Syllabus revised in 26th BoS for 4th Year (7th & 8th Semester)

Department of Zoology

B.Sc. Zoology

B.Sc. Zoology

Four-Year Undergraduate Program

FYUP (Eight-Semester Course) As per NEP

Course Contents & Syllabus

(For students enrolled in 2022-23, 2023-24, 2024-25 academic session)

Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar Garhwal-246174 (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 *OR* 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 *OR* 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 fulfillment of the conditions as laid down in NHEQF *(securing minimum required 40 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits***).***
- **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 *OR* 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 *OR* 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 fulfillment of the conditions as laid down in NHEQF*(securing minimum required 40 credits + 4 Credits in*** one vocational course/skills-enhancement course of 4 credits**.**
- **Under Graduate Diploma (Zoology)**

Third Year (V Semester)	Discipline Specific Elective (DSE)	Credits	Name of the Course	Remarks
		4+2	**DSE (Anyone)** (Theory-1; Practical-1)	**DSE Basket:** **DSE-1.** Applied Zoology **DSE-2.** Wildlife 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/ Entrepreneur-Ship 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)
	Extra curricular 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 (Anyone)** (Theory-1; Practical-1)	**DSE Basket:** **DSE-1.** Applied Zoology **DSE-2.** Wildlife 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)**
  Student on exit after successfully completing three years (i.e., securing minimum required 120 credits along with securing additional 2 credits under SSD course work) will be awarded "Bachelor's Degree" of three year, in related field/discipline/subject.

Self and Social Development (SSD) course work	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: (1) Community Connect & Service (2) Extracurricular Activities Both the coursework will carry 2 (Two credits). Student may select any one of the above 2 course work. **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 fulfillment of minimum hours towards CCS. **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 setup by university will verify the student participation in activities for award of credits for the coursework
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. ***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.***	

Guidelines for Entry and Exit under FYUP

Exit options under FYUP for the students pursuing Four Year Under Graduate Program (FYUP) under NEP 2020 and Essential requirements in case of exit at different levels

First Year (UG Certificate Programme)

UG Certificate programme (for those who wish to exit the Bachelors programme after completing I year (2 semesters- I & II) of the U.G. programme , securing 40 credits.

Further, in addition, they have to complete one Skill enhancement/vocational course of 4 credits during the summer vacation of the first year.

Second Year (UG Diploma Programme)

Diploma programme (for those who wish to exit the Bachelors programme after successfully completing II year (4 semesters-I, II, III, IV) of the U.G. programme , securing 80 credits.

Further in addition, they have to complete one Skill enhancement/vocational course of 4 credits during the summer vacation of the second year

Third Year (Bachelors Degree)

3-year Bachelor's programme (for those who wish to exit the Bachelors programme after completing III years (6 semesters- I, II, III, IV, V, VI) of the programme, securing 120 credits along with additional 2 credits under Self and social Development course work (SSD).

Fourth Year (B.Sc. Honours)

After completing the requirements of a three-year Bachelor's Degree, candidates shall be allowed to continue studies in the fourth year of the undergraduate programme to pursue and complete the Bachelor's Degree with Honours (4 Year).

Fourth Year (B.Sc. Honours with Research)

After completing the requirements of a three-year Bachelor's Degree, candidates who secure a minimum CGPA of 7.5 shall be allowed to continue studies in the fourth year of the undergraduate programme to pursue and complete the Bachelor's Degree with Honours with research (4 Year).

Fourth Year-NHEQF Level-6

In the fourth Year of Four-Year Undergraduate Program (FYUP) two types of programs are offered:

1. U.G. with Honours

2. U.G. Honours with Research

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

Revised in 26th BoS

Fourth Year (VII Semester with Honours)	**Major Subject (Zoology)**	**Credit**	**Name of Course**	**Remarks**
	Core Zoology-5 (CZ-5) Core Zoology-6 CZ-6) Core Zoology-7 (CZ-7)	5+5+5	CZ-5 Molecular Biology of the Cell CZ-6 Microbiology & Parasitology CZ-7 Animal Structure & Function	These courses will be based on the core subject selected by the students for PG
	Major Practical (LC-1)	5	LC-1 Lab Course Based on Core Zoology (CZ-5, CZ-6, & CZ-7)	
	Major Elective Zoology (EZ-1)	2	Elective Course: Anyone from EZ-1 basket (EZF-1/EZEnt-1/EZEvs-1)	**Major Elective Course Basket (EZ-1)** EZF-1: Fish Biology I EZEnt-1: Entomology I EZEvs-1: Environmental Biology I
	Major Elective Practical (LCE-1)	2	LCE-1 Lab Course Elective Based on EZF-1/EZEnt-1/EZEvs-1	
	Minor Zoology (ZM-1)	4	Minor Elective Course:Anyone from EZM-1 (EZM-1a/EZM-1b) For students with Core subjects other than Zoology (Without Practical)	**Minor Elective Course Basket (EZM-1)** EZM-1a: Aquatic Biodiversity EZM-1b: Animal Biotechnology*
	TOTAL	**28**		

Fourth Year (VIII) Semester with Honours)	**Major Subject (Zoology)**	**Credit**	**Name of Course**	**Remarks**
	Core Zoology-8 (CZ-8) Core Zoology-9 (CZ-9) Core Zoology-10 (CZ-10)	5+5+5	CZ-8 Immunology CZ-9 Toxicology CZ-10 Advanced Developmental Biology	These courses will be based on the core subject selected by the students for PG
	Major Practical (LC-2)	5	LC-2 Lab Course Based on Core Zoology (CZ-8, CZ-9 & CZ-10)	
	Major Elective Zoology (EZ-2)	2	Elective Course: Anyone from EZ-2 basket (EZF-2/EZEnt-2/EZEvs-2)	**Major Elective Course Basket (EZ-2)** EZF-2: Fish Biology II EZEnt-2: Entomology II EZEvs-2: Environmental Biology II
	Major Elective Practical (LCE-2)	2	LCE-2 Lab Course Elective Based on EZF-2/EZEnt-2/ EZEvs-2	
	Minor Zoology (ZM-2)	4	Minor Elective Course: Anyone from EZM-2 (EZM-2a/EZM-2b) For students with Core subjects other than Zoology (Without Practical)	**Minor Elective Course Basket (EZM-2)** EZM-2a: Assisted Reproductive Biology Techniques EZM-2b: Environmental Pollution and Global Issues*
	TOTAL	**28**		

Swayam Course: *SN: 28 https://onlinecourses.swayam2.ac.in/cec25_es02/preview

Note: After completing four years (eight semesters) with above mentioned courses, the student will be awarded a Bachelor of Science degree, B.Sc. (Honours) in Zoology.

B.Sc. (Honours with Research) Fourth Year [VII & VIII Semester] Revised in 26th BoS

Candidates who secure a minimum CGPA of 7.5 will be allowed to continue studies in the fourth year of the undergraduate programme leading to the four years bachelor's degree (Honours with Research).

Fourth Year (VII Semester with Research)	**Major Subject (Zoology)** Core Zoology-5 (CZ-5) Core Zoology-6 (CZ-6)	5+5	CZ-5. Molecular Biology of the Cell CZ-6. Microbiology & Parasitology	These courses will be based on the core subject selected by the students for PG
	Major Practical (LC-1)	5	LC-1. Lab Course Based on CZ-5 & CZ-6	
	Major Elective Zoology (EZ-1)	2	Elective Course: Anyone from EZ-1 basket (EZF-1/EZEnt-1/EZEvs-1)	**Major Elective Course Basket EZ-1** EZF-1: Fish Biology I EZEnt-1: Entomology I EZEvs-1: Environmental Biology I
	Major Elective Practical (LCE-1)	2	LCE-1 Lab Course Elective Based on EZF-1/EZEnt-1/ EZEvs-1	
	Research Methodology Zoology (RMZ)	5	RMZ. Research Methodology	Students will learn the basic research methodology with a focus on data analysis for application in research-based work to be carried out in the VIII Semester
	Minor Zoology (ZM-1)	4	Minor Elective Course:Anyone from EZM-1 (EZM-1a/EZM-1b) For students with Core subjects other than Zoology (Without Practical)	**Minor Elective Course Basket (EZM-1)** EZM-1a: Aquatic Biodiversity EZM-1b: Animal Biotechnology*
	TOTAL	**28**		
Note: Dissertation Topic for FYUP (Honours with Research) will be issued in the 7th semester				

Fourth Year (VIII Semester with Research)	**Major Subject (Zoology)** Core Zoology-7 (CZ-7R)	5	CZ-7R Immunology	This course will be based on core subject selected by the students for PG
	Major Practical (LC-2)	3	LC-2 Lab Course Based on CZ-7R	
	Major Elective Zoology (EZ-2)	2	Elective Course: Anyone from EZ-2 basket (EZF-2/EZEnt-2/EZEvs-2)	**Major Elective Course Basket EZ-2** ZMEF-2: Fish Biology II ZMEEnt-2: Entomology II ZMEEvs-2: Environmental Biology II
	Major Elective Practical (LCE-2)	2	LCE-2 Lab Course Elective Based on EZF-2/EZEnt-2/ EZEvs-2	
	Research Dissertation (RD)	12	Dissertation (Topic will be issued in the 7th semester)	Student will conduct minor research work, OR will do a research-based field study and submit the dissertation/report at the end of the semester.
	Minor Zoology (ZM-2)	4	Minor Elective Course: Anyone from EZM-2 (EZM-2a/EZM-2b) For students with Core subjects other than Zoology (Without Practical)	**Minor Elective Course Basket (EZM-2)** EZM-2a: Assisted Reproductive Biology Techniques EZM-2b: Environmental Pollution and Global Issues*
	Total	**28**		
Note: After completing four years (eight semesters) with the above mentioned courses, the student will be awarded a Bachelor of Science degree, B.Sc. (Honours with Research in Zoology).				

