 8.5		
Good	‘B+’	60-69	7	≥ 6.5 - < 7.5		
Above Average	‘B’	50-59	6	≥ 5.5 - < 6.5	Second Class Hons.	
Fair	‘C’	45-49	5	≥ 5.0 - < 5.5		
Pass	‘D’	40-44	4	≥ 4.0 - < 5.0		
Fail	‘F’	Below 40	0	Below 4.0		Fail
Absent	‘AB’	00	0			Fail
Malpractice	‘M’	00	0			MP

N.B.

- *A candidate has to secured Grade D or above to pass in each of the paper (Individually in Theory, Practical and Project)*
- *FAIL /MP/HARD CASE and Back Paper Clearance candidates in any Semester Examination are not eligible for award of Distinction.*

CALCULATION OF GP, SGPA, CGPA AND PERCENTAGE OF MARK

A student's level of competence shall be categorized by a GRADE POINT AVERAGE to be specified as: SGPA- Semester Grade Point Average, CGPA- Cumulative Grade Point Average

- Grade Point- Integer equivalent of each letter grade
- CREDIT- Integer signifying the relative emphasis of individual course item(s) in a semester as indicated by the Course structure and syllabus.

CREDIT POINT: CREDIT x GRADE POINT for each course item

CREDIT INDEX: Σ CREDIT POINT of course items in each Semester

GRADE POINT AVERAGE = $\frac{\text{CREDIT INDEX}}{\Sigma \text{CREDIT}}$

Semester Grade Point Average (SGPA) = $\frac{\text{CREDIT INDEX for each semester}}{\Sigma \text{CREDIT}}$

Cumulative Grade Point Average (CGPA) = $\frac{\text{CREDIT INDEX of all previous Semesters up to the 6}^{\text{th}} / 8^{\text{th}} \text{ Semester}}{\Sigma \text{CREDIT}}$

Case a: Equivalent Percentage of Mark = $(\text{CGPA} - 0.50) \times 10$ (for $\text{CGPA} > 4.5$ and $\text{CGPA} \leq 10$)

Case b: Equivalent Percentage of Mark = $\text{CGPA} \times 10$ (for $\text{CGPA} \leq 4.5$)

2% of the total as grace mark subject to maximum of 5 (five) marks in single paper shall be given to pass in a semester. This shall be applicable in each semester

UG PROGRAMME IN ZOOLOGY

Program Outcomes (PO):

- PO1 - Students gain knowledge and skill in the fundamentals of animal sciences, understands the complex interactions among various living organisms.
- PO2 – Analyse complex interactions among the various animals of different phyla, their distribution and their relationship with the environment.
- PO3 – Apply the knowledge of internal structure of cell, its functions in control of various metabolic functions of organisms.
- PO4 – Understands the complex evolutionary processes and behaviour of animals.
- PO5 – Correlates the physiological processes of animals and relationship of organ systems.
- PO6 – Gain knowledge of small scale industries like sericulture, fish farming, bee keeping, aquaculture, animal husbandry, poultry farm.
- PO7 – Understands about various concepts of genetics and its importance in human health.
- PO8 - Apply the knowledge and understanding of Zoology to one's own life and work.
- PO9 – Develops empathy and love towards the animals

Program Specific Outcomes (PSO):

- PSO1. Understand the nature and basic concepts of cell biology, genetics, taxonomy, physiology, biochemistry, ecology, evolutionary biology, developmental biology and applied and economic zoology.
- PSO2. Analyse the relationships among animals, plants and microbes.
- PSO3. Perform procedures as per laboratory standards in the areas of Taxonomy, Physiology, Ecology, Cell biology, Genetics, tools and techniques of Zoology, Biochemistry, molecular biology, Reproductive Biology and Animal biotechnology.
- PSO4. Understand the applications of biological sciences in Apiculture, Aquaculture, Sericulture, Animal Husbandry, Poultry Farm.
- PSO5. Gains knowledge about effective communication and skills of problem solving methods.
- PSO6. Contributes the knowledge for Nation building.

SEMESTER I

CORE I: PAPER I

Invertebrates: Protista to Echinodermata

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the general characteristics of non-chordate groups of organisms.
- Acquire knowledge regarding classification of the taxa with examples.
- Develop an understanding of important phenomena associated with each taxon.
- Acquire skills in identifying representative species of groups studied.
- Illustrate phylogenetic distribution of lower groups of Non-chordates.
- Understand elaboration of coelomic evolution and metamerism on Coelomates with their classification up to their class and excretion system in Annelidans.
- Recognize insect vision, respiration and metamorphosis in Arthropoda with reference to Termites and in evolutionary significance of Onychophora with general characteristics.
- Obtain an over view of the general features, respiration, Gastropodan evolution, mechanism of torsion, and significance of larval life stages.
- Acquire knowledge on general characters and classification of Echinoderms and their affinities with Chordates.

Course Outcome:

- Utilize information to understand the differences of the groups studied.
- Develop skills in examining diversity of the taxa.
- Develops skills in elaborating the general features and evolutionary significance of the coelomate from Annelida to Echinoderms.
- Impactful visual understanding and enables the students to correlate the evolutionary significance of each organism on the phylogenetic tree.
- Study on various general features and characteristics of body symmetry and arrangement with various vision types, excretory systems and developmental stage give a strong fundamental understanding on the subject on Coelomates.

Learning Outcome

- Systematically understand the diverse group of organisms from Protista to Cnidaria and Ctenophora
- Systematically understand the diverse group of organisms that make up Phyla Platyhelminthes and Nematelminthes.
- Understand the diverse organisms that make up Phyla from Annelida, Arthropoda and Onychophora.
- Understand the diverse organisms that make up Phyla from Mollusca and Echinodermata and significant processes associated.

Unit 1: Protista to Cnidaria and Minor Phylum Ctenophora

General characteristics and Classification up to classes. Locomotion, Nutrition and Reproduction in Protista, Life cycle and pathogenicity of *Plasmodium vivax*, Canal system and spicules in sponges, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora.

Unit 2: Platyhelminthes and Nemathelminthes

General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes

Unit 3: Annelida, Arthropoda and Onychophora

General characteristics and Classification up to classes. Evolution of coelom and metamerism. Excretion in Annelida, Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

Unit 4: Mollusca and Echinodermata

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva. Water-vascular system in Echinoderms, Larval forms in Echinodermata

TEXT BOOKS

- ✓ Kotpal RL; *Modern Textbook of Zoology – Invertebrates*; Rastogi Publications - Meerut; 2016 edition.
- ✓ Richard Brusca, W. Moore, Stephen M. Shuster. *Invertebrates*; OUP USA; 3 edition (19 January 2016).

SUGGESTED READINGS

- ✓ Richard Fox, Robert D. Barnes, Edward E. Ruppert, *Invertebrate Zoology: A Functional Evolutionary Approach*, Brooks/Cole; 7th edition edition 2003
- ✓ Barrington, E.J.W. *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.
- ✓ Hyman, L.H. *Invertebrate Series (Recent edition)*.
- ✓ Parker JJ and WA Haswel *Textbook of Zoology*. Vol I and II.
- ✓ Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.
- ✓ Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science.

Invertebrates: Protista to Echinodermata

Practical

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*.
2. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*, Spicules and Spongin fibers.
3. Study of Cnidarians *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora*., *Ctenophore*.
4. Study of Life cycle stages of *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides* (Slides/micro-photographs).
5. Study of Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*.
6. Study of Arthropods – Crab, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx mori*, *Periplaneta americana*, termites, honey bees and *Peripatus*
7. Study of Molluscs and Echinodermata- *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.
Echinodermata - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
8. Study of digestive system, nephridia of earthworm (Virtual), T.S. through pharynx, gizzard, and typhlosolar region of earthworm, Mounting of mouth parts and dissection of digestive system and nervous system (Virtual) of *Periplaneta americana*.
9. To submit a Project Report on any related topic.

Suggested Reading

- ✓ Verma PS and Srivastava PC. (2011) *Advanced Practical Zoology*. S Chand Publication.
- ✓ S.S Lal. (2019) *Practical Zoology (Invertebrate)* Rastogi Publications.

CORE I: PAPER II

Diversity of Chordates: Protochordates to Mammalia

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The students learn about the salient features, diversity and distribution of all Chordates.
- To know the evolution of aquatic, amphibious and terrestrial vertebrates.
- To understand the importance of distribution of vertebrates in different realms.

Course Outcome:

- Understanding the origin, larval forms, distribution and adaptation of different vertebrates.
- Accumulating the knowledge and understanding on the classification, affinities and comparative anatomy of different vertebrates and their evolutionary significance.
- Learning the mechanism of flight and aquatic adaptations in birds and mammals.
- Obtaining knowledge pertaining to the distribution of animals particularly vertebrate in different realms.

Learning Outcome:

- Gain understanding of Protochordates and origin of Chordates.
- Knowledge regarding characteristics and classification of Agnatha, Pisces, Amphibia, and evolution of tetrapoda.
- Understanding characteristics and classification of Reptiles and Aves and their connecting links.
- Comprehend characteristics and organization of mammals, in addition to their distribution in zoogeographical realms.

Unit 1: Protochordates and Origin of Chordates

General characteristics and outline classification Chordata (Protochordata: Hemichordata, Urochordata and Cephalochordata). Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordat; Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Agnatha, Pisces & Amphibia

General characteristics and classification up to order. Migration, Parental care in fishes, Accessory respiratory organs in Pisces, Evolutionary significance of Dipnoi.
Amphibia: Origin of Tetrapoda (Evolution of terrestrial ectotherms); Parental care.

Unit 3: Reptilia & Aves

General characteristics and classification up to order. Affinities of Sphenodon; Poison apparatus and Biting mechanism in snakes. Archaeopteryx- a connecting link; Flight adaptations and Migration in birds.

Unit 4: Mammals & Zoogeography

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages. Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

PRACTICAL

1. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*, Urochordata, Sections of *Balanoglossus* through proboscis and branchio-genital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slides of *Herdmania* spicules, *Doliolum*, *Salpa*
2. Agnatha: *Petromyzon* and *Myxine*.
3. Fishes: *Scoliodon*, *Sphyrna*, *Pristis*, *Torpedo*, *Chimaera*, *Mystus*, *Heteropneustes*, *Labeo*, *Exocoetus*, *Echeneis*, *Anguilla*, *Hippocampus*, *Tetrodon/ Diodon*, *Anabas*, Flat fish.
4. Amphibia: *Ichthyophis/Ureotyphlus*, *Necturus*, *Bufo*, *Hyla*, *Alytes*, Salamander.
5. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*. Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws. Study of feathers.
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceus*.
8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

Text Books:

- ✓ *Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition*
- ✓ *Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.*
- ✓ *Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons.*

Suggested Readings:

- ✓ *Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.*
- ✓ *Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jonesand Bartlett Publishers Inc.*
- ✓ *Hickman CP, Roberts LS, Keen S, Larson A, I'AnsonH, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication.*

SEMESTER II
CORE I: PAPER III
Microbiology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of microbial diversity and classification.
- To understand microbial culture, growth and reproduction.
- To understand the importance of viral pathogenicity, nature of viral transmission.
- To comprehend the importance of Anti-viral drugs and vaccines.

Course Outcome:

- Obtaining knowledge pertaining to future scopes and modern trends of microbiology.
- Understanding the experimental approaches to explore the origin of microbes.
- Understanding the morphology, classification and significance of host-vector relationship.
- Learning the mechanism of action of microbial toxins and pathogenicity.
- Obtaining knowledge on pathogenic manifestation of Oncoviruses & HIV.

Learning Outcome:

- Finding the historical background and modern experimental approaches to understand the origin and development of microbiology.
- Analysing the general features, classification and pathogenicity of Archea and Eubacteria.
- Deducing knowledge on role of microbes in agriculture and healthcare sector.
- Interpreting the mechanism of antibacterial and anti-viral their mode of action, and importance of vaccines.

Unit-1

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

Unit-2

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction.

General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

Unit-3

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

Unit-4

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

CORE I: PAPER -IV

Cell Biology (4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Introducing prokaryotic and eukaryotic cells and their features, ultrastructure of plasma membrane and mechanism of transport of molecules across plasma membrane.
- To know the structure, function and properties of endomembrane & cytoskeletal network system and cell organelles.
- To understand the importance of mitochondria in aerobes, the role of mitochondrial electron transport chain, oxidative phosphorylation & mechanism of ATP synthesis.
- To study the structure and packaging of chromosome in nucleus, behaviour of chromosome during cell division, cell cycle and its regulation.

Course Outcome:

- Understanding the difference between prokaryotic and eukaryotic cells and the mechanism of transportation across their membrane system.
- Understanding the role of cytoskeleton in maintaining structural frame work, cell motility and cell organelles.
- Deciphering the role of mitochondria in cellular respiration and energy production.
- Obtaining knowledge on structure and function of nucleus, cell division and regulation of cell cycle.

Learning Outcome

Understanding Cell junctions and mechanism of transportation across membrane.

- Obtaining knowledge on structural and functional aspect of cytoskeleton and endomembrane system.
- Obtaining knowledge on nucleus, nucleosome and cell division and cell cycle regulation.
- Knowledge about mitochondrial respiratory chain, chemi-osmotic hypothesis and functions of peroxisome.

Unit 1: Overview of cells and plasma membrane

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure. Transport across membranes: Active and Passive transport, Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

Unit 2: Cytoskeleton & Endomembrane System

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments;
Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes.

Unit 3: Mitochondria and Peroxisomes

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis;
Mitochondrial Respiratory Chain, Chemo-osmotic hypothesis. Peroxisomes.

Unit 4: Nucleus, Cell Division and Cell Signalling

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin:
Euchromatin and Heterochromatin and packaging (nucleosome); Mitosis, Meiosis, Cell
cycle and its regulation; GPCR and Role of second messenger (cAMP).

Text Books:

- ✓ *Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.*
- ✓ *De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.*

Suggested Readings:

- ✓ *Bruce Albert, Bray Dennis, Lewis Julian, Raff Martin, Roberts Keith and Watson James (2008). Molecular Biology of the Cell, V Edition, Garland publishing Inc., New York and London.*
- ✓ *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.*
- ✓ *Suvarna S, Lyton C, Bancroft JD (2013) Theory and practice of histological techniques, Churchill Livingstone, Elsevier, UK*
- ✓ *Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.*

PRACTICAL

1. Understanding of simple and compound microscopes.
2. To study different cell types such as buccal epithelial cells, striated muscle cells using Methylene blue/any suitable stain (virtual/ slide/slaughtered tissue).
3. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
4. Study of various stages of meiosis in grasshopper testis
5. Preparation of permanent slide to show the presence of Barr body in human

female blood cells/cheek cells.

