

B.Sc. Zoology

**FOUR-YEAR UNDER GRADUATE PROGRAMME
(Eight-Semester Course)**



COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2022-2023)

HEMVATI NANDAN BAHUGUNA GARHWAL UNIVERSITY

Srinagar (Garhwal) 246 174 Uttarakhand

Department of Zoology
Hemvati Nandan Bahuguna Garhwal University, Srinagar-Garhwal, Uttarakhand

FOUR YEAR BACHELOR'S DEGREE PROGRAMME
WITH HONOURS/ RESEARCH (B.Sc. ZOOLOGY)

COURSE STRUCTURE & CONTENT

First Year (I Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-1)			
		4+2	Animal Diversity-I (Theory-1; Practical-1)	Core Course
	AIZ-1	2+2	Animal Diversity-1 (Theory-1; Practical-1)	For students with Core Subjects other than Zoology
	Skill Course Zoology (SZ-1—SZ-6)	2	Student will elect one course each in I & II Semester <i>OR</i> III & IV Semester	Skill Course Basket: SZ-1. Laboratory Techniques in Biology SZ-2. Basic Instrumentation SZ-3. Public Health and Hygiene SZ-4. Aquarium Fish Keeping SZ-5. Medical Diagnostics SZ-6. Bioinformatics
	Extra-curricular Courses/ CC (EC-1)	2	1. Understanding and connecting with Environment	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Note: Each Additional Interdisciplinary Course will be of two semesters. The student will opt the course from same subject in I & II Semester.

CZ (Core Course-Zoology); AIZ (Additional Interdisciplinary Course-Zoology); SZ (Skill Course-Zoology); CC (Compulsory Course)

First Year (II Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-2)			
		4+2	Animal Diversity-II (Theory-1; Practical-1)	Core Course
	AIZ-2	2+2	Animal Diversity-II (Theory-1; Practical-1)	For students with Core Subjects other than Zoology
	Skill Course Zoology (SZ-1—SZ-6)	2	Student will elect one course each in I & II Semester <i>OR</i> III & IV Semester	Skill Course Basket: SZ-1. Laboratory Techniques in Biology SZ-2. Basic Instrumentation SZ-3. Public Health and Hygiene SZ-4. Aquarium Fish Keeping SZ-5. Medical Diagnostics SZ-6. Bioinformatics
	Life Skills and Personality Development/ CC (LSPD)	2	1. Life skills and personality development	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Note: Each Additional Interdisciplinary will be of two semesters. The student will opt the course from same subject in I & II Semester.

- After completion of 1 year of study, if student opts **EXIT**, then a Certificate will be awarded subject to fulfilment of the conditions as laid down in NHEQF.
- 10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/apprenticeship.
- Under Graduate Certificate (Zoology)

Second Year (III Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-3)			
		4+2	Elementary Cell Biology & Molecular Biology (Theory-1; Practical-1)	Core Course
	AIZ-3	2+2	Elementary Cell Biology & Molecular Biology (Theory-1; Practical-1)	For students with Core Subjects other than Zoology
	Skill Course Zoology (SZ-1—SZ-6)	2	Student will elect one course each in I & II Semester <i>OR</i> III & IV Semester	Skill Course Basket: SZ-1. Laboratory Techniques in Biology SZ-2. Basic Instrumentation SZ-3. Public Health and Hygiene SZ-4. Aquarium Fish Keeping SZ-5. Medical Diagnostics SZ-6. Bioinformatics
	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC) ⁺	2	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Note: Student will have the choice to select Skill Course in III & IV Semester from subject other than the one opted in I & II Semester.
⁺Student has to opt either IKS or AMSC in III or IV Semester

Second Year (IV Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-4)			
		4+2	Physiology and Elementary Biochemistry (Theory-1; Practical-1)	Core Course
	AIZ-4	2+2	Physiology and Elementary Biochemistry (Theory-1; Practical-1)	For students with Core Subjects other than Zoology
	Skill Course Zoology (SZ-1—SZ-6)	2	Student will elect one course each in I & II Semester <i>OR</i> III & IV Semester	Skill Course Basket: SZ-1. Laboratory Techniques in Biology SZ-2. Basic Instrumentation SZ-3. Public Health and Hygiene SZ-4. Aquarium Fish Keeping SZ-5. Medical Diagnostics SZ-6. Bioinformatics
	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC) ⁺	2	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Note: Student will have the choice to select Skill Course in III & IV Semester from subject other than the one opted in I & II Semester.
⁺Student has to opt either IKS or AMSC in III or IV Semester

- After completion of 2 years of study, if student opts exit, then a Diploma will be awarded subject to the fulfilment of the conditions as laid down in NHEQF.
- 10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/ apprenticeship.
- Under Graduate Diploma (Zoology)

Third Year (V Semester)	Discipline Specific Elective (DSE)	Credits	Name of the Course	Remarks
		4+2	DSE (Any one) (Theory-1; Practical-1)	DSE Basket: DSE-1. Applied Zoology DSE-2. Wild Life Conservation & Management DSE-3. Principles of Genetics & Evolutionary Biology DSE-4. Animal Behaviour & Endocrinology DSE-5. Introduction to Developmental Biology DSE-6. Basics of Biotechnology
	Vocational Course/ Field Visit/ Entrepreneurship Skills	4	Vocational Course (VCZ): 1. Poultry Farming 2. Apiculture 3. Sericulture 4. Aquaculture 5. Fish Hatchery Operations 6. Vermiculture	Any one related to either Core Subject 1 or Core Subject 2 OR Field/ Industrial visit as per requirement of core course (Student will submit a brief report on visit at the end of the semester)
	Extracurricular Course-II/ CC	2	Culture, Traditions and Moral Values	Compulsory Course [Common University Syllabus]
	Languages-I	2	Indian, Modern, Regional Language-I	Hindi/Sanskrit/English/any other language as proposed by the University
	TOTAL	20		
Note: Student will have the option to study any two languages one each in V & VI Semester.				

Third Year (VI Semester)	Discipline Specific Elective (DSE)	Credits	Name of the Course	Remarks
		4+2	DSE (Any one) (Theory-1; Practical-1)	DSE Basket: DSE-1. Applied Zoology DSE-2. Wild Life Conservation & Management DSE-3. Principles of Genetics & Evolutionary Biology DSE-4. Animal Behaviour & Endocrinology DSE-5. Introduction to Developmental Biology DSE-6. Basics of Biotechnology
	Vocational Course/ Field Visit/ Entrepreneurship Skills	4	Vocational Course (VCZ): 1. Poultry Farming 2. Apiculture 3. Sericulture 4. Aquaculture 5. Fish Hatchery Operations 6. Vermiculture	Any one related to either CS-1 or CS-2 OR Field/ Industrial visit as per requirement of core course (Student will submit a brief report on visit at the end of the semester).
	Communication Skills/ CC	2	Communication skill Course (Based on soft skill development)	Student will select one language course [Common University Syllabus]
	Languages-II	2	Indian, Modern, Regional Language-II	Hindi/Sanskrit/English/any other language as proposed by the University
	TOTAL	20		
Note: Student will have the option to study any two languages one each in V & VI Semester.				

- In case of Exit after 3rd year, Graduate degree, Bachelor of Science (B.Sc.) will be awarded (Credits-120)
- 10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/apprenticeship.

Self and Social Development (SSD) course work	<p>This Self and Social Development course work will be compulsory for all student and the student will have the choice to complete any two forms of the following course work in any one of Eight Semester (I to VIII semester) of UG program:</p> <ol style="list-style-type: none"> (1) Community Connect & Service (2) Extracurricular Activities <p>Both the coursework will carry 2 (Two credits). Student may select any one of the above 2 course work.</p> <p>Community Connect & Service: Under community connect there will be a requirement of Minimum 30 hours of community service within any semester (I to IV). The courses will be based on community connect, Swachh Bharat, Ek Bharat Shrestha Bharat, NSS, etc. It will be based on number of hours devoted under this course. Concerned department will verify the fulfilment of minimum hours towards CCS.</p> <p>Extracurricular Activities: This course work required student participation in university demarcated activities such as (1) Participation/representation of institution in Intercollegiate activities/State level activities/National level activities. A committee set up by university will verify the student participation in activities for award of credits for the coursework</p>
<p><i>Student for successfully completing 4 Year U.G. Program degree along with securing the required credits (160 credits- for 4-year UG Program) will have to secure additional 2 credits under SSD.</i></p> <p><i>Student for successfully completing 3 Year U.G. Program degree (if he/she opts to exit after completing 3 years U.G. course) along with securing the required credits (120 credits- for 3-year UG Program) Student will have to secure same 2 credits under SSD.</i></p>	

Fourth Year (VII Semester with Honours)	Major Subject (One Only)	Credit	Name of Course	Remarks
	Core Zoology-5 (CZ-5) Core Zoology-6 (CZ-6)	3+3+2	CZ-5. Non-Chordata (3 Credit) CZ-6. Cell and Molecular Biology (3 Credit) LC-1. Lab Course (2 Credit)	These courses will be based on core subject selected by the students for PG and Research
	Major Elective Zoology (EZ-1)	2+2	Elective Course (Any one) (2 Credit) LC-2. Lab Course (2 Credit)	Elective Course Basket EZ-1a. Developmental Biology and Parasitology EZ-1b. Elementary Biotechnology and Microbiology EZ-1c. Toxicology
	Minor Core Zoology (CZM-1)	3	CZM-1. Endocrinology & Animal Behaviour (3 Credit)	For students with Core subjects other than Zoology (Without Practical)
	Minor Elective Zoology (EZM-1)	3	Minor Elective Course (Any one) [3 Credit] EZM-1a. Developmental Biology and Parasitology EZM-1b. Elementary Biotechnology and Microbiology EZM-1c. Toxicology	For students with Core subjects other than Zoology (Without Practical)
	Research Writing and Ethics	2	1. Research Writing and Ethics	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Fourth Year (VIII Semester with Honours)	Major Subject (One Only)	Credit	Name of Course	Remarks
	Core Zoology-7 (CZ-7)	4+4	CZ-7. Chordata (4 Credit) LC-3. Lab Course (4 Credit)	This course will be based on core subject selected by the students for PG and Research
	Major Elective Zoology (EZ-2)	2+2	Elective Course (Any one) (2 Credit) LC-4. Lab Course (2 Credit)	Elective Course Basket EZ-2a. Aquatic Biodiversity EZ-2b. Genetics, Evolution and Taxonomy EZ-2c. Assisted Reproductive Biology Techniques
	Minor Core Zoology (CZM-2)	3	CZM-2. Biological and Radiotracer Techniques (3 Credit)	For students with Core subjects other than Zoology (Without Practical)
	Minor Elective Zoology (EZM-2)	3	Minor Elective Course (Any one) [3 Credit] EZM-2a. Aquatic Biodiversity EZM-2b. Genetics, Evolution and Taxonomy EZM-2c. Assisted Reproductive Biology Techniques	For students with Core subjects other than Zoology (Without Practical)
	Basic Research Methods	2	1. Basic Research Methods	Compulsory Course [Common University Syllabus]
	Total	20		

Note: After the completion of Four years (eight semesters) with above mentioned courses the student will be awarded Bachelor of Science degree, B.Sc. (Honours).

Fourth Year (VII Semester with Research)	Major Subject (One Only)	Credits	Name of Course	Remarks
	Core Zoology-5 (CZ-5) Core Zoology-6 (CZ-6)	3+3+2	CZ-5. Non-Chordata (3 Credit) CZ-6. Cell and Molecular Biology (3 Credit) LC-1. Lab Course (2 Credit)	These courses will be based on core subject selected by the students for PG and Research
	Research Methodology Zoology (RMZ-1)	4	RMZ-1. Research Methodology	Student will learn the basic research methodology with focus on data analysis for application in research-based work to be carried out in VIII Semester
	Elective Course Zoology (EZ-1)	3+3	Elective Course (Any one) (3 Credit) LC-2. Lab Course (3 Credit)	Elective Course Basket EZ-1a. Developmental Biology and Parasitology EZ-1b. Elementary Biotechnology and Microbiology EZ-1c. Toxicology
	Research Writing and Ethics	2	1. Research Writing and Research Ethics	Compulsory Course [Common University Syllabus]
	TOTAL	20		

Fourth Year (VIII Semester with Research)	Major Subject (One Only)	Credit	Name of Course	Remarks
	Core Zoology-7 (CZ-7) Core Zoology-8 (CZ-8)	3+3+2	CZ-7. Chordata (3 Credit) CZ-8. Biostatistics and Computer Application (3 Credit) LC-3. Lab Course (2 Credit)	These courses will be based on core subject selected by the students for PG and Research
	Research Presentation Skills	2	Research Paper Presentation Skills (Oral and Poster)	Compulsory Course [Common University Syllabus]
	Elective Course Zoology (EZ-2)	3+3	Elective Course (Any one) (3 Credit) LC-4. Lab Course (3 Credit)	Elective Course Basket EZ-2a. Aquatic Biodiversity EZ-2b. Genetics, Evolution and Taxonomy EZ-2c. Assisted Reproductive Biology Techniques
	Dissertation	4	Dissertation/ Research- based field or industrial report	Student will conduct minor research work OR will do research-based field study and submit the dissertation/ report at the end of semester.
	TOTAL	20		

Note: After the completion of Four years (eight semesters) with above mentioned courses the student will be awarded Bachelor of Science degree, B.Sc. (Research).