FOUR- YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH

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	Wildlife 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)	Wildlife 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)] Revised in 26th BoS

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Molecular Biology of the Cell	5	0	0	5
SOLS/ZOO/CZ-6	Microbiology & Parasitology	5	0	0	5
SOLS/ZOO/CZ-7	Animal Structure & Function	5	0	0	5
SOLS/ZOO/CZ-8	Immunology	5	0	0	5
SOLS/ZOO/CZ-9	Toxicology	5	0	0	5
SOLS/ZOO/CZ-10	Advanced Developmental Biology	5	0	0	5
SOLS/ZOO/EZF-1	Fish Biology I	2	0	0	2
SOLS/ZOO/EZEnt-1	Entomology I	2	0	0	2
SOLS/ZOO/EZEvs-1	Environmental Biology I	2	0	0	2
SOLS/ZOO/EZF-2	Fish Biology II	2	0	0	2
SOLS/ZOO/EZEnt-2	Entomology II	2	0	0	2
SOLS/ZOO/EZEvs-2	Environmental Biology II	2	0	0	2
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5, CZ-6, & CZ-7)	0	0	5	5
SOLS/ZOO/LCE-1	Lab Course-2 (Based on EZF-1/EZEnt-1/EZEvs-1)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-3 (Based on CZ-8, CZ-9 & CZ-10)	0	0	5	5
SOLS/ZOO/LCE-2	Lab Course-4 (Based on EZF-2/EZEnt-2/EZEvs-2)	0	0	2	2
SOLS/ZOO/ZM-1a	Aquatic Biodiversity	4	0	0	4
SOLS/ZOO/ZM-1b	Animal Biotechnology*	4	0	0	4
SOLS/ZOO/ZM-2a	Assisted Reproductive Biology Techniques	4	0	0	4
SOLS/ZOO/ZM-2b	Environmental Pollution and Global Issues*	4	0	0	4

B.Sc. (Zoology)

Fourth Year [VII & VIII Semester (Honours with Research)] Revised in 26th BoS

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Molecular Biology of the Cell	5	0	0	5
SOLS/ZOO/CZ-6	Microbiology & Parasitology	5	0	0	5
SOLS/ZOO/CZ-7R	Immunology	5	0	0	5
SOLS/ZOO/RMZ	Research Methodology	5	0	0	5
SOLS/ZOO/RD	Research Dissertation	0	0	12	12
SOLS/ZOO/EZF-1	Fish Biology I	2	0	0	2
SOLS/ZOO/EZEnt-1	Entomology I	2	0	0	2
SOLS/ZOO/EZEvs-1	Environmental Biology I	2	0	0	2
SOLS/ZOO/EZF-2	Fish Biology II	2	0	0	2
SOLS/ZOO/EZEnt-2	Entomology II	2	0	0	2
SOLS/ZOO/EZEvs-2	Environmental Biology II	2	0	0	2
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5 & CZ-6)	0	0	5	5
SOLS/ZOO/LCE-1	Lab Course-2 (Based on EZF-1/EZEnt-1/EZEvs-1)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-3 (Based on CZ-7R)	0	0	3	3
SOLS/ZOO/LCE-2	Lab Course-4 (Based on EZF-2/EZEnt-2/EZEvs-2)	0	0	2	2
SOLS/ZOO/ZM-1a	Aquatic Biodiversity	4	0	0	4
SOLS/ZOO/ZM-1b	Animal Biotechnology*	4	0	0	4
SOLS/ZOO/ZM-2a	Assisted Reproductive Biology Techniques	4	0	0	4
SOLS/ZOO/ZM-2b	Environmental Pollution and Global Issues*	4	0	0	4

B.Sc. (Zoology)

Skill enhancement/Vocational course

UG certificate/UG diploma Program

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/ZEX-BZ	Basic Zoology	4	0	0	4

FOUR-YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH

B.Sc. (Zoology)
First, Second, Third, & Fourth Year (I - VIII Semester)

S.No.	Course Code & Title	Course outcomes
1.	SOLS/ZOO/CZ-1 Animal Diversity-I	The course provides a comprehensive understanding of general characters and classification of non-Chordates; their structure and biology; significance of coelom, metamerism and larval forms. Students will also able to identify and describe the morphology, adaptations in non-chordate animals and economic importance.
2.	SOLS/ZOO/CZ-2 Animal Diversity-II	This course provides deep understanding of the general characters and classification of organisms based on similar characteristics of their morphological and anatomical structure. Students will also able to explain the external features, anatomy, affinities, adaptations and characteristics of different vertebrate classes, including Pisces, Amphibia, Reptilia, Aves, and Mammalia.
3.	SOLS/ZOO/CZ-3 Elementary Cell Biology & Molecular Biology	Course provides comprehensive understanding of cell biology and molecular biology. Students will be able to understand the structure and function of cells, its organelles & bio-molecules; cell cycle, including mitosis & meiosis; DNA & RNA- structure and types, DNA damage & repair, regulation of gene expression.
4.	SOLS/ZOO/CZ-4 Physiology and Elementary Biochemistry	The course imparts the knowledge on fundamental principles of animal physiology, structural and functional complexity of physiological systems including reproductive physiology and endocrine glands. The students would be able to understand the structure, types, and functions of biomolecules; enzyme kinetics, inhibition, and regulation; metabolic pathways, including glycolysis, Kreb's cycle and lipid metabolism.
5.	SOLS/ZOO/CZ-1 (P) Animal Diversity-I (Practical)	The course provides a deeper understanding on animal diversity. Students will develop skills in observation, identification, and classification of animal forms from Protozoa to Echinodermata. They will have knowledge of salient features of invertebrate phyla, life cycles of parasitic animals including their adaptative features.
6.	SOLS/ZOO/CZ-2 (P) Animal Diversity-II (Practical)	The course provides a deeper understanding on chordate diversity. Students will develop skills to identify and classify the chordate specimens. Acquire knowledge on salient features of taxonomic groups from Protochordate to Mammalia, ability to distinguish poisonous and non-poisonous snakes.
7.	SOLS/ZOO/CZ-3(P) Elementary Cell Biology & Molecular Biology (Practical)	Upon completing this practical course, students will have hands-on experience and a deeper understanding of cell biology and molecular biology techniques. They will have practical skill to study the process of mitosis and meiosis; and perform molecular biology techniques, including DNA isolation, gel electrophoresis and restriction enzyme digestion
8.	SOLS/ZOO/CZ-4(P) Physiology and Elementary Biochemistry (Practical)	The course provides hands-on experience and a deeper understanding of physiological and biochemical processes. The students will be able to understand the structure and function of various physiological systems and identify the histological sections of mammalian tissues; and apply biochemical techniques to analyze biomolecules.
9.	SOLS/ZOO/AIZ-1 Animal Diversity-I	Course provides an understanding of general characters, classification, salient features, and biology of various non-chordate phyla. Students will acquire knowledge of significance of coelom, metamerism, and larval forms; parasitic adaptations in helminthes, economic importance of arthropods; unique features like canal system in sponges, water vascular system in starfish, and pearl formation in molluscs.

10.	SOLS/ZOO/AIZ-2 Animal Diversity-II	Upon completing this course, students will be able to understand the general characteristics and classification and affinities of various Chordate groups. They will have knowledge about the terrestrial adaptations in reptiles, aerial adaptations in birds, retrogressive metamorphosis, parental care, poisonous and nonpoisonous snakes.
11.	SOLS/ZOO/AIZ-3 Elementary Cell Biology & Molecular Biology	Course provides an understanding of cell biology and molecular biology. Students will be able to understand the structure and function of plasma membrane, cell organelles & bio-molecules; cell cycle; structure & types of DNA & RNA and regulation of gene expression.
12.	SOLS/ZOO/AIZ-4 Physiology and Elementary Biochemistry	The course imparts the knowledge of fundamental principles of animal physiology, structural and functional complexity of physiological systems, including reproductive physiology and endocrine glands. The students will have introductory knowledge of biomolecules, enzyme kinetics, and metabolism of carbohydrate, protein and lipid.
13.	SOLS/ZOO/AIZ-1 (P) Animal Diversity-I (Practical)	The course provides hands-on experience and a deeper understanding of animal diversity. Students will develop skills in observation, identification, and classification of animal forms from Protozoa to Echinodermata. They will have knowledge of salient features of invertebrate phyla, life cycles of parasitic animals, including their adaptive features.
14.	SOLS/ZOO/AIZ-2 (P) Animal Diversity-II (Practical)	The course provides hands-on experience and a deeper understanding of chordate diversity. Students will develop skills in identifying and classifying the chordate specimens, have knowledge of salient features of taxonomic groups from Protochordate to Mammalia, ability to distinguish poisonous and non-poisonous snakes.
15.	SOLS/ZOO/AIZ-3 (P) Elementary Cell Biology & Molecular Biology (Practical)	Upon completing this practical course, students will have hands-on experience and deeper understanding of cell biology and molecular biology techniques. They will have practical skill to study the process of mitosis and meiosis; and perform molecular biology techniques, including DNA isolation, gel electrophoresis, and restriction enzyme digestion
16.	SOLS/ZOO/AIZ-4 (P) Physiology and Elementary Biochemistry (Practical)	The course provides hands-on experience and a deeper understanding of physiological and biochemical processes. The students will be able to understand the structure and function of various physiological systems and identify the histological sections of mammalian tissues; and apply biochemical techniques to analyze biomolecules.
17.	SOLS/ZOO/SZ-1 Laboratory Techniques in Biology	The course provides comprehensive understanding of laboratory techniques and safety protocols in biology. Students will be able to prepare solutions and buffers for biological applications; use various laboratory equipment's; measure and calculate concentrations, volumes & masses accurately; prepare & preserve biological specimens and permanent slides.
18.	SOLS/ZOO/SZ-2 Basic Instrumentation	The course provides knowledge basic instrumentation used in biology and biochemistry. The students will be able to understand the principles and applications of various microscopy techniques; spectroscopy, fluorimetry, centrifugation, chromatography, electrophoresis, including pH &, turbidity meter, autoclave and biosafety cabinets.
19.	SOLS/ZOO/SZ-3 Public Health and Hygiene	The course provides comprehensive understanding of principles, practices, importance, and scope of public health and hygiene. They will be able to recognize environmental health hazards & their control measures; describe communicable and non-communicable diseases, the role of health education, government initiatives, and voluntary organizations in promoting public health.
20.	SOLS/ZOO/SZ-4 Aquarium Fish	The course provides foundational understanding of aquarium fish keeping. Students will be able to identify and describe various aquarium