6. Preparation of permanent slide to demonstrate:
 - i. DNA by Feulgen reaction
 - ii. DNA and RNA by MGP
 - iii. Mucopolysaccharides by PAS reaction
 - iv. Proteins by Mercuric bromophenol blue/Fast Green
7. Demonstration of osmosis (RBC/ Egg etc.).

Suggested Reading:

1. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. S Chand Publication.
2. S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.

SEMESTER-III

CORE I: PAPER V

Principles of Ecology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the concept of an ecosystem, its attributes, factors and functioning.
- Learn about population attributes, growth patterns, strategies; regulation and interactions.
- To appraise learners regarding various community characteristics.
- Comprehend biological data, learn graphical representation of data, sampling techniques, grasp basic statistics.
- Acquire skills on plotting survivorship curves, quadrat method of determining population density, diversity indices, techniques of preservation and mounting of plankton, determination of ecological parameters.

Course Outcome:

- Utilize information to understand interrelations and working of an ecosystem.
- Demonstrate the ability to comprehend data, plot graphs, present data and apply basic statistics.

Learning Outcome:

- Understand food chain dynamics and energy flow patterns.
- Gain knowledge about population dynamics.
- Understand community stratification and succession.
- Gain knowledge about representation of data, data processing and analysis.

Unit 1: Ecosystem and Applied Ecology

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Laws of limiting factors, Study of physical factors- (Light, temperature).

Unit 2: Population

Attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density- dependent

and independent factors, Population interactions, Gause's Principle with laboratory and field examples.

Unit 3: Community

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

Unit – 4: Biometry

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test).

Text Book:

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition*
- ✓ *Smith and Smith, Elements of Ecology, Global Edition; Pearson Education India; ninth edition (14 May 2015).*
- ✓ *Myra Samuels, J. Witmer, A. Schaffner, Statistics for the life sciences, Prentice Halls, Boston, 4th edition, 2012.*

Suggested Readings:

- ✓ *Kormondy, (2017). Concepts of Ecology, Updated 4/e, Pearson.*
- ✓ *Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc. Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.*
- ✓ *Ricklefs, R.E., (2000). Ecology. 5th Edition. Chiron Press.*
- ✓ *Dash M.C., Fundamentals of Ecology. Mc GrawHill*
- ✓ *Smith TM and Smith RL, Elements of Ecology, 8th Edition, Pearson education INC, USA*
- ✓ *Miller, G.T. and Spoolman, S.E. (2017) Environmental Science, 14th Edition. Cengage Publication, New Delhi.*

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition.*
- ✓ *Cengage Publication, New Delhi*
- ✓ *Web site: <https://www.cbd.int/>*
- ✓ *Baneerjee Pranab Kumar, Introduction to biostatistics, S Chand & Company; 3rd Rev. Edn. 2006 edition*
- ✓ *Chainy GBN, Mishra G, MohantyPK, 2004, Basic Biostatistics, Kalyani Publisher.*

PRACTICAL

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton collection, preservation and mounting, Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), BOD, COD, Free CO₂, Hardness, TDS.
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
5. Chi-square analysis using seeds/beads/Drosophila.
6. Problems on standard deviation.
7. Graphical representation of data (Frequency polygon and Histogram).

Suggested Reading:

- ✓ *Practical Ecology by David Slingsby, Ceridwen Cook, Red Globe Press London.*
- ✓ *Practical Methods in Ecology by Henderson Peter A. John Wiley and Sons Ltd.*
- ✓ *Practical Ecology by Rao K S, K.S. Rao. Anmol Publications.*

CORE I: PAPER-VI

Physiology: Controlling and Coordinating systems

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Develop an understanding of tissues and tissue systems with clarity on types and functions of each.
- Acquire knowledge on the muscle and nervous system.
- Obtain information about various receptors, their functioning and understand the mechanism of action.

Course Outcome:

- Acquire skills in differentiating tissues based on their structure and functions.
- Gain insights on the controlling and coordinating systems of the body.

Learning Outcome:

- Gain knowledge about tissue composition and function.
- Understand muscle types and mechanism of action.
- Understand functioning of different type of receptors.
- Acquire knowledge on osmoregulation and thermoregulation.

Unit 1: Tissues & Tissue system

Structure, location, classification and functions of epithelial tissue, connective tissue, muscular tissue and nervous tissue. Structure and types of bones and cartilages, Ossification, bone growth and resorption.

Unit 2: Muscle & Nervous System

Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction. Introduction to CNS, PNS and ANS. Structure of neuron, Types of neurons, Action potential and its propagation, Synapse and synaptic transmission, Neuromuscular junction; Reflex action.

Unit 3: Physiology of Special senses

Sensory Neurons-types; Physiology and pathway- hearing and balance, Olfaction, Gustation and Vision. Interoception – Nociceptors, Baroreceptors, Chemoreceptors, Thermoreceptors, Osmoreceptors, Cutaneous Receptors.

Unit 4: Homeostasis

Homeostasis and body fluids, Sources of body water and loss, Control of homeostasis, Homeostatic imbalances. Osmoregulation in fish, thermoregulation in Poikilotherms, homeotherms and heterotherms.

Text Books:

- ✓ *Marieb EN and Hoehn K, Human Physiology, (2013), 9th edition, Pearson Education, USA.*
- ✓ *Endocrinology, Hadley ME and Levine JE (2009), Pearson Education India; 6 edition.*
- ✓ *Textbook of Medical Physiology, Guyton & Hall, Elsevier, 12th edition, 2016.*

Suggested Books:

- ✓ *Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition., Lippincott W. & Wilkins*
- ✓ *Martini F H, Nath J L and Bartholomew E F (2015) Fundamentals of Anatomy and Physiology. Pearson Education Publication,*
- ✓ *Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B.Saunders Company.*
- ✓ *Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.*

Practical**Physiology: Controlling and Coordinating systems**

1. Demonstration of the unconditioned reflex action (Deep tendon reflex such as knee jerk reflex).
2. Study of permanent slides- Squamous epithelium, Striated muscle fibres, nerve cells and others relevant to the theory.
3. Microtomy: Preparation of permanent slides.
4. Models of mammalian tissues (Any five) /photographs.
5. Effect of salt concentration on cells.

CORE I: PAPER VII
Fundamentals of Biochemistry
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- To gain understanding of fundamentals of biochemistry and biological macromolecules.
- To understand structure, classification, properties and significance of biomolecules.
- Acquire knowledge on nomenclature, classification and mechanism of enzyme action, regulation and its kinetics.

Course Outcome:

- To understand the structure and biological importance of protein, carbohydrates, lipids, nucleic acids and enzymes.
- Providing knowledge on types of amino acids and its polymeric form.
- Learning the structure and pairing of nucleotides, denaturation and denaturation kinetics of DNA.
- Obtaining knowledge on enzymes and isoenzymes, specificity, inhibition, derivation of Michaelis-Menten equation.

Learning Outcome:

- Gaining knowledge on different classes of biological macromolecules such as carbohydrates, lipids and nucleic acids.
- Understanding the structure of proteins and its monomers.
- Learning the structure of nucleic acids, denaturation and renaturation kinetics of DNA.
- Interpret the activities of enzymes and isoenzymes.

Unit 1: Carbohydrates & Lipids

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

Unit 2: Proteins

Amino acids: Structure, Classification and General properties of α -amino acids; Physiological importance of essential and non-essential α -amino acids.

Proteins: Bonds stabilizing protein structure; Levels of organization in proteins; Renaturation, Denaturation; Introduction to simple and conjugate proteins

Immunoglobulins: Basic Structure, Classes and Function, Antigenic Determinants.

Unit 3: Nucleic Acids

Structure: Purines and pyrimidines, Nucleosides, Nucleotides, Nucleic acids. Cot Curves, Base pairing, Denaturation and Renaturation of DNA, Types of DNA and RNA, Complementarity of DNA, Hypo and Hyperchromaticity of DNA.

Unit 4: Enzymes

Nomenclature and classification, Cofactors, Specificity of enzyme action, Isozymes, Mechanism of enzyme action, Enzyme kinetics, Factors affecting rate of enzyme-catalyzed reactions, Derivation of Michaelis-Menten equation, Concept of K_m and V_{max} , Lineweaver-Burk plot, Multi-substrate reactions, Enzyme inhibition, Allosteric enzymes and their kinetics, Regulation of enzyme action.

Text Books:

- ✓ Satyanarayan and Chakrapani, (2017) *Biochemistry*, Elsevier; Fifth edition
- ✓ Cox, M.M and Nelson, D.L. (2008). *Lehninger's Principles of Biochemistry*, V Edition, W.H. Freeman and Co., New York.
- ✓ Jeremy M. Berg, Lubert Stryer, John L. Tymoczko, Gregory J. Gatto, *Biochemistry*, 8th edition, 2015.
- ✓ Victor W., Rodwell, David A., Bender, Kathleen M., Botham, Peter J., Kennelly, P. Anthony, *Harper's Illustrated Biochemistry*, 31st edition.

Suggested Readings:

- ✓ Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). *Harper's Illustrated Biochemistry*, XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.
- ✓ Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008). *Molecular Biology of the Gene*, VI Edition, Cold Spring Harbor Lab. Press, Pearson Publication.
- ✓ Hames, B.D. and Hooper, N.M. (2000). *Instant Notes in Biochemistry*, II Edition, BIOS Scientific Publishers Ltd., U.K.
- ✓ Devasena T. (2010). *Enzymology* Oxford University Press; 1 edition
- ✓ Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007). *Biochemistry*, VI Edition, W.H. Freeman and Co., New York.

Fundamentals of Biochemistry

Practical:

1. Qualitative tests of functional groups in carbohydrates, proteins and lipids.
2. Paper chromatography of amino acids.
3. Action of salivary amylase under optimum conditions.
4. Effect of pH, temperature and inhibitors on the action of salivary amylase/Urease/acid or alkaline phosphatase
5. Demonstration of proteins separation by SDS-PAGE.

SEMESTER-IV

CORE I: PAPER VIII

Endocrinology & Reproductive Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Insights on the history of endocrinology, study endocrine glands, hormones, control and regulation
- Acquire knowledge on the various facets of the reproductive system and their endocrine aspects.

Course Outcome:

- Essential clarity on endocrine gland structures, hormones, functions and their regulation.
- Scientific knowledge base on reproductive health and endocrine control.

Learning Outcome:

- Acquire information on the history of endocrinology, endocrine glands, and hormones.
- Gain an understanding of the Hypothalamo-hypophyseal axis and regulation of hormone action.
- Understand the endocrine aspects of reproductive system.
- Recognize different aspects of reproductive health and Assisted Reproductive Technology.

Unit 1: Introduction to Endocrinology

A brief history of endocrinology, Types of endocrine glands (Pituitary, Pineal, Thyroid, Parathyroid, Adrenal, Pancreas), their histology, hormones, functions and disorders; General characteristics of Hormones, Classification, Hormone receptors, Mechanism of hormone action (steroidal and non-steroidal hormones) and transduction .

Unit 2: Hypothalamo-hypophyseal Axis and Regulation of Hormone Action

Structure of hypothalamus, Hypothalamic nuclei, Neurosecretions, Neurohormones and their functions, Hypothalamo-hypophyseal portal system, Hypothalamic-pituitary-gonadal axis,

Hormone action at cellular and molecular level, Genetic control of hormone action. Regulation-Feedback mechanisms.

Unit 3: Reproductive System-endocrine aspects

Testis: Histology; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Sperm transportation in male tract; Ovary: Histology, folliculogenesis, ovulation, corpus luteum formation and regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles and their regulation, Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization, prevention of polyspermy; Hormonal control-implantation and gestation, foeto-maternal

relationship; Parturition and Lactation.

Unit 4: Reproductive Health

Infertility in male and female: causes, diagnosis and management; Assisted Reproductive Technology: sex selection, sperm banks, frozen embryos, in vitro fertilization, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST; Modern contraceptive technologies; Demographic terminology used in family planning.

Text Books:

- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Hadley, M.E. and Levine J.E. (2007). Endocrinology, 6th Edition. Pearson Prentice-Hall, Pearson Education Inc., New Jersey*
- ✓ *Austin, C.R. and Short, R.V. (1982) Reproduction in Mammals. Cambridge University Press.*
- ✓ *C. Donnell Turner (2012) General Endocrinology Pub- Affiliated East-West press Pvt. Ltd.-New Delhi; 6th Edition*
- ✓ *Tandulwadkar Sunita R (2015) The Art & Science Of Assisted Reproductive Technology, Jaypee Brothers Medical Publishers*

Suggested Readings:

- ✓ *Stephen Nussey and Saffron Whitehead (2001). Endocrinology: An Integrated Approach; Oxford: BIOS Scientific Publishers*
- ✓ *Tony M. Plant and Anthony J. Zeleznik (2015) Knobil and Neill's Physiology of Reproduction, Academic Press*

Endocrinology & Reproductive Biology

Practical:

1. Dissect and display of Endocrine glands in laboratory bred rat*.
2. Study of the permanent slides of all the endocrine glands.
3. Study and identification of endocrine disorders through images.
4. Compensatory ovarian/ adrenal hypertrophy in vivo bioassay in laboratory bred rat*.
5. Demonstration of Castration/ ovariectomy in laboratory bred rat*.
6. Estimation of plasma level of any hormone using ELISA.
7. Designing of primers of any hormone.
8. Examination of vaginal smear from live animals and examination of Human vaginal exfoliate cytology.
9. Surgical techniques: principles of surgery in endocrinology. Ovariectomy, hysterectomy, castration and vasectomy in rats. (*Subject to UGC guidelines)

10. Sperm count and sperm motility in rat.
11. Study of modern contraceptive devices.
12. Report on endocrine disorders in human.
13. Paper chromatographic separation of hormones.
14. Hypophysectomy in fish (Tilapia/catfish/ locally available fish)

CORE I: PAPER IX
Comparative Anatomy of Vertebrates
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand anatomical significance of organ system in vertebrates.
- Comprehend structure, function and various derivatives of Integumentary, Skeletal, digestive, respiratory, circulatory, urinogenital and nervous system.

Course Outcome:

- Learner gains detailed overview of the anatomical resemblance amongst vertebrates hierarchies.
- Acquires knowledge on cellular development of organ systems in the vertebrates and linear progression of cellular derivatives during organogenesis.
- Understand the process of linear and vertical cellular evolutionary processes.