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FOUR YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH

COURSE CODE

B.Sc. (Zoology)

First, Second & Third Year (I-VI Semester)

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-1	Animal Diversity-I	4	0	0	4
SOLS/ZOO/CZ-2	Animal Diversity-II	4	0	0	4
SOLS/ZOO/CZ-3	Elementary Cell Biology & Molecular Biology	4	0	0	4
SOLS/ZOO/CZ-4	Physiology and Elementary Biochemistry	4	0	0	4
SOLS/ZOO/CZ-1(P)	Animal Diversity-I (Practical)	0	0	2	2
SOLS/ZOO/CZ-2(P)	Animal Diversity-II (Practical)	0	0	2	2
SOLS/ZOO/CZ-3(P)	Elementary Cell Biology & Molecular Biology (Practical)	0	0	2	2
SOLS/ZOO/CZ-4(P)	Physiology and Elementary Biochemistry (Practical)	0	0	2	2
SOLS/ZOO/AIZ-1	Animal Diversity-I	2	0	0	2
SOLS/ZOO/AIZ-2	Animal Diversity-II	2	0	0	2
SOLS/ZOO/AIZ-3	Elementary Cell Biology & Molecular Biology	2	0	0	2
SOLS/ZOO/AIZ-4	Physiology and Elementary Biochemistry	2	0	0	2
SOLS/ZOO/AIZ-1(P)	Animal Diversity-I (Practical)	0	0	2	2
SOLS/ZOO/AIZ-2(P)	Animal Diversity-II (Practical)	0	0	2	2
SOLS/ZOO/AIZ-3(P)	Elementary Cell Biology & Molecular Biology (Practical)	0	0	2	2
SOLS/ZOO/AIZ-4(P)	Physiology and Elementary Biochemistry (Practical)	0	0	2	2
SOLS/ZOO/SZ-1	Laboratory Techniques in Biology	2	0	0	2
SOLS/ZOO/SZ-2	Basic Instrumentation	2	0	0	2
SOLS/ZOO/SZ-3	Public Health and Hygiene	2	0	0	2
SOLS/ZOO/SZ-4	Aquarium Fish Keeping	2	0	0	2
SOLS/ZOO/SZ-5	Medical Diagnostics	2	0	0	2
SOLS/ZOO/SZ-6	Bioinformatics	2	0	0	2
SOLS/ZOO/DSE-1	Applied Zoology	4	0	0	4
SOLS/ZOO/DSE-2	Wild Life Conservation & Management	4	0	0	4
SOLS/ZOO/DSE-3	Principles of Genetics & Evolutionary Biology	4	0	0	4
SOLS/ZOO/DSE-4	Animal Behaviour & Endocrinology	4	0	0	4
SOLS/ZOO/DSE-5	Introduction to Developmental Biology	4	0	0	4
SOLS/ZOO/DSE-6	Basics of Biotechnology	4	0	0	4
SOLS/ZOO/DSE-1(P)	Applied Zoology (Practical)	0	0	2	2
SOLS/ZOO/DSE-2(P)	Wild Life Conservation & Management (Practical)	0	0	2	2
SOLS/ZOO/DSE-3(P)	Principles of Genetics & Evolutionary Biology (Practical)	0	0	2	2
SOLS/ZOO/DSE-4(P)	Animal Behaviour & Endocrinology (Practical)	0	0	2	2
SOLS/ZOO/DSE-5(P)	Introduction to Developmental Biology (Practical)	0	0	2	2
SOLS/ZOO/DSE-6(P)	Basics of Biotechnology (Practical)	0	0	2	2
SOLS/ZOO/VCZ-1	Poultry Farming	4	0	0	4
SOLS/ZOO/VCZ-2	Apiculture	4	0	0	4
SOLS/ZOO/VCZ-3	Sericulture	4	0	0	4
SOLS/ZOO/VCZ-4	Aquaculture	4	0	0	4
SOLS/ZOO/VCZ-5	Fish Hatchery Operations	4	0	0	4
SOLS/ZOO/VCZ-6	Vermiculture	4	0	0	4

B.Sc. (Zoology)
Fourth Year (VII & VIII Semester) [Honours]

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Non-Chordata	3	0	0	3
SOLS/ZOO/CZ-6	Cell and Molecular Biology	3	0	0	3
SOLS/ZOO/CZ-7	Chordata	4	0	0	4
SOLS/ZOO/EZ-1a	Developmental Biology and Parasitology	2	0	0	2
SOLS/ZOO/EZ-1b	Elementary Biotechnology and Microbiology	2	0	0	2
SOLS/ZOO/EZ-1c	Toxicology	2	0	0	2
SOLS/ZOO/EZ-2a	Aquatic Biodiversity	2	0	0	2
SOLS/ZOO/EZ-2b	Genetics, Evolution and Taxonomy	2	0	0	2
SOLS/ZOO/EZ-2c	Assisted Reproductive Biology Techniques	2	0	0	2
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5 & CZ-6)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	0	0	2	2
SOLS/ZOO/LC-3	Lab Course-3 (Based on CZ-7)	0	0	4	4
SOLS/ZOO/LC-4	Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	0	0	2	2
SOLS/ZOO/CZM-1	Endocrinology & Animal Behaviour	3	0	0	3
SOLS/ZOO/CZM-2	Biological and Radiotracer Techniques	3	0	0	3
SOLS/ZOO/EZM-1a	Developmental Biology and Parasitology	3	0	0	3
SOLS/ZOO/EZM-1b	Elementary Biotechnology and Microbiology	3	0	0	3
SOLS/ZOO/EZM-1c	Toxicology	3	0	0	3
SOLS/ZOO/EZM-2a	Aquatic Biodiversity	3	0	0	3
SOLS/ZOO/EZM-2b	Genetics, Evolution and Taxonomy	3	0	0	3
SOLS/ZOO/EZM-2c	Assisted Reproductive Biology Techniques	3	0	0	3

B.Sc. (Zoology)
Fourth Year (VII & VIII Semester) [Research]

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Non-Chordata	3	0	0	3
SOLS/ZOO/CZ-6	Cell and Molecular Biology	3	0	0	3
SOLS/ZOO/CZ-7	Chordata	3	0	0	3
SOLS/ZOO/CZ-8	Biostatistics and Computer Application	3	0	0	3
SOLS/ZOO/CZ-9	Dissertation/ Research-based field or industrial report	0	0	4	4
SOLS/ZOO/RMZ	Research Methodology	4	0	0	4
SOLS/ZOO/EZ-1a	Developmental Biology and Parasitology	3	0	0	3
SOLS/ZOO/EZ-1b	Elementary Biotechnology and Microbiology	3	0	0	3
SOLS/ZOO/EZ-1c	Toxicology	3	0	0	3
SOLS/ZOO/EZ-2a	Aquatic Biodiversity	3	0	0	3
SOLS/ZOO/EZ-2b	Genetics, Evolution and Taxonomy	3	0	0	3
SOLS/ZOO/EZ-2c	Assisted Reproductive Biology Techniques	3	0	0	3
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5 & CZ-6)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	0	0	3	3
SOLS/ZOO/LC-3	Lab Course-3 (Based on CZ-7 & CZ-8)	0	0	2	2
SOLS/ZOO/LC-4	Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	0	0	3	3

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FOUR YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH
(B.Sc. Zoology)

SYLLABUS (w.e.f. 2022-23)

B.Sc. First Year (I Semester)

CORE ZOOLOGY (CZ-1 to CZ-4)
(Theory: 4 Credits; Practical: 2 Credits)

ADDITIONAL INTERDISCIPLINARY ZOOLOGY (AIZ-1 to AIZ-4)
(Theory: 2 Credits; Practical: 2 Credits)
[For students with Core Subjects other than Zoology]

SOLS/ZOO/CZ-1 Animal Diversity-I

4 Credits [60 hours]

Unit I. Introduction to Non-Chordata: General characters; Outline classification up to Classes [4 Hours]

Unit II. Protozoa: Salient features; Study of *Amoeba*, *Euglena* and *Paramecium* with reference to structure, locomotion, nutrition and reproduction (life history) [8 Hours]

Unit III. Origin of Metazoa.

Porifera: Salient features; Study of *Sycon* with reference to structure, reproduction (life history); Canal system in Syconoid sponge; Skeleton system [6 Hours]

Unit IV. Coelenterata: Salient features; Study of *Aurelia* with reference to morphology and reproduction (life history); Alternation of generation in Coelenterates [6 Hours]

Unit V. Helminthes: Salient features; Study of *Taenia* and *Ascaris* with reference to morphology, reproduction (life-cycle) and parasitic adaptations [6 Hours]

Unit VI. Annelida: Salient features; Types and significance of coelom; Metamerism and its significance; Study of *Nereis* and *Hirudinaria* with reference to morphology and reproduction; Parasitic adaptations of *Hirudinaria*; Trochophore larva and its significance [8 Hours]

Unit VII. Arthropoda: Salient features; Study of *Palaemon* with reference to morphology, respiration, excretion and reproduction; Zoological importance of *Peripatus* and *Limulus*; Economic importance of arthropods [8 Hours]

Unit VIII. Mollusca: Salient features; Study of *Pila* and *Unio* with reference to morphology, respiration and reproduction (life-history) [8 Hours]

Unit IX. Echinodermata: Salient features; Study of *Asterias* with reference to morphology, locomotion, water vascular system, mode of feeding and reproduction [6 Hours]

SOLS/ZOO/AIZ-1 Animal Diversity-I

2 Credits [30 Hours]

Unit I. Introduction to Non-Chordata: General characters; Outline classification up to Classes.

Protozoa: Salient features; Study of locomotion and nutrition in Protozoa [8 Hours]

Unit II. Origin of Metazoa.

Porifera: Salient features; Study of canal system and skeleton system in sponges.

Coelenterata: Salient features; Alternation of generation in Coelenterates; Corals and Coral reef [6 Hours]

Unit III. Helminthes: Salient features; Parasitic adaptations in helminths.

Annelida: Salient features; Types and significance of coelom; Metamerism and its significance; Trochophore larva and its significance [8 Hours]

Unit IV. Arthropoda: Salient features; Zoological importance of *Peripatus* and *Limulus*; Economic importance of arthropods.

Mollusca: Salient features; Torsion; Pearl formation

Echinodermata: Salient features; Study of water vascular system in star fish [8 Hours]

SUGGESTED READINGS

1. Barnes, RD: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington, EJW: Invertebrate Structure and Function, Nelson, 1987.
3. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
4. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
5. Kotpal, RL: Modern Text Book of Zoology: Invertebrates, Rastogi Publications, 12th edition, 2019
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.

SOLS/ZOO/CZ-1(P) Animal Diversity-I (Practical)

[2 Credits]

SOLS/ZOO/AIZ-1(P) Animal Diversity-I (Practical)

[2 Credits]

Study of museum specimens/slides:

Protozoa: *Amoeba, Euglena, Plasmodium, Paramecium, Trichomonas, Trypanosoma, Monocystis, Vorticella*

Porifera: *Sycon* (including T.S. and L.S.), *Hyalonema, Euplectella, Euspongia*

Coelenterata: *Obelia, Physalia, Aurelia, Tubipora, Metridium, Hydra, Gorgonia, Pennatula*

Platyhelminthes: *Taenia solium* and study of its life history stages, *Schistosoma, Fasciola*

Nemathelminthes: Male and female *Ascaris lumbricoides, Wuchereria, Ancylostoma*

Annelida: *Aphrodite, Nereis, Pheretima, Hirudinaria, Polygordias*

Arthropoda: *Palaemon, Cancer Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Musca*

Mollusca: *Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus*

Echinodermata: *Pentaceros, Ophiura, Echinus, Cucumaria, Antedon, Holothuria, Astreas*

B.Sc. First Year (II Semester)

SOLS/ZOO/CZ-2 Animal Diversity-II

4 Credits [60 Hours]

Unit I. Introduction to Chordata: General characters and outline classification of Chordates up to Classes.

Hemichordata: General characters and classification; *Balanoglossus*: morphology and development [6 Hours]

Unit II. Urochordata: General characters and classification; *Herdmania*: Morphology, blood vascular system, reproductive system and development [6 Hours]

Unit III. Cephalochordata: Classification and salient features; *Branchiostoma (=Amphioxus)*: Morphology, digestive, excretory, reproductive system and development [6 Hours]

Unit IV. Cyclostomata: General characters and classification; External features of *Petromyzon* and *Myxine*; Comparison between Lampreys and Hagfishes [4 Hours]

Unit V. Pisces: General characters of cartilaginous and bony fish;

Dipnoi: Distribution, General characters, and affinities;

External features, Digestive, Respiratory, Blood vascular, Nervous and Urinogenital system of *Scoliodon*;

Scales and fins of fishes, respiratory organs in fish [11 Hours]

Unit VI. Amphibia: General characters and classification, Elementary idea of parental care [3 Hours]

Unit VII. Reptilia: Terrestrial Adaptations; General characters and distribution of Chelonia, Rhynchocephalia, Ophidia and Crocodilia; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venom and Antivenom [8 Hours]

Unit VIII. Aves: General characters; Morphology, Digestive, Respiratory and Urinogenital System of *Columba*; Feathers in Birds; Aerial adaptations in birds [8 Hours]

Unit IX. Mammalia: General organization, salient features and distribution of Prototheria, Metatheria and Eutheria [8 Hours]

SOLS/ZOO/AIZ-2 Animal Diversity-II

2 Credits [30 Hours]

Unit I. Introduction to Chordata: General characters and outline classification of Chordates up to Classes.

Hemichordata: General characters, classification and affinities.

Urochordata: General characters, classification and affinities; Retrogressive metamorphosis in *Herdmania*

Cephalochordata: General characters, classification and affinities [8 Hours]

Unit II. Cyclostomata: General characters, classification and affinities; Comparison between Lampreys and Hagfishes.

Pisces: General characters, classification and affinities; Scales, fins and respiratory organs of fishes;

Dipnoi: Distribution, General characters, and affinities [8 Hours]

Unit III. Amphibia: General characters and classification, Elementary idea of parental care.

Reptilia: Terrestrial Adaptations; General characters, distribution and affinities; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venom and Antivenom [7 Hours]

Unit IV. Aves: General characters and classification; Feathers in Birds; Aerial adaptations in birds.

Mammalia: General characters, classification and distribution of Prototheria, Metatheria and Eutheria [7 Hours]

SUGGESTED READINGS

1. Kotpal, R.L.: Modern Text-book of Zoology, Vertebrates. Rastogi Publication, 2007
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
4. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
5. Pandey, B.N., Mathur, V. Biology of Chordates. PHI Learning Pvt. Ltd., Delhi, 2019

SOLS/ZOO/CZ-2(P) Animal Diversity-II (Practical)

[2 Credits]

SOLS/ZOO/AIZ-2(P) Animal Diversity-II (Practical)

[2 Credits]

Study of museum specimens/slides:

Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Agnatha: *Petromyzon, Myxine*

Pisces: *Sphyrna, Pristis, Torpedo, Exocoetus, Anguilla, Acipenser, Latimaria, Chimaera*

Amphibia: *Ichthyophis/ Ureotyphlus, Salamandra, Bufo, Hyla*

Reptilia: *Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis*; Key for Identification of poisonous and non-poisonous snakes

Aves: Study of six common birds from different orders

Mammalia: *Sorex, Bat, Funambulus, Loris, Platypus, Opossum, Kangaroo, Manis, Dolphin, Whale, Lutra, Camel, Polar Bear* (Photographs)

An "animal album" containing photographs, cut outs, with appropriate write up about the abovementioned taxa. Different taxa/ topics may be given to different sets of students for this purpose. These need not be repeated as drawings by the album maker.

B.Sc. Second Year (III Semester)

SOLS/ZOO/CZ-3 Elementary Cell Biology & Molecular Biology

4 Credits [60 Hours]

Unit I. Introduction to Cell theory; Comparison of a generalised Pro- & Eukaryote cell.

