

COURSE CONTENTS
FOR
BS (4-YEARS)
ZOOLOGY

Courses BS Zoology 5th Board of Studies

These courses are derived from HEC revised (2013) syllabus, recommended by Board of studies in its 5th meeting on Friday, 8th June 2018 chaired by the Honorable Vice Chancellor, Prof. Dr. Rahmat Ali and finally approved by the 4th meeting of the Academic Council on 11th June 2018.

Year-I			
Semester-I			
Course Category	Course Code	Course Title	Credits
Compulsory-I	ENG- 311	English-I (Functional English)	3(3+0)
Compulsory-II	PS-312	Pakistan Studies	2(2+0)
Compulsory-III	MCZ-313	Mathematics	3(3+0)
General- I	BOT-314	Botany - I (Diversity of Plants)	3(2+1)
General - II	CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)
Foundation-I	ZOO-316	Principles of Animal Life-I	4(3+1)
		Total Credits	18

Semester-II			
Course Category	Course Code	Course Title	Credits
Compulsory-IV	ENG- 321	English-II (Communication Skills)	3(3+0)
Compulsory-V	ISL-322	Islamic Studies	2(2+0)
General - III	SOC-323	Sociology	2(2+0)
General- IV	BOT-324	Botany-II (Plant Systematics, Anatomy and Development / Embryology)	3(2+1)
General - V	CHEM-325	Chemistry-II (Inorganic Chemistry)	3(2+1)
Foundation-II	ZOO-326	Principles of Animal Life-II	4(3+1)
		Total Credits	17

Year-II

Semester-III			
Course Category	Course Code	Course Title	Credits
Compulsory-VI	ENG- 431	English-III: Technical writing and presentation skills	3(3+0)
Compulsory-VII	BCS-432	Introduction to Computer	3(1+2)
General- VI	BOT-433	Botany-III (Cell Biology, Genetics and Evolution)	3(2+1)
General - VII	CHEM-334	Chemistry-III (Environmental Chemistry)	3(3+0)
Foundation-III	ZOO-435	Invertebrates	4(3+1)
		Total Credits	16

Semester-IV			
Course Category	Course Code	Course Title	Credits
Compulsory-VIII	ENG- 441	English-IV (Advanced Academic Reading and Writing)	3(3+0)
General - VIII	BOT-442	Botany IV (Plant Physiology and Ecology)	3(2+1)
Foundation-IV	ZOO-443	Chordates	4(3+1)
Foundation-V	ZOO-444	Animal Form and Function I	4(3+1)
Foundation-VI	ZOO-445	Animal Form and Function II	4(3+1)
		Total Credits	18

Year III			
Semester-V			
Course Category	Course Code	Course Title	Credits
Compulsory-IX	BST-551	Biostatistics	3(3+0)

Foundation-VII	ZOO-552	Biochemistry	4(3+1)
Major-I	ZOO-553	Cell & Molecular Biology	4(3+1)
Major-II	ZOO-554	Zoogeography & Paleontology	3(2+1)
Major-III	ZOO-555	Animal Behavior	3(2+1)
		Total Credits	17

Semester-VI			
Course Category	Course Code	Course Title	Credits
Foundation-VIII	ZOO-561	Biological Techniques	3(1+2)
Foundation-IX	ZOO-562	Evolution & Principles of Systematics	3(2+1)
Major-IV	ZOO-563	Developmental Biology	4(3+1)
Major-V	ZOO-564	Genetics	4(3+1)
Major-VI	ZOO-565	Synopsis & Research Methodology	2(2+0)
		Total Credits	16

Year -IV			
Semester-VII			
Course Category	Course Code	Course Title	Credits
Major-VII	ZOO-671	Environmental Biology	4(3+1)
Major-VIII	ZOO-672	Animal Physiology	4(3+1)
Major-IX	ZOO-673	Parasitology I	4(3+1)
Major-X	ZOO-674	Wildlife	2(2+0)
Elective-I	ZOO-675	Entomology	3(2+1)
		Total Credits	17

Semester-VIII			
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Course Category	Course Code	Course Title	Credits
Major-XI	ZOO-681	Bioinformatics	3(2+1)
Major-XII	ZOO-682	Thesis/Research Project/ Internship Or Special Paper	4(0+4) or 4(3+1)
Elective-II	ZOO-683	Applied Fisheries	4(3+1)
Elective-III	ZOO-684	Applied Entomology	3(2+1)
Elective-IV	ZOO-685	Parasitology II	3(2+1)
		Total Credits	17

$$18+17+16+18+17+16+17+17=136$$

Year-I		
Semester-I		
Course Code	Course Title	Credits
ENG-311	English-I (Functional English)	3(3+0)
PS-312	Pakistan Studies	2(2+0)
MCZ-313	Mathematics	3(3+0)
BOT-314	Botany - I (Diversity of Plants)	3(2+1)
CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)
ZOO-316	Principles of Animal Life-I	4(3+1)
	Total Credits	18

ENG-311	English-I (Functional English)	3(3+0)
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Course Contents

Basics of Grammar: Parts of speech and use of articles, Sentence structure, Active and passive voice, Practice in unified sentence, Analysis of phrase, clause and sentence structure, Transitive and intransitive verb, Punctuation and spelling Comprehension: Answers to questions on a given text

Discussion: General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening: To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills: Urdu to English

Paragraph writing: Topics to be chosen at the discretion of the teacher

Presentation skills: Introduction to presentations and deliberations

Note: Extensive reading is required for vocabulary building

PS-312	Pakistan Studies	2(2+0)
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Course Contents

Historical Perspective: Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah; Factors leading to Muslim separatism; People and Land: Indus Civilization, Muslim advent, Location and geo-physical features.