Learning Outcome:

- Acquire knowledge of the integument, and skeleton systems.
- Gain knowledge on the Gastro intestinal canal, associated glands, and respiration system.
- Obtain knowledge of the Circulatory and Urinogenital systems and their evolution.
- Comparative study of mammalian nervous system & sense organs.

Unit 1: Integumentary & Skeletal System

Structure, functions and derivatives of integument (Scale, claw, nail, hair, feather and dentition). Axial and appendicular skeleton, Jaw suspensorium, Visceral arches.

Unit 2: Digestive & Respiratory System

Alimentary canal and associated glands; Respiration through Skin, gills, lungs and air sacs; Accessory respiratory organs.

Unit 3: Circulatory and Urinogenital system

General plan of circulation, evolution of heart and aortic arches; Succession of kidney, Evolution of urinogenital ducts, Types of mammalian uteri.

Unit 4: Nervous System & Sense Organs

Comparative account of brain; Nervous system, Spinal cord, Cranial nerves in mammals. Classification of receptors: Brief account of visual and auditory receptors in man. Chemo and mechano-receptors

Practical

1. Study of placoid, cycloid and ctenoid scales through permanent slides/photographs
2. Disarticulated skeleton of Frog, Varanus, Fowl, Rabbit.
3. Carapace and plastron of turtle /tortoise (Photographs, charts etc).
4. Mammalian skulls: One herbivorous and one carnivorous animal.
5. Study of structure of any two organs (heart, lung, kidney, eye and ear) through ICT tools.
6. Project report submission on Integumentary derivatives.

Text Books:

- ✓ Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education
- ✓ Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies
- ✓ R. K. Saxena and Sumitra Saxena (2016). Comparative Anatomy of Vertebrates 2nd edition.

Suggested Readings:

- ✓ Hilderbrand, M and Gaslow G.E. *Analysis of Vertebrate tructure*, JohnWiley and Sons
- ✓ Walter, H.E. and Sayles, L.P; *Biology of Vertebrates*, Khosla Publishing House

CORE I: PAPER X
Physiology: Life Sustaining Systems
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of critical physiological processes.
- Understand anatomical attributes of Digestive, Respiratory, Renal and Cardiovascular system.
- Learn and develop an understanding of vital life-sustaining physiological processes.

Course Outcome:

- Appraise the significance of anatomical structures and physiological events.
- Apply information to understand the functioning of organisms.
- Demonstrate the ability to appreciate the occurrence of physiological actions.
- Understand interrelationships of life processes.
- Acquire practical skills in identifying different organs, and perform laboratory work based on theoretical applications

Learning Outcome:

- Acquire knowledge on digestion, respiration, renal and heart physiology.
- Understand the composition of blood grouping, functions and Blood clotting.

Unit 1: Physiology of Digestion

Structural organization and functions of gastrointestinal tract and associated glands; Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Hormonal control of secretion of enzymes in Gastrointestinal tract.

Unit 2: Physiology of Respiration

Histology of trachea and lung; Mechanism of respiration, Pulmonary ventilation; Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood; Respiratory pigments, Dissociation curves and the factors influencing it; Carbon monoxide poisoning; Control of respiration.

Unit 3: Renal Physiology

Structure of kidney and its functional unit, Mechanism of urine formation, Regulation of water balance, Regulation of acid-base balance, Homeostatic regulation of tubular reabsorption and secretion.

Unit 4: Blood and Physiology of Heart

Haemopoiesis, Components of blood and their functions; Structure and functions of

haemoglobin, Blood clotting system, Blood groups: Rh factor, ABO and MN.

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

Practical:

1. Determination of ABO Blood group.
2. Enumeration of red blood cells and white blood cells using haemocytometer.
3. Preparation of blood smear for differential count.
4. Estimation of haemoglobin using Sahli's haemoglobinometer.
5. Preparation of haemin and haemochromogen crystals.
6. Recording of blood pressure using a sphygmomanometer.
7. Examination of sections of mammalian slides: oesophagus, stomach, duodenum, ileum, rectum liver, trachea, lung, kidney.

Text Books:

- ✓ Marieb E.N. and Hoehn K.N. (2009) Human Physiology. Pearson Education Publication , 9th edition
- ✓ Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons.
- ✓ Guyton & Hall, (2016) Textbook of Medical Physiology. Elsevier, 12th edition.

Suggested Readings:

- ✓ Victor P. Eroschenko. (2008). diFiore's Atlas of Histology with Functional correlations. XII Edition. Lippincott W. & Wilkins.
- ✓ Vander A Sherman J. and Luciano D. (2014). Vander's Human Physiology: The Mechanism of Body Function. XIII Edition, McGraw Hills.
- ✓ Moyes C.D., Schulte PM (2016), Principles of physiology, 2nd edition, Pearson education, 3rd.
- ✓ Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. W.B. Saunders Company.

SEMESTER -V

CORE I: PAPER XI

Biochemistry of Metabolic Processes (4Credit, Theory-45h and Practical – 30h)

Programme Outcome

- Understanding of catabolism, anabolism and regulatory mechanism of intermediary metabolism.
- To learn the processes of carbohydrate, lipid and protein metabolism.
- To obtain knowledge on redox regulation and electron transport system.

Course Outcome:

- Gain overall knowledge and understanding on metabolic pathways and shuttle systems.
- Gain knowledge on carbohydrate metabolism related processes.
- Understanding of β -oxidation and catabolism of amino acids.
- Understanding on mitochondrial respiratory chain and oxidative phosphorylation.

Learning Outcome:

- Gain knowledge on the compartmentalization of metabolic pathways.
- Understand role of intermediate and carbohydrate regulatory metabolism.
- Gain knowledge on β and omega oxidation of saturated fatty acids.
- Understand the role of mitochondria in energy production during electron transport.

Unit 1: Overview of Metabolism

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

Unit 2: Carbohydrate Metabolism

Sequence of reactions and regulation of glycolysis, Citric acid cycle, Phosphate pentose pathway, Gluconeogenesis, Glycogenolysis and Glycogenesis.

Unit 3: Lipid and protein Metabolism

β -oxidation and omega -oxidation of saturated fatty acids with even and odd number of carbon atoms; Biosynthesis of palmitic acid; Ketogenesis

Catabolism of amino acids: Transamination, Deamination, Urea cycle; Fate of C-skeleton of Glucogenic and Ketogenic amino acids.

Unit 4: Oxidative Phosphorylation

Redox systems; Review of mitochondrial respiratory chain, Inhibitors and un-couplers of Electron Transport System.

Practical

1. Estimation of total protein in given solutions
2. Measurement of SGOT and SGPT activity.
3. Determination of GSH level in serum/tissue.
4. Measurement of GST activity.
5. To study the enzymatic activity of Trypsin/ Lipase.
6. To perform the Acid and Alkaline phosphatase assay from serum/ tissue.
7. Dry Lab (Virtual): To trace the labelled C atoms of Acetyl-CoA till they evolve as CO₂ in the TCA cycle.

Text Books:

- ✓ *Satyanarayan and Chakrapani, (2017) Biochemistry, Elsevier; Fifth edition.*
- ✓ *Cox, M.M and Nelson, D.L. (2008). Lehninger Principles of Biochemistry, V Edition, W.H. Freeman and Co., New York.*

Suggested Readings:

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

CORE I: PAPER XII

Principles of Genetics

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Obtain knowledge on the basic principles of genetics.
- To provide knowledge on the mechanism of sex determination and extra-chromosomal inheritance.
- To learn the process of DNA recombination, transposons and transposable elements.

Course Outcome:

- Acquire knowledge on the fundamentals of Mendelian and non-Mendelian genetics, chromosomal mapping and interaction of genes.
- Providing the knowledge and understanding on linkage, crossing over, sex determination and role of extra-chromosomal inheritance.
- Obtaining knowledge on chromosomal aberration, cause and consequences of mutations.

Learning Outcome:

- Understand principles of Mendelian genetics.
- Discern types of gene mutations and chromosomal aberrations with detection methods..
- Gain an understanding of mechanisms of sex determination and extra chromosomal inheritance.
- Understand the process of recombination and transposable genetic elements.

Unit 1: Mendelian Genetics, Linkage, Crossing Over and Chromosomal Mapping

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Sex-linked, sex-influenced and sex-limited characters inheritance. Polygenic inheritance with suitable examples; simple numerical based on it.

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanisms of crossing over including models of recombination, Recombination frequency as a measure of linkage intensity, Two factor and three factor crosses, Interference and coincidence, Somatic cell hybridization.

Unit 2: Mutations

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), Molecular basis of mutations in relation to UV light and chemical mutagens; Detection of mutations: CLB and sex- linked visible attached X method.

Unit 3: Sex Determination & Extra-chromosomal Inheritance

Chromosomal mechanisms of sex determination in Drosophila and Man; Criteria for extra-

chromosomal inheritance, Antibiotic resistance in Chlamydomonas, Mitochondrial mutations in Saccharomyces, Cytoplasmic inheritance in Paramecium.

Unit 4: Recombination in Bacteria and Viruses & Transposable Genetic Elements

Conjugation, Transformation, Transduction, Complementation test in Bacteriophage. Transposons in bacteria, Ac-Ds elements in maize and P elements in Drosophila, Transposons in human.

Practical

1. Study of Mendelian laws and gene interactions.
2. Linkage maps based on data from conjugation, transformation and transduction.
3. Linkage maps based on data from Drosophila crosses.
4. Study of human karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Experiments on epistatic interactions including test cross and back cross.
7. Experiments on probability and Chi-square test.
8. Study on sex linked inheritance in Drosophila.

Text Books:

- ✓ Benjamin Pierce, (2015) *Genetics- A Conceptual Approach*, 5th edition, WH Freemanpublication
- ✓ Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). *Concepts of Genetics*. X Edition.

Suggested Readings:

- ✓ Benjamin Cummings. Russell, P. J. (2009). *Genetics- A Molecular Approach*. III Edition.
- ✓ Snustad, D.P., Simmons, M.J. (2009). *Principles of Genetics*. V Edition. John Wileyand Sons Inc.
- ✓ Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. *Introduction to Genetic Analysis*. IX Edition. W. H. Freeman and Co.
- ✓ Fletcher H. and Hickey I. (2015). *Genetics*. IV Edition. GS, Taylor and Francis Group, New York and London.

CORE I: PAPER- XIII

Molecular Biology (4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Detailed information on DNA structure, different forms, their properties and types of RNA.
- Understanding mechanism of DNA replication and repair in prokaryotes and eukaryotes.
- Gain knowledge on mechanism of transcription and translation in prokaryotic and eukaryotic cells.
- Acquire knowledge on post transcriptional modifications of RNA.

Course Outcome:

- Gain knowledge on details of Watson-Crick Model of DNA, RNA types .
- Understand the process of DNA replication, transcription, translation and their regulatory mechanisms.
- Gain knowledge on genetic code & regulatory machinery.
- Understand gene expression and role of RNA interference elements.

Learning Outcome:

- Gain knowledge on the fundamentals of double helical structure of DNA, denaturation and renaturation kinetics DNA, mechanism of replication and repair of DNA.
- Acquire knowledge on process of transcription, translation and post-processing regulatory mechanisms.
- Obtain knowledge on splicing mechanism, RNA editing, Processing of rRNA and tRNA.
- Understand operon concept and regulation.

Unit 1: Nucleic Acids, DNA Replication & Repair

Salient features of DNA: Watson and Crick model of DNA, DNA denaturation and renaturation kinetics, Cot curves, C-value paradox, Salient features of RNA

DNA Replication in prokaryotes and eukaryotes: Semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear ds-DNA and RNA priming, replication of telomeres.

DNA repair mechanism: Base and nucleotide excision repair in bacteria, Mismatch repair, SOS repair.

Unit 2: Transcription & Translation

Transcription: RNA polymerase and transcription Unit, mechanism of transcription in

prokaryotes and eukaryotes, synthesis of rRNA and mRNA, transcription factors and regulation of transcription.

Translation: Genetic code, Degeneracy of the genetic code and Wobble Hypothesis, Process of protein synthesis in prokaryotes: Ribosome structure and assembly in prokaryotes, Fidelity of protein synthesis, Aminoacyl tRNA synthetase and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Inhibitors of protein synthesis; Difference between prokaryotic and eukaryotic translation.

Unit 3: Post Transcriptional Modifications and Processing of Eukaryotic RNA

Structure of globin mRNA; Split genes: concept of introns and exons, splicing mechanism, alternative splicing, exon shuffling, and RNA editing, Processing of rRNA and tRNA.

Unit 4: Gene Regulation &Regulatory RNAs

Transcription regulation in prokaryotes: Principles of transcriptional regulation with examples from Lac-operon and Trp-operon; Transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements; Gene silencing, RNA interference, miRNA, si-RNA.

Text books:

- ✓ Karp G, Iwasa J, Marshall W. Karp's Cell and Molecular Biology, 9th Edition. John Wiley and Sons. Inc. ISBN: 978-1-119-59816-9
- ✓ Krebs JE, Goldstein ES, Kilpatrick ST. (2018) Lewin's Gene XII, Jones and Bartlett Publishers, Inc. ISBN: 9781284104493.
- ✓ DeRobertis E. D. P. (2017) Cell and Molecular Biology 8th Edition. ISBN: 10-8184734506, 13-978-8184734508
- ✓ Lodish H, Berk A, Kaiser CA, Kreiger M, Bretscher A, Ploegh H, Amon A, Martin KC. (2016) Molecular Cell Biology.8th Edition. WH Freeman. ISBN: 10- 1464183392, 13-978-1464183393

Suggested Readings:

- ✓ *Becker W. M., Kleinsmith L.J., Hardin J, Bertoni G.P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.*
- ✓ *Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P (2002) Molecular Biology of the Cell, 4th Edition. ISBN: 10-0815332181, 13-978-0815332183*
- ✓ *Cooper G.M. and Robert E. Hausman R.E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.*
- ✓ *McLennan A., Bates A., Turner, P. and White M. (2015). Molecular Biology IV Edition. GS, Taylor and Francis Group, New York and London.*
- ✓ *Lewin's Genes XII- by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick*

PRACTICAL
Molecular Biology

1. Study of Polytene chromosomes from Chironomous / *Drosophila* larvae.
2. Preparation of liquid culture medium (LB) and raise culture of *E.coli*..
3. Estimation of the growth kinetics of *E. coli* by turbidity method.
4. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
5. Quantitative estimation of calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A 260 nm measurement).
6. Quantitative estimation of RNA using Orcinol reaction.
7. Study and interpretation of electron micrographs/photograph showing (a) DNA replication, (b) Transcription and (c) Split genes.