Elementary idea of cell fractionation; Light & Phase Contrast Microscopy, Confocal and Electron Microscopy (TEM & SEM) [8 Hours]

Unit II. Elementary knowledge of the structure & function of plasma membrane, cytoplasm [4 Hours]

Unit III. Introduction to the organelles constituting endomembrane system (Endoplasmic reticulum, Golgi complex, Lysosome, Peroxisome); Nucleus & Nucleolus; Ribosome; Mitochondria; Chloroplast; Introduction to cytoskeleton [10 Hours]

Unit IV. Basic features of Cell cycle; Mitosis & Meiosis [6 Hours]

Unit V. DNA as genetic material: Structure of DNA, Types of DNA; Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases; primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication [8 Hours]

Unit VI. DNA damage and repair: Causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, recombinational repair, non-homologous end joining [6 Hours]

Unit VII. RNA structure and types of RNA: Transcription in prokaryotes—Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains; Transcription in eukaryotes—Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing [10 Hours]

Unit VIII. Regulation of gene expression and translation: Regulation of gene expression in prokaryotes—Operon concept (inducible and repressible system), Genetic code and its characteristics; aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides [8 Hours]

SOLS/ZOO/AIZ-3 Elementary Cell Biology & Molecular Biology	2 Credits [30 Hours]
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Unit I. Introduction to Cell theory; Comparison of a generalised Pro- & Eukaryote cell. Elementary knowledge of the structure & function of plasma membrane, cytoplasm [6 Hours]

Unit II. Introduction to the organelles constituting endomembrane system (Endoplasmic reticulum, Golgi complex, Lysosome, Peroxisome); Nucleus & Nucleolus; Ribosome; Mitochondria; Chloroplast; Introduction to cytoskeleton; Basic features of Cell cycle; Mitosis & Meiosis [10 Hours]

Unit III. DNA as genetic material: Structure of DNA, Types of DNA; Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases; primosome, replisome [6 Hours]

Unit IV. RNA structure and types of RNA: Transcription in prokaryotes—Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains; Transcription in eukaryotes—Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation.

Regulation of gene expression and translation: Regulation of gene expression in prokaryotes—Operon concept (inducible and repressible system), aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides [8 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House, 1996
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)
7. Pandey, B.N. B.Sc. Zoology Series: Cytology, Genetics and Molecular Genetics. Tata McGraw Hill, 2012

SOLS/ZOO/CZ-3(P) Elementary Cell Biology & Molecular Biology (Practical)	[2 Credits]
SOLS/ZOO/AIZ-3(P) Elementary Cell Biology & Molecular Biology (Practical)	[2 Credits]

1. Photographs of prokaryotic cell
2. Photographs of cell organelles
3. Stages of Mitosis by squash technique
4. Photographs of structure of DNA, RNAs
5. Diagrams of translation, transcription
6. Preparation of solutions for Molecular Biology experiments.
7. Isolation of chromosomal DNA from bacterial cells.
8. Isolation of Plasmid DNA by alkaline lysis method
9. Agarose gel electrophoresis of genomic DNA & plasmid DNA
10. Preparation of restriction enzyme digests of DNA samples
11. Demonstration of AMES test or reverse mutation for carcinogenicity

SOLS/ZOO/CZ-4 Physiology and Elementary Biochemistry

4 Credits [60 Hours]

A. PHYSIOLOGY

Unit I. Nerve and muscle: Introduction to CNS, PNS, ANS; Structure of a neuron, Types of neurons; Types of muscle, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction [6 Hours]

Unit II. Digestion: Comparative Physiology of vertebrate digestion e.g., Digestion in different segments of the alimentary canal; Absorption of carbohydrates, proteins, lipids. Ruminant stomach in ungulates [8 Hours]

Unit III. Respiration: Comparative account of vertebrate respiration; Transport of oxygen and carbon dioxide in blood [6 Hours]

Unit IV. Osmoregulation and thermoregulation: Osmoregulation in fishes, structure of nephron, mechanism of urine formation. Thermoregulation in poikilotherms, homeotherms and heterotherms. Aestivation and Hibernation [8 Hours]

Unit V. Cardiovascular system: Blood: Comparative account of circulatory system (Open and Closed), Composition of Blood, Lymph, tissue fluid, comparative anatomy of vertebrate heart and aortic arches. Homeostasis, Heart structure, Origin and conduction of the cardiac impulse, cardiac cycle [6 Hours]

Unit VI. Reproduction and Endocrine Glands: Autocrine, paracrine, juxtacrine and endocrine mode of action; Introduction to Endocrine glands: Structure and function of hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenal and gonads' Reproductive physiology of male and female fertility [6 Hours]

B. BIOCHEMISTRY

Unit VII. Introduction to Biomolecules: Carbohydrates, Proteins, Lipids: structure, types and functions [6 Hours]

Unit VIII. Introduction to Enzymology: Mechanism of action, Kinetics, inhibition and regulation [6 Hours]

Unit IX. Introduction to metabolism of Carbohydrate, Protein and Lipids: Glycolysis, Krebs's cycle, pentose phosphate pathway, glycogen metabolism, electron transport chain, transamination, deamination, urea cycle, β -oxidation in fatty acids [8 Hours]

SOLS/ZOO/AIZ-4 Physiology and Elementary Biochemistry

2 Credits [30 Hours]

A. PHYSIOLOGY

Unit I. Nerve and muscle: Structure of a neuron, Types of neurons; Types of muscle, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction.

Digestion: Physiology of digestion in different segments of the alimentary canal; Absorption of carbohydrates, proteins, lipids [8 Hours]

Unit II. Respiration: Pulmonary ventilation, Respiratory volumes and capacities; Transport of oxygen and carbon dioxide in blood.

Excretion: Structure of nephron, Mechanism of Urine formation.

Cardiovascular system: Open and Closed circulatory system, Composition of Blood; Structure of Heart, Origin and conduction of the cardiac impulse, cardiac cycle.

Reproduction and Endocrine Glands: Physiology of male & female reproduction; Introduction to Endocrine glands [8 Hours]

B. BIOCHEMISTRY

Unit III. Introduction to Biomolecules: Carbohydrates, Proteins and Lipids: structure, types and functions; Introduction to metabolism of Carbohydrate, Protein and Lipids [10 Hours]

Unit IV. Enzymes: Mechanism of action, Kinetics, inhibition and regulation [4 Hours]

SUGGESTED READINGS

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H. Freeman and Co.
2. Hall, John E. (2015). Guyton and Hall Textbook of Medical Physiology, W.B. Saunders Company
3. Jain, A.K. (2018). Textbook of Physiology, Arya Publications

- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry. XXVIII Edition. Lange Medical Books/ Mc Graw Hill
- Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H Freeman and Co.
- Schmidt-Nielsen, Knut (1997). Animal Physiology: Adaptation and Environment, Cambridge University Press
- Singh, HR and N. Kumar Animal Physiology and related Biochemistry, SL, Nagin Chand and Co, Delhi
- Tortora, G.J.& Derrickson, B.H. (2009). Principles of Anatomy and Physiology, 12th edn., John Wiley & Sons, Inc.
- Widmaier, E.P., Raff, H. & Strang, K.T. (2008) Vander's Human Physiology, 11th edn., McGraw Hill

SOLS/ZOO/CZ-4(P) Physiology and Elementary Biochemistry (Practical)	[2 Credits]
SOLS/ZOO/AIZ-4(P) Physiology and Elementary Biochemistry (Practical)	[2 Credits]

A. PHYSIOLOGY

- Preparation of hemin crystals
- Examination of permanent histological sections of mammalian pituitary, thyroid, parathyroid, pancreas, adrenal
- Examination of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage, blood cells
- Models/ Photographs: Structure of neuron, types and structure of muscles, structure of heart
- Charts/ Photographs: Glycolysis, Krebs's cycle, electron transport chain

B. BIOCHEMISTRY

- Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose)
- Colour reactions to identify functional group in the given solution of proteins
- Study of activity of salivary amylase under optimum conditions

SKILL COURSE (SZ-1—SZ-6)

(Theory: 2 Credits)

[Student will elect one course each *EITHER* in I & II *OR* in III & IV Semester]

SOLS/ZOO/SZ-1 Laboratory Techniques in Biology	2 Credits [30 Hours]
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Unit I. Solutions Preparation: Solute, Solvent, Solution; Water-based or aqueous solution for biological application, Methods for dissolving the solute in purified water and adjusting the pH of the solution. Method for addition of the quantity sufficient (QS) to reach the desired volume; Buffer solution; Molarity, Normality [6 Hours]

Unit II. Concentration and Measuring Volumes: Serial dilution, Use of a serial dilution to prepare standards for generating a standard curve; Serological Pipettes, Pipettors use of pipet-aid [4 Hours]

Unit III. Measuring Mass: Analytical balance, Weighing, tarring [2 Hours]

Unit IV. Study the parts of a compound microscope - eye piece and objective lens, condenser lens, mirror, stage, coarse and fine adjustment knobs, and their basic functions. Micrometry- Measuring microscopic organism, measuring cell size in permanent slide viz. protozoan, microscopic invertebrates, egg diameter etc. Recording of microscopic images and videos using microscopic camera [6 Hours]

Unit V. Museum preparation- Preserving macroscopic organisms (invertebrate and vertebrate specimen). Permanent slide preparation: basic histological and histochemical techniques [6 Hours]

Unit VI. Laboratory safety: Laboratory lay out, wet lab, storage of chemicals and glassware. Maintenance of Laboratory equipment (microscopes, centrifuge, incubators, analytical and electronic balances, electrophoretic units, pH meter, turbidity meter etc.); precautions while working in laboratory [6 Hours]

SUGGESTED READINGS

- Charles R Cantor, Paul R. Schimmel (2008). Biophysical Chemistry (Techniques for the Study of Biological Structure and Function), Part II, W.H. Freeman and Company, ISBN-13: 978-0716711902
- Plummer David T. (2004). Introduction to Practical Biochemistry, 3rd edition, Tata McGraw Hill, ISBN-9780070994874

3. Wester John G. (2008). Bioinstrumentation, Wiley & Sons, ISBN-97881265136
4. Wilson Keith, John Walker (2010). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, ISBN-978052173167

SOLS/ZOO/SZ-2 Basic Instrumentation	2 Credits [30 Hours]
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Unit I. Principles and applications of Microscopy: Light, phase contrast, confocal, transmission electron microscopy (TEM & SEM) [2 Hours]

Unit II. Principle and application of Colorimeter. Principle of UV-Visible absorption spectrophotometry, instrumentation and applications, Fluorimetry: Phenomena of fluorescence, intrinsic and extrinsic fluorescence, instrumentation and applications [6 Hours]

Unit III. Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, differential centrifugation, density gradient centrifugation [4 Hours]

Unit IV. Basic principles of chromatography: Partition coefficient, concept of theoretical plates, various modes of chromatography (paper, thin layer, column), preparative and analytical applications, LPLC and HPLC. Principle and applications of: Paper Chromatography, Thin Layer Chromatography. Molecular Sieve Chromatography, Ion Exchange Chromatography, Affinity Chromatography [8 Hours]

Unit V. Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE. Agarose gel electrophoresis, buffer systems in electrophoresis. Electrophoresis of proteins and nucleic acids, protein and nucleic acid blotting, detection and identification [6 Hours]

Unit VI. Principle and applications of pH meter, autoclave, biosafety cabinets/practices; polymerase chain reaction; Water analysis kit; Principle and application of Turbidity meter, Conductivity meter, Flow meter; Types of Owen & Incubators-BOD & COD Incubator [4 Hours]

SUGGESTED READINGS

1. Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd ed., W.H. Freeman and Company, New York
2. Plummer D. T. (1998). An Introduction to Practical Biochemistry, 3rd ed., Tata McGraw Hill Education Pvt. Ltd., New Delhi

SOLS/ZOO/SZ-3 Public Health and Hygiene	2 Credits [30 Hours]
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Unit I. Definition of Public health; Types of hygiene; Examples of public hygiene; Importance of public health; Key elements of public health; Scope of Public health and Hygiene; Nutrition and health – classification of foods, Nutritional deficiencies - Vitamin deficiencies [6 Hours]

Unit II. Environment and Health hazards – Environmental degradation, Pollution and associated health hazards [4 Hours]

Unit III. Communicable diseases and their control measures such as Measles, Polio, Chikungunya, Rabies, Plague, Leprosy and AIDS; Pandemic-Covid 19 [6 Hours]

Unit IV. Non-Communicable diseases and their preventive measures such as Hypertension, Coronary Heart diseases, Stroke, Diabetes, Obesity and Mental ill-health [6 Hours]

Unit V. Health Education in India: WHO Programmes, Government and Voluntary Organizations and their health services; Precautions, First Aid and Awareness on sporadic diseases [6Hours]

Unit VI. Relationship of environmental, social, cultural, occupational and political factors and systems on health and health care [2 Hours]

SUGGESTED READINGS

1. Bolduan, Charlest Frederick, Nils William Bolduan 1949. Public Health and Hygiene (4th ed.), Philadelphia: Saunders
2. Dass, K 2021. Public Health and Hygiene, Notion Press ISBN-10: 1639209603, ISBN-13: 978-1639209606
3. Goel, Arvind Kumar 2005. A College Textbook of Health & Hygiene, ABD Publishers, ISBN 8189011863, 9788189011864
4. Kumaresan, V, R. Sorna Raj, Public Health and Hygiene, Saras Publication ISBN: 9789386519689
5. Park, K. 2007. Preventive and Social Medicine, B.B. Publishers

6. Shanmugavel, G., Binu George 2021. Textbook of Public Health and Hygiene, Darshan Publishers, ISBN, 9386739550, 9789386739551
7. Wagh, Sudhir R., Vinod B. Kakade, Jiwan P. Sarwade Public Health and Hygiene Success Publications, ISBN 9789351585053

SOLS/ZOO/SZ-4 Aquarium Fish Keeping	2 Credits [30 Hours]
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Unit I. Introduction to Aquarium Fish Keeping: Scope of Aquarium fish keeping; Types of aquaria, Aquarium setup and accessories, Aquarium filters; Criteria of selection for aquarium fishes [4 Hours]

Unit II. Biology of Aquarium Fishes: Exotic and Endemic species of Aquarium Fishes (Exotic Aquarium Fishes–Puffer, Humphead & Siamese Tiger fish; Endemic Aquarium Fishes – Zebra Danio, Striped Panchax & Honey Gourami); Common characters and sexual dimorphism of Aquarium fishes: Fresh water (Guppy, Gold fish, Angel fish), Brackish water (Molly, Sword tail, Ray fish), and Marine (Moorish idol, Anemone fish & Butterfly fish) [8 Hours]

Unit III. Food and feeding of Aquarium fishes: Use of live fish feed organisms. Preparation and composition of formulated fish feeds [2 Hours]

Unit IV. Aquarium Fish Diseases: Parasitic, Bacterial, Viral, Protozoan, Fungal & Deficiency diseases [4 Hours]

Unit V. Fish Transportation: Live fish transport - Conditioning, packing, transport and quarantine methods; Factors associated with live fish transport [4 Hours]

Unit VI. Maintenance of Aquarium: General Aquarium maintenance; Water quality requirements: Maintenance and Temperature control; Budget for setting up an Aquarium/ ornamental Fish Farm as a Cottage Industry [8 Hours]

SUGGESTED READINGS

1. Bailey, Mary, Gina Sandford (1999). The Complete Guide to Aquarium Fish Keeping, Lorenz Books
2. Hargreaves, Vincent B. (2007). Complete Book of the Freshwater Aquarium 2007 Thunder Bay Pr., ISBN-10: 159223514X, ISBN-13: 978-1592235148
3. Saha, Sanjib (2022). Aquarium Fish Keeping, Techno World, Kolkata

SOLS/ZOO/SZ-5 Medical Diagnostics	2 Credits [30 Hours]
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Unit I. Introduction to Medical Diagnostics and its importance [2 Hours]

Unit II. Diagnostic's Methods Used for Analysis of Blood, Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain, Platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.) [10 Hours]

Unit III. Diagnostic Methods Used for Urine Analysis; Urine Analysis: Physical characteristics; Abnormal constituents [8 Hours]

Unit IV. Non-infectious Diseases: Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose using Glucometer/ Kit [3 Hours]

Unit V. Infectious Diseases: Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis [3 Hours]

Unit VI. Tumours Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan (using photographs) [4 Hours]

SUGGESTED READINGS

1. Cheesbrough M., J. McArthur (1976). A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses, Churchill Livingstone ISBN: 9780443011443
2. Godkar P.B. and Godkar D.P. (2014). Textbook of Medical Laboratory Technology, 3rd Edition, Bhalani Publishing House
3. Hall, John E. (2015). Guyton and Hall Textbook of Medical Physiology, Saunders
4. Park, K. (2007), Preventive and Social Medicine, B.B. Publishers
5. Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

Unit I. Introduction to Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics [2 Hours]

Unit II: Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System [4 Hours]

Unit III: Biological Sequence Databases: National Center for Biotechnology Information (NCBI) - Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database; EMBL Nucleotide Sequence Database (EMBL-Bank) - Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools. DNA Data Bank of Japan (DDBJ) - Introduction, Resources at DDBJ, Data Submission at DDBJ; Protein Information Resource (PIR) - About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR; Swiss-Prot - Introduction and Salient Features [10 Hours]

Unit IV: Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTAL W, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM) [8 Hours]

Unit V: Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction [4 Hours]

Unit VI: Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement [2 Hours]

SUGGESTED READINGS

1. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.
2. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
3. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley Blackwell.