Government and Politics in Pakistan: Political and constitutional phases: 1947-58; 1958-71; 1971-77; 1977-88; 1988-99; 1999 onward.

Contemporary Pakistan: Economic institutions and issues, Society and social structure, Ethnicity, Foreign policy of Pakistan and challenges, Futuristic outlook of Pakistan.

MCZ-313	Mathematics	3(3+0)
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Course Contents

Preliminaries: Real-number system, complex numbers, introduction to sets, set operations, functions, types of functions.

Matrices: Introduction to matrices, types, matrix inverse, determinants, system of linear equations, Cramer's rule.

Quadratic Equations: Solution of quadratic equations, qualitative analysis of roots of a quadratic equation, equations reducible to quadratic equations, cube roots of unity, relation between roots and coefficients of quadratic equations.

Sequences and Series: Arithmetic progression, geometric progression, harmonic progression.

Binomial Theorem: Introduction to mathematical induction, binomial theorem with rational and irrational indices.

Trigonometry: Fundamentals of trigonometry, trigonometric identities.

BOT-314	Botany – I (Diversity of Plants)	3(2+1)
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Course Contents

Comparative study of life form, structure, reproduction and economic significance of:

1. Viruses (RNA and DNA types) with special reference to TMV
2. Bacteria and Cyanobacteria (Nostoc, Anabaena, Oscillatoria) with specific reference to biofertilizers, pathogenicity and industrial importance;
3. Algae (Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia)
4. Fungi (Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus), their implication on crop production and industrial applications.
5. Lichens (Phycia)
6. Bryophytes
 - i. Riccia
 - ii. Anthoceros
 - iii. Funaria
7. Pteridophytes.
 - i. Fossils and fossilization
 - ii. Psilopsida (Psilotum)
 - iii. Lycopsidea (Selaginella)
 - iv. Sphenopsida (Equisetum)
 - v. Pteropsida (Marsilea)
 - vi. Seed Habit h)
8. Gymnosperms
 - i. Cycas
 - ii. Pinus
 - iii. Ephedra

Lab Outline:

Culturing, maintenance, preservation and staining of microorganisms. Study of morphology and reproductive structures of the types mentioned in theory. Identification of various types mentioned from prepared slides and fresh collections.

CHEM-315	Chemistry-I (Organic Chemistry)	3(2+1)
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Course Content:**Basic Concepts of Organic Chemistry:**

Bonding and hybridization, localized and delocalized bonding, structure aromaticity, inductive effect, dipole moment, resonance and its rules, hyperconjugation, classification and nomenclature of organic compounds including IUPAC system, types of organic reactions (an overview).

Chemistry of Hydrocarbons: Saturated, unsaturated and aromatic hydrocarbons with emphasis on synthesis and free radical, electrophilic addition and electrophilic substitution reactions.

Chemistry of Functional Groups: Hydroxyl, ether and amino groups, preparation and properties of alcohols, phenols, ethers, and amines with focus on reaction mechanism and applications, carbonyl compounds, preparations and reaction mechanism of aldehydes and ketones and their applications, carboxylic acids and their derivatives, acidity of carboxylic acids and effect of substituents on their acidity, preparation and reactions of carboxylic acids and their derivatives including esters, amides, acid halides and acid anhydrides.

Practicals:

Qualitative analysis of compounds with different functional groups, synthesis of organic compounds using as a tool for understanding techniques like reflux, distillation, filtration, recrystallization and yield calculation, organic syntheses may include preparation of benzanilide from benzoyl chloride, succinic anhydride from succinic acid, phthalimide from phthalic anhydride, oximes and hydrazones from carbonyl compounds, and an ester from a carboxylic acid and alcohol etc.

ZOO-316	Principles of Animal Life-I	4(3+1)
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Course Contents

Scope of Zoology: Introduction; significance and applications of zoology; animal diversity; the scientific method; environment and world resources.

The Chemical Basis of Animal Life: Brief introduction to biomolecules; carbohydrates, lipids, proteins, and nucleic acids.

Cellular Organization: Structure of animal cells, cell membrane, cytoplasm and its organelles: ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, cytoskeleton, cilia and flagella, centrioles and microtubules, vacuoles; the nucleus: nuclear envelope, chromosomes and nucleolus.

Animal tissues: Types: epithelial, connective, muscle and nervous tissue; organs and organ systems.

Enzymes: Structure, types; function and factors affecting their activity; cofactors and coenzymes.