	Keeping	fish species; learn fish nutrition & feeding practices, common fish diseases, fish transportation and quarantine.
21.	SOLS/ZOO/SZ-5 Medical Diagnostics	The course provides with a comprehensive understanding of medical diagnostics and its applications. Students will be able to analyze blood and urine samples; diagnose non-infectious diseases (diabetes, hypertension), infectious diseases (tuberculosis, hepatitis) and get familiar with medical imaging techniques (X-ray, PET, MRI, CT scan).
22.	SOLS/ZOO/SZ-6 Bioinformatics	The course provides students with a comprehensive understanding of bioinformatics principles. Students will be able to utilize biological databases and tools (NCBI, BLAST); perform sequence alignments and phylogenetics and apply bioinformatics in drug discovery, genomics.
23.	SOLS/ZOO/DSE-1 Applied Zoology	After successfully completing the course, the students will be able to understand the application of Zoology for the benefit of mankind and get skills for self-employment in applied branches of zoology.
24.	SOLS/ZOO/DSE-2 Wildlife Conservation & Management	The course provides understanding on wildlife conservation, values and strategies. Students will be able to analyze wildlife habitats; estimate population dynamics; apply wildlife legislation and manage wildlife populations in protected areas.
25.	SOLS/ZOO/DSE-3 Principles of Genetics & Evolutionary Biology	The course provides knowledge of principles of genetics and evolutionary biology. Students will be able to understand inheritance patterns, genetic disorders, karyotyping, sex determination and mutation. Students will have knowledge of theories of organic evolution, evidences and process of evolution, species concept, fossils and fossilization.
26.	SOLS/ZOO/DSE-4 Animal Behaviour & Endocrinology	The course provides an understanding of animal behavior & endocrinology principles. Students will be able to analyze communication methods in animals; recognize neural and hormonal control of behavior; endocrine system, hormone actions, biosynthesis and function; reproductive endocrinology.
27.	SOLS/ZOO/DSE-5 Introduction to Developmental Biology	The course provides knowledge about the basic concept and significance of developmental biology. Students will acquire knowledge of gametogenesis, fertilization and early developmental processes in sea urchin, frog, chick, mammals. Students will also gain knowledge of extra-embryonic membranes, placenta, primary organizer, organogenesis and teratogenesis,
28.	SOLS/ZOO/DSE-6 Basics of Biotechnology	The course provides a foundational understanding of biotechnology. Students will be able to apply genetic engineering tools; recognize healthcare applications; understand environmental and agricultural applications, and familiar with cloning, transgenesis.
29.	SOLS/ZOO/DSE-1 (P) Applied Zoology (Practical)	The course provides knowledge of practical skill for deeper understanding on applied zoology, enhancing students' knowledge of parasites, pests, and animal management. Students will able to identify and describe life stages of parasites, recognize arthropod and their role in disease transmission; insect damage to plants and stored grains; poultry, animal breeding practices; and aquarium maintenance.
30.	SOLS/ZOO/DSE-2 (P) Wild Life Conservation & Management (Practical)	The course provides hands-on experience in wildlife conservation management, equipping students with practical skills for fieldwork. Students will be able to identify flora & fauna; use wildlife study equipments; recognize animal evidence; apply field techniques for assessment; estimate abundance and diversity; and know population estimation methods.
31.	SOLS/ZOO/DSE-3 (P) Principles of Genetics & Evolutionary Biology (Practical)	The course provides hands-on experience in genetics and evolution, enhancing students' understanding of fundamental concepts. Students will be able to understand genetics concepts; analyze evolutionary relationships (fossil evidence, homology, analogy) and interpret

		phylogenetic relationships (horse evolution, Darwin's Finches).
32.	SOLS/ZOO/DSE-4 (P) Animal Behaviour & Endocrinology (Practical)	The course provides hands-on experience in animal behavior and endocrinology. Students will be able to understand animal behavior through visual aids; recognize endocrine disorders and their effects; identify histological structures of endocrine glands; estimate cholesterol and glucose levels in biological samples.
33.	SOLS/ZOO/DSE-5 (P) Introduction to Developmental Biology (Practical)	The course develop skills in developmental biology, enhancing students' understanding of embryonic development and placentation. The students will be able to identify the pre & post embryonic development stages of frog, chick, mammals; placental structure; analyze embryonic development through histological sections and ultrasound scans.
34.	SOLS/ZOO/DSE-6 (P) Basics of Biotechnology (Practical)	The course provides hands-on experience and understanding in biotechnology, equipping students with practical skills in molecular biology techniques. Students will be able to isolate plasmid DNA and perform transformation; apply molecular techniques; analyze DNA sequences and fingerprints; separate proteins using SDS-PAGE.
35.	SOLS/ZOO/VCZ-1 Poultry Farming	This course imparts knowledge of various aspects of poultry and their commercial rearing. Students will be able to become familiar with various Indian breeds of poultry, their biology & rearing techniques. They will acquire skills of management of poultry farm, understanding of various disease-causing pathogens, and parasites of poultry and their management.
36.	SOLS/ZOO/VCZ-2 Apiculture	The course develops entrepreneurship skills in Apiculture for the production of Honey. Students will have knowledge on biology and rearing of Bees. They will also have skills for harvesting, processing, preservation and marketing of honey, bee wax propolis.
37.	SOLS/ZOO/VCZ-3 Sericulture	The course develops entrepreneurship skill in sericulture to produce raw silk by raising high-yielding silkworm races/breeds/hybrids to increase the income of poor sections living in the rural areas. Students will have knowledge of the biology of the silkworm and mulberry, silkworm disease and pest.
38.	SOLS/ZOO/VCZ-4 Aquaculture	The course imparts knowledge of cultivable fishes, various farming system, fish pond management, ornamental fish culture, prawn culture and farming of pearl oyster. They will also have skill for induced breeding, nutritionally balanced fish diet and management of common diseases in fish farming.
39.	SOLS/ZOO/VCZ-5 Fish Hatchery Operations	The course imparts understanding of fish hatchery operations and management. Students will be able to understand about the freshwater fish seed resources and natural breeding; induced breeding; manage fish hatcheries; spawn rearing & nursery ponds; handle fish seed packing and transportation.
40.	SOLS/ZOO/VCZ-6 Vermiculture	The course imparts a comprehensive understanding of vermiculture principles and practices. Students will be able to describe earthworm biology and life cycles; design and manage earthworm farming and vermin-composting; utilize vermin-compost in agriculture; identify earthworm enemies and troubleshoot common problems.
41.	SOLS/ZOO/CZ-5 Molecular Biology of the Cell	Students will come out with the knowledge of the structure, function, & working mechanism of cells in the body. Students will also gain an understanding of mechanisms of cellular signaling, cell cycle regulation, and cytoskeletal dynamics; processes of cellular transformation, malignancy, apoptosis, and idea of basics of stem cells, their applications and tissue renewal.
42.	SOLS/ZOO/CZ-6 Microbiology & Parasitology	This course provides a deep understanding of microbes, parasites, their diseases, and preventive measures. Students will gain knowledge of classification, physiology, and microbial genetics; microbiological

		techniques - sterilization, culturing, and isolation; biology and life cycles of parasitic protozoa and helminthes, and the role of arthropod vectors in disease transmission.	
43.	SOLS/ZOO/CZ-7 Animal Structure & Function	The course provides a comprehensive understanding of animal structure and function, including locomotion, digestion, respiration; comparative anatomy and physiology of invertebrates as well as vertebrates; evolution of complex body systems; adaptations in various animal groups such as flight adaptations in birds and aquatic adaptations in mammals.	
44.	SOLS/ZOO/LC-1 Lab Core-I	This lab course provides students with hands-on experience and practical skills related to life forms, cell structure, and their functions. Students will develop proficiency in microscopic techniques and cell biology experiments; lab techniques to isolate and analyze DNA & RNA; identification and characterization of microorganisms, life cycles of parasites, structure & function of animal systems.	
45.	SOLS/ZOO/EZ-1 Elective-I	SOLS/ZOO/EZF-1 Fish Biology I	This course imparts in-depth knowledge of systematics, phylogeny, distribution, and classification of fish, general characters, and affinities of Agnatha, Placoderms, Holocephali, and Dipnoi. Students will also gain knowledge of the structure and development of Scales and Fins of fishes, skeletal system, alimentary canal and its associated glands, as well as the structure and functioning of heart, gills and urinogenital system of teleosts.
		SOLS/ZOO/EZEnt-1 Entomology I	This course provides knowledge to describe the external morphology of insects, including body structure, segmentation, and appendages. The students will also be able to classify insects into different orders, understanding their general characters, habits, habitats and the role of insects in ecosystems and potential impacts on human.
		SOLS/ZOO/EZEvs-1 Environmental Biology I	This course provides an overview of environmental biology and its applications. Students will acquire knowledge of terrestrial and aquatic biomes, key ecological concepts like habitat fragmentation, community patterns, population dynamics, and the impact of invasive species, pollutants on ecosystems, and human health.
46.	SOLS/ZOO/LCE-1 Lab Elective-I	It provides practical training related to the elective course ZE-01	
47.	SOLS/ZOO/CZ-8 or CZ- 7R Immunology	Students will acquire comprehensive knowledge of immunity with an understanding of the application of immunological tools for animal and human well-being. Students will gain knowledge about the components and mechanisms of the immune system; types of immunity, immune responses, hypersensitivity, transplantation, vaccines, autoimmune diseases and immunotherapy.	
48.	SOLS/ZOO/CZ-9 Toxicology	It provides a deep understanding of basic concepts of toxicology (toxicants- types, kinetics, & dynamics). The student will also acquire knowledge and be able to explain the mechanisms of toxicity and interactions of toxicants with biomolecules; effect of pollutants, heavy metals, pesticides, endocrine disruptors and human health.	
49.	SOLS/ZOO/CZ-10 Advanced	This course imparts comprehensive knowledge of recent advances in developmental biology. It provides insights into gametogenesis,	

	Developmental Biology	fertilization, early embryonic development, embryonic induction, organogenesis, including limb development, metamorphosis, regeneration, apoptosis and their significance. Students will be able to understand embryonic stem cells, cloning of animals, ageing, teratogenesis, and congenital growth abnormalities.	
50.	SOLS/ZOO/LC-2 Lab Core-II	This lab course provides students with hands-on experience and practical skills in laboratory techniques. The students will be able to understand immunological concepts, including immune cells and immunoglobulins, and apply toxicological principles to analyze the effects of toxic substances on living organisms. Students will visualize and understand the complex concepts of developmental biology through ICT tools and models.	
51.	SOLS/ZOO/EZ-2 Elective-II	SOLS/ZOO/EZF-2 Fish Biology II	This course imparts comprehensive knowledge of specialized characteristics of fishes, including accessory and respiratory organs, weberian ossicles, electric organs and luminescent organs. Students will also gain an in-depth understanding of the social, reproductive, migratory, foraging and parental behaviors of fish. Additionally, they will acquire detailed knowledge of fish physiology, embryology and endocrinology.
		SOLS/ZOO/EZEnt-2 Entomology II	This course imparts knowledge of the structure and physiology of the digestive, circulatory, respiratory, nervous, sensory and reproductive systems of insects. Students will also understand early embryology & developmental processes of insects, parasitism, predation, and social life in insects.
		SOLS/ZOO/EZEvs-2 Environmental Biology II	It imparts knowledge of natural resources, concept of sustainable development, protected areas, biodiversity conservation, global environmental problems, natural disasters, and hazards in hills. It also provides insights into the application of remote sensing and GIS in environmental management.
52.	SOLS/ZOO/LCE-2 Lab Elective-II	It provides practical training related to the elected subject ZE-02	
53.	SOLS/ZOO/ZEX-BZ	Students will be able to develop skills to set up start-up programs. They will get knowledge about the farming (Cattle, Sheep, Poultry, & fish) practice, which will help them to enhance their production skills.	