B.Sc. Third Year (V & VI Semester)

DISCIPLINE SPECIFIC ELECTIVE (DSE)

(Theory-4 Credits; Practical-2 Credits)

[Student will elect any one in V & VI Semester]

Unit I. Introduction to Host-parasite Relationship: Host, Definitive host, Intermediate host, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis [4 Hours]

Unit II. Epidemiology of Diseases: Transmission, Prevention and control of diseases—Tuberculosis, swine flu, typhoid, Covid-19 [5 Hours]

Unit III. Rickettsiae and Spirochaetes: Brief account of *Rickettsia prowazekii*, *Borrelia recurrentis* and *Treponema pallidum* [4 Hours]

Unit IV. Parasitic Protozoa: Life history and pathogenicity of *Entamoeba histolytica*, *Plasmodium vivax*, *Leishmania donovani* and *Trypanosoma gambiense* [5 Hours]

Unit V. Parasitic Helminthes: Life history and pathogenicity of *Schistosoma haematobium*, *Ancylostoma duodenale* and *Wuchereria bancrofti* [5 Hours]

Unit VI. Insects of Economic Importance: Biology, Control and damage caused by *Helicoverpa armigera*, *Pyrilla perpusilla* and *Papilio demoleus*, *Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum*; Safe storage of stored grains [8 Hours]

Unit VII. Insects of Medical Importance: Life cycle, medical importance and control of *Pediculus humanus corporis*, *Anopheles*, *Culex*, *Aedes*, *Xenopsylla cheopis*, *Phlebotomus argentipes* [10 Hours]

Unit VIII. Animal Husbandry: Domestic animals of economic importance; Preservation and artificial insemination in cattle; Induction of early puberty and synchronization of estrus in cattle [8 Hours]

Unit IX. Poultry Farming: Principles of poultry breeding, Management of breeding stock and broilers, Processing and preservation of eggs [6 Hours]

Unit X. Fish Technology: Genetic improvements in aquaculture industry; Induced breeding and transportation of fish seed [5 Hours]

SUGGESTED READINGS

1. Arora, D. R and Arora, B. (2001). Medical Parasitology. II Edition. CBS Publications and Distributors.
2. Atwal, A.S. (1986). Agricultural Pests of India and South East Asia, Kalyani Publishers.
3. Dennis, H. (2009). Agricultural Entomology. Timber Press (OR).
4. Dunham R.A. (2004). Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K.
5. Hafez, E. S. E. (1962). Reproduction in Farm Animals. Lea & Fabiger Publisher
6. Kumar, Vinay et al. (2014). Robbins And Cotran Pathologic Basis of Disease South Asia Edition
7. Park, K. (2007). Preventive and Social Medicine. XVI Edition. B.B Publishers.
8. Pedigo, L.P. (2002). Entomology and Pest Management, Prentice Hall.

SOLS/ZOO/DSE-1(P) Applied Zoology (Practical)	[2 Credits]
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1. Study of *Plasmodium vivax*, *Entamoeba histolytica*, *Trypanosoma gambiense*, *Ancylostoma duodenale*, *Leishmania donovani* and *Wuchereria bancrofti* and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: *Pediculus*, *Culex*, *Anopheles*, *Aedes* and *Xenopsylla*.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs.
4. Identifying feature and economic importance of *Helicoverpa armigera*, *Papilio demoleus*, *Pyrilla perpusilla*, *Callosobruchus chinensis*, *Sitophilus oryzae* and *Tribolium castaneum*
5. Visit to poultry farm or animal breeding centre and submission of visit report.
6. Preparation and maintenance of freshwater aquarium.

SOLS/ZOO/DSE-2 Wild Life Conservation & Management	4 Credits [60 Hours]
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Unit I. Wild life - Values of wild life; Our conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies [4 Hours]

Unit II. Habitat analysis; Evaluation and management of wild life - Physical parameters (Topography, Geology, Soil and Water); Biological Parameters (food, cover, forage, browse and cover estimation); Standard evaluation procedures: remote sensing and GIS [8 Hours]

Unit III. Management of habitats - Setting back succession; Grazing logging; Mechanical treatment; Advancing the successional process; Cover construction; Preservation of general genetic diversity [6 Hours]

Unit IV. Population estimation: Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Pug marks and census method [10 Hours]

Unit V. National Organizations involved in wild life conservation; Wildlife Legislation – Wildlife Protection Act - 1972, its amendments and implementation; CITES; IUCN Red Data Book [6 Hours]

Unit VI. Management planning of wild life in protected areas; Estimation of carrying capacity; Ecotourism / wild life tourism in forests; Concept of climax persistence; Ecology of disturbance [8 Hours]

Unit VII. Management of excess population and translocation; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animal [6 Hours]

Unit VIII. Zoogeographic areas of Indian Subcontinent; Protected Areas: National Parks/ Sanctuaries/Biosphere Reserves of Indian subcontinent; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve [12 Hours]

SUGGESTED READINGS

1. Sharma, BD: High Altitude Wildlife of India. Oxford 7 IBH Publ. Co. Pvt. Ltd. 1994.
2. Negi, SS: Himalayan Wildlife: Habitat and Conservation. Indus Publ. Company, New Delhi 1992.
3. Pullin, AS: Conservation Biology, Cambridge University Press, 2002.

SOLS/ZOO/DSE-2(P) Wild Life Conservation & Management (Practical)**[2 Credits]**

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)
3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques for flora and fauna
5. PCQ, Ten tree method, Circular, Square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment, Tree canopy cover assessment, Shrub cover assessment.
6. Trail/ transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)
7. Photograph of wild animals
8. Zoogeographic areas of Indian Subcontinent
9. National Parks/ Sanctuaries/Biosphere Reserves of Indian subcontinent
10. Population estimation: capture-recapture method

SOLS/ZOO/DSE-3 Principles of Genetics & Evolutionary Biology**4 Credits [60 Hours]****A. Genetics**

Unit I. Mendel's law; Exceptions to Mendel's law; Chromosomal theory of Inheritance; Sex-linked inheritance & genetic disorders; Linkage & Crossing Over [8 Hours]

Unit II. Chromosome structure; Euchromatin; Heterochromatin; Polytene and lamp brush chromosomes. Chromosome banding, Karyotyping; Fine structure of gene and allelism; Sex determination and Sex Linkage [10 Hours]

Unit III. Cytoplasmic Inheritance, Polygenic Inheritance, Mutation, population and evolution genetics, Hardy-Weinberg Principle [10 Hours]

B. Evolution

Unit IV. Historical development of the concept of evolution.

Theories of organic evolution: Lamarckism (Neo-Lamarckism); Darwinism (Neo-Darwinism); Modern synthetic theory.

Evidences in favour of evolution: Comparative anatomy, Comparative Embryology, Palaeontology, Biochemistry & Genetics [10 Hours]

Unit V. Processes of Evolutionary Change: Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection.

Species Concept: Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric) [10 Hours]

Unit VI. Palaeontology: Fossils and fossilization, Incompleteness of fossil record, Dating of fossils, Significance of fossil record; Geological distribution of animals; Mass extinction (Causes, five major extinctions, K-T extinction in detail), Role of extinction in evolution;-Evolution of Horse [12 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
6. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
7. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
8. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
9. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
10. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson

11. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
12. Robert, H. Tamarin (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
13. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
14. William S. Klung Cummings, Spencer and Pallidino (2019). Concepts of Genetics, Pearson Education, Pearson

SOLS/ZOO/DSE-3(P) Principles of Genetics & Evolutionary Biology (Practical)	[2 Credits]
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A. Genetics

1. Study of Mendelian Inheritance and gene interactions (Non Mendelian Inheritance) using suitable examples. Verify the results using Chi-square test.
2. Study of Linkage, recombination, gene mapping using the data.
3. Study of Human Karyotypes (normal and abnormal).

B. Evolution

1. Study of fossil evidences from plaster cast models and pictures
2. Study of homology and analogy from suitable specimens/ pictures
3. Charts:
 - a. Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors
 - b. Darwin's Finches with diagrams/ cut outs of beaks of different species
4. Visit to Natural History Museum, submission of report

SOLS/ZOO/DSE-4 Animal Behaviour & Endocrinology	4 Credits [60 Hours]
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A. Animal Behaviour

Unit I. The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.

Instinct: Definition and characteristics (sign stimuli and Fixed Action Pattern).

Learning behaviour: Definition. Spatial learning. Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.

Timing of behaviour: Biological rhythms. The Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism [12 Hours]

Unit II. Communication: Visual, olfactory, acoustic (bird songs, amphibian calls); echolocation in bats, electrolocation in fish.

Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.

Neural control of behaviour: Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour.

Hormonal Control of behaviour: Hormone brain relationships. Sexual behaviour in mammals (e.g. rat).

Sociobiology: Elements of sociality and social grouping in animals [15 Hours]

B. Endocrinology

Unit III. Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion).

Hormones and Physiological actions of the endocrine glands in mammals: Pituitary, Thyroid, Parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus and Pineal.

Hormone biosynthesis: Protein peptide hormones (gonadotropins, thyrotropin, corticotropin, steroids and catecholamines).

Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adenylyl cyclase, Cyclic nucleotide cascade [18 Hours]

Unit IV. Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH-effects on Leydig cells, negative feedback regulation).

Organization & physiological actions of the Ovary: Folliculogenesis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man [15 Hours]

SUGGESTED READINGS

1. Alcock, John: Animal Behaviour, 4th edition, Sinauer Associates, Inc. 1989.
2. Bentley P.J.: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980

3. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
4. Goldsworthy G J et al: Endocrinology, Blackie, 1981.
5. Goodenough et al.: Perspectives on Animal Behaviour. Wiley & Sons, New York. 1993.
6. Goodman Maurice: Basic and Medical Endocrinology, Raven Press.
7. Grier, JW: Biology of Animal Behaviour, Mosby, 1984
8. Hadley, Mac E.: Endocrinology, Prentice-Hall International ed.1988/1992
9. Krebs, NB & JR Davies: An Introduction to Behavioural Ecology (3rd ed.), Blackwell, 1993
10. Wilson, JW et al.: Williams Textbook of Endocrinology, 9th edition, Saunders, 1998

SOLS/ZOO/DSE-4(P) Animal Behaviour & Endocrinology (Practical)	[2 Credits]
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1. Animal Behaviour photographs/videos/models
2. Slides & Photographs of Endocrine disorders
3. Examination of histological sections from photomicrographs/ permanent slides of rat/human endocrine glands
4. Cholesterol estimation from serum sample
5. Glucose estimation from blood sample

SOLS/ZOO/DSE-5 Introduction to Developmental Biology	4 Credits [60 Hours]
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Unit I. Basic concepts in developmental biology;

Gametogenesis: Events in spermatogenesis. Morphology of mature mammalian spermatozoon; Events in Oogenesis, Significance of oogenesis. Vitellogenesis in birds; Comparison between Spermatogenesis & Oogenesis

Fertilization: Mechanism of fertilization; Capacitation, Molecular events - Block to polyspermy. Egg activation; Elementary idea of parthenogenesis.

Unit II. Types of eggs and cleavage. Role of yolk during cleavage; Products of cleavage (Morula and Blastula). Fate map: fate map of early blastula of Frog, Fate of germ layers. Types of morphogenetic movements. Gastrulation in sea urchin, frog, chick and mammal. Neurogenesis & Notogenesis.

Unit III. Extra Embryonic Foetal Membrane (Chick). Development of chick embryo up to 72 hours. Types, formation and function of Placenta in mammals. Metamorphic events in frog life cycle and its hormonal regulation.

Unit IV. Elementary concept of primary organizer; Induction; nature and its mechanism of action; Development of eye and limbs; Totipotency; Teratogenesis; *Drosophila* development up to gastrulation; Differential expression of genes in *Drosophila*.

SUGGESTED READINGS

1. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
2. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
3. Twyman, RM: BIOS Instant Notes in Developmental Biology, Taylor & Francis, 2000.

SOLS/ZOO/DSE-5(P) Introduction to Developmental Biology (Practical)	[2 Credits]
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1. Frog - Study of developmental stages - whole mounts and sections through permanent slides – cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
2. Chick- Study of developmental stages - sections through permanent slides – cleavage stages, primitive streak stage, 24, 36, 48, 72 hours of incubation
3. Study of the different types of placentae- histological sections through permanent slides or photomicrographs.
4. Study of placental development in humans by ultrasound scans.
5. Examination of gametes - frog/rat - sperm and ova through permanent slides or photomicrographs.

Unit I. What is Biotechnology?

Historical inputs. Biotechnology as a 'tool' not a 'product'. Interdisciplinary nature.

Foundation of Biotechnology: Importance of basic Biology disciplines eg. Human, Animal and Plant Physiology, Genetics, Cell and Molecular Biology, Microbiology, Biochemistry, Immunology and Chemical engineering [12 Hours]

Unit II. Introduction to Genetic Engineering. Tools and techniques.

Enzymes, Restriction endonuclease.