SEMESTER-VI

CORE I: PAPER XIV

Developmental Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the phases of development, changes, regulation and the concepts of ageing and teratogenesis.
- Gain knowledge on In- Vitro fertilization and amniocentesis.

Course Outcome:

- Understand the basic concepts of gametogenesis, fertilization and embryogenesis.
- Gain knowledge on interferences in developmental biology.

Learning Outcome:

- Apprise the historical perspectives of Developmental Biology with the basic concepts.
- Understanding of the phases and changes associated with early, late and post- embryonic development

Unit 1: Introduction to Developmental Biology, Gametogenesis & Fertilization

Historical perspective and basic concepts: Phases of development, Cell-Cell interaction, Pattern formation, Differentiation and growth, Differential gene expression, Cytoplasmic determinants and asymmetric cell division. Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal); Changes in gametes, Blocks to polyspermy.

Unit 2: Early Embryonic Development

Cleavage: Planes and patterns of cleavage, Types of Blastula, Fate maps (including Techniques); Early development of frog and chick up to gastrulation; Embryonic induction and organizers.

Unit 3: Late Embryonic Development

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, Placenta (Structure, types and functions of placenta).

Unit 4: Post Embryonic Development & Interferences in Developmental Biology

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

Text Books:

- ✓ *Lewis Wolpert (2010). Principles of Development. II Edition, Oxford University Press.*
- ✓ *Gilbert, S. F. (2017). Developmental Biology, XI Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.*

Suggested Readings:

- ✓ *Carlson, R. F. Patten's Foundations of Embryology.*
- ✓ *Kalthoff (2008). Analysis of Biological Development, II Edition, McGraw-Hill Publishers.*
- ✓ *Verma PS and Agrawal VK, Chordata Embryology (2010) (S Chand Publication).*

Developmental Biology**Practical:**

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages).
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages).
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture.
4. Study of different sections of placenta (photomicrograph/slides).
5. Project report on *Drosophila* culture/chick embryo development.
6. Study of developmental stages by raising chick embryo in the laboratory.
7. Estimation of calcium in egg shell.
8. Estimation of carbohydrates and proteins in egg.

CORE I: PAPER -XV

Taxonomy and Evolutionary Biology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Familiarize learners with concepts of Taxonomy.
- Gain overview of the beginning of life and evolutionary theories.
- Understand various physical forces or stress pressures during evolution.
- Gain knowledge on correlates of epigenetic changes in the cellular footprints of animals and genetic lineages exerted through various physical forces.
- Comprehend the origin of evolution in Hominides with reference to Primates, validate evidence of human origin by molecular and phylogenetic sequence analysis.

Course Outcome:

- Understand concepts of taxonomy. Obtain knowledge of life initiation and its evolution through the chronological landscape.
- Know the evolutionary relationship of organisms with response to various physical forces leading to adaptive evolution.
- Strengthen student's analytical approach to evolutionary relationships.

Learning Outcome:

- Acquisition of knowledge on concepts of taxonomy and species.
- Acquaint learners with theories of evolution, evidences, and the process of changes over time.
- Gain knowledge on construction and interpretation of phylogenetic tree in relation to evolution.

Unit 1: Concepts of Taxonomy

Importance & Applications of biosystematics; taxonomic characters, Hierarchy categories; biological classification; Taxonomic procedures: collections, preservation, curation, identification, Keys; International Code of Zoological Nomenclature (ICZN): operative principles, important rules; Zoological nomenclature; Chemo and sero taxonomy, Cytotaxonomy, Numerical taxonomy, and DNA barcoding. Taxonomic publications: Kinds, Major features of manuscript for publication.

Unit 2: Theories, Evidences of Evolution and Extinction

Life's Beginnings: Chemogeny, RNA world, Biogeny, Evolution of eukaryotes. Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism. Evidences of Evolution: Fossil record (types of fossils, transitional forms, geological time scale, evolution of horse), Sources of variations: Heritable variations and their role in evolution. Extinctions, Background and mass extinctions (causes and effects), detailed example of K-T extinction.

Unit 3: Process of Evolutionary changes

Population genetics: Hardy-Weinberg Law (statement and derivation of equation, application of law to human Population); Evolutionary forces upsetting H-W equilibrium; Natural selection (concept of fitness, selection coefficient, derivation of one

unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection). Genetic Drift (mechanism, founder's effect, bottleneck phenomenon); Role of Migration and Mutation in changing allele frequencies.

Unit 4: Products of evolution, Species concept, Origin and Evolution of man

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation-allopatric, sympatric, Parapatric. Adaptive radiation/ macroevolution (exemplified by Galapagos finches). Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular analysis of human origin. Phylogenetic trees, multiple sequence alignment, construction and interpretation of phylogenetic trees.

Text Books:

- ✓ *Principle of Animal Taxonomy*; G.G. Simpson. Oxford IBH Publishing Company.
- ✓ *Elements of Taxonomy*. E. Mayer.
- ✓ *The diversity of life (The College Edition)*, E.O. Wilson. W.W. Northern & co.
- ✓ *Theory and Practice of Animal Taxonomy*. V.C. Kapoor. Oxford & IBH Publishing Co. Pvt. LTD.
- ✓ *Advancement in Invertebrate Taxonomy and Biodiversity*. Rajeev Gupta. Agrobios International. Campbell, N.A. and Reece J.B (2011). *Biology*. IX Edition. Pearson, Benjamin, Cummings.
- ✓ Rastogi B.B., (2018). *Organic Evolution*, MedTech; 3rd edition

Suggested Readings:

- ✓ B.K. and Hallgrimson, B. (2008). *Evolution IV Edition*. Jones and Barlett Publishers.
- ✓ Douglas, J. Futuyma (1997). *Evolutionary Biology*. Sinauer Associates.
- ✓ Ridley, M (2004) *Evolution III Edition* Blackwell publishing Hall.

Taxonomy and Evolutionary Biology

Practical

1. Study of equipment used in sample collection.
2. Use of taxonomic keys in identification.
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Study of fossils from models/pictures
5. Study of homology and analogy from suitable specimens
6. Study and verification of Hardy-Weinberg Law by chi-square analysis
7. Demonstration of the role of natural selection and genetic drift in changing allele frequencies using simulation studies
8. Graphical representation and interpretation of data of height/weight of a sample of 100 humans in relation to their age and sex.
9. Construction of phylogenetic trees with the help of bioinformatics tools (Clustal X, Phylip, NJ) and its interpretation.

Text Books

- ✓ *Principles of Taxonomy by Ashok Verma.*
- ✓ *Evolutionary Biology with Practical by Tripurari Mishra.*

FOURTH YEAR WITHOUT RESEARCH

Semester VII

Core I. PAPER- XVI

Instrumentation and Techniques

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The programme will impart the basic understanding on instrumentation and techniques.
- Students will gain knowledge on working principles of scientific equipment's.
- Programme strengthens student's skills in handling laboratory equipment's and performing experiments.

Course Outcome:

- Insights into basic understanding of instruments and their operational principles.
- Students will gain knowledge on principles of centrifugation, and chromatographic techniques like Paper chromatographic, TLC, Column chromatography (GC, GEC, Ion-exchange, affinity and HPLC).
- Course will strengthen the learners on basic techniques on gel electrophoresis and blotting.

Learning Outcome:

- Understand the basic principles of microscopy, spectrophotometer and radioisotope techniques.
- Gain knowledge on principle and techniques of centrifugation and chromatography.
- Knowledge in electrophoresis and blotting technique.

Unit I:

Instrumentation and operation: Principle of Light, Fluorescence and Electron Microscopes and their applications. UV-Visible absorption Spectroscopy: Principle, instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltammetry, pH electrode. Radioisotope techniques: Measurement of radioactivity in biological materials (carbon dating, Geiger-Muller counting and liquid scintillation counting).

Unit II:

Centrifugation techniques: Basic principles of sedimentation, Rotor types, Types of centrifugation. Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

Unit III:

Electrophoretic techniques: Principle and applications of electrophoresis of proteins (SDSPAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels) and Nucleic acids (Agarose gel electrophoresis).

Unit IV:

Blotting techniques: Principle, Instrumentation and applications (Southern, Northern and Western blotting). Flow cytometry; Basic principle, Instrumentation and application.

Text Book Reading:

- Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)
- Biophysical Chemistry: Principles and techniques – Upadhyay A, Upadhyay K and Nath N (Himalaya Publishing House).
- An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).
- A Textbook of Biophysics- R N Roy (NCBA, New Central Book Agency)

SUGGESTED READING

- Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978-1-11943660-7. 37
- Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.
- Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science Texts Series, DOI 10.1007/978-1-4419-1478-1-27.
- Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.

Practical

Instrumentation and Techniques

1. Calibration of pH meter using standards and determine the pH of water samples.
2. Isolation of genomic DNA from animal tissue/blood.
3. Quantification and purity check of isolated DNA.
4. Agarose gel electrophoresis of DNA.
5. SDS PAGE (Demonstration).
6. Isolation of Mitochondria.
7. Study of Microscopic methods.
8. Study of Microtomy and Histological techniques.
9. Blotting (Demonstration).

Core I: PAPER- XVII
Biostatistics and Bioinformatics
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The programme gives the information to students on concepts of biostatistics and bioinformatics.
- The knowledge of biostatistics gives the dynamics application of population sampling methods and utilities through various methods and statistical tools.
- The study of bioinformatics will impart the deep knowledge on various informatics tools and web resources for analysis of cellular biomolecules.

Course Outcome:

- To understand the various methods of sampling towards qualitative and quantitative analysis of its distributions in population.
- Students will be acquainted with the measures of central tendency and dispersion through mean, median and mode.
- Learners will be able to understand the function and application of probability distribution, hypothesis testing and principal component analysis.
- This course will make the students understand the biological data bases through various web resources by studying bioinformatics.

Learning Outcome:

- Studying this course student will utilize their knowledge of statistical analysis while working with biological samples and applying its functional applicability through bioinformatics.
- Students will be able to disseminate the concept of central tendency and dispersion, measure of ranges, variance, and deviations.
- Learning outcome on probability theory and distribution will make the student understand the concept of dispersion and its distribution, hypothesis testing and principal component analysis.
- Students will gain the knowledge on utilizing bioinformatics web resources for structural and functional analysis of biological macromolecules.

Unit-I

Introduction: definition and scope of biostatistics. Concepts of population and methods of sampling. Simple random sampling, stratified sampling, systematic and clustered sampling. Types of biological data: Qualitative and quantitative, cross sectional and time series, discrete and continuous. Data Measurement scales: Nominal, ordinal, interval and ratio. Data presentation: Tabular and graphical. Histogram and Frequency distribution, cumulative

frequency distributions and its graphical representation.

Unit-II

Basic concept of measures of Central tendency and Dispersion. Mean, Median and Mode. Arithmetic, Geometric and Harmonic means. Measure of Range, Variance (sample and population), Quartile deviation, Mean deviation, Standard deviation and their relative measures.

Unit-III

Probability distributions: Normal (Dispersion percentage & Z-score) and binomial distribution. Inferential statistics: Hypothesis testing (Null hypothesis), p-value, χ^2 test, t-test (one sample t-test and paired sample t-test). Principal component analysis.

Unit-IV

Introduction to bioinformatics and its web resources: NCBI, EMBL-EBI, ExPASy, etc. Biological data resources, access and management. Various genome across the tree of life and major sequencing projects. Data base to store and analyze DNA, RNA, protein sequences and 3-D structures (motifs and domains). Local and Global Sequence alignment programs. Genome and protein BLAST. Scoring matrices, E-value and Bit-score. OTUs and molecular phylogenetics.

Text Book Reading:

- Basics Biostatistics- GBN Chainy (Kalyani publishers)
- Biostatistical analysis- Jerrold H. Zar 5th Edition
- Introduction to Bioinformatics- Arthur M Lesk (Oxford University Press)

Suggested Reading:

- Welham, S. J, Gezan, S. A, Clark, S. J, Mead, A. 2014. Statistical Methods in Biology [electronic resource]. Design and Analysis of Experiments and Regression Hoboken: CRC Pres.
 - Pavan Kumar Agrawal and Rahul Shrivastava. 2017. Bioinformatics Database Resources chapter – 4. DOI: 10.4018/978-1-5225-1871-6.ch004
 - Basic Statistical analysis- Richard C. Sprinthal - 9th edition (Pearson)
 - Fundamentals of Biostatistics- Bernard Rosner- 8th edition (Brooks/Cole)
- Biostatistics and Bioinformatics

Practical

1. Data presentation by histogram and frequency tables (diagrams and graphs).
2. Determination of Arithmetic mean, geometric mean and harmonic mean.
3. Analysis of problems on Mean, Median and Modes.
4. Analysis of problems on χ^2 test, t-test.
5. Analysis of problem on Assumption and validations of Hypothesis testing.
6. Use of bioinformatics tools (online) for analysis of sequence similarity of DNA, RNA and Proteins.

Core I: PAPER- XVIII
Animal Biotechnology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Acquires knowledge on animal biotechnology.
- Gain knowledge of techniques in molecular biology and genetic engineering.
- Skills learners on methods of animal cell culture, Recombinant DNA technology and gene therapy.

Course Outcome:

- Students gain understanding of cloning vectors, restriction enzymes, genomic and cDNA libraries.
- Understand the process and applications of genetically modified organisms/ animals.

Learning Outcome:

- The study outcome will help the students in applying their knowledge of animal biotechnology in biological research and pharmaceuticals.
- Molecular techniques strengthen learners for extrapolating the functional relevance of nucleic acid.
- Gain knowledge on transgenics and knockout mice.
- Acquire skills in animal cell culture and cloning, expression of transgenes, recombinant protein production, and gene therapy.

Unit 1: Introduction to Animal Biotechnology

Concept and scope of biotechnology, cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC and Expression vectors (characteristics).

Restriction enzymes: Nomenclature, detailed study of Type II, Construction of genomic and cDNA libraries and screening by colony and plaque hybridization

Transformation techniques: Calcium chloride method and electroporation

Unit 2: Molecular Techniques

Blotting: Southern, Northern and Western blotting, DNA sequencing: Sanger method

Polymerase Chain Reaction, DNA Finger Printing and DNA microarray

Unit 3: Genetically Modified Organisms

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

Unit 4: Culture Techniques and Applications

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

Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene

therapy.