Energy Harvesting: Aerobic and anaerobic respiration: glycolysis, citric acid cycle and electron transport chain; fermentation, the major source of ATP.

Reproduction and Development: Types; asexual and sexual, gametogenesis, fertilization, metamorphosis, zygote and early development.

Ecological Concepts: Ecosystem, types, homeostasis, biomes, food chain, food web, energy flow and thermodynamics; biogeochemical cycles, and limiting factors, populations and communities, human population growth, pollution, resource depletion and biodiversity.

Practicals

1. Tests for different carbohydrates, proteins and lipids.

Note: Emphasis on the concept that tests materials have been ultimately obtained from living organisms and constituted their body.

2. Study of the prepared slides of epithelial tissue (squamous, cuboidal, columnar), connective tissue (adipose, cartilage, bone, blood), nervous tissue and muscle tissue (skeletal, smooth and cardiac).

Note: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used.

3. Plasmolysis and deplasmolysis in blood. Preparation of blood smears.
4. Protein digestion by pepsin.
5. Ecological notes on animals of a few model habitats.
6. Field observation and report writing on animals in their ecosystem (a terrestrial and an aquatic ecosystem study).

Semester-II		
Course Code	Course Title	Credits
ENG-321	English-II (Communication Skills)	3(3+0)
ISL-322	Islamic Studies	2(2+0)
SOC-323	Sociology	2(2+0)
BOT-324	Botany-II (Plant Systematics, Anatomy and Development / Embryology)	3(2+1)
CHEM-325	Chemistry-II (Inorganic Chemistry)	3(2+1)
ZOO-326	Principles of Animal Life-II	4(3+1)
	Total Credits	17

ENG-321	English-II (Communication Skills)	3(3+0)
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Course contents:

Communication

Definition, nature and importance of communication, Types of communication (verbal, non-verbal communication etc), effective communication, barriers of communication.

Technical Writing

Report writing, c.v., letters, applications

Oral Communication

Bad listening habits, effective listening oral presentations, steps/procedures, instructional presentations, persuasive presentations, interviews and group discussions.

ISL-322	Islamic Studies	2(2+0)
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Course Contents

Introduction to Quranic Studies: Basic Concepts of Quran: History of Quran; Uloom-ul-Quran

Study of Selected Text of Holy Quran: Verses of Surah Al-Baqra Related to Faith (Verse No-284-286), Verses of Surah Al-Hujrat Related to Adab AlNabi (Verse No-1-18), Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11), Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77), Verses of Surah Al-Inam Related to Ihkam(Verse No-152-154)

Study of Selected Text of Holy Quran: Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No.6,21,40,56,57,58.), Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment, Verses of Surah Al-Saf Related to Tafakar,Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I: Life of Muhammad Bin Abdullah (Before Prophet Hood); Life of Holy Prophet (S.A.W) in Makkah; Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II: Life of Holy Prophet (S.A.W) in Madina: Important Events of Life Holy Prophet in Madina; Important Lessons Derived from the life of Holy Prophet in Madina

Introduction to Sunnah: Basic Concepts of Hadith; History of Hadith; Kinds of Hadith; Uloom -ul-Hadith; Sunnah & Hadith; Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence: Basic Concepts of Islamic Law & Jurisprudence; History & Importance of Islamic Law & Jurisprudence; Sources of Islamic Law & Jurisprudence; Nature of Differences in Islamic Law; Islam and Sectarianism

Islamic Culture & Civilization: Basic Concepts of Islamic Culture & Civilization; Historical Development of Islamic Culture & Civilization; Characteristics of Islamic Culture & Civilization; Islamic Culture & Civilization and Contemporary Issues

Islam & Science: Basic Concepts of Islam & Science; Contributions of Muslims in the Development of Science; Quran & Science

Islamic Economic System: Basic Concepts of Islamic Economic System; Means of Distribution of wealth in Islamic Economics; Islamic Concept of Riba; Islamic Ways of Trade & Commerce

Political System of Islam; Basic Concepts of Islamic Political System; Islamic Concept of Sovereignty; Basic Institutions of Govt. in Islam

Islamic History: Period of Khlaft-E-Rashida; Period of Ummayyads; Period of Abbasids

Social System of Islam; Basic Concepts of Social System of Islam; Elements of Family; Ethical Values of Islam.

SOC-323	Sociology	2(2+0)
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1. Introduction
 - a. Definition, Scope, and Subject Matter
 - b. Sociology as a Science
 - c. Historical back ground of Sociology
2. Basic Concepts
 - a. Group, Community, Society
 - b. Associations
 - i. Non-Voluntary
 - ii. Voluntary
 - c. Organization
 - i. Informal
 - ii. Formal
 - d. Social Interaction
 - i. Levels of Social Interaction
 - ii. Process of Social Interaction

- a) Cooperation
- b) Competition
- c) Conflict
- d) Accommodation
- e) Acculturation and diffusion
- f) Assimilation
- g) Amalgamation

3. Social Groups

- a. Definition and Functions
- b. Types of social groups
 - i. In and out groups
 - ii. Primary and Secondary group
 - iii. Reference groups
 - iv. Informal and Formal groups
 - v. Pressure groups