Ligases, Alkaline phosphatase, Reverse transcriptase, DNA polymerase, Vectors-plasmids, phages, cosmids. Biotechnology hazards and safety. Social, moral and ethical issues [12 Hours]

Unit III. Biotechnology in health care. Therapeutic products (Hormones, regulatory proteins, antibiotics). Prenatal diagnosis of genetic diseases. Vaccines, Immunodiagnosics (RIA, ELISA, IRMA) and DNA probe for disease identification. Gene therapy. Human Genome and Biomedicine [12 Hours]

Unit IV. Introduction to Environmental Biotechnology. Bioprocessing Techniques. Enzyme Biotechnology. Single cell proteins. Food and Beverage Biotechnology. Biotechnology in animal agriculture. Biotechnology in plant agriculture [12 Hours]

Unit V. Genetics and Biotechnology: Introduction, Animal Cloning (therapeutic and Reproductive), Genetic manipulation at organism level: Transgenesis, Knock in and Knock out models (Cre-Lox P system), CRIPER-CAS9 technology, genome editing in nature and artificial species improvement of plants and animals. Genetic manipulation at cellular and molecular level, transfection technologies, adenoviral and lentiviral based methods; Industrial genetics; Cell fusion and hybridoma techniques [12 Hours]

SUGGESTED READINGS

1. Das H.K.: Textbook of Biotechnology, Wiley India Pvt. Limited, ISBN 8126505567, 2004
2. Dubey R.C.: A Textbook of Biotechnology, S. Chand Publishing, 1993
3. Thieman, William, Michael A. Palladino: Introduction to Biotechnology, Pearson Education India; 3rd edition, ISBN-10: 9789332535060, 2014

1. Isolation of plasmid DNA from *E. coli*.
2. Transformation of *E. coli* (pUC 18/19) and calculation of transformation efficiency.
3. Restriction Endonuclease Digestion of plasmid DNA.
4. Ligation of Target DNA
5. Gene amplification using PCR
6. DNA sequencing: Interpretation of sequence from the data provided.
7. Analysis of DNA fingerprint
8. Separation of proteins by SDS-PAGE

VOCATIONAL COURSE (VCZ-1—VCZ-6)

(Theory, 4 Credits; 60 Hours)

[Student will elect any one related to Core Subject 1 or Core Subject 2 in V & VI Semester]

Unit I. Introduction: Poultry breeds – description of different breeds – day old chicks, broilers and layers, Japanese Quail, Ducks, Turkey Farming.

Different systems of Poultry Farming – Layers for Egg Production (day old chicks, rearing from 20th week), Broilers for Table purpose and Hatcheries for chick production

Rearing Types/ Systems - Deep litter system and Cage System, multitiered cage system.

External morphology of variety of Fowls: Plymouth Rock, Light Sussex, Minorca, Rhode Island, Red and White Leghorn.

Game and Ornamental purpose varieties [20 Hours]

Unit II. Poultry shed: The layout of Poultry houses; Shed for the placement of chicks – ventilation opening, feeder, water, moisture level, dust.

Infrastructure requirement, Types of Shed and their construction.

Poultry Equipment, their use and maintenance [6 Hours]

Unit III. Feeding of Poultry: Poultry feed classification and principles of feeding; Feed additives and supplements; Feed requirement of chicks, birds, feed chart, balanced feed, waste minimization, proper Feed Conversion Ratio [6 Hours]

Unit IV. Management of a Poultry Farm: Management of Egg Layers – Management of Broilers in large scale farms.

Cleaning, disinfection, sanitization and fumigation of tools/ equipment and shed; maintenance of comfort environment for chicks- adequate light, heat, clean water, feed; Footbath at the entrance (Chemicals/ disinfectants); Handling & caring health management, vaccination etc.; Poultry diseases - Viral, Bacterial, Fungal, Protozoan and Parasitic Lice etc.; Prevention and precautions during vaccination [12 Hours]

Unit V. Progressive plans to promote Poultry as a Self-Employment venture; Support systems available at various District/State/National level; State/Central Government Schemes for giving impetus for entrepreneurship development.

Indian breed of poultry: Aseel, Chittagong, Kadaknath and Busra

Field Visit & Interaction with Poultry Farmers and other Support Agencies [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. Poultry Production and Management by J. Prasad, Kalyani Publishers (2015)
2. Poultry Science and Practice by N. Ghosh, CBS Publishers & Distributors (2015)

SOLS/ZOO/VCZ-2 Apiculture	4 Credits [60 Hours]
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Unit I. Biology of Bees: History, classification and biology of honey bees; Species of honey bees (*Apis dorsata*, *Apis cerana indica*, *Apis florea*, *Apis mellifera*, *Melipona irridipennis*); Specific Characteristics and suitability for geographic condition; Climatic requirement of different bee species; Social organization of honey bee colony [18 Hours]

Unit II: Rearing of Bees. Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Flora for apiculture; Selection of Bee Species for Apiculture; Modern method of apiculture – Tools and appliances for modern method.

Enemies and diseases of Honey bee, Control and Preventive measures [16 Hours]

Unit III: Harvesting, Processing and Preservation of Honey. Methods of harvesting honey; Processing of honey; Preservation of honey; Indigenous method for extraction of honey [6 Hours]

Unit IV: Economic Importance. Honey, Bees Wax, Propolis etc.- Production, Chemical composition of Honey bee wax; Economic, nutritional and medicinal value [4 Hours]

Unit V: Entrepreneurship in Apiculture. Bee keeping industry – Requirements of Commercial Bee Keeping, Recent efforts, Government sponsored scheme, Modern method in employing honey bees for cross pollination in horticultural gardens.

Field Visit & Interaction with Bee Keepers and other Support Agencies [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. Bisht D.S. (2016). Apiculture, ICAR Publication
2. Gupta, JK. (2016). Apiculture ICAR PDF Book
3. Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
4. Singh S. (1962). Beekeeping in India, Indian council of Agricultural Research, New Delhi

SOLS/ZOO/VCZ-3 Sericulture	4 Credits [60 Hours]
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Unit I. Introduction to Sericulture: Origin and history of sericulture. Ancient silk route and map of India; Temperate and tropical climate for sericulture practice. Distribution and Races Exotic and indigenous races Mulberry and non-mulberry Sericulture

Types of silkworms: Mulberry Silkworm (*Bombyx mori*), Tasar Silkworm (*Antheraea paphia*), Muga Silkworm (*Antheraea assama*), Eri Silkworm (*Attacus ricinii*), Oak Silkworm (*Antheraea pernyi*) and Gaint Silkworm (*Attacus alts*) [20 Hours]

Unit II. Biology of Silkworm: Life cycle of *Bombyx mori*, Morphology of the egg, larva, pupa, adult; Structure of silk gland and secretion of silk.

Voltinism in silk worm: univoltine, bivoltine, poly or multivoltine.

Biology of Mulberry: Botanical description of mulberry. Economic importance of mulberry Plant, *Morus L.* and its species [10 Hours]

Unit III. Rearing of Silkworms: Selection of mulberry variety and establishment of mulberry garden, rearing house and rearing appliances disinfectants (formalin, bleaching powder); RKO Silkworm rearing technology: types of mountages, spinning, harvesting and storage of cocoons; Physical and commercial characters of Cocoons, Importance of by-products of Sericulture [10 Hours]

Unit IV. Pests of silkworm: Uzi fly, dermestid beetles and vertebrates.

Silkworm diseases: Protozoan disease, Bacterial disease, Fungal disease, Viral disease, Sotto disease, septicemia, galtine; Control and prevention of pests and diseases [6 Hours]

Unit V. Entrepreneurship in Sericulture: Prospects of Sericulture in India, Sericulture industry in different states, self-employment venture, potential in mulberry and non-mulberry sericulture.

Visit to various sericulture centres [14 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. A Guide for Bivoltine Sericulture: K. Sengupta, Director, CSR & TI, Mysore (1989)
2. An Introduction to Sericulture: Ganga, G., J. Sulochana Chetty, Oxford & IBH Pub. Co. (1991)
3. Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore (1987)
4. Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore (1987)
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan (1972)
6. Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore (1986)
7. Manual of Silkworm Egg Production: M. N. Narasimhanna, CSB, Bangalore (1988)
8. Principles of Sericulture (Translated from Japanese): Hasao Aruga, Oxford & IBH Pub. Co. Pvt.. Ltd., New Delhi (1994)
9. Silkworm Rearing: Wupang-Chun and Chen Da-Chung, FAO, Rome (1988)

SOLS/ZOO/VCZ-4 Aquaculture

4 Credits [60 Hours]

Unit I: Aquaculture: Definition and Scope, commercially important cultivable finfish species in freshwater, brackish water and marine water environments; Types of farming systems: extensive, semi-intensive and intensive culture; Cage culture; Integrated fish farming [14 Hours]

Unit II: Fish ponds: types and their management; Fish polyculture with special reference to indigenous & exotic major carps; Induced breeding: Hypophysation and use of synthetic hormone, significance of Induced breeding [12 Hours]

Unit III: Prawn culture, ornamental fish culture and its significance; Commercially important fresh water and marine ornamental fish species; Maintenance of aquaria; Farming of pearl oyster [10 Hours]

Unit IV: Fish feed: Fish feed ingredients; Type of feeds and feeders used in Aquaculture; Commonly occurring diseases in aquaculture and their control [8 Hours]

UNIT V: Field visit to fish farm, hatchery complex, and onsite interactions with progressive fish farmers [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. A Textbook of Fish Biology and Fisheries, 3rd Edition by S.S. Khanna and H.R. Singh, NPH, Delhi (2014)
2. Aquaculture by John E. Bardach, Wiley India Pvt Ltd (1974)
3. Aquaculture: Principles and Practices by T.V.R. Pillay, Wiley India Pvt Ltd (2011)
4. Introduction to Aquaculture by Matthew Landau, Wiley (1991)
5. Textbook of Fish Culture by Marcel Heut, Fishing News Books Ltd (1972)

Unit I. Freshwater fish seed resources; Natural breeding of finfishes; Historical perspective of fish seed collection; Sexual maturity, breeding season and development of gonads [10 Hours]

Unit II. Induced breeding of Indian major carps (Catla, Rohu, Mrigala) and exotic carps (Silver carp, Grass carp); Environmental factors affecting spawning; Fish pituitary gland, synthetic hormones for induced breeding of fishes; Fish brood stock management and transportation of brood fish [12 Hours]

Unit III. Different types of fish hatcheries: traditional double-walled hapa, Chinese carp hatchery, glass jar hatchery, Flow throw hatchery; Egg and embryonic developmental stages; Causes of mortality of fish eggs and spawn in hatchery operation and their treatment [12 Hours]

Unit IV. Spawn rearing techniques: nursery and rearing pond management; Packing and transportation of fish seed and use of anaesthetics/ disinfectants in fish breeding and transport; Cryopreservation of semen [10 Hours]

Unit V. Field visits to *Fish hatchery [16 Hours]

(Students will prepare and submit report on their field visits)

* Suggested hatcheries in Uttarakhand: Trout hatchery, Bairangna, District Chamoli; Gangori hatchery, District Uttarkashi; Koteshwar hatchery (Common carp and Masheer fish seed), Koteshwar, District Tehri; Carp hatchery, Kashipur, US Nagar

SUGGESTED READINGS

1. Broodstock Management and Quality Fish Seed Production in Freshwater Fishes by K K Marx, NPH, Delhi (2019)
2. Fish Hatchery Management by Robert G. Piper, Andesite Press (2015)
3. Induced Fish Breeding: A Practical Guide for Hatcheries by Nihar Ranjan Chattopadhyay, Academic Press; 1st edition (2016)
4. Text Book of Breeding and Hatchery Management of Carps by Gupta and Mohapatra, NPH, Delhi (2008)

Unit I. Introduction to vermiculture: Definition, meaning, history, economic importance; Role in bio transformation of the residues and production of organic fertilizers; The matter and humus cycle. Ground population, transformation process in organic matter; useful species of earthworms (Local species and Exotic species of earthworms) [12 Hours]

Unit II. The earthworm species: Biology of *Eisenia fetida* (Taxonomy, anatomy, physiology and reproduction of Lumbricidae; Vital cycle of *Eisenia fetida*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, pH, light, and climatic factors).

Biology of *Eudrilus eugeniae* (Taxonomy anatomy, physiology and reproduction of Eudrilidae; Vital cycle of *Eudrilus eugeniae*: alimentation, fecundity, annual reproducer potential and limit factors) [12 Hours]

Unit III. Earthworm farming: Earthworm compost for home gardens; Conventional commercial composting; Earthworm Farming (Vermiculture), Extraction (harvest), vermicomposting harvest and processing; Nutritional Composition of Vermicompost for plants; Vermiwash collection, composition & use; Enemies of Earthworms, Common problems their prevention and solution [12 Hours]

Unit IV. The working group experience with *E. fetida* populations compartment with farm industrial residues (frigorific, cow places, feed-lot, aviaries exploitations, and solid urban residues); Lineaments to vermicomposting elaboration projects; Considerations about economic aspects of this activity [12 Hours]

Unit V. Demonstration of vermiculture in field [12 Hours]

(Students will prepare and submit report on their visit to demonstration unit)

SUGGESTED READINGS

1. Ahmad, S Rehan: CBCS Skill Enhancement Course Vermicompost Production (Set of 5 Books), Nitya Publications, Bhopal, 2020
2. Edwards, Clive A., Norman Q. Arancon, Rhonda L. Sherman: Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management, CRC Press, 2010
3. Keshav Singh: A Textbook of Vermicompost: Vermiwash and Biopesticides, Biotech Books, 2014
4. NPCS Board of Consultants & Engineers: The Complete Technology Book on Vermiculture and Vermicompost, Asia Pacific Business Press Inc., 2004

B.Sc. [Honours] Fourth Year (VII & VIII Semester)

B.Sc. VII Semester (Honours)

CORE ZOOLOGY (CZ-5—CZ-6)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-5 Non-Chordata

3 Credits [45 Hours]

Unit I. Major and minor invertebrate phyla: General characters, organization, classification up to Order and their types; Origin and evolution of lower and higher invertebrates; Overview of economic importance of invertebrates.

Protozoa: Comparative morphology of all classes; Locomotor organelles and locomotion; **Nutrition:** holophytic, holozoic, saprozoic, myxotrophic and parasitic; **Reproduction:** Asexual and sexual reproduction, parthenogenesis and regeneration [12 Hours]

Unit II. Porifera: Comparative morphology of all classes; Types of canal system; **Reproduction:** Asexual, sexual reproduction and regeneration in sponges.

Coelenterata: Comparative morphology of all classes; Polymorphism; Coral reefs & their formation; General characters and affinities of Ctenophora.

Helminthes: Comparative morphology of Platyhelminthes and Aschelminthes [11 Hours]

Unit III. Minor Group: Classifications to order level, characters and affinities of Phoronida and Rotifera.

Annelida: Classification to order level, comparative morphology of all classes; Segmental organs.

Arthropoda: Classification to order level; Appendages and mouth parts in insects; Larval forms in Crustacea; Arachnida.

Organization and affinities of *Onychophora* [12 Hours]

Unit IV. Mollusca: Classification to order level; Comparative morphology of all classes; Major features of the respiratory and reproductive systems; Larval forms, Torsion and Pearl formation.