Text Books:

- BD Singh, (2014) Biotechnology: Expanding Horizons, Kalyani Publishers
- U.Satyanarayana and U Chakrapani, (2014) Biotechnology, Books & Allied Ltd
- T.A. Brown. (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell. ISBN-10-9781119072560
- S.B. Primrose and R.M. Twyman (2006) Principles of Gene Manipulation and Genomics. 7th Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3
- Richard J. Reece (2003) *Analysis of Genes and Genomes. 8th Edition. ISBN: 978-0-470-84380-2*

Suggested Readings:

- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- Brown, T.A. (2015). Gene Cloning and DNA Analysis. 7th Edition, Academic Press, California, USA.

Practical

Animal Biotechnology

1. Genomic DNA isolation from E. coli / Animal tissue
2. Plasmid DNA isolation (pUC 18/19) from E. coli
3. Restriction digestion of plasmid DNA / Lambda Phage DNA
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through photographs
 - a. Southern Blotting
 - b. Northern Blotting
 - c. Western Blotting
 - d. DNA Sequencing (Sanger's Method)
 - e. PCR
 - f. DNA fingerprinting.

Core I: PAPER- XIX
Immunology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Imparts the knowledge of immunological defense system of human body.
- Understand the type and functions of various immune cells.
- Learner gain knowledge on primary functions of immune system and role of vaccine in combating disease.

Course Outcome:

- Knowledge on types and cells of immune system and their functions in physiological defense against pathogens.
- Understand the functions of various antigens and immunoglobins in cellular response.
- Learners gain knowledge of structure and function of cell surface and secreted molecules.
- Understand naturally occurring allergens and their role in hypersensitive reactions.

Learning Outcome:

- Gain of knowledge and expertise in the field of immunology to cater to the functional applicability of immunological defence in health care management.
- Learner acquainted with structural components of immune cells with their functions like antigenicity, immunogenicity and antigen antibody interactions.
- Understand the role of MHC, Cytokines, and Complement system in immunological defence.
- Gain knowledge on immune cells eliciting hypersensitive reactions and types of vaccines and production.

Unit 1: Innate and Adaptive Immunity

Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate immunity, Adaptive immunity (Cell mediated and humoral), passive: Artificial and natural Immunity, Active: Artificial and natural Immunity.

Unit 2: Antigens and Immunoglobulins

Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Immunoglobulins: Structure and functions of different classes of immunoglobulins, Antigen antibody interactions, Immunoassays (ELISA- Direct, Indirect, Competitive, Sandwich and RIA).

Unit 3: Major Histocompatibility Complex, Cytokines and Complement system

Structure and functions of MHC molecules. Endogenous and exogenous pathways of

antigen processing and presentation; Cytokines – Types, properties and functions, Complement System -Components and pathways of complement activation.

Unit 4: Hypersensitivity and Vaccines

Gell and Coombs' causes of hypersensitive reactions, classification and brief description of various types of hypersensitivities. Vaccines -various types of vaccines, Advances in vaccine production.

Text Books:

- Abbas K. Abul and Lechtman H. Andrew (2017). Cellular and Molecular Immunology. V Edition. Saunders Publication.
 - Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J (2017). Immunology, VI Edition. W.H. Freeman and Company.
 - Fahim Halim Khan (2009). The Elements of Immunology. Pearson Education.
- Suggested Readings:
- Peter J. Delves and Seamus J. Martin (2017) Roitt's Essential Immunology, Wiley-Blackwell; 13th edition. Immunology- Weir
 - Lab manual in Biochemistry, Immunology and Biotechnology- Arti Nigam and Archana Ayyagari (McGraw-Hill Education (India)).

Immunology

Practical

1. Study of lymphoid organs.
2. Histological study of spleen, thymus, skin and lymph nodes through slides/ photographs
3. Preparation of stained blood film to study various types of White blood cells.
4. ABO blood group determination.
5. Total WBC counting.
6. Differential count.
7. WIDAL Test.
8. Demonstration of ELISA.
9. Demonstration of Bone marrow smears to study Immune cells.

SEMESTER VIII

Core I: PAPER- XX

Aquatic Biology and Toxicology (4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Acquire knowledge on aquatic biomes
- Gain an understanding of the freshwater and marine realm and the factors influencing the systems.
- Obtain information on the management of resources associated with such systems.

Course Outcome:

- Skills obtained in estimating environmental parameters in the laboratory.
- Taxonomic basis of identification established.
- Prepare the students for a career in aquatic resources management and sustainable utilization

Learning Outcome:

- Acquire knowledge about Ocean, sea floor profile and mangroves.
- Gain knowledge about beneficial bioactive compounds from marine system.
- Understand relationship between toxicant dose concentration and response.
- Gain knowledge about POP's, contaminants and their mode of action.

Unit 1: Aquatic Biomes

Brief introduction of the aquatic biomes: Fresh water ecosystem (lakes, wetlands, streams and rivers); Marine ecosystem (Differences between Seas and oceans, profile of floor, zones (intertidal, oceanic, pelagic, benthic), estuaries- structure and types, coral reefs and mangroves.

Unit 2: Fresh water and Marine Biology

Lakes: Origin and classification, Lakes and Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbondioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous Streams: Different stages of stream development, Physico-chemical, environment, Adaptation of hill-stream fishes.

Seas and Oceans: Physico-chemical environmental factors in a marine environment, Adaptations of deep-sea organisms. Plankton, nekton, and benthos; Animal associations in marine environment- Natural associations-community, commensalism, parasitism, symbiosis in different groups; Marine Resources-algal, animal, mineral and Drugs.

Unit 3: Toxicology

Introduction to Toxicology: Sub disciplines of Toxicology, Dose-Response graphs, acute

and chronic toxicity, Measurement of LD50 and LC50 values, Bioassay with examples (Vertebrate and Invertebrate).

Unit 4: Mechanism of Toxicity

Mechanisms of Toxicity of OCIs, OPIs group of pesticides, Delivery, Absorption, Distribution, Excretion, Biotransformation, Bioaccumulation, Biomagnification, Risk

45

Assessment, Hazard Identifications (Assessing Toxicity of Chemicals), POPs (Persistent organic pollutants), Metals (Arsenic, Lead, Mercury).

Text Books:

1. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition.
2. Trivedi and Goyal: Chemical and biological methods for water pollution studies Welch: Limnology, Vols. I-II.
3. Techniques in Aquatic Toxicology, Vol-II (Gary K. Ostrader Edn.), Routledge, Taylor & Francis Group, USA.
4. A textbook of Marine ecology – N B Nair and D M Thumpty

Suggested Readings:

1. Anathakrishnan: Bioresources Ecology 3rd Edition
2. Odum and Barrett: Fundamentals of Ecology, 5th Edition
3. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition
4. Trivedi and Goyal: Chemical and biological methods for water pollution studies
5. Welch: Limnology, Vols. I-II
6. George Karleskint, James Small, Richard Turner: Introduction To Marine Biology
7. John H Duffs.; Howard G J Worth.; (Editors). (2015). "Fundamental Toxicology". 2nd Edition Publisher: Royal Society of Chemistry; UK, 516 pages
8. Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
9. Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.
10. Fundamentals of Aquatic Toxicology; Rand, G.M and Petrocelli, S.R.(Eds), (1985), Hemisphere Publishing Corporation, Washington.

Aquatic Biology and Toxicology

Practical

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplankton, zooplankton and benthos.
3. Determine the amount of Turbidity/ transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a water body.
4. Instruments used in limnology/ marine Biology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, quadrat, grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/ Marine bioreserve/ Fisheries Institutes/ one time field study.

Core I: PAPER- XXI
Wildlife and Conservation Biology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the significance of wild life conservation.
- Gain knowledge on wild life and the need of habitable environmental parameters.
- Acquire skills on conservation strategies and wild life management.

Course Outcome:

- Gains overview of wild life conservation strategies through various acts and regulatory agencies.
- Strengthens learner's towards understanding scientific approaches to evaluate health status of wild animals and focus man-animal conflicts.

Learning Outcome:

- Acquire knowledge about the importance of conservation.
- Gain knowledge about implementation of wildlife laws.
- Understand methods of estimating population.
- Understand major conservation projects and maintenance of sanctuaries.

Unit 1: Introduction to Wildlife

Values of wild life: Positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies, Conservation and protection Laws, Wild animal of India and Odisha. Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

Unit 2: Management of Habitats

Setting back succession; Grazing logging; Mechanical treatment; Advancing the succession process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats, *In-situ* and *Ex-situ* conservation, Wild life Protection acts, Wildlife trade and its related laws.

Unit 3 Population estimation

Attributes of population: Density, natality, mortality, sex ratio computation, Bayesian models in abundance estimation (Spatial and Non Spatial); Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Census methods; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals.

Unit 4 Management planning of wildlife in protected areas

Estimation of carrying capacity; Ecotourism/ wildlife tourism in forests; Concept of climax persistence; Ecology of perturbation, National parks & sanctuaries, Community

reserve; Important features of protected areas in India; Tiger conservation: Tiger reserves in India; Management challenges in Tiger reserve.

Text Books:

1. The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.
2. Gopal Rajesh (2011) Fundamentals of Wildlife Management, Natraj Publishers.
3. Caughley G and Sinclair ARE. (1994). Wildlife Ecology and Management. Blackwell Science.

Suggested Readings:

1. Woodroffe R, Thirgood S and Rabinowitz A (2005) People and Wildlife, Conflictor Coexistence? Cambridge University.
2. Bookhout TA (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.
3. Sutherland WJ (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.
4. Hunter ML, Gibbs JB and Sterling EJ (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

Wildlife and Conservation

PRACTICAL

1. Study of equipments used in sample collection (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
2. Study of museum specimens/ pictures (relevant to Wild Life).
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
5. Identification and Demonstration of different field techniques of fauna (Odisha and India)
6. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, animal sounds.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
8. Submission of field study report (national park/ reserve forest/ sanctuary).
9. Visit to Forest/ W i l d l i f e Sanctuary/ Biodiversity Park/ Zoological Park to study animals and prepare a short report.

Core I: PAPER- XXII
Chronobiology & Animal Behaviour
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Trace the origin and history of Ethology; appreciate the significant contributions of notable animal behaviour researchers.
- Understand behaviour patterns, comprehend the physiology underlying behavioural expressions, and acquire knowledge regarding the field and laboratory study of animals behaviour.
- An understanding of social and sexual behaviour.

- Relate cues to chronobiological events and understand biological rhythms and their significance.

Course Outcome:

- Demonstrate the ability to comprehend and gauge animal behaviour in context.
- Be able to evaluate behaviour with the tools and techniques learned.

Learning Outcome:

- Acquisition of knowledge on ethology and significant contributions of researchers in the field.
- Capability to effectively understand behavioural learning patterns
- A keen sense of observation, inquiry, and capability for understanding social behaviour
- Understand chronobiological behavioural patterns.

Unit 1: Animal Behaviour

Origin and history of Ethology and Behaviour as a discipline of science; Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Tools and techniques of behavioral studies; Proximate and ultimate behaviour; Innate behaviour, Instinct, Stimulus filtering, Sign stimuli, and Code breakers.

Unit 2: Patterns of Behaviour

Stereotyped Behaviours (Orientation, Reflexes); Individual behavioural patterns; Instinct vs Learnt Behaviour; Associative learning, classical and operant conditioning, Habituation, Imprinting; Reproductive behaviour patterns- Sexual dimorphism, Mate choice, Intrasexual selection (male rivalry), Inter-sexual selection (female choice), courtship, mating systems, parental care (fish, amphibians, birds, and mammals).

Unit 3 Social Behaviour

Social Behaviour: Concept of Society; Communication and the senses; Pheromones; Altruism; Insects' society with Honey bee as an example; Foraging in honey bee and advantages of the waggle dance. Hormones, drugs and behaviour.

Unit 4: Chronobiology

Historical developments in chronobiology; Biological oscillation: the concept of Average, amplitude, phase and period. Adaptive significance of biological clocks, Relevance of biological clocks, Types and characteristics of biological rhythms: Short-and Long-term rhythms; Circadian rhythms; Tidal rhythms and Lunar rhythms; Concept of synchronization and masking; Photic- and non-photic zeitgebers; Circannual rhythms; Photoperiod and regulation of seasonal reproduction of vertebrates; Role of melatonin.

Text Books:

- John A (2009) *Animal Behaviour*. 9th Edition, Sinauer Associate Inc., USA.
- Vinod Kumar (2002) *Biological Rhythms*: Narosa Publishing House, Delhi/ Springer-Verlag, Germany.

Suggested Readings:

- AK Pati. *Chronobiology: The Dimension of Time in Biology and Medicine*. PINSA (Biological Sciences). Part B67 (6) 323-372, Dec., 2001.
- David Mc F. *Animal Behaviour*. Pitman Publishing Limited, London, UK.
Manning A and Dawkins MS. *An Introduction to Animal Behaviour*. Cambridge University Press, USA.
- Paul WS and John A (2013) *Exploring Animal Behaviour*. 6th Edition. Sinauer Associate Inc., Massachusetts, USA.
- Jay C. Dunlap, Jennifer J. Loros, Patricia J. DeCoursey (Ed). 2004, *Chronobiology*
- Biological Time Keeping: J, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.

Chronobiology and Animal Behaviour

Practical

1. To study nests and nesting habits of the birds and social insects.
2. To study the behavioural responses of wood lice in dry and humid conditions.
3. To study geotaxis behaviour in earthworms.
4. To study the phototaxis behaviour in insect larvae.
5. Study and actogram construction of locomotor activity of suitable animal models.
6. Study of circadian functions in humans (daily eating, sleep and temperature patterns).
7. Statistical analysis of animal behaviours.
8. Visit to Forest/ Wildlife Sanctuary/ Biodiversity Park/ Zoological Park to study behavioural activities of animals and prepare a short report.

CoreI: Paper- XXIII

Research Project

(4Credit)

Research project will be undertaken by each students following the guidelines. At the end Project report will be submitted by the students. The project report will be evaluated by the external examiner.

FOURTH YEAR WITH RESEARCH

Semester VII

Core I. PAPER- XVI

Instrumentation and Techniques

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The programme will impart the basic understanding on instrumentation and techniques.
- Students will gain knowledge on working principles of scientific equipment's.
- Programme strengthens student's skills in handling laboratory equipment's and performing experiments.

Course Outcome:

- Insights into basic understanding of instruments and their operational principles.
- Students will gain knowledge on principles of centrifugation, and chromatographic techniques like Paper chromatographic, TLC, Column chromatography (GC, GEC, Ion-exchange, affinity and HPLC).
- Course will strengthen the learners on basic techniques on gel electrophoresis and blotting.