B. Sc. First Year (I Semester)

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

SYLLABUS (*w.e.f.* 2025-26)

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]

Recommended Books:

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]

Recommended Books:

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: Semi conservative 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]

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]

Recommended Books:

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

B.Sc. Second Year (IV Semester)

SOLS/ZOO/CZ-4 Physiology and Elementary Biochemistry 4 Credits [60 Hours]

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]

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, Kreb's cycle, pentose phosphate pathway, glycogen metabolism, electron transport chain, transamination, deamination, urea cycle, ß-oxidation in fatty acids [8 Hours]

SOLS/ZOO/AIZ-4 Physiology and Elementary Biochemistry 2 Credits [30 Hours]

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]

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]

Recommended Books:

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

4. 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
5. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H Freeman and Co.
6. Schmidt-Nielsen, Knut (1997). Animal Physiology: Adaptation and Environment, Cambridge University Press
7. Singh, HR and N. Kumar Animal Physiology and related Biochemistry, SL, Nagin Chand and Co, Delhi
8. Tortora, G.J.& Derrickson, B.H. (2009). Principles of Anatomy and Physiology, 12th edn., John Wiley & Sons, Inc.
9. 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]**

PHYSIOLOGY

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

BIOCHEMISTRY

6. Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose)
7. Colour reactions to identify functional group in the given solution of proteins
8. 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]**

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]

Recommended Books:

1. 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
2. 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]

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, Flourimetry: 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]

Recommended Books:

1. Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd ed.,
2. W.H. Freeman and Company, New York
3. 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]

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]

Recommended Books:

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]

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]

Recommended Books:

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]

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]

Recommended Books:

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.

SOLS/ZOO/SZ-6 Bioinformatics 2 Credits [30 Hours]

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]

Recommended Books:

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]

SOLS/ZOO/DSE-1 Applied Zoology 4 Credits [60 Hours]

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]

Recommended Books:

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]

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]

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]

Recommended Books:

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]

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]

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]

Recommended Books:

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 Palldino (2019). Concepts of Genetics, Pearson Education, Pearson

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

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).

Evolution

1. Study of fossil evidences from plaster cast models and pictures
2. Study of homology and analogy from suitable specimens/ pictures/ 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
3. Visit to Natural History Museum, submission of report

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

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]

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 adynelate 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: Folliculogensis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man [15 Hours]

Recommended Books:

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]

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]

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*.

Recommended Books:

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]

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.

SOLS/ZOO/DSE-6 Basics of Biotechnology 4 Credits [60 Hours]

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, Immunodiagnostics (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]

Recommended Books:

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

SOLS/ZOO/DSE-6(P) Basics of Biotechnology (Practical) [2 Credits]

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]

SOLS/ZOO/VCZ-1 Poultry Farming 4 Credits [60 Hours]

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, and 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)

Recommended Books:

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]**

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)

Recommended Books:

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]

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 (*Antherea 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)

Recommended Books:

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)

Recommended Books:

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)

SOLS/ZOO/VCZ-5 Fish Hatchery Operations 4 Credits [60 Hours]

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

Recommended Books:

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)

SOLS/ZOO/VCZ-6 Vermiculture 4 Credits [60 Hours]

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 comportment 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)

Recommended Books:

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)

CORE ZOOLOGY (CZ-5, CZ-6 & CZ-7)
[Theory: 5 Credits; Lab Course: 5 Credits]

SOLS/ZOO/CZ-5 Molecular Biology of the Cell **5 Credits [75 Hours]**

UNIT I

Plasma membrane: Structure- organisation, lipids, proteins & glucoconjugates; liposomes, black membrane; function- ionic transport, transporter proteins, types of transport (symport, antiport, active & passive), endocytosis and exocytosis.

Endomembrane system: intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathway.

UNIT II

Mitochondria: Ultrastructure, chemiosmotic process, respiratory chain, ATP synthetase, and genetic organisation.

Cytoskeleton: Nature and function of the cytoskeletal filaments, cilia and flagella, molecular motors

Cell junctions, cell adhesion and the extracellular matrix.

UNIT III

Cell signaling, general principles of cell signaling, signaling via G-protein-linked cell-surface receptors, enzyme-coupled cell-surface receptors, intracellular mediators, target cell adaptation

Cell cycle: overview, cell cycle control system, mechanism and control of cell division.

UNIT IV

Cellular transformation and malignancy, retroviruses

The molecular genetics of cancer and apoptosis

Basic knowledge of stem cells and tissue renewal

Recommended Books:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). Molecular biology of the cell: seventh international student edition, WW Norton & Company.
2. B. Sarkar: Cell Structure and Function, Medtech, ISBN: 978-9385998362
3. Karp et al. (2020) Karp's Cell and Molecular Biology: Concepts and Experiments, Ninth edition, Wiley
4. Lodish et al. (2016) Molecular Cell Biology, 8th edition, W. H. Freeman & Co Ltd.
5. P.K. Gupta: Cell Biology, Himalaya Publishing House, ISBN: 978-9350246696
6. P.S. Verma & V.K. Agarwal: Cell Biology (Cytology, Biomolecules and Molecular Biology, S Chand Publishing, ISBN: 978-9385676147
7. Sarkar B. (2017) Cell structure and Function, MEDTCH Publication 978-93-85998-36-2

SOLS/ZOO/CZ-6 Microbiology & Parasitology **5 Credits [75 Hours]**

Microbiology

Unit I

General features of microorganisms; classification of bacteria & staining techniques

Physiology, genetics, & reproduction of animal viruses

Pathological significance of bacteria and viruses

Bacteriophages, lysogenic & lytic cycle

Microbial enzymes; microbes and fermentation

Unit II

Physical and chemical methods of sterilization

Microbial cultures techniques; media enrichment techniques (formulation & optimization)

Types of microbial products

Cell lines & cloning

Bacterial growth and metabolism

Isolation and selection of industrially important microorganisms

Parasitology

Unit III

Introduction to parasites: parasitism and different types of animal associations, mode of transmission, morphological adaptation in different groups of parasites, zoonosis and larva migrans

Parasitic infections and their monitoring

Protozoan parasites: biology, life cycle and diseases caused by selected pathogenic protozoans of man, preventive and control measures (*Entamoeba*, *Trypanosomes*, *Leishmania, Trichomonas, Giardia* & *Plasmodium*)

Unit IV

Helminth parasites: biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria*, & *Taenia*)

Introduction to arthropods and vectors of human diseases: mosquitoes (dengue, yellow fever, chikungunya, zika fever, japanese encephalitis), lice, flies & ticks

Chemical, biological & environmental control of arthropod vectors

Recommended Books:

1. D.K. Sharma: Microbiology: Alpha Science, ISBN: 978-1842657508.
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. K.D. Chatterjee (2009): Parasitology (Protozoology and Helminthology) XIII Edition. CBS Publications and Distributors.
4. L. S. Roberts & J. Janovy (2009): Foundation of Parasitology, 8th edition, McGraw Hill Higher Education, Boston.
5. Pelczar: Microbiology, Tata McGraw Hill,1993
6. R.C. Dubey: A Textbook of Microbiology: S. Chand & Company, ISBN: 978-9355015273.
7. Smyth (1994): Introduction to Animal Parasitology, Cambridge University Press.

SOLS/ZOO/CZ-7 Animal Structure & Function **5 Credits [75 Hours]**

Unit I

Locomotion in protozoa

Hydrostatic movement in coelenterata, annelida & echinodermata

Feeding pattern and digestion in lower metazoan, mollusca & echinodermata

Unit II

Types of coeloms, metamerism

Organs & mechanism of respiration: gills, lungs & trachea

Organs & mechanism of excretion: coelom ducts, nephridia & malpighian tubule

Larval forms of invertebrates

Unit III

Vertebrate integument & its derivatives

Appendicular skeleton in amphibia, reptilia, aves & mammalia

Evolution of heart, portal & lymphatic system

Biting mechanism of snakes & adaptive radiation in reptiles

Unit IV

Urinogenital system & nervous system

Organs & mechanism of respiration in aquatic & terrestrial vertebrates

Flight adaptations in aves & mammals

Aquatic adaptations in mammals

Dentition in mammals

Recommended Books:

1. Barrington E.J.W. Invertebrate structure and function. Thomas Nelson and sons Ltd., London.
2. Kingslay J.S, Outlines of Comparative anatomy of vertebrates, Central Book Depot, Allahabad.
3. Kotpal, R.L. Modern T.B. of Zoology Vertebrates 5th ed. (2021). Rastogi Publication Meerut.
4. Pandey B.N. & Mathur V. Biology of Chordates (2018) PHI Learning Pvt Ltd Delhi
5. Russet Hunter W.D.D. Biology of higher invertebrate The Macmillan Co. Ltd., London.
6. Waterman A.J. Chordate Structure and Functions Macmillan Co. New York.

SOLS/ZOO/LC-1 Lab Course-1 (Based on CZ-5, CZ-6 & CZ-7) [5 Credits]

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Molecular Biology of the Cell

1. Microscopic measurement of cells and microorganisms
2. Permanent slides of cell division (mitosis & meiosis)
3. Study of different stages of mitosis by squash technique
4. Study of different stages of meiosis in grasshopper testis
5. Slide preparation of interphase nuclei in buccal epithelium
6. Study of polytene chromosomes in drosophila larvae.
7. Preparation of blood smear
8. Preparation of solutions for molecular biology experiments.
9. Isolation of dna from animal tissue
10. DNA and RNA concentration and purity estimation using UV-vis spectrophotometer
11. RNA estimation using the Orcinol method

Microbiology & Parasitology

1. Transfer of bacteria: aseptic techniques
2. Preparation of smears and simple staining
3. Gram staining of microorganisms
4. Acid-fast staining
5. Study of museum specimens of parasites
6. Study of life stages of *Entamoeba*, *Trypanosoma* & *Plasmodium* through permanent Slides/microphotographs
7. Study of adult and life stages of *Fasciola*, *Schistosoma* & *Wuchereria* through permanent slides/micro photographs/live material

Animal Structure & Functions

1. Study of permanent slides of protozoa (*Amoeba*, *Paramecium* and *Euglena*)
2. Demonstration of ciliary and flagellar movement in the protozoan
3. Study of permanent slides of larval forms in invertebrates
4. Study of appendicular skeleton of frog, varanus, fowl & rabbit
5. Mounting of fish scales and gills
6. Study of mechanism of respiration in aquatic and terrestrial vertebrates (chart/model/video)
7. Museum specimens of invertebrate and vertebrate animals

MAJOR ELECTIVE ZOOLOGY (EZ-1: EZ F-1/ EZ Ent-1/ EZ Evs-1)
(Theory- 2 Credits; Lab Course-2 Credits)
[Anyone]

B. Sc. VII Semester (Honours)

SOLS/ZOO/EZF-1. Fish Biology-I **2 Credits [30 Hours]**

UNIT I

Introduction and history of ichthyology; systematics and phylogeny

Origin and evolution, zoogeographical distribution

Schemes of classification of fossil and recent fishes

General characters of teleost and elasmobranch fishes

UNIT II

Agnatha: characters, basic biology and affinities of cyclostomes and ostracoderms

Placoderms: general characters and affinities.

Holocephali: salient features, external and internal morphology and affinities

Dipnoi: salient features and affinities.