Echinodermata: Classification to order level; Water vascular system; Larval forms and affinities [10 Hours]

SUGGESTED READINGS

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and Function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
5. Kotpal: Modern Text-book of Zoology: Invertebrates. Rastogi Publications, Meerut
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillian, 1972.

SOLS/ZOO/CZ-6 Cell and Molecular Biology

3 Credits [45 Hours]

A. Cell Biology

Unit I. Ultrastructure of prokaryotic and eukaryotic cells.

Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes; Function - Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).

Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.

Cytoskeleton: Components, functions & derived organelles (cilium, flagellum).

Mitochondria: Structure function & genetic organisation. Ribosome: Biosynthesis & formation in nucleolus [10 Hours]

Unit II. Signal transductions.

Cell signaling: Types of signaling, Cell surface receptor mediated signaling.

Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).

Cellular transformation and malignancy; Retroviruses; Apoptosis and causes of cancer [10 Hours]

B. Molecular Biology

Unit III. The central dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes; Structural polymorphism of DNA & RNA; Three-dimensional structure of t-RNA [10 Hours]

Unit IV. DNA replication; Genetic code; Transcription and translation in prokaryotes and eukaryotes; RNA processing; Mutations & DNA repair systems; P bodies; Concept of Epigenetics, Chromatin remodelling, Non-Coding RNAs [15 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, CCH, a Wolters Kluwer Business, Lippincott Williams & Wilkins, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House.
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (S. Chand & Co.)

SOLS/ZOO/LC-1 Lab Course-1 (Based on CZ-5 & CZ-6)
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[2 Credits]

Non-Chordata

1. Slides of Protozoa
2. Slides & Museum specimen of Porifera, Coelenterata, Helminthes, Annelida, Arthropoda, Mollusca & Echinodermata
3. Slides of Phoronida and Rotifera
4. Specimen: *Beroe*, *Peripatus*

Cell Biology

1. Permanent slides of cell division (Mitosis & Meiosis)
2. Study of mitotic cell division by squash technique
3. Slide preparation of interphase nuclei in buccal epithelium
4. Study of meiotic cell division in grasshopper testis
5. Preparation of blood smear

Molecular Biology

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity
7. DNA isolation from animal tissue
8. Separation of DNA molecules from Agarose Gel Electrophoresis
9. RNA isolation from Baker's Yeast
10. Estimation of RNA by orcinol method

MAJOR ELECTIVE ZOOLOGY (EZ-1a—EZ-1c)

(Theory-2 Credits; Lab Course-2 Credits)

[Any one]

SOLS/ZOO/EZ-1a. Developmental Biology and Parasitology

2 Credits [30 Hours]

A. Developmental Biology

Unit I. Early development of Frog and Chick up to gastrulation.

Concept of organiser and embryonic inductions.

Implantation of embryo in human, Placenta (structure, Types and Function) [7 Hours]

Unit II. Metaplasia & trans differentiation; Ageing: mechanism, concepts and theories. Cloning of animals by nuclear transfer.

Regeneration in Vertebrates: Tail, Limb, Lens and retina.

Teratogenesis: Teratogenic agents and their effects on embryonic development [8 Hours]

B. Parasitology

Unit III. Parasitism and evolution of parasitism.

Host parasite relationship, Parasitic adaptations in Protozoa.

Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Trypanosomes & Plasmodium*) [7 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes.

Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Schistosoma & Wuchereria*).

Introduction to arthropod vectors of human diseases [8 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
6. Dogiel, VA: General Parasitology, 1964
7. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
8. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
9. Kalthoff, K.O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
10. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
11. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008
12. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
13. Read, P.W.: Animal Parasites, Prentice Hall, 1977
14. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
15. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
16. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

Lab Course based on EZ-1a [2 Credits]

Developmental Biology

1. Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
2. Study of whole mounts and sections of developmental stages of frog (Cleavage stages, blastula, gastrula, neurula, tail bud stages) through permanent slides/ ICT tools/ models/ charts/ photographs etc.
3. Study of developmental stages of whole mounts of chick embryo (Primitive streak -13 and 18 hours, 20, 24, 28, 33, 36 and 48 hours of incubation) through permanent slides/ ICT tools/models/photographs.
4. Window preparation in Hen's Egg and through ICT tools (videos)

Parasitology

1. Study of museum specimen of parasites.
2. Study of life stages of *Trypanosoma & Plasmodium* through permanent slides/ micro photographs.
3. Study of adult and life stages of *Schistosoma & Wuchereria* through permanent slides/micro photographs.

SOLS/ZOO/EZ-1b. Elementary Biotechnology and Microbiology	2 Credits [30 Hours]
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A. Biotechnology

Unit I. History & future perspective. General steps of gene cloning technology, genomic & C-DNA library; A general concept of first-generation DNA and Next Generation DNA/RNA Sequencing, tools for nucleic-acid/protein detection, Polymerase chain reaction, Reverse Transcription PCR, Real Time PCR [10 Hours]

Unit II. Gene therapy; DNA finger printing; Products of recombinant DNA technology.

Human genome project and its applications [4 Hours]

B. Microbiology

Unit III. Bacteria, Virus and Fungi - classification, staining techniques, pathological significance. Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [8 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques; Microbial fermentation: Microbes in decomposition and recycling processes; Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [8 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill, 1993

Lab Course based on EZ-1b. [2 Credits]

Biotechnology

1. Isolation of genomic and plasmid DNA
2. Agarose gel electrophoresis
3. SDS-PAGE for protein isolation
4. Restriction digestion, Cloning Vectors

Microbiology

1. Transfer of Bacteria: Aseptic Techniques
2. Preparation of Smears and Simple Staining
3. Gram Staining
4. Acid-Fast Staining

SOLS/ZOO/EZ-1c. Toxicology	2 Credits [30 Hours]
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Unit I. Introduction of toxicology: Definition, history and scope of toxicology;

Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals & Radioactive substances [6 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure; Factors affecting toxicity;

Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [8 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [6 Hours]

Unit IV. Bio-distribution, biomagnification biotransformation of xenobiotics and process of elimination; Microplastics [10 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018): The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest (2010): A Textbook of Modern Toxicology, Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim (2017): Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram (2019): Textbook of Toxicology, by, Dreamtech Press, ISBN-10: 9389520274

Lab Course based on EZ-1c. [2 Credits]

1. Care and maintenance of laboratory animals
2. Toxic substances: Wastewater, Carcinogens, Heavy Metals, Pesticides, Insecticides
3. Preparation of various concentrations
4. Study of Acute, subacute, chronic & sub chronic toxicity
5. LC50 for 24, 36, 48, 72 and 96 hours
6. Dose-response relationship
7. Analysis of Toxicants by Chromatography (Paper, TLC, GC)

SOLS/ZOO/LC-2 Major Elective Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	[2 Credits]
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MINOR CORE ZOOLOGY (CZM-1)
[Theory-1; 3 Credits]
(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/CZM-1 Endocrinology & Animal Behaviour

3 Credits [45 Hours]

A. Endocrinology

Unit I. Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion).

Hormones and Physiological actions of the endocrine glands in mammals: Pituitary, Thyroid, parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus & Pineal.

Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adenylate cyclase, Cyclic nucleotide cascade [12 Hours]

Unit II. Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH-effects on Leydig cells, negative feedback regulation).

Organization & physiological actions of the Ovary: Folliculogenesis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles [10 Hours]

B. Animal Behaviour

Unit III. The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.

Instinct: Definition and characteristics (Sign stimuli and Fixed Action Pattern).

Learning behaviour: Definition; Spatial learning, Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.

Timing of behaviour: Biological rhythms; The Biological Clock; Circadian rhythms and their synchronisation seasonal rhythms; Photoperiodism [10 Hours]

Unit IV. Communication: Visual, olfactory, acoustic. Bird songs. Amphibian calls. Communication in bats.

Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.

Neural control of behaviour: Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour.

Hormonal Control of behaviour; Hormone brain relationships; Elements of sociality and social grouping in animals [13 Hours]

SUGGESTED READINGS

1. Alcock, John: Animal Behaviour, 4th edition, Sinauer Associates, Inc. 1989.
2. Bentley P.J.: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980
3. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
4. Gardner, David G. & Dolores M. Shobac: Greenspan's Basic and Clinical Endocrinology, 10th edition (A&L Lange Series), McGraw Hill / Medical, 2017
5. Goldsworthy G J et al: Endocrinology, Blackie, 1981.
6. Goodenough et al.: Perspectives on Animal Behaviour. Wiley & Sons, New York. 1993.
7. Goodman Maurice: Basic and Medical Endocrinology, Raven Press.
8. Grier, JW: Biology of Animal Behaviour, Mosby, 1984
9. Hadley, Mac E.: Endocrinology, Prentice-Hall International ed.1988/1992
10. Halliday, T.R.: Animal Behaviour Vol. 1 & 2 Communication, 1983
11. Krebs, NB & JR Davies: An Introduction to Behavioural Ecology (3rd ed.), Blackwell, 1993
12. Lehner, PN: Handbook of Ethological Methods, Garland STPM Press, New York, 1979
13. Palmer, JD et al.: An Introduction to Biological Rhythms, Academic Press, New York, 1976
14. Ross, C.W. & F.B. Salisbury: Plant Physiology, Brooks/Cole, 1991
15. Saunders, DS: Insect Clocks Pergamon Press, 1982
16. Wilson, JW et al.: Williams Textbook of Endocrinology, 9th edition, Saunders, 1998

MINOR ELECTIVE ZOOLOGY (EZM-1a—EZM-1c)
[Theory: 3 Credits]
(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/EZM-1a. Developmental Biology and Parasitology	3 Credits [45 Hours]
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A. Developmental Biology

Unit I. Development and differentiation of sperm and oocytes, capacitation, vitellogenesis; Mechanism of fertilization;

Early development of Frog and Chick up to gastrulation;

Concept of organiser and embryonic inductions;

Implantation of embryo in human;

Limb morphogenesis [13 Hours]

Unit II. Development in *Drosophila* up to gastrulation; Molecular basis of development;

Metaplasia & trans differentiation.

Ageing: mechanism, concepts and theories;

Regeneration, Teratogens.

Regeneration in Vertebrates: Tail, Limb, Lens and retina;

Metamorphosis in Amphibia: morphogenetic and biochemical Changes and hormonal regulation [10 Hours]

B. Parasitology

Unit III. Parasitism and evolution of parasitism.

Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica*, Trypanosomes, *Leishmania donovani* & *Plasmodium*) [10 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes; Common trematode, cestode and nematode parasites; Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria* & *Taenia*);

Introduction to arthropod vectors of human diseases (mosquitoes, lice, flies & ticks) [12 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Casselman, W.G.: Histochemical Techniques, John Wiley, 1959
6. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
7. Dogiel, VA: General Parasitology, 1964
8. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
9. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
10. Kalthoff, K. O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
11. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
12. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008
13. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
14. Pedersen, R.A., G.P. Schatten eds.: Current Topics in Developmental Biology, Academic Press, 1996
15. Read, P.W.: Animal Parasites, Prentice Hall, 1977
16. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
17. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
18. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

A. Biotechnology

Unit I. History, definition & scope.

Introduction to recombinant DNA technology - gene cloning, general idea of cloning vectors, restriction digestion, ligation, competent cell preparation, transformation and analysis of clones; Genomic & C-DNA library; Tools for detecting DNA/RNA and protein, first generation DNA and protein-sequencing, Next Generation RNA sequencing, polymerase chain reaction, Reverse Transcription PCR, Real time PCR [15 Hours]

Unit II. Gene therapy; DNA finger printing; Transgenic and knock out animals and plants; Primary culture, and cell lines; Tissue and organ culture; Transfection methods & transgenic and knock out animals; Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites;

Products of recombinant DNA technology; Human genome project and its applications [10 Hours]

B. Microbiology

Unit III. Classification of Virus, Bacteria and Fungi -, staining techniques, pathological significance; Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [10 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques;

Microbial fermentation: Microbes in decomposition and recycling processes.

Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [10 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill, 1993

Unit I. Introduction of toxicity: Definition, history, scope & sub-divisions of toxicology

Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals & Radioactive substances [12 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure (inhalation, injection & through food or intestinal); Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms

Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) & UV rays.

Bio-distribution, biomagnification, biotransformation of xenobiotics and process of elimination.

Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [15 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [10 Hours]

Unit IV. Chemical nature of toxicants: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins; Microplastics.

Pesticides, Radioactive compounds & Heavy metals [8 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018) The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest: A Textbook of Modern Toxicology (2010), Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim: Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, (2017), CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram: Textbook of Toxicology, by, Dreamtech Press (2019), ISBN-10: 9389520274

CORE ZOOLOGY (CZ-7)
[Theory: 4 Credits; Lab Course: 4 Credits]

SOLS/ZOO/CZ-7 Chordata

4 Credits [60 Hours]

Unit I: Origin and evolution of chordata.

General characters, classification and development of Urochordata and Cephalochordata.

Affinities of Hemichordata, Urochordata & Cephalochordata [15 Hours]

Unit II: Origin and evolution of Vertebrates.

General Characters, Classification and affinities of Cyclostomata.

Salient features of different groups of fishes; Comparison between Chondrichthyes and Osteichthyes; Dipnoi & Coelacanth.

Origin and evolution of Amphibia; Gymnophiona; Parental care in Amphibia; Neoteny & Paedogenesis [20 Hours]

Unit III: General characters and classification of Reptilia; Origin of Reptilia and adaptive radiation in Reptilia; Characters and affinities of Chelonia, Rhynchocephalia and Crocodilia.

General characters and classification of Aves; Origin and ancestry of birds; Characters and affinities of Ratitae; Origin and mechanism of flight in birds; Palate in birds; Migration in birds [15 Hours]

Unit IV: General characters and classification of mammals; Origin of mammals; Characters and affinities of Prototheria and Metatheria.

Dentition in mammals; Aquatic and flying adaptations in mammals; Adaptive radiation in mammals [10 Hours]

SUGGESTED READINGS

1. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Kotpal RL: Modern Text Book of Zoology Vertebrates; Rastogi Publications, 2007
4. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962.
5. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
6. Young JZ: The Life of Vertebrates, Oxford, 1950.

SOLS/ZOO/LC-3 Lab Course-3 (Based on CZ-7)

[4 Credits]

1. Slides of Protochordata, whole mount and cross sections of *Balanoglossus*, *Herdmania* and *Amphioxus*
2. Museum Specimens: Protochordata, Cyclostomata, Pisces, Amphibia, Reptile, Bird & Mammals.
3. General anatomy and neural gland of *Herdmania* using charts and computer software.
4. Afferent and efferent arteries, cranial nerves, membranous labyrinth, eye muscles and their innervation, brain of any fish.
5. Articulated and disarticulated bones of Frog, Varanus, Carapace & Plastron of Tortoise, Fowl and Rabbit
6. Flight muscles, perching mechanism, air sacs and anatomy of the neck region in pigeon through charts/ models/computer software
7. Slides: Scales of fish

MAJOR ELECTIVE ZOOLOGY (EZ-2a—EZ-2c)
(Theory-2 Credits; Lab Course-2 Credits)
[Any One]

SOLS/ZOO/EZ-2a. Aquatic Biodiversity

2 Credits [30 Hours]

Unit I. Definition, concept, scope and measurement of biodiversity.