4. Socialization and Personality

- a. Personality, Factors in Personality Formation
- b. Socialization, Agencies of Socialization
- c. Role and Status

BOT-324	Botany-II (Plant Systematics, Anatomy and Development / Embryology)	3(2+1)
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Course Outline:

a) Plant systematics

1. Introduction to Plant Systematics: aims, objectives and importance.
2. Classification: brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to International Code of Botanical Nomenclature (ICBN). Vienna code.
4. Morphology: a detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families:
 - i. Ranunculaceae
 - ii. Brassicaceae (Cruciferae)
 - iii. Fabaceae (Leguminosae)
 - iv. Rosaceae
 - v. Euphorbiaceae
 - vi Cucurbitaceae
 - vii. Lamiaceae (Labiatae)
 - viii. Apiaceae (Umbelliferae)

ix. Asteraceae (Compositae)

x. Liliaceae (Sen. Lato)

b) Anatomy

1. Cell wall: structure and chemical composition

2. Concept, structure and function of various tissues like:

i. Parenchyma

ii. Collenchyma

iii. Sclerenchyma

iv. Phloem Epidermis (including stomata and trichomes)

v. Xylem

3. Meristem: types, stem and root apices

4. Vascular cambium

5. Structure and development of root, stem and leaf. Primary and secondary growth of dicot stem, periderm

6. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.

c) Development/Embryology

1. Early development of plant body:

2. Capsella bursa-pastoris

3. Structure and development of Anther Microsporogenesis, Microgametophyte

4. Structure of Ovule Megasporogenesis Megagametophyte

5. Endosperm formation

6. Parthenocarpy

7. Polyembryony

Lab Outline:

Plant Systematics

1. Identification of families given in syllabus with the help of keys.

2. Technical description of common flowering plants belonging to families mentioned in theory.

3. Field trips shall be undertaken to study and collect local plants.

4. Students shall submit 40 fully identified herbarium specimens.

Anatomy and Embryology

1. Study of stomata and epidermis.

2. Tissues of primary body of plant.

3. Study of xylem 3-dimensional plane of wood.

4. T. S of angiosperm stem and leaf.

5. Anatomy of germinating seeds

6. Study of pollens

CHEM-325	Chemistry-II (Inorganic Chemistry)	3(2+1)
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Course Contents:

Chemical Bonding: Types of chemical bonding, ionic and covalent bonding, localized bond approach, theories of chemical bonding, valence bond theory (VBT), hybridization

and resonance, prediction of molecular shapes using Valence Shell Electron Pair Repulsion (VSEPR) model, molecular orbital theory (MOT) applied to diatomic molecules, delocalized approach to bonding, bonding in electron deficient compounds, hydrogen bonding.

Acids and Bases: Brief concepts of chemical equilibrium, acids and bases including soft and hard acids and bases (SHAB), concept of relative strength of acids and bases, significance of pH, pKa, pKb and buffer solutions, theory of indicators, solubility, solubility product, common ion effect and their industrial applications.

p-Block Elements: Physical and chemical properties of p-block elements with emphasis on some representative compounds, inter-halogens, pseudo-halogens and polyhalides.

Practicals:

Lab safety and good laboratory practices, knowledge about material safety data sheets (MSD), disposal of chemical waste and first-aid practices, qualitative analysis of salt mixtures, quantitative analysis, acid- base titrations, preparation and standardization of acid and alkali solutions, redox titrations, preparation and standardization of potassium permanganate solution and its use for the determination of purity of commercial potassium oxalate or oxalic acid, preparation and standardization of sodium thiosulfate solution and its use in determination of copper in a given sample, gravimetric analysis, determination of barium in a given sample, determination of chloride in a given solution.

ZOO-326	Principles of Animal Life-II	4(3+1)
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Course Contents

Cell Division: Cell cycles: Mitosis and meiosis; control of the cell cycle.

Inheritance Patterns: Mendelian genetics; inheritance patterns; gene, structure, chemical composition and types.

Chromosomes and Gene Linkage: Eukaryotic chromosomes; linkage and crossing over; chromosomal aberrations.

Cellular Control: DNA: the genetic material; DNA replication in prokaryotes and eukaryotes; control of gene expression in eukaryotes; gene mutation; recombinant DNA technologies and their applications.

Animal Behavior: Behaviour and its types, proximate and ultimate causes; anthropomorphism; development of behavior; learning; factors controlling animal behavior; communication; behavioral ecology; social behavior.

Evolution: A Historical Perspective: Theories of evolution: Natural selection Lamarckism and neo larmarckism, Darwinism and neo Darwinian.

Evolution and Gene Frequencies: Hardy-Weinberg principle; evolutionary mechanisms: population size, genetic drift, gene flow, de Vries mutation theory and rates of evolution, polymorphism; species and speciation; molecular evolution; mosaic evolution.