Learning Outcome:

- Understand the basic principles of microscopy, spectrophotometer and radioisotope techniques.
- Gain knowledge on principle and techniques of centrifugation and chromatography.
- Knowledge in electrophoresis and blotting technique.

Unit I:

Instrumentation and operation: Principle of Light, Fluorescence and Electron Microscopes and their applications. UV-Visible absorption Spectroscopy: Principle, instrumentation and application.

Principles of electrochemical techniques: Electrochemical cells and reactions, potentiometry and voltammetry, pH electrode. Radioisotope techniques: Measurement of radioactivity in biological materials (carbon dating, Geiger-Muller counting and liquid scintillation counting).

Unit II:

Centrifugation techniques: Basic principles of sedimentation, Rotor types, Types of centrifugation. Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).

Unit III:

Electrophoretic techniques: Principle and applications of electrophoresis of proteins (SDSPAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels) and Nucleic acids (Agarose gel electrophoresis).

Unit IV:

Blotting techniques: Principle, Instrumentation and applications (Southern, Northern and Western blotting). Flow cytometry; Basic principle, Instrumentation and application.

Text Book Reading:

- Principles and techniques of Biochemistry and Molecular biology- Wilson K and Walker J (Cambridge University press)
- Biophysical Chemistry: Principles and techniques – Upadhyay A, Upadhyay K and Nath N (Himalaya Publishing House).
- An Introduction to practical Biochemistry- David T. Plummer (Tata McGraw Hill).
- A Textbook of Biophysics- R N Roy (NCBA, New Central Book Agency)

SUGGESTED READING

- Mark F. Vitha. 2018. Spectroscopy: Principles and Instrumentation. Wiley, ISBN: 978-1-11943660-7. 37
- Kay Ohlendieck and Stephen E. Harding. 2017. Centrifugation and ultracentrifugation. Basic principles of sedimentation.
- Baraem Ismail and Suzanne Nielsen. 2010. Basic Principles of Chromatography. Food Science Texts Series, DOI 10.1007/978-1-4419-1478-1-27.
- Biochemistry Laboratory: Modern Theory and Techniques: United States Edition - Rodney Boyer.

Practical

Instrumentation and Techniques

1. Calibration of pH meter using standards and determine the pH of water samples.
2. Isolation of genomic DNA from animal tissue/blood.
3. Quantification and purity check of isolated DNA.
4. Agarose gel electrophoresis of DNA.
5. SDS PAGE (Demonstration).
6. Isolation of Mitochondria.
7. Study of Microscopic methods.
8. Study of Microtomy and Histological techniques.
9. Blotting (Demonstration).

Core I: PAPER- XVII
Biostatistics and Bioinformatics
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The programme gives the information to students on concepts of biostatistics and bioinformatics.
- The knowledge of biostatistics gives the dynamics application of population sampling methods and utilities through various methods and statistical tools.
- The study of bioinformatics will impart the deep knowledge on various informatics tools and web resources for analysis of cellular biomolecules.

Course Outcome:

- To understand the various methods of sampling towards qualitative and quantitative analysis of its distributions in population.
- Students will be acquainted with the measures of central tendency and dispersion through mean, median and mode.
- Learners will be able to understand the function and application of probability distribution, hypothesis testing and principal component analysis.
- This course will make the students understand the biological data bases through various web resources by studying bioinformatics.

Learning Outcome:

- Studying this course student will utilize their knowledge of statistical analysis while working with biological samples and applying its functional applicability through bioinformatics.
- Students will be able to disseminate the concept of central tendency and dispersion, measure of ranges, variance, and deviations.
- Learning outcome on probability theory and distribution will make the student understand the concept of dispersion and its distribution, hypothesis testing and principal component analysis.
- Students will gain the knowledge on utilizing bioinformatics web resources for structural and functional analysis of biological macromolecules.

Unit-I

Introduction: definition and scope of biostatistics. Concepts of population and methods of sampling. Simple random sampling, stratified sampling, systematic and clustered sampling. Types of biological data: Qualitative and quantitative, cross sectional and time series, discrete and continuous. Data Measurement scales: Nominal, ordinal, interval and ratio. Data presentation: Tabular and graphical. Histogram and Frequency distribution, cumulative frequency distributions and its graphical representation.

Unit-II

Basic concept of measures of Central tendency and Dispersion. Mean, Median and Mode. Arithmetic, Geometric and Harmonic means. Measure of Range, Variance (sample and

population), Quartile deviation, Mean deviation, Standard deviation and their relative measures.

Unit-III

Probability distributions: Normal (Dispersion percentage & Z-score) and binomial distribution. Inferential statistics: Hypothesis testing (Null hypothesis), p-value, χ^2 test, t-test (one sample t-test and paired sample t-test). Principal component analysis.

Unit-IV

Introduction to bioinformatics and its web resources: NCBI, EMBL-EBI, ExPASy, etc. Biological data resources, access and management. Various genome across the tree of life and major sequencing projects. Data base to store and analyze DNA, RNA, protein sequences and 3-D structures (motifs and domains). Local and Global Sequence alignment programs. Genome and protein BLAST. Scoring matrices, E-value and Bit-score. OTUs and molecular phylogenetics.

Text Book Reading:

- Basics Biostatistics- GBN Chainy (Kalyani publishers)
- Biostatistical analysis- Jerrold H. Zar 5th Edition
- Introduction to Bioinformatics- Arthur M Lesk (Oxford University Press)

Suggested Reading:

- Welham, S. J, Gezan, S. A, Clark, S. J, Mead, A. 2014. Statistical Methods in Biology [electronic resource]. Design and Analysis of Experiments and Regression Hoboken: CRC Pres.
 - Pavan Kumar Agrawal and Rahul Shrivastava. 2017. Bioinformatics Database Resources chapter – 4. DOI: 10.4018/978-1-5225-1871-6.ch004
 - Basic Statistical analysis- Richard C. Sprinthal - 9th edition (Pearson)
 - Fundamentals of Biostatistics- Bernard Rosner- 8th edition (Brooks/Cole)
- Biostatistics and Bioinformatics

Practical

1. Data presentation by histogram and frequency tables (diagrams and graphs).
2. Determination of Arithmetic mean, geometric mean and harmonic mean.
3. Analysis of problems on Mean, Median and Modes.
4. Analysis of problems on χ^2 test, t-test.
5. Analysis of problem on Assumption and validations of Hypothesis testing.
6. Use of bioinformatics tools (online) for analysis of sequence similarity of DNA, RNA and Proteins.

Core I: PAPER- XVIII
Animal Biotechnology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Acquires knowledge on animal biotechnology.
- Gain knowledge of techniques in molecular biology and genetic engineering.
- Skills learners on methods of animal cell culture, Recombinant DNA technology and gene therapy.

Course Outcome:

- Students gain understanding of cloning vectors, restriction enzymes, genomic and cDNA libraries.
- Understand the process and applications of genetically modified organisms/ animals.

Learning Outcome:

- The study outcome will help the students in applying their knowledge of animal biotechnology in biological research and pharmaceuticals.
- Molecular techniques strengthen learners for extrapolating the functional relevance of nucleic acid.
- Gain knowledge on transgenics and knockout mice.
- Acquire skills in animal cell culture and cloning, expression of transgenes, recombinant protein production, and gene therapy.

Unit 1: Introduction to Animal Biotechnology

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

Unit 2: Molecular Techniques

Blotting: Southern, Northern and Western blotting, DNA sequencing: Sanger method
Polymerase Chain Reaction, DNA Finger Printing and DNA microarray

Unit 3: Genetically Modified Organisms

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

Unit 4: Culture Techniques and Applications

Animal cell culture, expressing cloned genes in mammalian cells, Molecular diagnosis of genetic diseases (Cystic fibrosis, Thalassemia, Haemophilia and Sickle cell anemia), Recombinant DNA in medicines: Recombinant insulin and human growth hormone, Gene therapy.

Text Books:

- BD Singh, (2014) Biotechnology: Expanding Horizons, Kalyani Publishers
- U.Satyanarayana and U Chakrapani, (2014) Biotechnology, Books & Allied Ltd
- T.A. Brown. (2016) Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell. ISBN-10-9781119072560
- S.B. Primrose and R.M. Twyman (2006) Principles of Gene Manipulation and Genomics. 7th Edition. Wiley-Blackwell. ISBN: 978-1-405-13544-3
- Richard J. Reece (2003) *Analysis of Genes and Genomes. 8th Edition. ISBN: 978-0-470-84380-2*

Suggested Readings:

- Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
- Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.
- Brown, T.A. (2015). Gene Cloning and DNA Analysis. 7th Edition, Academic Press, California, USA.

Practical

Animal Biotechnology

1. Genomic DNA isolation from E. coli / Animal tissue
2. Plasmid DNA isolation (pUC 18/19) from E. coli
3. Restriction digestion of plasmid DNA / Lambda Phage DNA
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from the data provided.
6. To study following techniques through photographs
 - a. Southern Blotting
 - b. Northern Blotting
 - c. Western Blotting
 - d. DNA Sequencing (Sanger's Method)
 - e. PCR
 - f. DNA fingerprinting.

SEMESTER VIII

Core I: PAPER- XIX

Aquatic Biology and Toxicology **(4Credit, Theory-45h and Practical – 30h)**

Programme Outcome:

- Acquire knowledge on aquatic biomes
- Gain an understanding of the freshwater and marine realm and the factors influencing the systems.
- Obtain information on the management of resources associated with such systems.

Course Outcome:

- Skills obtained in estimating environmental parameters in the laboratory.
- Taxonomic basis of identification established.
- Prepare the students for a career in aquatic resources management and sustainable utilization

Learning Outcome:

- Acquire knowledge about Ocean, sea floor profile and mangroves.
- Gain knowledge about beneficial bioactive compounds from marine system.
- Understand relationship between toxicant dose concentration and response.
- Gain knowledge about POP's, contaminants and their mode of action.

Unit 1: Aquatic Biomes

Brief introduction of the aquatic biomes: Fresh water ecosystem (lakes, wetlands, streams and rivers); Marine ecosystem (Differences between Seas and oceans, profile of floor, zones (intertidal, oceanic, pelagic, benthic), estuaries- structure and types, coral reefs and mangroves.

Unit 2: Fresh water and Marine Biology

Lakes: Origin and classification, Lakes and Ecosystem, Lake morphometry, Physico-chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbondioxide). Nutrient Cycles in Lakes-Nitrogen, Sulphur and Phosphorous Streams: Different stages of stream development, Physico-chemical, environment, Adaptation of hill-stream fishes.

Seas and Oceans: Physico-chemical environmental factors in a marine environment, Adaptations of deep-sea organisms. Plankton, nekton, and benthos; Animal associations in marine environment- Natural associations-community, commensalism, parasitism, symbiosis in different groups; Marine Resources-algal, animal, mineral and Drugs.

Unit 3: Toxicology

Introduction to Toxicology: Sub disciplines of Toxicology, Dose-Response graphs, acute and chronic toxicity, Measurement of LD50 and LC50 values, Bioassay with examples (Vertebrate and Invertebrate).

Unit 4: Mechanism of Toxicity

Mechanisms of Toxicity of OCIs, OPIs group of pesticides, Delivery, Absorption, Distribution, Excretion, Biotransformation, Bioaccumulation, Biomagnification, Risk

45

Assessment, Hazard Identifications (Assessing Toxicity of Chemicals), POPs (Persistent organic pollutants), Metals (Arsenic, Lead, Mercury).

Text Books:

1. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition.
2. Trivedi and Goyal: Chemical and biological methods for water pollution studies Welch: Limnology, Vols. I-II.
3. Techniques in Aquatic Toxicology, Vol-II (Gary K. Ostrader Edn.), Routledge, Taylor & Francis Group, USA.
4. A textbook of Marine ecology – N B Nair and D M Thumpty

Suggested Readings:

1. Anathakrishnan: Bioresources Ecology 3rd Edition
2. Odum and Barrett: Fundamentals of Ecology, 5th Edition
3. Pawlowski: Physicochemical Methods for Water and Wastewater Treatment, 1st Edition
4. Trivedi and Goyal: Chemical and biological methods for water pollution studies
5. Welch: Limnology, Vols. I-II
6. George Karleskint, James Small, Richard Turner: Introduction To Marine Biology
7. John H Duffs.; Howard G J Worth.; (Editors). (2015). "Fundamental Toxicology". 2nd Edition Publisher: Royal Society of Chemistry; UK, 516 pages
8. Environmental toxicology; John H. Duffs, 1980, Edward Arnold Publishers, New Delhi.
9. Elements of toxicology; J. P Shukla and Pandey, Radha Publishers, New Delhi.
10. Fundamentals of Aquatic Toxicology; Rand, G.M and Petrocelli, S.R.(Eds), (1985), Hemisphere Publishing Corporation, Washington.

Aquatic Biology and Toxicology

Practical

1. Determine the area of a lake using graphimetric and gravimetric method.
2. Identify the important macrophytes, phytoplankton, zooplankton and benthos.
3. Determine the amount of Turbidity/ transparency, Dissolved Oxygen, Free Carbon dioxide, Alkalinity (carbonates & bicarbonates) in water collected from a water body.
4. Instruments used in limnology/ marine Biology (Secchi disc, Van Dorn Bottle, Conductivity meter, Turbidity meter, quadrat, grab sampler) and their significance.
5. A Project Report on a visit to a Sewage treatment plant/ Marine bioreserve/ Fisheries Institutes/ one time field study.

Core I: PAPER- XX
Wildlife and Conservation Biology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the significance of wild life conservation.
- Gain knowledge on wild life and the need of habitable environmental parameters.
- Acquire skills on conservation strategies and wild life management.

Course Outcome:

- Gains overview of wild life conservation strategies through various acts and regulatory agencies.
- Strengthens learner's towards understanding scientific approaches to evaluate health status of wild animals and focus man-animal conflicts.

Learning Outcome:

- Acquire knowledge about the importance of conservation.
- Gain knowledge about implementation of wildlife laws.
- Understand methods of estimating population.
- Understand major conservation projects and maintenance of sanctuaries.

Unit 1: Introduction to Wildlife

Values of wild life: Positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies, Conservation and protection Laws, Wild animal of India and Odisha. Habitat analysis, Physical parameters: Topography, Geology, Soil and water; Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

Unit 2: Management of Habitats

Setting back succession; Grazing logging; Mechanical treatment; Advancing the succession process; Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats, *In-situ* and *Ex-situ* conservation, Wild life Protection acts, Wildlife trade and its related laws.

Unit 3 Population estimation

Attributes of population: Density, natality, mortality, sex ratio computation, Bayesian models in abundance estimation (Spatial and Non Spatial); Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Census methods; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animals.