Types of Biodiversity: Species, Genetic, Community, Ecosystem.

Factors governing biodiversity: Historical & Proximate [4 Hours]

Unit II. Aquatic ecosystems and their characteristics.

Freshwater biodiversity; Marine biodiversity.

Biodiversity data bases [10 Hours]

Unit III. Threats to habitats and biological diversity in freshwater and marine ecosystems.

Endemic species: Definition, concept and scope; Hot spots

Endangered species: Definition, concept and scope.

Conservation: Definition, concept and scope.

Ramsar Convention [10 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies from Himalaya

Environmental flows: Importance for the aquatic flora & fauna. Environmental flows assessment methodology: Hydrological, hydraulics rating, habitat simulation & holistic [6 Hours]

SUGGESTED READINGS

1. AlgaeBase, Diatoms of North America, <http://www.insecta.bio.spbu.ru/z/faun-eur.htm>; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family; <https://aqgrisi.nbfgr.res.in/listing/family/71>)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water For People And Nature, Island Press (2003)

Lab Course based on EZ-2a. [2 Credits]

1. Sampling and analysis of plankton
2. Sampling and analysis of benthic organisms
3. Chlorophyll estimation of periphytic algae
4. Study of ecological indices
5. Study of endangered species and protection
6. Study of local fish fauna
7. Study of river/ natural pond habitat and organisms

SOLS/ZOO/EZ-2b. Genetics, Evolution and Taxonomy

2 Credits [30 Hours]

A. Genetics

Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles.

Modification of Dihybrid ratios and their biochemical basis [6 Hours]

Unit II. Linkage and Crossing over; Sex Linked inheritance and genetic disorders; Mutations and chromosomal aberrations.

Operon hypothesis, Lac operon (positive and negative control).

Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic Drift [10 Hours]

B. Evolution

Unit III. Natural Selection: Types of selection; Role of Mutation in Evolution.

Micro and Macroevolution; Genetic drift and gene flow

Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory; Fossils and fossilization, Geological distribution of animals.

Evolution of Horse [8 Hours]

C. Taxonomy

Unit IV. Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.

Biological Species Concept.

Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations [6 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Palldino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrímsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

Lab Course based on EZ-2b. [2 Credits]

Genetics

1. Genetics problems related to Mendelian inheritance
2. Preparation of Drosophila Polytene Chromosome Squashes

Evolution

1. Evidences of organic evolution
2. Photographs/ Models of Evolution

Taxonomy

1. List of animals with common and zoological names
2. List of household pests with common and zoological names
3. Classification of 10 common fish, amphibia, reptiles, bird and mammals

SOLS/ZOO/EZ-2c. Assisted Reproductive Biology Techniques	2 Credits [30 Hours]
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Unit I. Scope of reproductive technologies; functional anatomy of male & female reproductive system; Induced release of gametes and its significance [7 Hours]

Unit II. Multiple ovulation, superovulation; In-vitro oocyte maturation; Biochemistry of semen, semen composition and formation; Cryopreservation of gametes [8 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer; In-vitro fertilization; Transgenic animals and their uses [7 Hours]

Unit IV. Contraception; Immunocontraception; Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [8 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)

3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)

Lab Course based on EZ-2c. [2 Credits]

1. Study of functional anatomy of male reproductive system with the help of photographs, chart and models
2. Study of functional anatomy of female reproductive system with the help of photographs, chart and models
3. Study of the histological details of testes, ovary and pituitary with the help of permanent slide, photographs and charts.
4. Physical examination of cryopreserved semen of bull for sperm count
5. Preparation of chart and model based on theory topics

SOLS/ZOO/LC-4 Major Elective Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	[2 Credits]
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MINOR CORE ZOOLOGY (CZM-2)
[Theory-1; 3 Credits]
(For students with Core subjects other than Zoology)

CZM-2. Biological and Radiotracer Techniques	3 Credits [45 Hours]
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Unit I. Analytical separation methods: Chromatography - General principle and application; Adsorption chromatography, Partition chromatography, Gas chromatography, liquid chromatography, Paper chromatography, Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC (High Performance/Pressure Liquid chromatography) [12 Hours]

Unit II. Electrophoresis: General principle and application; Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native, Denaturing & Reducing), Disc Gel electrophoresis, Slab Gel electrophoresis, Isoelectrofocussing (IEF), Isotachophoresis [8 Hours]

Unit III. Centrifugation: Basic principles. Common centrifuges used in laboratory (clinical, high speed & ultracentrifuges). Sedimentation rate, Sedimentation coefficient, Zonal centrifugation, Equilibrium density gradient centrifugation.

Types of rotors (fixed angle, swing bucket), Types of centrifugation- Preparative, differential & density gradient.

Microscopy: Light, phase contrast, Fluorescence and Confocal microscopy, Scanning and Transmission Electron microscopy, Cryo-electron microscopy and Atomic force microscopy [10 Hours]

Unit IV. Biosensors: Introduction & principles. First, second & third generation instruments, cell based biosensors, enzyme immunosensors.

Spectroscopic methods: Principle and applications of UV-visible, IR, NMR, ESR Spectroscopy. Principle & application of X-ray crystallography.

Application of radioisotopes in biology. Properties and units of radioactivity. Radioactive isotopes and half-life.

Measurement of radioactivity: GM Counter, gamma counter, liquid scintillation counter.

Tracer techniques of Autoradiography, Radioimmunoassay.

Safety rules in handling of radioisotopes and hazardous chemicals [15 Hours]

SUGGESTED READINGS

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. J.F. Robyt & B.J. White, Biochemical Technique: Theory & Practical, Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry

MINOR ELECTIVE ZOOLOGY (EZM-2a—EZM-2c)
[Theory: 3 Credits]
(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/EZM-2a. Aquatic Biodiversity

3 Credits [45 Hours]

Unit I. Definition, concept, scope and measurement of biodiversity; Biodiversity loss (causes & effects).

Types of Biodiversity: Species, Genetic, Community, Ecosystem.

Factors governing biodiversity: Historical & proximate [7 Hours]

Unit II. Types of aquatic ecosystem & biomes and their characteristics.

Freshwater biodiversity: Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands; Over view of freshwater biodiversity in important rivers, lakes, reservoirs and wetlands of India with emphasis on Himalaya.

Introduction to Marine biodiversity.

Biodiversity data bases [15 Hours]

Unit III. Threats to habitats and their conservation.

Endemic species & Endangered species: Definition, concept, scope.

Conservation: Definition, concept, scope.

Ramsar Convention; Physical and chemical characteristics of wetlands.

Over view of biodiversity in Wetlands of India with emphasis on Himalaya [15 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies.

Environmental flows: Importance for the aquatic flora & fauna. Environmental flows assessment methodology (Hydrological, hydraulics rating, habitat simulation & holistic). Ecosystem Services: Concept & scope [8 Hours]

SUGGESTED READINGS

1. AlgaeBase, Diatoms of North America, <http://www.insecta.bio.spbu.ru/z/faun-eur.htm>; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family; <https://aqgrisi.nbfr.res.in/listing/family/71>)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water for People and Nature, Island Press (2003)

SOLS/ZOO/EZM-2b. Genetics, Evolution and Taxonomy

3 Credits [45 Hours]

A. Genetics

Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles, Pedigree analysis; Eugenics.

Modification of Dihybrid ratios and their biochemical basis; Fine structure of Gene; Statistical tools (Probability and Significance Testing) [10 Hours]

Unit II. Linkage and Crossing over, Genetic mapping techniques; Sex linked inheritance and genetic disorders; Mutations and chromosomal aberrations.

Operon hypothesis, Lac operon (positive and negative control); Regulation of gene expression in eukaryotes.

Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic drift and gene flow [12 Hours]

B. Evolution

Unit III. Natural Selection: Types of selection and selection coefficient; Role of mutation in evolution (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).

Micro and Macroevolution; Genetic drift and gene flow

Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory.

Palaeontology: Fossils and fossilization, mass extinction, geological time scale; Evolution of Horse; Evolution of Man [10 Hours]

C. Taxonomy

Unit IV. Systematics and Taxonomy: Definition, concepts, history, scope and application of biosystematics; **Principles of Zoological Classification:** Theories of biological classification, hierarchies of categories and the higher taxa.

Concept of Species: Species category, different concepts and intraspecific categories.

Modern trends in taxonomy: Behavioural taxonomy, cytotaxonomy and molecular taxonomy.

Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.

Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations.

Taxonomic characters and taxonomic keys; Preservation of collected material and curating [13 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Pallidino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrímsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

SOLS/ZOO/EZM-2c. Assisted Reproductive Biology Techniques
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3 Credits [45 Hours]

Unit I. Scope of mammalian reproductive technologies, Functional anatomy of male and female reproductive system, Induced release of gametes and its significance [10 Hours]

Unit II. Multiple ovulation, superovulation. In-vitro oocyte maturation. Biochemistry of Semen, Semen composition and formation. Assessment of sperm functions. Cryopreservation of gametes and embryos [12 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer, zygote intrafallopian transfer, In-vitro fertilization, embryo transfer. Transgenic animals and their uses [12 Hours]

Unit IV. Contraception; Immunocontraception: Antibody mediated fertilization block and termination of gestation. Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [11 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)
3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)



B.Sc. [Research] Fourth Year (VII & VIII Semester)

B.Sc. VII Semester (Research)

CORE ZOOLOGY (CZ-5—CZ-6)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-5 Non-Chordata

3 Credits [45 Hours]

Unit I. Major and minor invertebrate phyla: General characters, organization, classification up to Order and their types; Origin and evolution of lower and higher invertebrates; Overview of economic importance of invertebrates.

Protozoa: Comparative morphology of all classes; Locomotor organelles and locomotion; **Nutrition:** holophytic, holozoic, saprozoic, myxotrophic and parasitic; **Reproduction:** Asexual and sexual reproduction, parthenogenesis and regeneration [12 Hours]

Unit II. Porifera: Comparative morphology of all classes; Types of canal system; **Reproduction:** Asexual, sexual reproduction and regeneration in sponges.

Coelenterata: Comparative morphology of all classes; Polymorphism; Coral reefs & their formation; General characters and affinities of Ctenophora.

Helminthes: Comparative morphology of Platyhelminthes and Aschelminthes [11 Hours]

Unit III. Minor Group: Classifications to order level, characters and affinities of Phoronida and Rotifera.

Annelida: Classification to order level; Comparative morphology of all classes; Segmental organs.

Arthropoda: Classification to order level; Appendages and mouth parts in insects; Larval forms in Crustacea; Arachnida.

Organization and affinities of *Onychophora* [12 Hours]

Unit IV. Mollusca: Classification to order level; Comparative morphology of all classes; Major features of the respiratory and reproductive systems; Larval forms, Torsion and Pearl formation.

Echinodermata: Classification to order level; Water vascular system; Larval forms and affinities [10 Hours]

SUGGESTED READINGS

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and Function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
5. Kotpal: Modern Text-book of Zoology: Invertebrates. Rastogi Publications, Meerut
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.

SOLS/ZOO/CZ-6 Cell and Molecular Biology

3 Credits [45 Hours]

A. Cell Biology

Unit I. Ultrastructure of prokaryotic and eukaryotic cells.

Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes; Function - Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).

Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.

Cytoskeleton: Components, functions & derived organelles (cilium, flagellum).

Mitochondria: Structure function & genetic organisation; Ribosome: Biosynthesis & formation in nucleolus [10 Hours]

Unit II. Signal transductions.

Cell signaling: Types of signaling, Cell surface receptor mediated signaling.

Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).

Cellular transformation and malignancy; Retroviruses; Apoptosis and causes of cancer [10 Hours]

B. Molecular Biology

Unit III. The central dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes; Structural polymorphism of DNA & RNA; Three-dimensional structure of t-RNA [10 Hours]

Unit IV. DNA replication; Genetic code; Transcription and translation in prokaryotes and eukaryotes; RNA processing; Mutations & DNA repair systems; P bodies; Concept of Epigenetics, Chromatin remodelling, Non-Coding RNAs [15 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, CCH, a Wolters Kluwer Business, Lippincott Williams & Wilkins, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House.
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)

SOLS/ZOO/LC-1 Lab Course-1 (Based on CZ-5 & CZ-6)	[2 Credits]
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Non-Chordata

1. Slides of Protozoa
2. Slides & Museum specimen of Porifera, Coelenterata, Helminthes, Annelida, Arthropoda, Mollusca & Echinodermata
3. Slides of Phoronida and Rotifera
4. Specimen: *Beroe*, *Peripatus*

Cell Biology

1. Permanent slides of cell division (Mitosis & Meiosis)
2. Study of mitotic cell division by squash technique
3. Slide preparation of interphase nuclei in buccal epithelium
4. Study of meiotic cell division in grasshopper testis
5. Preparation of blood smear

Molecular Biology

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity
7. DNA isolation from animal tissue
8. Separation of DNA molecules from Agarose Gel Electrophoresis
9. RNA isolation from Baker's Yeast
10. Estimation of RNA by orcinol method

RESEARCH METHODOLOGY ZOOLOGY (RMZ)

[Theory: 4 Credits]

SOLS/ZOO/RMZ Research Methodology	4 Credits [60 Hours]
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Unit I. Foundations of Research: Meaning, Objectives, Motivation: Research Methods vs Methodology, Types of Research: Analytical vs Descriptive, Quantitative vs Qualitative, Basic vs Applied [8 Hours]

Unit II. Research Design: Need for research design— Features of good design, Important concepts related to good design; Observation and Facts, Prediction and Explanation, Development of Models.

Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs [20 Hours]

Unit III. Data Collection, Analysis and Report Writing, Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies, Technical Reports and Thesis writing, Preparation of Tables and Bibliography. Data Presentation using digital technology [16 Hours]

Unit IV. Ethical Issues, Intellectual Property Rights, Commercialization, Copy Right, Royalty, Patent law, Plagiarism, Citation, Acknowledgement [16 Hours]

SUGGESTED READINGS

1. Anthony, M., Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon
2. Coley, S.M. and Scheinberg, C.A. 2008. Proposal Writing: Effective Grantmanship, 3rd edition, Sage Publications
3. Kothari, C.R. 2009. Research Methodology, New Age International
4. Wadhera, B.L. 2002. Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law Publishing
5. Walliman, N. 2011. Research Methods- The Basics. Taylor and Francis, London, New York

ELECTIVE COURSE ZOOLOGY (EZ-1a—EZ-1c)
(Theory-3 Credits; Lab Course-3 Credits)
[Any one]

SOLS/ZOO/EZ-1a. Developmental Biology and Parasitology	3 Credits [45 Hours]
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C. Developmental Biology

Unit I. Development and differentiation of sperm and oocytes, capacitation, vitellogenesis; Mechanism of fertilization;

Early development of Frog and Chick up to gastrulation;

Concept of organiser and embryonic inductions;

Implantation of embryo in human;

Limb morphogenesis [13 Hours]

Unit II. Development in *Drosophila* up to gastrulation; Molecular basis of development; Metaplasia & trans differentiation.