Practicals

1. Study of mitosis in onion root tip.
2. Study of meiosis in grasshopper testis (students should prepare the slide).

3. Problem based study of Mendelian ratio in animals.
4. Multiple alleles study in blood groups.
5. Survey study of a genetic factor in population and its frequency.
6. Study of karyotypes of *Drosophila*, mosquito.
7. Study of cytochemical detection of DNA in protozoa and avian blood cell.
8. Study to demonstrate nervous or endocrine basis of behavior (conditioned reflex or aggression or parental behavior).
9. Study to demonstrate social behaviour (documentary film be shown, honey bee, monkey group in a zoo).

Note for 1-2: Prepared microscopic and/or projection slides and/or CD ROM computer projections must be used).

Semester-III		
Course Code	Course Title	Credits
ENG-431	English-III: Technical writing and presentation skills	3(3+0)
BCS-432	Introduction to Computer	3(1+2)
BOT-433	Botany-III (Cell Biology, Genetics and Evolution)	3(2+1)
CHEM-434	Chemistry-III (Environmental Chemistry)	3(3+0)
ZOO-435	Invertebrates	4(3+1)
	Total Credits	16

ENG-431	English-III: Technical writing and presentation skills	3(3+0)
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Presentation skills, Essay writing, Descriptive, narrative, discursive, argumentative, Academic writing, how to write a proposal for research paper/term paper, How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency), Technical Report writing, Progress report writing

Note: Extensive reading is required for vocabulary building

Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing

BCS-432	Introduction to Computer	3(1+2)
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Brief history of computers and their applications: Major components of computer, computer and society, the social impact of computer age, computers in offices industry and education, office automation tools; word processing, graphic packages, data bases and spread sheets, current prints, research and prospects, legal and moral aspects of computer science, using internet

Laboratory work pertaining to above course

BOT-433	Botany-III (Cell Biology, Genetics and Evolution)	3(2+1)
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Course outline:

a) Cell biology

- Structures and Functions of Bio-molecules i. Carbohydrates
ii. Lipids
iii. Proteins
iv. Nucleic Acids
- Cell: Physico-chemical nature of plasma membrane

and cytoplasm.

3. Ultrastructure of plant cell with a brief description and functions of the following organelles
 - i. Cell wall
 - ii. Endoplasmic reticulum
 - iii. Plastids
 - vi. Mitochondria
 - v. Ribosomes vi. Dictyosomes
 - vii. Vacuole
 - viii. Microbodies (Glyoxysomes and Peroxisomes)
4. Nucleus: Nuclear membrane, nucleolus, ultrastructure and morphology of chromosomes, karyotype analysis
5. Reproduction in somatic and embryogenic cell, mitosis and meiosis, cell cycle
6. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.

b) Genetics

1. Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance.
2. Sex linked inheritance, sex linkage in *Drosophila* and man (colour blindness), XO, XY, WZ mechanisms, sex limited and sex linked characters, sex determination.
3. Linkage and crossing over: definition, linkage groups, construction of linkage maps, detection of linkage.
4. Molecular genetics; DNA replication. Nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. *lac* operon).
5. Transmission of genetic material in Bacteria: Conjugation and gene recombination in *E.coli*, transduction and transformation.
6. Principles of genetic engineering / biotechnology; Basic genetic engineering techniques.
7. Application of genetics in plant improvement: Induction of genetic variability (gene mutation, recombination), physical and chemical mutagens, selection, hybridization and plant breeding techniques. Development and release of new varieties.

8. Introduction to germplasm conservation

c) Evolution

The nature of evolutionary forces, adaptive radiations, differential reproductive potential, first plant cell, origin of organized structures, early aquatic and terrestrial ecosystem, first vascular plant.

Lab Outline: Cell

Biology

1. Study of cell structure using compound microscope and elucidation of ultrastructure from electron microphotographs
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.
5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics

1. Genetical problems related to transmission and distribution of genetic material.
2. Identification of DNA in plant material. Carmine staining.
3. Study of salivary gland chromosomes of *Drosophila*.

CHEM-434	Chemistry-III (Environmental Chemistry)	3(3+0)
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Course Contents:

Atmospheric Pollution:

The atmosphere, composition, temperature and pressure profile, role of free radicals in the atmosphere, temperature inversion and photochemical smog, particulate matter in the atmosphere, Industrial pollutants, atmospheric aerosols, acid-rain major sources, mechanism, control measures and effects on buildings and vegetation, global warming, major greenhouse gases, mechanism, control measures and global impact, the stratospheric ozone-the ozone hole, CFCs, ozone protection, biological consequences of ozone depletion.

Water Pollution:

Water pollution and waste water treatment, municipal, industrial and agricultural sources of pollution, heavy metals contamination of water, eutrophication, detergents and phosphates in water, water quality criteria, water purification: primary, secondary and advanced treatment, removal of nitrogen and phosphorous compounds from polluted water, organic matter in water and its decomposition.

Land pollution:

Soil and mineral resources, general principles of metal extraction, heavy metals contamination of soil, toxicity of heavy metals, bio-accumulation of heavy metals, organic matter in soil, macro and micro-nutrients in soil, ion-exchange in soil, soil pH and nutrients availability.

Green Chemistry:

Atom economy, integrated pest management control (IPMC), ionic liquids, super critical extraction technology, green synthesis, recycling, carbon dioxide sequestering, water based paints.