Unit 4 Management planning of wildlife in protected areas

Estimation of carrying capacity; Ecotourism/ wildlife tourism in forests; Concept of climax persistence; Ecology of perturbation, National parks & sanctuaries, Community reserve; Important features of protected areas in India; Tiger conservation: Tiger reserves in India; Management challenges in Tiger reserve.

Text Books:

1. The diversity of life (The College Edition), E.O.Wilson. W.W. Northern & co.
2. Gopal Rajesh (2011) Fundamentals of Wildlife Management, Natraj Publishers.
3. Caughley G and Sinclair ARE. (1994). Wildlife Ecology and Management. Blackwell Science.

Suggested Readings:

2. Woodroffe R, Thirgood S and Rabinowitz A (2005) People and Wildlife, Conflictor Coexistence? Cambridge University.
2. Bookhout TA (1996). Research and Management Techniques for Wildlife and Habitats, 5th Edition. The Wildlife Society, Allen Press.
3. Sutherland WJ (2000). The Conservation Handbook: Research, Management and Policy. Blackwell Sciences.
4. Hunter ML, Gibbs JB and Sterling EJ (2008) Problem-Solving in Conservation Biology and Wildlife Management: Exercises for Class, Field, and Laboratory. Blackwell Publishing.

Wildlife and Conservation**PRACTICAL**

1. Study of equipments used in sample collection (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses).
2. Study of museum specimens/ pictures (relevant to Wild Life).
3. Preservation and curation of specimens (Submission of 2 specimens collected and preserved).
4. Determination of population density in a natural/ hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
5. Identification and Demonstration of different field techniques of fauna (Odisha and India)
6. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers, animal sounds.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
8. Submission of field study report (national park/ reserve forest/ sanctuary).
9. Visit to Forest/ W i l d l i f e Sanctuary/ Biodiversity Park/ Zoological Park to study animals and prepare a short report.

CoreI: Paper- XXI
Research Project
(12Credit)

Research project will be undertaken by each students following the guidelines. At the end Project report will be submitted by the students. The project report will be evaluated by the external examiner.

Core II(Minor I)/Core III(Minor II) - ZOOLOGY

Minor I/II (Paper- I)

Semester-I / II

Invertebrates: Protista to Echinodermata

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the general characteristics of non-chordate groups of organisms.
- Acquire knowledge regarding classification of the taxa with examples.
- Develop an understanding of important phenomena associated with each taxon.
- Acquire skills in identifying representative species of groups studied.
- Illustrate phylogenetic distribution of lower groups of Non-chordates.
- Understand elaboration of coelomic evolution and metamerism on Coelomates with their classification up to their class and excretion system in Annelidans.
- Recognize insect vision, respiration and metamorphosis in Arthropoda with reference to Termites and in evolutionary significance of Onychophora with general characteristics.
- Obtain an over view of the general features, respiration, Gastropodan evolution, mechanism of torsion, and significance of larval life stages.
- Acquire knowledge on general characters and classification of Echinoderms and their affinities with Chordates.

Course Outcome:

- Utilize information to understand the differences of the groups studied.
- Develop skills in examining diversity of the taxa.
- Develops skills in elaborating the general features and evolutionary significance of the coelomate from Annelida to Echinoderms.
- Impactful visual understanding and enables the students to correlate the evolutionary significance of each organism on the phylogenetic tree.
- Study on various general features and characteristics of body symmetry and arrangement with various vision types, excretory systems and developmental stage give a strong fundamental understanding on the subject on Coelomates.

Learning Outcome

- Systematically understand the diverse group of organisms from Protista to Cnidaria and Ctenophora
- Systematically understand the diverse group of organisms that make up Phyla Platyhelminthes and Nematelminthes.
- Understand the diverse organisms that make up Phyla from Annelida, Arthropoda and Onychophora.
- Understand the diverse organisms that make up Phyla from Mollusca and Echinodermata and significant processes associated.

Unit 1: Protista to Cnidaria and Minor Phylum Ctenophora

General characteristics and Classification up to classes. Locomotion, Nutrition and Reproduction in Protista, Life cycle and pathogenicity of *Plasmodium vivax*, Canal system and spicules in sponges, Metagenesis in Obelia, Polymorphism in Cnidaria, Corals and coral reefs, Evolutionary significance of Ctenophora.

Unit 2: Platyhelminthes and Nemathelminthes

General characteristics and Classification up to classes. Life cycle and pathogenicity of *Fasciola hepatica* and *Taenia solium*, Life cycle, and pathogenicity of *Ascaris lumbricoides* and *Wuchereria bancrofti*. Parasitic adaptations in helminthes

Unit 3: Annelida, Arthropoda and Onychophora

General characteristics and Classification up to classes. Evolution of coelom and metamerism. Excretion in Annelida, Vision and Respiration in Arthropoda. Metamorphosis in Insects. Social life in bees and termites. Onychophora: General characteristics and Evolutionary significance.

Unit 4: Mollusca and Echinodermata

General characteristics and Classification up to classes. Respiration in Mollusca. Torsion and detorsion in Gastropoda. Evolutionary significance of trochophore larva. Water-vascular system in Echinoderms, Larval forms in Echinodermata

TEXT BOOKS

- ✓ Kotpal RL; *Modern Textbook of Zoology – Invertebrates*; Rastogi Publications - Meerut; 2016 edition.
- ✓ Richard Brusca, W. Moore, Stephen M. Shuster. *Invertebrates*; OUP USA; 3 edition (19 January 2016).

SUGGESTED READINGS

- ✓ Richard Fox, Robert D. Barnes, Edward E. Ruppert, *Invertebrate Zoology: A Functional Evolutionary Approach*, Brooks/Cole; 7th edition edition 2003
- ✓ Barrington, E.J.W. *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.
- ✓ Hyman, L.H. *Invertebrate Series (Recent edition)*.
- ✓ Parker JJ and WA Haswel *Textbook of Zoology*. Vol I and II.
- ✓ Barrington, E.J.W. (1979). *Invertebrate Structure and Functions*. II Edition, E.L.B.S. and Nelson.
- ✓ Barnes, R.S.K., Calow, P., Olive, P. J. W., Golding, D.W. and Spicer, J.I. (2002). *The Invertebrates: A New Synthesis*, III Edition, Blackwell Science.

Invertebrates: Protista to Echinodermata

Practical

1. Study of whole mount of *Euglena*, *Amoeba* and *Paramecium*, Binary fission and Conjugation in *Paramecium*.
2. Study of *Sycon* (T.S. and L.S.), *Hyalonema*, *Euplectella*, *Spongilla*, Spicules and Spongin fibers.
3. Study of Cnidarians *Obelia*, *Physalia*, *Millepora*, *Aurelia*, *Tubipora*, *Corallium*, *Alcyonium*, *Gorgonia*, *Metridium*, *Pennatula*, *Fungia*, *Meandrina*, *Madrepora*., *Ctenophore*.
4. Study of Life cycle stages of *Fasciola hepatica*, *Taenia solium* and *Ascaris lumbricoides*
 - i. (Slides/micro-photographs).
5. Study of Annelids - *Aphrodite*, *Nereis*, *Heteronereis*, *Sabella*, *Serpula*, *Chaetopterus*, *Pheretima*, *Hirudinaria*.
6. Study of Arthropods – Crab, *Limulus*, *Palamnaeus*, *Palaemon*, *Daphnia*, *Balanus*, *Sacculina*, *Eupagurus*, *Scolopendra*, *Julus*, *Bombyx mori*, *Periplaneta americana*, termites, honey bees and *Peripatus*
7. Study of Molluscs and Echinodermata- *Chiton*, *Dentalium*, *Pila*, *Doris*, *Helix*, *Unio*, *Ostrea*, *Pinctada*, *Sepia*, *Octopus*, *Nautilus*.
 - i. Echinodermata - *Pentaceros/Asterias*, *Ophiura*, *Clypeaster*, *Echinus*, *Cucumaria* and *Antedon*
8. Study of digestive system, nephridia of earthworm (Virtual), T.S. through pharynx, gizzard, and typhlosolar region of earthworm, Mounting of mouth parts and dissection of digestive system and nervous system (Virtual) of *Periplaneta americana*.
9. To submit a Project Report on any related topic.

Suggested Reading

- ✓ Verma PS and Srivastava PC. (2011) *Advanced Practical Zoology*. S Chand Publication.
- ✓ S.S Lal. (2019) *Practical Zoology (Invertebrate)* Rastogi Publications.

Core II (MINOR I)/ Core III (Minor II): PAPER II
(SEMESTER III/IV)

Diversity of Chordates: Protochordates to Mammalia

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- The students learn about the salient features, diversity and distribution of all Chordates.
- To know the evolution of aquatic, amphibious and terrestrial vertebrates.
- To understand the importance of distribution of vertebrates in different realms.

Course Outcome:

- Understanding the origin, larval forms, distribution and adaptation of different vertebrates.
- Accumulating the knowledge and understanding on the classification, affinities and comparative anatomy of different vertebrates and their evolutionary significance.
- Learning the mechanism of flight and aquatic adaptations in birds and mammals.
- Obtaining knowledge pertaining to the distribution of animals particularly vertebrate in different realms.

Learning Outcome:

- Gain understanding of Protochordates and origin of Chordates.
- Knowledge regarding characteristics and classification of Agnatha, Pisces, Amphibia, and evolution of tetrapoda.
- Understanding characteristics and classification of Reptiles and Aves and their connecting links.
- Comprehend characteristics and organization of mammals, in addition to their distribution in zoogeographical realms.

Unit 1: Protochordates and Origin of Chordates

General characteristics and outline classification Chordata (Protochordata: Hemichordata, Urochordata and Cephalochordata). Study of larval forms in protochordates; Retrogressive metamorphosis in Urochordat; Dipleurula concept and the Echinoderm theory of origin of chordates.

Unit 2: Agnatha, Pisces & Amphibia

General characteristics and classification up to order. Migration, Parental care in fishes, Accessory respiratory organs in Pisces, Evolutionary significance of Dipnoi.
Amphibia: Origin of Tetrapoda (Evolution of terrestrial ectotherms); Parental care.

Unit 3: Reptilia & Aves

General characteristics and classification up to order. Affinities of Sphenodon; Poison apparatus and Biting mechanism in snakes. Archaeopteryx- a connecting link; Flight adaptations and Migration in birds.

Unit 4: Mammals & Zoogeography

General characters and classification up to order; Affinities of Prototheria; Adaptive radiation with reference to locomotory appendages. Zoogeographical realms, Theories pertaining to distribution of animals, Plate tectonic and Continental drift theory, distribution of vertebrates in different realms.

PRACTICAL

1. Protochordata: *Balanoglossus*, *Herdmania*, *Branchiostoma*, Urochordata, Sections of *Balanoglossus* through proboscis and branchio-genital regions, Sections of *Amphioxus* through pharyngeal, intestinal and caudal regions. Permanent slides of *Herdmania* spicules, *Doliolum*, *Salpa*
2. Agnatha: *Petromyzon* and *Myxine*.
3. Fishes: *Scoliodon*, *Sphyrna*, *Pristis*, *Torpedo*, *Chimaera*, *Mystus*, *Heteropneustes*, *Labeo*, *Exocoetus*, *Echeneis*, *Anguilla*, *Hippocampus*, *Tetrodon/ Diodon*, *Anabas*, Flat fish.
4. Amphibia: *Ichthyophis/Ureotyphlus*, *Necturus*, *Bufo*, *Hyla*, *Alytes*, Salamander.
5. Reptilia: *Chelone*, *Trionyx*, *Hemidactylus*, *Varanus*, *Uromastix*, *Chamaeleon*, *Ophiosaurus*, *Draco*, *Bungarus*, *Vipera*, *Naja*, *Hydrophis*, *Zamenis*, *Crocodylus*. Key for Identification of poisonous and non-poisonous snakes
6. Aves: Study of six common birds from different orders. Types of beaks and claws. Study of feathers.
7. Mammalia: *Sorex*, Bat (Insectivorous and Frugivorous), *Funambulus*, *Loris*, *Herpestes*, *Erinaceus*.
8. Power point presentation on study of any two examples representing two different classes.. Submission of report on local species.

Text Books:

- ✓ *Kotpal RL; Modern Textbook of Zoology –Vertebrates; Rastogi Publications - Meerut; 2016 edition*
- ✓ *Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford University Press.*
- ✓ *Tiwari SK (2006) Fundamentals of World Zoogeography, Sarup & Sons.*

Suggested Readings:

- ✓ *Pough H. Vertebrate life, VIII Edition, 2007 Pearson International.*
- ✓ *Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jonesand Bartlett Publishers Inc.*
- ✓ *Hickman CP, Roberts LS, Keen S, Larson A, I'AnsonH, Isenhour DJ Integrated Principle of Zoology, 14th edition, 2008, McGrawHill publication.*

Core II (MINOR I)/ Core III (Minor II): PAPER III
(SEMESTER V/VI)
Microbiology
(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Knowledge of microbial diversity and classification.
- To understand microbial culture, growth and reproduction.
- To understand the importance of viral pathogenicity, nature of viral transmission.
- To comprehend the importance of Anti-viral drugs and vaccines.

Course Outcome:

- Obtaining knowledge pertaining to future scopes and modern trends of microbiology.
- Understanding the experimental approaches to explore the origin of microbes.
- Understanding the morphology, classification and significance of host-vector relationship.
- Learning the mechanism of action of microbial toxins and pathogenicity.
- Obtaining knowledge on pathogenic manifestation of Oncoviruses & HIV.

Learning Outcome:

- Finding the historical background and modern experimental approaches to understand the origin and development of microbiology.
- Analysing the general features, classification and pathogenicity of Archea and Eubacteria.
- Deducing knowledge on role of microbes in agriculture and healthcare sector.
- Interpreting the mechanism of antibacterial and anti-viral their mode of action, and importance of vaccines.

Unit-1

History and development of microbiology: Biogenesis and abiogenesis, Contribution of Francesco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Robert Koch (germ theory), Edward Jenner and Alexander Fleming's experiments on discovery of Penicillin, Modern trends and future scope of Microbiology.

Unit-2

Microbial systems of classification: General features of Bergey's manual for classification of microbes, Whittaker's five kingdom concept, Carl Woese's 3 domain classification, Lynn Margulis theory of endosymbiotic theory. General features of Archaea: Structure, Nutrition and Reproduction.

General features, pathogenicity of Mycoplasma, Rickettsia and Spirochaetes.