UNIT III

Comparative morphology of teleosts and elasmobranchs; integuments (teleosts & elasmobranchs), colouration and its significance, mechanism of colour change

Exoskeleton: structure and development of placoid and non-placoid scales

Fins and their origin

Skeletal system: skull, vertebrae, girdles, opercular bones & pharyngeal bones

UNIT IV

Comparative morphology of organs in teleosts and elasmobranchs: alimentary canal and associated glands, modifications based on different feeding behaviour

Structure of heart, afferent and efferent branchial arteries, structure of gill and pseudo-branch

Brain and cranial nerves

Urinogenital system

Recommended Books:

1. Ayappan & Jena. Handbook of Fisheries and Aquaculture, Directorate of Information & Publication of Agriculture, ICAR Publication, New Delhi 110012
2. Gupta, S.K. and Gupta, P.C. General and Applied Ichthyology (Fish and Fisheries). S Chand Publications, New Delhi- 110055
3. Khanna, S.S. and Singh, H.R. A textbook of Fish Biology and Fisheries. Narendra Publishing House, Delhi- 110006
4. Pandey & Shukla. Fish and Fisheries 4th Edition 2021 Rastogi Publication Meerut 250002
5. Sarkar U.K., Fisheries Biology: New approaches and changing perspectives (2021). Narendra Publishing House. ISBN: 978-9389996579

SOLS/ZOO/EZEnt-1 Entomology-I **2 Credits [30 Hours]**

UNIT I

Introduction to external morphology: body wall and segmentation

Head: structure of head, appendages and antennae

Thorax: pro, meso and metathorax; legs

Wings: origin, structure, and articulation

Abdomen: structure, appendages; external female and male genitalia

UNIT II

Classification of insects with special reference to different orders

General characters, habits, habitats, importance of the insect orders- Collembola, Protura, Diplura, Thysanura, Ephemerida, Placoptera, & Odonata

General characters, habits, habitats, importance of the insect orders- Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera & Zoraptera.

UNIT III

General characters, habits, habitats, importance of the insect orders- Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera & Trichoptera.

UNIT IV

General characters, habits, habitats, importance of the insect orders- Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, & Diptera

Recommended Books:

1. Ananthakrishnan TR: Applied Entomology
2. Ayyar, TVR: Handbook of Economic Entomology for South India, International Book & Periodical Supply Service, 1984.
3. Bhutani DK & Jotwani MG: Insects in Vegetables, Periodical Expert Book Agency
4. Community development & Co-operation, New Delhi, 1968.
5. Evans JW: Insect Pests and Their Control, Periodical Expert Book Agency, 1984.
6. Mehta PR & Varma BK: Plant Protection, Directorate of Extension, Ministry of Food,
7. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979

SOLS/ZOO/EZEvs-1 Environmental Biology-I 2 Credits [30 Hours]

UNIT I

Introduction to environmental biology, its multidisciplinary nature and scope
Components of environment: atmosphere, lithosphere & hydrosphere
Climate (micro, regional, and global)
Hydrological cycle & soil profile

UNIT II

Terrestrial biomes of the world, their characteristics and major biota (grassland, desert, forest, tundra)
Aquatic biomes (lotic, lentic, marine, estuaries & coral reef),
Wetlands of india
Environmental adaptations: aquatic, aerial, desert, arboreal, fossorial & defensive

UNIT III

Island biogeography theory
Habitat fragmentation, habitat selection, corridors, community patterns (gradients and continuum) and community indices. Ecological niche
Population cycles and fluctuations; dispersal, intra & inter-specific relationship
Models of succession: pioneer & climax concept

UNIT IV

Concept of biological indicators; biological monitoring, indicator organisms
Invasive species and its impact
Biological Control: Biomagnification, bioassimilation & bioaccumulation
Elementary Toxicology, Xenobiotics: carcinogenic (heavy metals, radioactive substances, & pesticides) and their chemical nature

Recommended Books:

1. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
2. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
3. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

SOLS/ZOO/LCE-1	2 Credits
Lab course based on EZ-1 (EZF-1/EZEnt-1/EZEvs-1)	

MINOR ZOOLOGY (ZM-1: ZM-1a/ZM-1b)
(Theory- 4 Credits)
[Anyone]
[For Students with Core subjects other than Zoology (Without Practical)]

SOLS/ZOO/ZM-1a Aquatic Biodiversity **4 Credits [60 Hours]**

UNIT I

Definition, Concept, Scope, and Measurement of Biodiversity.
Types of Biodiversity: Species, Genetic, Community, Ecosystem.
Factors Governing Biodiversity: Historical & Proximate

UNIT II

Aquatic Ecosystems and Their Characteristics. Freshwater
Biodiversity; Marine Biodiversity.
Biodiversity Databases

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

UNIT IV

Impact of Hydroelectric Projects (HEP) On Aquatic Biodiversity; Environmental
Impact Assessment (EIA): Case Studies from the Himalaya
Environmental Flows: Importance for the Aquatic Flora & Fauna
Environmental Flows Assessment Methodology: Hydrological, Hydraulics Rating, Habitat Simulation & Holistic

Recommended Books:

1. Dodds W K: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
2. Gaston K J & J I Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
3. Jhingran V G: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
4. Nautiyal *et.al*: Ecology & Diversity of Freshwater Environments Trans media, Srinagar Garhwal, 2005
5. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
6. Odum E P.: Fundamentals of Ecology, Cengage Learning (2004)
7. Postel Sandra & Brian Richter: Rivers for Life-Managing Water for People and Nature, Island Press (2003)

SOLS/ZOO/ZM-1b Animal Biotechnology* **4 Credits [60 Hours]**

***# Swayam Course: 142:** https://onlinecourses.swayam2.ac.in/cec25_ma07/preview

B. Sc. VIII Semester (Honours) Revised in 26th BoS

CORE ZOOLOGY (CZ-8)
[Theory: 5 Credits]

SOLS/ZOO/CZ-8 Immunology	**5 Credits [75 Hours]**

UNIT I

Introduction to immunology
Components of the immune system: primary and secondary lymphoid organs
Types of immunity: innate immunity vs. Acquired immunity
Antigens: essential features of antigens, antigenic determinants
Adjuvants & immunoglobulins: structure, functions & types

UNIT II

Immunity and its types: active, passive, cell-mediated & humoral immunity
Immune response: primary and secondary response
Cellular components: neutrophils, macrophages, dendritic cells and Natural Killer (NK) Cells
Inflammation: acute vs. Chronic inflammation
Cytokines and their role
Complement System: Activation, functions and regulation
Adaptive Immunity: Characteristics, Cells (T & B Cells) & Major Histocompatibility Complex (MHC)

UNIT III

Introduction to hypersensitivity: types and pathogenicity
Introduction to transplantations
Vaccines: types & applications
Blood Groups: AB, Rh System, significance, practical application & Erythroblastosis fetalis

UNIT IV

Techniques in Immunology: RIA, ELISA, Western Blotting & Immuno fluorescence
Immunotherapy: Monoclonal antibodies & hybridoma technology
Immunodeficiencies: Primary and secondary immune deficiencies
Autoimmune Diseases: Mechanisms and examples (rheumatoid arthritis & lupus)

Recommended Books:

1. A. Paul: Textbook of Immunology: Books & Allied Pvt. Ltd., ISBN: 978-9384294724.
2. A.K. Abbas: Basic Immunology: Elsevier India, ISBN:978-8131259573.
3. B. Annadurai: A Textbook of Immunology & Immuno Technology: S. Chand & Company, ISBN: 978-8121928076.
4. Elgert & Elgert: Immunology.
5. Kuby: Immunology (4th ed.).
6. Roitt, Male & Brostoff: Immunology (3rd ed).

CORE ZOOLOGY (CZ- 9)
[Theory: 5 Credits]

SOLS/ZOO/CZ-9 Toxicology	**5 Credits [75 Hours]**

UNIT I

Definition and scope of toxicology
Branches of toxicology (environmental, clinical, forensic & industrial)
Basic principles of toxicology: dose-response relationship, toxicokinetics (absorption, distribution, metabolism & excretion), toxicodynamics (mechanisms of action)
Types of toxins (chemical, biological & physical)

UNIT II

Cellular and molecular mechanisms of toxicity
Interaction of toxicants with biomolecules (proteins, DNA & lipids)
Xenobiotics and their toxic effects

Biotransformation of xenobiotics (phase I & phase II reactions)
Toxicity at the level of organs and systems

UNIT III

Toxicological screening methods (acute, sub-acute & chronic toxicity testing)
Bioassays and toxicity testing models
In vitro and in vivo testing approaches
Ethics & regulations for the use of laboratory animals in toxicity studies
Carcinogenicity, mutagenicity & teratogenicity

UNIT IV

Pollutants and their effects on ecosystems
Heavy metals (lead, mercury & cadmium) toxicity
Pesticides and herbicides: mechanisms of action and environmental impact
Endocrine disruptors and their role in wildlife and human health
Case studies of environmental toxicities

Recommended Books:

1. Balram Pani: Textbook of Toxicology: Dreamtech Press, Wiley, ISBN-13: 978-9389520279.
2. D.E. Hathway: Molecular aspects of Toxicology: The Royal Society of Chemistry, ISBN 9780851860688.
3. Hans Marquardt: Toxicology: Academic Press, ISBN-13: 978-0124732704.
4. Omkar: Concepts of Toxicology: Gangarams Book Bureau, ISBN: 978819329344.
5. P.K. Gupta: Fundamental of Toxicology- Essential Concepts and Applications: Academic Press. ISBN: 9780128054260

CORE ZOOLOGY (CZ- 10)
[Theory: 5 Credits]

SOLS/ZOO/CZ-10 Advanced Developmental Biology	**5 Credits [75 Hours]**

UNIT I

Gonadal differentiation: development and differentiation of sperm and oocytes, physical and biochemical characteristics of semen
Ovarian follicular growth and differentiation: structural and hormonal changes during major developmental events
Biochemical changes in ovum during vitellogenesis and ovulation process
Ovum transport in mammals, Multiple Ovulation and Embryo Transfer Technology (MOET)
Fertilization: Process and events, pre-fertilization events, physical and chemical changes at Fertilization, Capacitation, Acrosomal reaction and penetration, Activation of oocyte and amphimixis

UNIT II

Embryonic induction and competence theory: inducing agents and mechanism of induction
Concept of organizer and embryonic inductions
Development in drosophila: cleavage, gastrulation; molecular basis of development- maternal-effect genes, segmentation genes and homeotic selector genes
Early embryonic development in vertebrates (frog & chick): cleavage- types and significances, fate maps, blastulation, gastrulation- morphogenetic cellular movements and mechanism of axes & germ layers formation

UNIT III

General concept of organogenesis: limb morphogenesis- development and patterning of vertebrate limb, proximal, distal and dorso-ventral axis formation
Extra-embryonic membranes in birds, implantation of embryo in humans, placenta (structure, types & functions); cloning of animals by nuclear transfer