ZOO-435	Invertebrates	4(3+1)
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Course Contents

Introduction: Architectural pattern of an animal, taxonomy and phylogeny, major subdivisions of animal kingdom with evolutionary perspective.

Animal-Like Protists: The Protozoa; life within a single plasma membrane; symbiotic life-styles. Protozoan taxonomy: (up to phyla, subphyla and super classes, wherever applicable). Pseudopodia and amoeboid locomotion; cilia and other pellicular structures; nutrition; genetic control and reproduction; symbiotic ciliates; further phylogenetic considerations.

Multicellular and Tissue Levels of Organization: origins of multicellularity; animal origins. Phylum porifera: cell types, body wall, and skeletons; water currents and body forms; maintenance functions; reproduction. Phylum Cnidaria (coelenterata) the body wall and nematocysts; alternation of generations; maintenance functions; reproduction and classification up to class. Phylum Ctenophora; further phylogenetic considerations.

Triploblastics and Acoelomate Body Plan: Phylum Platyhelminthes: classification up to class; the free-living flatworms and the tapeworms; Phylum Nemertea; Phylum Gastrotricha; further phylogenetic considerations.

Pseudocoelomate Body Plan: Aschelminths: general characteristics; classification up to phyla with external features; feeding and the digestive system; other organ systems; reproduction and development of Phylum Rotifera and Phylum Nematoda; Phylum Kinorhyncha. Some important nematode parasites of humans; further phylogenetic considerations.

Molluscan Success: relationships to other animals; origin of the coelom; molluscan characteristics; classification up to class. The characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods; further phylogenetic considerations.

Annelida: The Metameric Body Form: relationship to other animals, metamerism and tagmatization; External structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development in different classes; further phylogenetic considerations.

Arthropods: Blueprint for Success: classification and relationships to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up \ to class; further phylogenetic considerations; phylogeny and adaptive diversification.

Echinoderms: relationships to other animals; echinoderm characteristics; classification up to class. Maintenance functions, regeneration, reproduction, and development; further phylogenetic considerations.

Lesser Invertebrates: The lophophorates, entoprocts, cycliophores, and chaetognaths.

Practicals

Museum study of representative Phyla, Permanent slide preparations

1. Study of Euglena, Amoeba, Entamoeba, Plasmodium, Trypanosoma,
2. Paramecium as representative of animal like protists. (Prepared slides).
3. Study of sponges and their various body forms.
4. Study of principal representative classes of Phylum Cnidaria.
5. Study of principal representative classes of Phylum Platyhelminthes.
6. Study of representative of Phylum Rotifera, Phylum Nematoda.
7. Study of principal representative classes of Phylum Mollusca.
8. Study of principal representative classes of Phylum Annelida.
9. Study of principal representative classes of groups of Phylum Arthropoda.
10. Brief notes on medical/economic importance of the following:
Plasmodium, Entamoeba histolitica, Leishmania, Liverfluke, Tapeworm, Earthworm, Silkworm, Citrus butterfly.

Semester-IV		
Course Code	Course Title	Credits
ENG-441	English-IV (Advanced Academic Reading and Writing)	3(3+0)
BOT-442	Botany IV (Plant Physiology and Ecology)	3(2+1)
ZOO-443	Chordates	4(3+1)
ZOO-444	Animal Form and Function I	4(3+1)
ZOO-445	Animal Form and Function II	4(3+1)
	Total Credits	18

ENG-441	English-IV (Advanced Academic Reading and Writing)	3(3+0)
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1. The art of listening

2. What is good listening?

3. Types of listening

- Appreciative
- Listening for pleasure or enjoyment
- Empathetic
- Comprehensive
- Critical

4. Tips for good listening

- Face the speaker
- Maintain eye contact
- Minimize the external distractions
- Respond appropriately
- Focus on what the speaker is saying
- Minimize the internal distractions
- Keep an open mind
- Avoid letting the speaker know how you handled a similar situation
- Even if the speaker is launching a complaint against you, wait until they finish to defend yourself
- Engage yourself
- Body language
- Silence
- Touching
- Some audio listening

5. Ways to become effective listener

- Setting the stage

- Appropriate Physical Environment
- Removal of distraction
- Be open and accessible
- Maintain relaxed, open posture that shows concentration
- Ensure mutual understanding reflect feelings
- Offer acknowledgement (say uh, huh)
- Paraphrase main ideas
- Interrupt to clarify
- Confirm next step

6. Barrier to Listening include

- Worry, fear, anger, grief and depression
- Individual bias and prejudice
- Semantics and language differences
- Noise and verbal “clutter”
- Preoccupation, boredom and shrinking attention spans
- Act distracted (look at your watch!)
- Tell your own story without acknowledging their
- Give no response
- Invalidate response, be negative
- Interrupt
- Criticize
- Diagnose what we said
- Give advice/solution quickly
- Change the subject
- Reassure without acknowledgment

7. Communication

- Communication skills
- Types of communications
- Importance and benefit of effective communication
- Components of communication
- Nonverbal communication
- Barriers to communication
- Difference between hearing and listening
- Essential of communication (Dos)
- Essential of communication (Don'ts)
- Ways to improve the communication
- Common ways to communicate with