Unit-3

Isolation, culture and maintenance of microorganisms: Microbial growth, continuous culture (chemostat), Factors influencing growth of microbes, Role of microbes in agriculture and healthcare industry. Reproduction of Eubacteria, Genetic recombination in bacteria (Transformation, Conjugation and Transduction).

Unit-4

Virion and viroids: General characteristics and classification of viruses, morphology, nature of viral transmission. Bacteriophage replication, Oncoviruses & HIV: structure, transmission, pathogenicity and replication. Microbial toxins: types, mode of actions and pathogenicity (Exo and Endo-toxin). Antibiotics and their mode of action, Anti-virals and vaccine.

PRACTICAL

1. Study on aseptic techniques in microbiology: various methods of sterilization process.
2. Preparation and formulation of microbial media and methods of inoculation.
3. Methods of isolation of bacteria: spread plate, streak plate, pour plate, serial dilution.
4. Sampling and quantification of microorganisms in air, water and soil.
5. Morphological identification of microorganisms from various habitats through simple staining, differential staining, acid fast staining, spore staining.
6. Methods of microscopic measurements, micrometer (ocular and stage), haemocytometer.
7. Preparation of bacterial growth curve.

CORE II/ MINOR I: ZOOLOGY (FOURTH YEAR HONS WITHOUT RESEARCH)

SEMESTER-VII

PAPER IV: Cell Biology (4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Introducing prokaryotic and eukaryotic cells and their features, ultrastructure of plasma membrane and mechanism of transport of molecules across plasma membrane.
- To know the structure, function and properties of endomembrane & cytoskeletal network system and cell organelles.
- To understand the importance of mitochondria in aerobes, the role of mitochondrial electron transport chain, oxidative phosphorylation & mechanism of ATP synthesis.
- To study the structure and packaging of chromosome in nucleus, behaviour of chromosome during cell division, cell cycle and its regulation.

Course Outcome:

- Understanding the difference between prokaryotic and eukaryotic cells and the mechanism of transportation across their membrane system.
- Understanding the role of cytoskeleton in maintaining structural framework, cell motility and cell organelles.
- Deciphering the role of mitochondria in cellular respiration and energy production.
- Obtaining knowledge on structure and function of nucleus, cell division and regulation of cell cycle.

Learning Outcome

Understanding Cell junctions and mechanism of transportation across membrane.

- Obtaining knowledge on structural and functional aspect of cytoskeleton and endomembrane system.
- Obtaining knowledge on nucleus, nucleosome and cell division and cell cycle regulation.
- Knowledge about mitochondrial respiratory chain, chemi-osmotic hypothesis and functions of peroxisome.

Unit 1: Overview of cells and plasma membrane

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure. Transport across membranes: Active and

Passive transport, Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

Unit 2: Cytoskeleton & Endomembrane System

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments; Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes.

Unit 3: Mitochondria and Peroxisomes

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis; Mitochondrial Respiratory Chain, Chemo-osmotic hypothesis. Peroxisomes.

Unit 4: Nucleus, Cell Division and Cell Signalling

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome); Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

Text Books:

- ✓ Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.
- ✓ De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.

Suggested Readings:

- ✓ Bruce Albert, Bray Dennis, Lewis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.
- ✓ 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.
- ✓ Suvarna S, Lyton C, Bancroft JD (2013) *Theory and practice of histological techniques*, Churchill Livingstone, Elsevier, UK
- ✓ Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

PRACTICAL

8. Understanding of simple and compound microscopes.
9. To study different cell types such as buccal epithelial cells, striated muscle cells using Methylene blue/any suitable stain (virtual/

slide/slaughtered tissue).

10. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
11. Study of various stages of meiosis in grasshopper testis
12. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
13. Preparation of permanent slide to demonstrate:
 - i. DNA by Feulgen reaction
 - ii. DNA and RNA by MGP
 - iii. Mucopolysaccharides by PAS reaction
 - iv. Proteins by Mercuric bromophenol blue/Fast Green
14. Demonstration of osmosis (RBC/ Egg etc.).

Suggested Reading:

3. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. Chand Publication.
4. S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.

SEMESTER-VIII

MINOR I: PAPER -V

Principles of Ecology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the concept of an ecosystem, its attributes, factors and functioning.
- Learn about population attributes, growth patterns, strategies; regulation and interactions.
- To appraise learners regarding various community characteristics.
- Comprehend biological data, learn graphical representation of data, sampling techniques, grasp basic statistics.
- Acquire skills on plotting survivorship curves, quadrat method of determining population density, diversity indices, techniques of preservation and mounting of plankton, determination of ecological parameters.

Course Outcome:

- Utilize information to understand interrelations and working of an ecosystem.
- Demonstrate the ability to comprehend data, plot graphs, present data and apply basic statistics.

Learning Outcome:

- Understand food chain dynamics and energy flow patterns.
- Gain knowledge about population dynamics.
- Understand community stratification and succession.
- Gain knowledge about representation of data, data processing and analysis.

Unit 1: Ecosystem and Applied Ecology

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Laws of limiting factors, Study of physical factors- (Light, temperature).

Unit 2: Population

Attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density- dependent and independent factors, Population interactions, Gause's Principle with laboratory and field examples.

Unit 3: Community

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

Unit – 4: Biometry

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test).

Text Book:

- ✓ Odum, E.P. and Barrett, G.W., (2018). *Fundamentals of Ecology*, 5th Edition
- ✓ Smith and Smith, *Elements of Ecology*, Global Edition; Pearson Education India; ninth edition (14 May 2015).
- ✓ Myra Samuels, J. Witmer, A. Schaffner, *Statistics for the life sciences*, Prentice Halls, Boston, 4th edition, 2012.

Suggested Readings:

- ✓ Kormondy, (2017). *Concepts of Ecology*, Updated 4/e, Pearson.

- ✓ *Colinvaux, P. A. (1993). Ecology. II Edition. Wiley, John and Sons, Inc.*
- ✓ *Krebs, C. J. (2001). Ecology. VI Edition. Benjamin Cummings.*
- ✓ *Ricklefs, R.E., (2000). Ecology. 5th Edition. Chiron Press.*
- ✓ *Dash M.C., Fundamentals of Ecology. Mc GrawHill*
- ✓ *Smith TM and Smith RL, Elements of Ecology, 8th Edition, Pearson education INC, USA*
- ✓ *Miller, G.T. and Spoolman, S.E. (2017) Environmental Science, 14th Edition. Cengage Publication, New Delhi.*
- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition. Cengage Publication, New Delhi Web site: <https://www.cbd.int/>*
- ✓ *Baneerjee Pranab Kumar, Introduction to biostatistics, S Chand & Company; 3rd Rev. Edn. 2006 edition*
- ✓ *Chainy GBN, Mishra G, MohantyPK, 2004, Basic Biostatistics, Kalyani Publisher.*

PRACTICAL

8. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
9. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
10. Study of an aquatic ecosystem: Phytoplankton and zooplankton collection, preservation and mounting, Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), BOD, COD, Free CO₂, Hardness, TDS.
11. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary.
12. Chi-square analysis using seeds/beads/Drosophila.
13. Problems on standard deviation.
14. Graphical representation of data (Frequency polygon and Histogram).

Suggested Reading:

- ✓ *Practical Ecology by David Slingsby, Ceridwen Cook, Red Globe Press London.*
- ✓ *Practical Methods in Ecology by Henderson Peter A. John Wiley and Sons Ltd.*
- ✓ *Practical Ecology by Rao K S, K.S. Rao. Anmol Publications.*

CORE II/ MINOR I: ZOOLOGY (FOURTH YEAR HONS WITH RESEARCH)

SEMESTER-VII

PAPER IV: Cell Biology (4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Introducing prokaryotic and eukaryotic cells and their features, ultrastructure of plasma membrane and mechanism of transport of molecules across plasma membrane.
- To know the structure, function and properties of endomembrane & cytoskeletal network system and cell organelles.
- To understand the importance of mitochondria in aerobes, the role of mitochondrial electron transport chain, oxidative phosphorylation & mechanism of ATP synthesis.
- To study the structure and packaging of chromosome in nucleus, behaviour of chromosome during cell division, cell cycle and its regulation.

Course Outcome:

- Understanding the difference between prokaryotic and eukaryotic cells and the mechanism of transportation across their membrane system.
- Understanding the role of cytoskeleton in maintaining structural framework, cell motility and cell organelles.
- Deciphering the role of mitochondria in cellular respiration and energy production.
- Obtaining knowledge on structure and function of nucleus, cell division and regulation of cell cycle.

Learning Outcome

Understanding Cell junctions and mechanism of transportation across membrane.

- Obtaining knowledge on structural and functional aspect of cytoskeleton and endomembrane system.
- Obtaining knowledge on nucleus, nucleosome and cell division and cell cycle regulation.
- Knowledge about mitochondrial respiratory chain, chemi-osmotic hypothesis and functions of peroxisome.

Unit 1: Overview of cells and plasma membrane

Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, Various models of plasma membrane structure. Transport across membranes: Active and

Passive transport, Facilitated transport. Cell junctions: Tight junctions, Desmosomes, Gap junctions.

Unit 2: Cytoskeleton & Endomembrane System

Structure and Functions: Microtubules, Microfilaments and Intermediate filaments; Structure and Functions: Endoplasmic Reticulum, Golgi apparatus, Lysosomes.

Unit 3: Mitochondria and Peroxisomes

Mitochondria: Structure, Semi-autonomous nature, Endosymbiotic hypothesis; Mitochondrial Respiratory Chain, Chemi-osmotic hypothesis. Peroxisomes.

Unit 4: Nucleus, Cell Division and Cell Signalling

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Nucleolus; Chromatin: Euchromatin and Heterochromatin and packaging (nucleosome); Mitosis, Meiosis, Cell cycle and its regulation; GPCR and Role of second messenger (cAMP).

Text Books:

- ✓ Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley and Sons. Inc.
- ✓ De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.

Suggested Readings:

- ✓ Bruce Albert, Bray Dennis, Lewis Julian, Raff Martin, Roberts Keith and Watson James (2008). *Molecular Biology of the Cell*, V Edition, Garland publishing Inc., New York and London.
- ✓ 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.
- ✓ Suvarna S, Lyton C, Bancroft JD (2013) *Theory and practice of histological techniques*, Churchill Livingstone, Elsevier, UK
- ✓ Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. V Edition. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.

PRACTICAL

15. Understanding of simple and compound microscopes.
16. To study different cell types such as buccal epithelial cells, striated muscle cells using Methylene blue/any suitable stain (virtual/

slide/slaughtered tissue).

17. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
18. Study of various stages of meiosis in grasshopper testis
19. Preparation of permanent slide to show the presence of Barr body in human female blood cells/cheek cells.
20. Preparation of permanent slide to demonstrate:
 - i. DNA by Feulgen reaction
 - ii. DNA and RNA by MGP
 - iii. Mucopolysaccharides by PAS reaction
 - iv. Proteins by Mercuric bromophenol blue/Fast Green
21. Demonstration of osmosis (RBC/ Egg etc.).

Suggested Reading:

5. Verma PS and Srivastava PC. (2011) Advanced Practical Zoology. Chand Publication.
6. S.S Lal. (2019) Practical Zoology (Invertebrate) Rastogi Publications.

MINOR I: PAPER -V

Principles of Ecology

(4Credit, Theory-45h and Practical – 30h)

Programme Outcome:

- Understand the concept of an ecosystem, its attributes, factors and functioning.
- Learn about population attributes, growth patterns, strategies; regulation and interactions.
- To appraise learners regarding various community characteristics.
- Comprehend biological data, learn graphical representation of data, sampling techniques, grasp basic statistics.
- Acquire skills on plotting survivorship curves, quadrat method of determining population density, diversity indices, techniques of preservation and mounting of plankton, determination of ecological parameters.

Course Outcome:

- Utilize information to understand interrelations and working of an ecosystem.
- Demonstrate the ability to comprehend data, plot graphs, present data and apply basic statistics.

Learning Outcome:

- Understand food chain dynamics and energy flow patterns.
- Gain knowledge about population dynamics.
- Understand community stratification and succession.
- Gain knowledge about representation of data, data processing and analysis.

Unit 1: Ecosystem and Applied Ecology

Ecology: Autecology and synecology, Types of ecosystems with one example in detail, Food chain: Detritus and grazing food chains, Linear and Y-shaped food chains, Food web, Energy flow through the ecosystem, Ecological pyramids Nutrient and biogeochemical cycle with one example of Nitrogen cycle. Laws of limiting factors, Study of physical factors- (Light, temperature).

Unit 2: Population

Attributes of population: Density, natality, mortality, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation - density- dependent and independent factors, Population interactions, Gause's Principle with laboratory and field examples.

Unit 3: Community

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

Unit – 4: Biometry

Biological data, graphical representation of data (frequency polygon and histogram), sampling techniques, measures of central tendency (Mean, median and mode), Measures of dispersion (range, quartile deviation, mean deviation and standard deviation), Hypothesis and hypothesis testing (Chi-square test, t- test).

Text Book:

- ✓ *Odum, E.P. and Barrett, G.W., (2018). Fundamentals of Ecology, 5th Edition*
- ✓ *Smith and Smith, Elements of Ecology, Global Edition; Pearson Education India; ninth edition (14 May 2015).*
- ✓ *Myra Samuels, J. Witmer, A. Schaffner, Statistics for the life sciences, Prentice Halls, Boston, 4th edition, 2012.*

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PRACTICAL

15. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
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SAMPLE QUESTION SET

UG (NEP) C-I ZOOL -1.1.1 (Non-Chordates I: Protista to Pseudocoelomates) END SEMESTER EXAMINATION (2024 BATCH ONWARDS)

MODEL QUESTION PATTERN

FULL MARKS: 100

The figures in the right-hand margin indicate Marks.

PART-I Marks (1x10=10)

(One mark each in the form of fill in the blanks/one word answer covering all units)

- Q 1. a) Muscular swellings or lappets are typical of the larva stage... of *Fasciola hepatica*.

PART-II

(At least two questions from any of the units. All are compulsory. Answer maximum 50 words)

[2x9=18]

- Q 2. a) Write the unique features of Class Phytomastogophorea?

PART-III

(At least two questions from any of the units. Answer maximum 250 words Answer any 8 out of 10 questions)

[5x8=40]

- Q 3. a) What is the evolutionary significance of Ctenophora?

PART-IV

(At least two questions from any of the units. Answer maximum 800 words Answer any 4 out of 5 questions)

[8x4=32]

- Q 4. a) How are helminths adapted to a parasitic mode of life?

OR

- b) What are the typical features of Nematelminthes?