UNIT IV

Metamorphosis: Amphibian metamorphosis; aging- mechanism & concept, regeneration: modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration
Apoptosis: Definition, mechanism and significance. Embryonic stem cells and their applications; teratogenesis- teratogenic agents and their effects on embryonic development, congenital and cancerous growth

Recommended Books:

1. Analysis of Biological Development, Kalthoff (2nd Ed., 2000), McGraw-Hill Science, New Delhi, India.
2. Balinsky: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London.
3. Berill: Development Biology. Tata McGraw-Hill Publishing Co. Ltd.
4. Gilbert: Developmental Biology (10th Ed). Sinauers Associates Publ. Massachusetts, 2010.
5. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
6. Singh I.: Human Embryology (2021) Jaypee Brothers

SOLS/ZOO/LC-2
Lab course based on CZ-8, CZ-9 & CZ-10) [5 Credits]

A complete record of laboratory work will be maintained by every student. The practical work will consist of the following:

Immunology

1. Identification of various immune cells with the help of charts/photographs
2. Study of different immunoglobulins with the help of charts/photographs
3. Determination of total red blood cells and white blood cells in the blood sample
4. Estimation of serum proteins
5. Study of lymphoid organs through permanent slides/charts/models
6. Testing of blood groups
7. ELISA

Toxicology

1. Care and maintenance of laboratory animals
2. Toxic substances: waste water, carcinogens, heavy metals, pesticides, and insecticides
3. Study of acute, sub-acute, chronic and sub-chronic toxicity
4. Calculation of LC50 with the help of data provided
5. Study of behavioural responses (fish/insects/any available animal) to some important toxicants
6. Dose-response relationship
7. Analysis of toxicants by chromatography (paper, TLC & GC)
8. Effect of toxicants on haematological and biochemical indices

Advanced Developmental Biology

1. Study of different types of eggs from collected/preserved material
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.
3. Study of developmental stages of whole mounts of chick embryo (upto 48 hours of incubation) through permanent slides/ ICT tools/ models/ photographs
4. Study of the development of chick by window preparation
5. Study of the different types of placenta through charts/models/ICT tools
6. Study of apoptosis, cancers, and teratogenesis with the models/charts/ICT tools
7. Study of cloning techniques with the help of ICT tools/models/charts/photographs
8. Study of the reproductive system in mammals with the help of ICT tools/models/charts/photographs

B. Sc. VIII Semester (Honours)

MAJOR ELECTIVE ZOOLOGY (EZ-2: EZ F-2/ EZ Ent-2/ EZ Evs-2)
(Theory- 2 Credits; Lab Course- 2 Credit)
[Anyone]

SOLS/ZOO/ EZF-2 Fish Biology-II 2 Credits [30 Hours]

UNIT I

Accessory respiratory organs in fishes
Swim bladder and its modifications, gas secreting complex and its functions
Weberian ossicles: Structure and arrangement, working mechanism and functions
Electric organs: Structure, mechanism of electric discharge and functions
Bioluminescence: Luminescent organs, mechanism of light emission and significance
Sound production in fishes

UNIT II

Fish behavior: Social, ecological, reproductive, migratory, and foraging behavior
Parental care in fishes
Receptor organs: Eye, acoustico-lateralis system, olfactory organs, and taste buds
Migration in fishes: Patterns, causes, and factors influencing
Parental care and viviparity in fishes
Pheromones and their role in sexual behavior of fish

UNIT III

Fertilization and development of fish eggs (teleost)
Cleavage, blastulation, gastrulation and fate map; hatching and post-embryonic development
Respiration: Functional organization of gill lamellae, blood supply of gill, mechanism of gas exchange and counter-current mechanism.
Physiology of excretion and osmo-regulation, mechanism of water-salt balance in freshwater, marine and estuarine fishes
Reproductive physiology: Spawning patterns, stimulating factors and follicular atresia
Haemopoiesis: Composition of blood, haemopoietic tissues, and synthesis of haemoglobin
Physiology of thermo-regulation in fishes

UNIT IV

Pituitary gland: Micro-anatomy, hormones of pituitary and their physiological actions
Structure and functions of thyroid and pancreatic islets in fishes
Location and functions of corpuscles of stannius, pineal and urophysis in fishes

Recommended Books:

1. Gupta S.K. Fish & Fisheries Digest Part 3 Light & Electricity (2022). ISBN: 9798784666574
2. Khanna S. S. & Singh H.R.: A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014
3. Kyle: The Biology of Fishes, 2007.
4. Munshi J.D. & Munshi J.S.D.: Fundamentals of Freshwater Biology, Narendra Publ. House, 1995.
5. Ojha J.: Biology of Hill Stream Fish, Narendra Publication House, 2002.
6. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.

SOLS/ZOO/EZ Ent-2. Entomology-II 2 Credits [30 Hours]

UNIT I

Digestive system: Structure, physiology of digestion and absorption of different types of food. Structure of circulatory system: Haemolymph, its composition and function
Physiology of respiration, tracheal system, spiracles, respiration in aquatic insects
Nervous system: Structural basis, excretion: structure and physiology of malpighian tubules and their secondary functions
Reproduction: Male and female gonads

UNIT II

Structure of compound eye, mosaic vision
Production and reception of sound, light producing organs
Pheromones and hormones: Neurosecretion and co-ordination, metamorphosis: types, hormonal control of metamorphosis

UNIT III

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, various types of larvae and pupae, moulting, diapauses, oviparity, viviparity, and ovo-viviparity in insects

UNIT IV

Abiotic factors: Effect of temperature, light, and humidity on growth of insect population, biotic potential, malthusian principle, and dynamics of population fluctuation, hibernation, and aestivation
Biotic factors: Parasitism, predation, and social life in insects, phase theory of locust and parental care

Recommended Books:

1. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
2. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
3. Mani MS, Introduction to High Entomology, Mathuen & Coy Ltd. 1962.
4. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
5. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy, Ltd.

SOLS/ZOO/EZEvs-2 Environmental Biology-II 2 Credits [30 Hours]

UNIT I

Natural resources: Management and conservation
Renewable and non-renewable resources
Concept and currencies of sustainable development
Biodiversity and its conservation
Environmental protection laws

UNIT II

Concept of protected areas: sanctuaries, national parks and biosphere reserves
IUCN categories, biodiversity hot spots and conventions on biodiversity
International efforts in biodiversity conservation (UNFP, IUCN, WWF), CITES, UNESCO's World Heritage Mission, and Convention on Biological Diversity (CBD)

UNIT III

Global environmental problems: climate change, greenhouse effect, acid rain, ozone layer depletion, deforestation, desertification, marine pollution, and urbanization
Exposure to toxicants: routes and sites of exposure (inhalation, injection, and through food or intestinal)
Duration and frequency of exposure: acute, subacute, chronic, and sub chronic
Chemical nature of toxicants: Receptors and mechanism of action of DDT, lead (Pb) and UV rays

UNIT IV

Environmental problems/hazards in hills: earthquake, landslide, soil erosion, sedimentation, cloud burst, flash floods, and glacial retreat
Application of remote sensing and Geographical Information Systems (GIS) in Environmental Management
Disasters: Types and management

Recommended Books:

1. D.E. Hathway: Molecular aspects of Toxicology: The Royal Society of Chemistry, Burlington House, London.
2. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005
3. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
4. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
5. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

SOLZ/ZOO/LCE-2	**2 Credits**
Lab course based on EZ-2 (EZ F-2/ EZ Ent-2/ EZ Evs-2)	

MINOR ZOOLOGY (ZM-2: ZM-2a/ZM-2b)
(Theory- 4 Credits)
[Anyone]
[For Students with Core subjects other than Zoology (Without Practical)]

SOLS/ZOO/ZM-2a Assisted Reproductive Biology Techniques	**4 Credits [30 Hours]**

UNIT I

Scope of Reproductive Technologies; Functional Anatomy of Male & Female Reproductive System; Induced Release of Gametes and Its Significance

UNIT II

Multiple Ovulation, Super ovulation; In-Vitro Oocyte Maturation; Biochemistry of Semen, Semen Composition and Formation; Cryopreservation of Gametes

UNIT III

Intra- Cytoplasmic Sperm Injection, Gamete Intra fallopian Transfer; In-Vitro Fertilization; Transgenic Animals and their Uses

UNIT IV

Contraception; Immuno contraception; Other Contraception Technologies: Surgical Methods, Hormonal Method, Physical Barrier, IUCD

Recommended Books:

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.AndLopez,K.H:HumanReproductiveBiology(ThirdEdition),AcademicPress(2006)
3. Weissman,Ariel,ColinM.Howles,ZeevShoham:TextbookofAssistedReproductiveTechniques,Volume 1: Laboratory Perspectives, CRC Press (2018)

SOLS/ZOO/ZM-2b Environmental Pollution and Global issues*	**4 Credits [30 Hours]**

***Swayam Course: * SN: 28** https://onlinecourses.swayam2.ac.in/cec25_es02/preview

B.Sc. [Honours with Research] Fourth Year (VII & VIII Semester)
CORE ZOOLOGY (CZ-5- & CZ-6)
[Theory: 5 Credits]

SOLS/ZOO/CZ-5 Molecular Biology of the cell	5 Credits [75 Hours]

UNIT I

Plasma membrane: Structure- organisation, lipids, proteins & glucoconjugates; liposomes, black membrane; function- ionic transport, transporter proteins, types of transport (symport, antiport, active & passive), endocytosis and exocytosis.

Endomembrane system: intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathway.

UNIT II

Mitochondria: Ultrastructure, chemiosmotic process, respiratory chain, ATP synthetase, and genetic organisation.

Cytoskeleton: Nature and function of the cytoskeletal filaments, cilia and flagella, molecular motors

Cell junctions, cell adhesion and the extracellular matrix.

UNIT III

Cell signaling, general principles of cell signaling, signaling via G-protein-linked cell-surface receptors, enzyme-coupled cell-surface receptors, intracellular mediators, target cell adaptation

Cell cycle: overview, cell cycle control system, mechanism and control of cell division.