8. Barrier to communication

- Noise
- Inappropriate medium
- Assumption/misconception
- Emotion
- Language difference
- Poor listening skill
- Distraction

9. Public speaking

- Talk, conversation, speech and rhetoric
- Speaking opportunities at work place, home daily life

10. PS and conversation

- Organization of thought
- Tailoring the message to the right audience
- Interesting start
- Consideration of audience feedback
- PS is structural
- PS requires normal language
- PS requires delivery method

11. The speech communication process

- Speaker
- Message
- Channel
- Listener
- Feedback
- Interference
- Situation

12. Analysis of audience

- PS is audience centered
- Kind of audience
- Psychology of audience
- Care of egocentrism of people
- Demographic analysis of audience
- Observable traits
- Age, gender, racial, ethical background, religion group

13. Situational audience analysis

- Unique traits of speaking situation
- Size
- Physical setting

14. Disposition toward the topic

- Interest , knowledge , attitude

15. Disposition towards the speaker

16. Disposition towards the occasion

17. Organization of speech

18. Connectives

- Transition
- Internal previews

- Internal summaries
- Signposts

19. Supporting material

- Example
- Statistics
- Testimony

20. Beginning and ending of speech

- Get attention and interest
- Reveal the topic
- Establish credibility and Goodwill
- Preview the body of the speech
- Signal the end of the speech
- Reinforce the central idea

21. Many more things to remember for effective speech

- Use language accurately
- Use language clearly
- Use language Vividly
 - Imagery
 - Concrete words
 - Simile
 - Metaphor
 - Rhythm
 - Parallelism
 - Repetition
 - Alliteration
 - Antithesis

22. Speech delivery

- Types of delivery
 - Read from manuscript
 - Reciting from memory
 - Impromptu
 - Extemporaneously

23. Vocalization of speech

- Volume- loudness or softness
- Pitch- speed rate at which you speak
- Pauses
- Variety
- Pronunciation
- Articulation
- Dialect

24. Interviewing

- The nature and type of interview

- Interview structure
- How to be interviewed for a job
- How to be interviewed for an information-gathering interview
- The responsibilities of an interviewer

25. Types of interviews

- Information gathering interview
- Appraisal interview
- Problem solving interview
- Persuasion interview

26. Structure of interview

- Opening
- Body
- Conclusion

How to be interviewed for a job?

- Be aware of your skills and abilities
- Prepare your resume
 - A written concise, organized description of your qualifications
 - Components
 - Personal information
 - Career objectives
 - Education and Objectives
 - education
 - experience
 - Honor and special accomplishments
 - Optional information
 - Identify the need of your employer
 - Listen respond and ask appropriate questions
 - Follow up after the interview
 - Ask appropriate questions

25. The right use of Diction

A	An	Accept	Except	Advice
Advise	Effect	Affect	Alright	Most
Amount	Between	Among	Amount	Number
As, As If, As Though	Like	Be sure and	Try and	Could of
Should of	Might of	Would of	Different than	Different from
Due to	Because of	Enthused/enthuse	Fewer	less
Hopefully	Irregardless	Lead	Led	Lend
Loan	Life	Lay	Principal	principle
Rise	Raise	Sit	Sat	Supposed to
Used to	Then	Than	Senior to	Junior to

26. Short stories reading and then presenting them in their own words in class

1. The gift of Magi (O, Henry)
2. The diamond necklace
3. over coat
4. His first flight
5. Rustam and suhrab

27. Common grammatical error

28. Successful strategies for group meeting

- Definition of group meetings
- Formation of a group meeting
- Background information on group meeting
- Purpose and kind of meeting
- Solving problem in meeting or groups
- Leadership responsibilities in meeting
- Participant responsibilities in meeting

29. Resume (Vita, Qualification Brief)

- Opening section
- Education
- Work experience
- Achievements
- Awards
- Service activities
- Personal data
- References
- Sample resume

30. Letters. Emails and memos

31. Watching some movies or listening material from ILETS or TOFEL courses based on thematic or important course related issues and then writing as assignment or doing some quiz on them.

BOT-442	Botany IV (Plant Physiology and Ecology)	3(2+1)
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Plant Physiology

Water relations: **Properties of water, water potential, Absorption of water**

Diffusion, Osmosis, osmotic potential, Stomata regulation

Mineral nutrition: Soil as a source of minerals. Essential mineral elements and their role plants metabolism. Deficiency symptoms of macronutrient

Photosynthesis: Introduction, Mechanism of photosynthesis; Differences between C₃ and C₄ plants, Factors affecting the process of photosynthesis

Respiration: Mechanism; Glycolysis, Krebs cycle and Electron transport. Anaerobic respiration. Respiratory quotients

Growth: Definition; role of auxins, gibberellins, cytokinins, abscisic acid and ethylene in controlling growth. Introduction to plant tissue culture

Photoperiodism: Definition, Classification of plants based on photoperiod

Dormancy: Definition and causes of seed and bud dormancy

Plant Movements: Classification of plant movements

Practical

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations
3. Measurement of leaf water potential by the dye method
4. Determination of the temperature at which beetroot cells lose their permeability
5. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a porometer/by cobalt chloride paper method
6. Chemical tests for the Starch, Cellulose, Lignin and Proteins
7. Extraction of amylase from germinating wheat seeds and study of its effect on starch breakdown
8. Measurement of carbon dioxide evolution during respiration of germinating seeds by the titration method
9. Measurement of light and temperature. Effect of light and temperature on seed germination

Ecology

Introduction, branches of ecology, levels of ecological organization, species, population, community and ecosystem, role of light, soil, water, temperature, topography and air as ecological factors, biotic factors, Concepts of Limiting factors, habitat and niche.