Ageing: mechanism, concepts and theories;

Regeneration, Teratogens.

Regeneration in Vertebrates: Tail, Limb, Lens and retina;

Metamorphosis in Amphibia: morphogenetic and biochemical Changes and hormonal regulation [10 Hours]

D. Parasitology

Unit III. Parasitism and evolution of parasitism.

Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica*, Trypanosomes, *Leishmania donovani* & *Plasmodium*) [10 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes; Common trematode, cestode and nematode parasites; Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria* & *Taenia*);

Introduction to arthropod vectors of human diseases (mosquitoes, lice, flies & ticks) [12 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
6. Dogiel, VA: General Parasitology, 1964
7. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
8. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
9. Kalthoff, K.O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
10. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
11. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributors, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008

12. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
13. Read, P.W.: Animal Parasites, Prentice Hall, 1977
14. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
15. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
16. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

Lab Course EZ-1a. [3 Credits]

Developmental Biology

1. Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
2. Study of whole mounts and sections of developmental stages of frog (Cleavage stages, blastula, gastrula, neurula, tail bud stages) through permanent slides/ ICT tools/ models/ charts/ photographs etc.
3. Study of developmental stages of whole mounts of chick embryo (Primitive streak -13 and 18 hours, 20, 24, 28, 33, 36, 48, 72, and 96 hours of incubation) through permanent slides/ ICT tools/models/photographs.
4. Window preparation in Hen's Egg and through ICT tools (videos)
5. Sperm count from any domestic animal (Source of semen: Government Artificial Insemination Centre).
6. Study of the developmental stages and life cycle of *Drosophila* from stock culture.

Parasitology

4. Study of museum specimen of parasites.
5. Study of life stages of *Entamoeba histolytica*, *Trypanosoma*, *Leishmania donovani* & *Plasmodium* through permanent slides/ micro photographs.
6. Study of adult and life stages of *Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria* & *Taenia* through permanent slides/micro photographs.
7. Study of nematode/cestode parasites from the intestine of sheep/goat.

SOLS/ZOO/EZ-1b. Elementary Biotechnology and Microbiology	3 Credits [45 Hours]
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C. Biotechnology

Unit I. History, definition & scope.

Introduction to recombinant DNA technology - gene cloning, general idea of cloning vectors, restriction digestion, ligation, competent cell preparation, transformation and analysis of clones; Genomic & C-DNA library; Tools for detecting DNA/RNA and protein, first generation DNA and protein-sequencing, Next Generation RNA sequencing, polymerase chain reaction, Reverse Transcription PCR, Real time PCR [15 Hours]

Unit II. Gene therapy; DNA finger printing; Transgenic and knock out animals and plants; Primary culture, and cell lines; Tissue and organ culture; Transfection methods & transgenic and knock out animals; Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites.

Products of recombinant DNA technology; Human genome project and its applications [10 Hours]

D. Microbiology

Unit III. Classification of Virus, Bacteria and Fungi - staining techniques, pathological significance.

Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [10 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques.

Microbial fermentation: Microbes in decomposition and recycling processes.

Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [10 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill, 1993

Lab Course EZ-1b. [3 Credits]

Biotechnology

1. Isolation of genomic and plasmid DNA

2. Agarose gel electrophoresis
3. RNA isolation and estimation
4. SDS-PAGE for Proteins
5. Cloning vectors and Restriction Digestion

Microbiology

1. Transfer of Bacteria: Aseptic Techniques
2. Preparation of Smears and Simple Staining
3. Gram Staining
4. Acid-Fast Staining
5. Isolation of Bacteria by Dilution Techniques
6. Isolation of Bacterial Culture from water & soil sample
7. Special Media for Isolating Bacteria

SOLS/ZOO/EZ-1c. Toxicology	3 Credits [45 Hours]
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Unit I. Introduction of toxicology: Definition, history, scope & sub-divisions of toxicology

Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals and Radioactive substances [12 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure (inhalation, injection and through food or intestinal); Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms

Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) and UV rays. Bio-distribution, biomagnification, biotransformation of xenobiotics and process of elimination.

Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [15 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [10 Hours]

Unit IV. Chemical nature of toxicants: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins; Microplastics. Pesticides, Radioactive compounds & Heavy metals [8 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018) The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest: A Textbook of Modern Toxicology (2010), Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim: Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, (2017), CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram: Textbook of Toxicology, by, Dreamtech Press (2019), ISBN-10: 9389520274

Lab Course EZ-1c. [3 Credits]

1. Care and maintenance of laboratory animals
2. Toxic substances: Wastewater, Carcinogens, Heavy Metals, Pesticides, Insecticides
3. Preparation of various concentrations
4. Study of Acute, subacute, chronic & sub chronic toxicity
5. LC50 for 24, 36, 48, 72 and 96 hours
6. Dose-response relationship
7. Histological/Histopathological study of slides
8. Monitoring of different pollutants in air, water, soil and animals
9. Analysis of Toxicants by Chromatography (Paper, TLC, GC)

SOLS/ZOO/LC-2 Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	[3 Credits]
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CORE ZOOLOGY (CZ-7—CZ-8)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-7 Chordata

3 Credits [45 Hours]

Unit I: General Characters, classification development of Urochordata and Cephalochordata. Affinities of Hemichordata, Urochordata & Cephalochordata [12 Hours]

Unit II: General Characters, Classification and affinities of Cyclostomata
Salient features of different groups of fishes; Chondrichthyes, Osteichthyes, Dipnoi and Coelacanth.
Origin and evolution of Amphibia; Neoteny & Paedogenesis [11 Hours]

Unit III: General characters and classification of Reptilia; Origin of Reptilia and adaptive radiation in Reptilia; Characters and affinities of Chelonia and Rhynchocephalia.
General characters and classification of Aves; Origin and ancestry of birds; Characters and affinities of Ratitae; Origin and mechanism of flight in birds; Palate in birds; Migration in birds [12 Hours]

Unit IV: General characters and classification of mammals; Origin of mammals; Characters and affinities of Prototheria and Metatheria.
Dentition in mammals; Adaptive radiation in mammals; Aerial and Aquatic adaptations in mammals [10 Hours]

SUGGESTED READINGS

1. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Kotpal RL: Modern Text Book of Zoology Vertebrates; Rastogi Publications, 2007
4. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962
5. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
6. Young JZ: The Life of Vertebrates, Oxford, 1950

SOLS/ZOO/CZ-8 Biostatistics and Computer Application

3 Credits [45 Hours]

A. Biostatistics

Unit I. Importance of statistics in biological research; Introduction to some distributions of random variables: Binomial, Poisson, normal; Basic/Descriptive statistics: Measures of central tendency and measures of dispersion, Skewness & kurtosis; Simple correlation and linear regression (scatter diagram, regression coefficients, regression lines) [13 Hours]

Unit II. Students-t, chi-square and F-Tests of Significance testing and their purpose; Introduction to Statistical softwares. MS Excel and their purpose [12 Hours]

B. Computer Application

Unit III. Introduction to Computers: Mini, micro, mainframe and super computers; Components of a computer system (CPU, I/O units). Data storage device, Memory concepts [10 Hours]

Unit IV. Software and types of software.

Computer applications in biology and information communications (databases, e-mail and local networks) [10 Hours]

SUGGESTED READINGS

1. Balagurusamy, E.: Fundamentals of Computers, McGraw Hill Education, 2011
2. Khan, Khanum, Shiba Khan: Fundamentals of Biostatistics, Ukaaz Publications, 1994
3. Khanal, A.B.: Mahajan's Methods in Biostatistics, The Health Sciences Publishers, 2015
4. Le, C.T.: Introductory Biostatistics, John Wiley & Sons Publication, 2003
5. Rajaraman, V.: Fundamentals of Computers, 5th edition, PHI Learning Pvt. Ltd., 2010
6. Sinha, P., Sinha, P.K.: Computer Fundamentals: Concepts, Systems and Applications, 8th edition, BPB Publications, 2004
7. Zar, JH.: Biostatistical Analysis, Prentice-Hall/Pearson, 2010

Chordata

1. Slides of Protochordata, whole mount and cross sections of *Balanoglossus*, *Herdmania* and *Amphioxus*
2. Museum Specimens: Protochordata, Cyclostomata, Pisces, Amphibia, Reptile, Bird & Mammals.
3. Articulated and disarticulated bones of Frog, Varanus, Carapace & Plastron of Tortoise, Fowl and Rabbit
4. Slides: Scales of fish

Biostatistics and Computer Application

1. Calculation of mean, mode, median from the given data.
2. Calculation of standard deviation, standard error and coefficient of variation from the given data.
3. Calculation of correlation coefficient and regression coefficient from the given data and interpretation of results. Developing regression equation, Drawing the scatter diagram and regression lines and interpretation of results.
4. Calculation of t (paired and unpaired), chi square, and F values from the given data and interpretation of results.
5. Computer components/hardware: Key board, mouse, VDU, CPU, Microprocessor, Hard disk drive, Flash drive, CD ROM drive
6. Computer software: System software (Operating system, BIOS, Device Driver, Assembler, Compiler, Loader), Application software (Word Processing Software, Spreadsheet Software, Enterprise Software, Programming Software), E-mail, LAN, WAN, Statistical calculations with MS Excel.

ELECTIVE COURSE (EZ-2a—EZ-2c)**(Theory-3 Credits; Lab Course-3 Credits)****[Any one]****SOLS/ZOO/EZ-2a. Aquatic Biodiversity****3 Credits [45 Hours]****Unit I.** Definition, concept, scope and measurement of biodiversity; Biodiversity loss (causes & effects).**Types of Biodiversity:** Species, Genetic, Community, Ecosystem.**Factors governing biodiversity:** Historical & proximate [7 Hours]**Unit II.** Types of aquatic ecosystem & biomes and their characteristics.

Freshwater biodiversity: Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands; Over view of freshwater biodiversity in important rivers, lakes, reservoirs and wetlands of India with emphasis on Himalaya.

Introduction to Marine biodiversity.

Biodiversity data bases [15 Hours]

Unit III. Threats to habitats and their conservation.**Endemic species & Endangered species:** Definition, concept, scope.**Conservation:** Definition, concept, scope.

Ramsar Convention; Physical and chemical characteristics of wetlands.

Over view of biodiversity in Wetlands of India with emphasis on Himalaya [15 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies.**Environmental flows:** Importance for the aquatic flora & fauna. Environmental flows assessment methodology (Hydrological, hydraulics rating, habitat simulation & holistic). Ecosystem Services: Concept & scope [8 Hours]**SUGGESTED READINGS**

1. AlgaeBase, Diatoms of North America, <http://www.insecta.bio.spbu.ru/z/faun-eur.htm>; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family;https://aqgrisi.nbfgr.res.in/listing/family/71)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)

7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water For People And Nature, Island Press (2003)

Lab Course EZ-2a [3 Credits]

1. Sampling and analysis of plankton
2. Sampling and analysis of macrobenthic organisms
3. Determination of mesh size of plankton net and size of plankton
4. Preparation of permanent slides
5. Chlorophyll estimation of periphytic algae
6. Measurement of primary production
7. Study of ecological indices
8. Study of local fish fauna
9. Study of endangered species and protection
10. Study of river habitat and organisms
11. Study of natural pond habitat and organisms

(Candidates will submit a report on field visit to any nearby pond/ lake/ stream/ river during the session)

SOLS/ZOO/EZ-2b. Genetics, Evolution and Taxonomy	3 Credits [45 Hours]
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D. Genetics

Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles, Pedigree analysis; Eugenics.

Modification of Dihybrid ratios and their biochemical basis; Fine structure of Gene; Statistical tools (Probability and Significance Testing) [10 Hours]

Unit II. Linkage and Crossing over, Genetic mapping techniques; Sex linked inheritance and genetic disorders; Mutations and chromosomal aberrations.

Operon hypothesis, Lac operon (positive and negative control); Regulation of gene expression in eukaryotes.

Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic drift and gene flow [12 Hours]

E. Evolution

Unit III. Natural Selection: Types of selection and selection coefficient; Role of mutation in evolution (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).

Micro and Macroevolution; Genetic drift and gene flow

Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory.

Palaeontology: Fossils and fossilization, mass extinction, geological time scale; Evolution of Horse; Evolution of Man [10 Hours]

F. Taxonomy

Unit IV. Systematics and Taxonomy: Definition, concepts, history, scope and application of biosystematics; **Principles of Zoological Classification:** Theories of biological classification, hierarchies of categories and the higher taxa.

Concept of Species: Species category, different concepts and intraspecific categories.

Modern trends in taxonomy: Behavioural taxonomy, cytotaxonomy and molecular taxonomy.

Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.

Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations.

Taxonomic characters and taxonomic keys; Preservation of collected material and curating [13 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.

3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Pallidino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

Lab Course EZ-2b [3 Credits]

Genetics

1. Genetics problems related to Mendelian inheritance
2. Preparation of Drosophila Polytene Chromosome Squashes

Evolution

1. Evidences of organic evolution
2. Photographs of Evolution
3. Models
4. Fossils

Taxonomy

1. List of animals with common and zoological names
2. List of household pests with common and zoological names
3. Classification of 10 common fish, amphibia, reptiles, bird and mammals
4. Preparation of inventory of roadside trees in the campus

SOLS/ZOO/EZ-2c. Assisted Reproductive Biology Techniques	3 Credits [45 Hours]
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Unit I. Scope of mammalian reproductive technologies, Functional anatomy of male and female reproductive system, Induced release of gametes and its significance [10 Hours]

Unit II. Multiple ovulation, superovulation. In-vitro oocyte maturation. Biochemistry of Semen, Semen composition and formation. Assessment of sperm functions. Cryopreservation of gametes and embryos [12 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer, zygote intrafallopian transfer, In-vitro fertilization, embryo transfer. Transgenic animals and their uses [12 Hours]

Unit IV. Contraception; Immunocontraception: Antibody mediated fertilization block and termination of gestation. Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [11 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)
3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)

Lab Course EZ-2c [3 Credits]

1. Study of functional anatomy of male reproductive system with the help of photographs, chart and models
2. Study of functional anatomy of female reproductive system with the help of photographs, chart and models
3. Study of menstrual cycle with the help of photographs, charts and models
4. Study of the histological details of testes, ovary and pituitary with the help of permanent slide, photographs and charts.
5. Physical examination of cryopreserved semen of bull for sperm count
6. Study of sperm motility behaviour of cryopreserved sperm (semen straw may be obtained from nearby veterinary hospital/ artificial semen center)
7. Assessment of sperm functions
8. Thawing of cryopreserved semen straw
9. Transgenic animals and their uses
10. Preparation of chart and model based on theory topics
11. Visit to nearby artificial insemination center of livestock department

(Candidates must produce at the time of practical examination their preparations, collection, practical record books and a report on field visit to artificial insemination center done during the session.)

SOLS/ZOO/LC-4 Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)

[3 Credits]