UNIT IV

Cellular transformation and malignancy, retroviruses

The molecular genetics of cancer and apoptosis

Basic knowledge of stem cells and tissue renewal

Recommended Books:

1. Alberts, B., Heald, R., Johnson, A., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2022). Molecular biology of the cell: seventh international student edition, WW Norton & Company.
2. B. Sarkar: Cell Structure and Function, Medtech, ISBN: 978-9385998362
3. Karp et al. (2020) Karp's Cell and Molecular Biology: Concepts and Experiments, Ninth edition, Wiley
4. Lodish et al. (2016) Molecular Cell Biology, 8th edition, W. H. Freeman & Co Ltd.
5. P.K. Gupta: Cell Biology, Himalaya Publishing House, ISBN: 978-9350246696
6. P.S. Verma & V.K. Agarwal: Cell Biology (Cytology, Biomolecules and Molecular Biology, S Chand Publishing, ISBN: 978-9385676147
7. Sarkar B. (2017) Cell structure and Function, MEDTCH Publication 978-93-85998-36-2

CORE ZOOLOGY (CZ - 6)
[Theory: 5 Credits]

SOLS/ZOO/CZ-6 Microbiology & Parasitology	5 Credits [75 Hours]

Microbiology

Unit I

General features of microorganisms; classification of bacteria & staining techniques

Physiology, genetics, & reproduction of animal viruses

Pathological significance of bacteria and viruses

Bacteriophages, lysogenic & lytic cycle

Microbial enzymes; microbes and fermentation

Unit II

Physical and chemical methods of sterilization

Microbial cultures techniques; media enrichment techniques (formulation & optimization)

Types of microbial products

Cell lines & cloning

Bacterial growth and metabolism

Isolation and selection of industrially important microorganisms

Parasitology

Unit III

Introduction to parasites: parasitism and different types of animal associations, mode of transmission, morphological adaptation in different groups of parasites, zoonosis and larva migrans

Parasitic infections and their monitoring

Protozoan parasites: biology, life cycle and diseases caused by selected pathogenic protozoans of man, preventive and control measures (*Entamoeba*, *Trypanosomes*, *Leishmania, Trichomonas, Giardia* & *Plasmodium*)

Unit IV

Helminth parasites: biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris*, *Schistosoma*, *Fasciola*, *Wuchereria*, & *Taenia*)

Introduction to arthropods and vectors of human diseases: mosquitoes (dengue, yellow fever, chikungunya, zika fever, japanese encephalitis), lice, flies & ticks

Chemical, biological & environmental control of arthropod vectors

Recommended Books:

1. D.K. Sharma: Microbiology: Alpha Science, ISBN: 978-1842657508.
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. K.D. Chatterjee (2009): Parasitology (Protozoology and Helminthology) XIII Edition. CBS Publications and Distributors.
4. L. S. Roberts & J. Janovy (2009): Foundation of Parasitology, 8th edition, McGraw Hill Higher Education, Boston.
5. Pelczar: Microbiology, Tata McGraw Hill,1993
6. R.C. Dubey: A Textbook of Microbiology: S. Chand & Company, ISBN: 978-9355015273.
7. Smyth (1994): Introduction to Animal Parasitology, Cambridge University Press.

SOLZ/ZOO/LC-1 Lab course based on CZ-5 & CZ-6	**5 Credits**

Molecular Biology of the Cell

1. Microscopic Measurement of Cells and Microorganisms
2. Permanent Slides of Cell Division (Mitosis & Meiosis)
3. Study of Different Stages of Mitosis by Squash Technique
4. Study of Different Stages of Meiosis in Grasshopper Testis
5. Slide Preparation of Interphase Nuclei in Buccal Epithelium
6. Study of Polytene Chromosomes in Drosophila Larvae.
7. Preparation of Blood Smear
8. Preparation of Solutions for Molecular Biology Experiments.
9. Isolation of DNA from Animal Tissue
10. DNA and RNA concentration and purity estimation using UV-Vis Spectrophotometer
11. RNA Estimation Using the Orcinol Method

Microbiology & Parasitology

1. Cleaning of Glassware and Sterilization Techniques
2. Preparation of Media for Animal Cell Culture
3. Transfer of Bacteria: Aseptic Techniques

4. Preparation of Smears and Simple Staining
5. Gram Staining of Micro Organism
6. Bacteriological Testing of Milk
7. Antibiotic Sensitivity Test
8. Study Of Museum Specimens of Parasites.
9. Study Of Life Stages of *Trypanosoma* &*Plasmodium* Through Permanent Slides/ Microphotographs/Charts
10. Study Of Adult and Life Stages of *Schistosoma* &*Wuchereria* Through Permanent Slides/Micro Photographs/Models or Live Material
11. Study Of Arthropods and Vectors of Human Diseases (Mosquitoes, Lice, Flies & Ticks)

MAJOR ELECTIVE ZOOLOGY (EZ-1: EZ F-1/ EZ Ent-1/ EZ Evs-1)
(Theory- 2 Credits)
[Anyone from Elective Basket EZ-1]

SOLS/ZOO/ EZF-1 Fish Biology -1 2 Credits [30 Hours]

UNIT I

Introduction and history of ichthyology; systematics and phylogeny

Origin and evolution, zoogeographical distribution

Schemes of classification of fossil and recent fishes

General characters of teleost and elasmobranch fishes

UNIT II

Agnatha: characters, basic biology and affinities of cyclostomes and ostracoderms

Placoderms: general characters and affinities.

Holocephali: salient features, external and internal morphology and affinities

Dipnoi: salient features and affinities.

UNIT III

Comparative morphology of teleosts and elasmobranchs; integuments (teleosts & elasmobranchs), colouration and its significance, mechanism of colour change

Exoskeleton: structure and development of placoid and non-placoid scales

Fins and their origin

Skeletal system: skull, vertebrae, girdles, opercular bones & pharyngeal bones

UNIT IV

Comparative morphology of organs in teleosts and elasmobranchs: alimentary canal and associated glands, modifications based on different feeding behaviour

Structure of heart, afferent and efferent branchial arteries, structure of gill and pseudo-branch

Brain and cranial nerves

Urinogenital system

Recommended Books:

1. Ayappan & Jena. Handbook of Fisheries and Aquaculture, Directorate of Information & Publication of Agriculture, ICAR Publication, New Delhi 110012
2. Gupta, S.K. and Gupta, P.C. General and Applied Ichthyology (Fish and Fisheries). S Chand Publications, New Delhi- 110055
3. Khanna, S.S. and Singh, H.R. A textbook of Fish Biology and Fisheries. Narendra Publishing House, Delhi- 110006
4. Pandey & Shukla. Fish and Fisheries 4th Edition 2021 Rastogi Publication Meerut 250002
5. Sarkar U.K., Fisheries Biology: New approaches and changing perspectives (2021). Narendra Publishing House. ISBN: 978-9389996579

SOLS/ZOO/EZ Ent-1 Entomology-I 2 Credits [30 Hours]

UNIT I

Introduction to external morphology: body wall and segmentation

Head: structure of head, appendages and antennae

Thorax: pro, meso and metathorax; legs

Wings: origin, structure, and articulation

Abdomen: structure, appendages; external female and male genitalia

UNIT II

Classification of insects with special reference to different orders

General characters, habits, habitats, importance of the insect orders- Collembola, Protura, Diplura, Thysanura, Ephemerida, Placoptera, & Odonata

General characters, habits, habitats, importance of the insect orders- Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera & Zoraptera.

UNIT III

General characters, habits, habitats, importance of the insect orders- Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera & Trichoptera.

UNIT IV

General characters, habits, habitats, importance of the insect orders- Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, & Diptera

Recommended Books:

8. Ananthakrishnan TR: Applied Entomology
9. Ayyar, TVR: Handbook of Economic Entomology for South India, International Book & Periodical Supply Service, 1984.
10. Bhutani DK & Jotwani MG: Insects in Vegetables, Periodical Expert Book Agency
11. Community development & Co-operation, New Delhi, 1968.
12. Evans JW: Insect Pests and Their Control, Periodical Expert Book Agency, 1984.
13. Mehta PR & Varma BK: Plant Protection, Directorate of Extension, Ministry of Food,
14. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979

SOLS/ZOO/EZEvs-1 Environmental Biology-I 2 Credits [30 Hours]

UNIT I

Introduction to environmental biology, its multidisciplinary nature and scope
Components of environment: atmosphere, lithosphere & hydrosphere
Climate (micro, regional, and global)
Hydrological cycle & soil profile

UNIT II

Terrestrial biomes of the world, their characteristics and major biota (grassland, desert, forest, tundra)
Aquatic biomes (lotic, lentic, marine, estuaries & coral reef),
Wetlands of india
Environmental adaptations: aquatic, aerial, desert, arboreal, fossorial & defensive

UNIT III

Island biogeography theory
Habitat fragmentation, habitat selection, corridors, community patterns (gradients and continuum) and community indices. Ecological niche
Population cycles and fluctuations; dispersal, intra & inter-specific relationship

Models of succession: pioneer & climax concept

UNIT IV

Concept of biological indicators; biological monitoring, indicator organisms
Invasive species and its impact
Biological Control: Biomagnification, bioassimilation & bioaccumulation
Elementary Toxicology, Xenobiotics: carcinogenic (heavy metals, radioactive substances, & pesticides) and their chemical nature

Recommended Books:

1. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
2. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
3. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

SOLS/ZOO/LCE-1	**2 Credit**
Lab course based on EZ-1 (EZF-1/EZEnt-1/EZEvs-1)	

RESEARCH METHODOLOGY ZOOLOGY (RMZ)
[Theory: 5 Credits]

SOLS/ZOO/RMZ Research Methodology	5 Credits [60 Hours]

UNIT I

Foundations of Research: Meaning, Objectives, Motivation: Research Methods vs Methodology
Types of Research**:** Analytical vs Descriptive, Quantitative vs Qualitative, Basic vs Applied

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

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
Intellectual Property Rights, Commercialization, Copy Right, Royalty, Patent law, Plagiarism, Citation, Acknowledgement

UNIT IV

Biostatistics: Importance in Research; Descriptive Statistics: Measures of Central Tendency (Mean, Median, Mode), Variability (Range, Variance, Standard Deviation); Probability Theory: Basic Concepts, Probability Distributions (Normal, Binomial, Poisson); Inferential Statistics: Hypothesis Testing (t-tests, Chi-square tests, ANOVA); Correlation and linear regression analysis

Recommended Books

1. Anthony, M., Graziano, A.M. and Raulin, M. L. 2009. Research Methods: A Process of Inquiry, Allynand Bacon
2. Coley, S.M. and Scheinberg, C.A. 2008. Proposal Writing: Effective Grantmanship, 3rd edition, Sage Publications
3. K. Janardhan & P. H. Rao: Fundamentals of Biostatistics, I K International Publishing House Pvt. Ltd, ISBN: 978-9380578712
4. Kothari,C.R. 2009.Research Methodology, New Age International
5. S.P. Gupta: Statistical Methods, Sultan Chand and Sons, ISBN: 978-9351611127
6. Wadhera, B.L. 2002. Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law Publishing
7. Walliman, N. 2011. Research Methods-The Basics. Taylorand Francis, London, NewYork

MINOR ZOOLOGY (ZM-1: ZM-1a/ZM-1b)
(Theory- 4 Credits)
[Anyone]
[For Students with Core subjects other than Zoology (Without Practical)]

SOLS/ZOO/ZM-1a Aquatic Biodiversity	**4 Credits [60 Hours]**

UNIT I

Definition, Concept, Scope, and Measurement of Biodiversity.
Types of Biodiversity: Species, Genetic, Community, Ecosystem.
Factors Governing Biodiversity: Historical & Proximate

UNIT II

Aquatic Ecosystems and Their Characteristics. Freshwater
Biodiversity; Marine Biodiversity.
Biodiversity Databases

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

UNIT IV

Impact of Hydroelectric Projects (HEP) On Aquatic Biodiversity; Environmental
Impact Assessment (EIA): Case Studies from the Himalaya
Environmental Flows: Importance for the Aquatic Flora & Fauna
Environmental Flows Assessment Methodology: Hydrological, Hydraulics Rating, Habitat Simulation & Holistic

Recommended Books:

1. Dodds W K: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
2. Gaston K J & J I Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
3. Jhingran V G: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
4. Nautiyal *et.al*: Ecology & Diversity of Freshwater Environments Trans media, Srinagar Garhwal, 2005
5. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
6. Odum E P.: Fundamentals of Ecology, Cengage Learning (2004)
7. Postel Sandra & Brian Richter: Rivers for Life-Managing Water for People and Nature, Island Press (2003)

SOLS/ZOO/ZM-1b Animal Biotechnology*	**4 Credits [60 Hours]**

***# Swayam Course: 142:** https://onlinecourses.swayam2.ac.in/cec25_ma07/preview

CORE ZOOLOGY (CZ-7R)
[Theory: 5 Credits]

SOLS/ZOO/CZ-7R Immunology **5 Credits [75 Hours]**

UNIT I

Introduction to immunology
Components of the immune system: primary and secondary lymphoid organs
Types of immunity: innate immunity vs. Acquired immunity
Antigens: essential features of antigens, antigenic determinants
Adjuvants & immunoglobulins: structure, functions & types

UNIT II

Immunity and its types: active, passive, cell-mediated & humoral immunity
Immune response: primary and secondary response
Cellular components: neutrophils, macrophages, dendritic cells and Natural Killer (NK) Cells
Inflammation: acute vs. Chronic inflammation
Cytokines and their role
Complement System: Activation, functions and regulation
Adaptive Immunity: Characteristics, Cells (T & B Cells) & Major Histocompatibility Complex (MHC)

UNIT III

Introduction to hypersensitivity: types and pathogenicity
Introduction to transplantations
Vaccines: types & applications
Blood Groups: AB, Rh System, significance, practical application & Erythroblastosis fetalis

UNIT IV

Techniques in Immunology: RIA, ELISA, Western Blotting & Immuno fluorescence
Immunotherapy: Monoclonal antibodies & hybridoma technology
Immunodeficiencies: Primary and secondary immune deficiencies
Autoimmune Diseases: Mechanisms and examples (rheumatoid arthritis & lupus)

Recommended Books:

1. A. Paul: Textbook of Immunology: Books & Allied Pvt. Ltd., ISBN: 978-9384294724.
2. A.K. Abbas: Basic Immunology: Elsevier India, ISBN:978-8131259573.
3. B. Annadurai: A Textbook of Immunology & Immuno Technology: S. Chand & Company, ISBN: 978-8121928076.
4. Elgert & Elgert: Immunology.
5. Kuby: Immunology (4th ed.).
6. Roitt, Male & Brostoff: Immunology (3rd ed).

SOLZ/ZOO/LC-2 **3 Credits**
Lab course based on CZ-7R

Immunology

1. Identification of Various Immune Cells with the Help of Charts/Photographs
2. Study of Different Immunoglobulins with the Help of Charts/Photographs
3. Determination of Total Red Blood Cells and White Blood Cells in the Blood Sample
4. Estimation of Serum Proteins
5. Study of Lymphoid Organs Through Permanent Slides/Charts/Models
6. Testing of Blood Groups
7. Study of Autoimmune Diseases with the Help of Charts/Models

8. Study of Vaccine Preparation with the Help of ICT Tools/Charts/Models
9. Study of Adaptive Immunity with the Help of ICT Tools/Charts
10. Study of Hypersensitivity with the Help of ICT Tools/Charts
11. Study of Hybridoma Technology with the Help of ICT Tools/Charts
12. Study of Transplantation Techniques with the Help of ICT Tools/Charts
13. ELISA
14. Electrophoresis
15. Western Blotting

MAJOR ELECTIVE ZOOLOGY (EZ-2: EZ F-2/ EZ Ent-2/ EZ Evs-2)
(Theory- 2 Credits)
[Anyone]

SOLS/ZOO/ EZF-2 Fish Biology-II **2 Credits [30 Hours]**

UNIT I

Accessory respiratory organs in fishes
Swim bladder and its modifications, gas secreting complex and its functions
Weberian ossicles: Structure and arrangement, working mechanism and functions
Electric organs: Structure, mechanism of electric discharge and functions
Bioluminescence: Luminescent organs, mechanism of light emission and significance
Sound production in fishes

UNIT II

Fish behavior: Social, ecological, reproductive, migratory, and foraging behavior
Parental care in fishes
Receptor organs: Eye, acoustico-lateralis system, olfactory organs, and taste buds
Migration in fishes: Patterns, causes, and factors influencing
Parental care and viviparity in fishes
Pheromones and their role in sexual behavior of fish

UNIT III

Fertilization and development of fish eggs (teleost)
Cleavage, blastulation, gastrulation and fate map; hatching and post-embryonic development
Respiration: Functional organization of gill lamellae, blood supply of gill, mechanism of gas exchange and counter-current mechanism.
Physiology of excretion and osmo-regulation, mechanism of water-salt balance in freshwater, marine and estuarine fishes
Reproductive physiology: Spawning patterns, stimulating factors and follicular atresia
Haemopoiesis: Composition of blood, haemopoietic tissues, and synthesis of haemoglobin
Physiology of thermo-regulation in fishes

UNIT IV

Pituitary gland: Micro-anatomy, hormones of pituitary and their physiological actions
Structure and functions of thyroid and pancreatic islets in fishes
Location and functions of corpuscles of stannius, pineal and urophysis in fishes

Recommended Books:

1. Gupta S.K. Fish & Fisheries Digest Part 3 Light & Electricity (2022). ISBN: 9798784666574
2. Khanna S. S. & Singh H.R.: A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014
3. Kyle: The Biology of Fishes, 2007.
4. Munshi J.D. & Munshi J.S.D.: Fundamentals of Freshwater Biology, Narendra Publ. House, 1995.
5. Ojha J.: Biology of Hill Stream Fish, Narendra Publication House, 2002.
6. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.

SOLS/ZOO/EZ Ent-2. Entomology-II 2 Credits [30 Hours]

UNIT I

Digestive system: Structure, physiology of digestion and absorption of different types of food. Structure of circulatory system: Haemolymph, its composition and function
Physiology of respiration, tracheal system, spiracles, respiration in aquatic insects
Nervous system: Structural basis, excretion: structure and physiology of malpighian tubules and their secondary functions
Reproduction: Male and female gonads

UNIT II

Structure of compound eye, mosaic vision
Production and reception of sound, light producing organs
Pheromones and hormones: Neurosecretion and co-ordination, metamorphosis: types, hormonal control of metamorphosis

UNIT III

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, various types of larvae and pupae, moulting, diapauses, oviparity, viviparity, and ovo-viviparity in insects

UNIT IV

Abiotic factors: Effect of temperature, light, and humidity on growth of insect population, biotic potential, malthusian principle, and dynamics of population fluctuation, hibernation, and aestivation
Biotic factors: Parasitism, predation, and social life in insects, phase theory of locust and parental care

Recommended Books:

1. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
2. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
3. Mani MS, Introduction to High Entomology, Mathuen & Coy Ltd. 1962.
4. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
5. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy, Ltd.

SOLS/ZOO/EZEvs-2 Environmental Biology-II 2 Credits [30 Hours]

UNIT I

Natural resources: Management and conservation
Renewable and non-renewable resources
Concept and currencies of sustainable development
Biodiversity and its conservation
Environmental protection laws

UNIT II

Concept of protected areas: sanctuaries, national parks and biosphere reserves
IUCN categories, biodiversity hot spots and conventions on biodiversity
International efforts in biodiversity conservation (UNFP, IUCN, WWF), CITES, UNESCO's World Heritage Mission, and Convention on Biological Diversity (CBD)

UNIT III

Global environmental problems: climate change, greenhouse effect, acid rain, ozone layer depletion, deforestation, desertification, marine pollution, and urbanization
Exposure to toxicants: routes and sites of exposure (inhalation, injection, and through food or intestinal)
Duration and frequency of exposure: acute, subacute, chronic, and sub chronic
Chemical nature of toxicants: Receptors and mechanism of action of DDT, lead (Pb) and UV rays

UNIT IV

Environmental problems/hazards in hills: earthquake, landslide, soil erosion, sedimentation, cloud burst, flash floods, and glacial retreat
Application of remote sensing and Geographical Information Systems (GIS) in Environmental Management
Disasters: Types and management

Recommended Books:

1. D.E. Hathway: Molecular aspects of Toxicology: The Royal Society of Chemistry, Burlington House, London.
2. Joshi, P C and Joshi, N. Ecology and Environment. Himalayan Publishing House, Delhi, 2005
3. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bungalow Road, Delhi Ecology and Environment
4. Singh, H. R. Environmental biology. S Chand & Company, New Delhi., 2014
5. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.

SOLZ/ZOO/LCE-2	**2 Credits**
Lab course based on EZ-2 (EZ F-2/ EZ Ent-2/ EZ Evs-2)	

RESEARCH DISSERTATION (RD)
[Theory: 12 Credits]

SOLS/ZOO/RD Research Dissertation	**12 Credits**

Note: The topic will be issued in the 7th Semester.

MINOR ZOOLOGY (ZM-2: ZM-2a/ZM-2b)
(Theory- 4 Credits)
[Anyone]
[For Students with Core subjects other than Zoology (Without Practical)]

SOLS/ZOO/ZM-2a Assisted Reproductive Biology Techniques	**4 Credits [30 Hours]**

UNIT I
Scope of Reproductive Technologies; Functional Anatomy of Male & Female Reproductive System; Induced Release of Gametes and Its Significance

UNIT II
Multiple Ovulation, Super ovulation; In-Vitro Oocyte Maturation; Biochemistry of Semen, Semen Composition and Formation; Cryopreservation of Gametes

UNIT III
Intra- Cytoplasmic Sperm Injection, Gamete Intra fallopian Transfer; In-Vitro Fertilization; Transgenic Animals and their Uses

UNIT IV
Contraception; Immuno contraception; Other Contraception Technologies: Surgical Methods, Hormonal Method, Physical Barrier, IUCD

Recommended Books:

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.AndLopez,K.H:HumanReproductiveBiology(ThirdEdition),AcademicPress(2006)
3. Weissman,Ariel,ColinM.Howles,ZeevShoham:TextbookofAssistedReproductiveTechniques,Volume 1: Laboratory Perspectives, CRC Press (2018)

SOLS/ZOO/ZM-2b Environmental Pollution and Global issues*	**4 Credits [30 Hours]**

*Swayam Course: * SN: 28 **https://onlinecourses.swayam2.ac.in/cec25_es02/preview**