Populations; Population distribution and abundance, population dynamics, distribution limits, carrying capacity and environmental resistance

Community: organization, various concepts of community, community dynamics.

Ecosystem: structure and function, energy flow and material cycling within ecosystem. Biomes of the world, characteristics of urban, agricultural and industrial ecosystems.

Terrestrial and aquatic ecosystems in Pakistan, their distribution and potential threats to these ecosystems, plant geography and animal distribution.

Ecological production: primary and secondary productivity, productivity of different ecosystems, Systems ecology, ecological modeling, landscape ecology, landscape changes and their importance

Practicals

Measurement of environmental factors on land, water and air. Ecosystems: pond, agricultural or grassland, forest. Community analysis through different sampling techniques (quadrat, Transect). Population dynamics of grasshoppers. Adaptive features of animals in relation to food and environment. Food chain studies through analysis of gut contents. Analysis of polluted and fresh water for biotic and abiotic variations. Field visits for study of selected terrestrial habitat and writing notes. Development of an ecological management plan of some selected area

ZOO-443	Chordates	4(3+1)
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Course Contents

Protochordates: Structure, anatomy and organ systems; reproduction; life histories and metamorphosis; phylogenetic relationships; further phylogenetic considerations.

Fishes: Vertebrate Success in Water: phylogenetic relationships; Agnatha and Gnathostomata: locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Amphibians: The first terrestrial vertebrates: phylogenetic relationships; Caudata, Gymnophiona, and Anura; Structure and locomotory adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction, development, and metamorphosis; further phylogenetic considerations.

Reptiles: The First Amniotes: cladistic interpretation of the amniotic lineage; Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodilia; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development; further phylogenetic considerations.

Birds: Feathers, flight and endothermy: phylogenetic relationships; ancient birds and the evolution of flight; diversity of modern birds; adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development; migration and navigation.

Mammals: Specialized teeth, endothermy, hair and viviparity; diversity of mammals; adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

Practicals

Museum study of:

1. Protochordates
2. Pisces
3. Amphibia
4. Reptilia
5. Aves
6. Mammalia
7. Field trips to study animal diversity in an ecosystem.

Note: Preserved specimen and/or colored projection slide and/or CD ROM projection of computer must be used.

ZOO-444	Animal Form and Function I	4(3+1)
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Course Contents

Protection, Support, and Movement: Protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of

invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates.

Communication I: Nerves: Neurons: structure and function; neuron-neuron communication: introductory accounts of resting membrane potential, action potential (nerve impulse) and transmission of the action potential between cells; invertebrate and vertebrate nervous systems: the ventral nerve cord and ganglia, the vertebrate brain, the spinal cord, cranial and spinal nerves; autonomic nervous system.

Communication II: Senses: Sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates; lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.

Communication III: The Endocrine System and Chemical Messengers:

Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action; some hormones of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals.

Circulation, Immunity, and Gas Exchange: Internal transport and circulatory systems in invertebrates: characteristics of invertebrate coelomic fluid, hemolymph, and blood cells; transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; the human heart: blood pressure and the lymphatic system;

immunity: nonspecific defenses, the immune response; gas exchange: respiratory surfaces; invertebrate and vertebrate respiratory systems: cutaneous exchange, gills, lungs, and lung ventilation; human respiratory system: gas transport.

Practicals

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin.
2. Study and notes of skeleton of *Labeo*, *Rana tigrina*, *Varanus*, fowl and rabbit.
Note: Exercises of notes on the adaptations of skeletons to their function must be done.
3. Earthworm or leech; cockroach, freshwater mussel, *Channa* or *Catla catla* or *Labeo* or any other local fish, frog, pigeon and rat or mouse and rabbits are representative animals for study in dissections.
4. Study of models or preserved brains of representative animals and notes on adaptations.
5. Study of nervous system of earthworm and a fish.
6. Study of endocrine system in an insect and a rabbit
7. Study of different types of blood cells in blood smear of rabbit.

8. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).
9. Study of respiratory system in cockroach or locust and a vertebrate representative (Model).

ZOO-445	Animal Form and Function II	4(3+1)
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Course Contents

Nutrition and Digestion: Evolution of nutrition; the metabolic fates of nutrients in heterotrophs; digestion; animal strategies for getting and using food, diversity in digestive structures of invertebrates and vertebrates; the mammalian digestive system: gastrointestinal motility and its control, oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.

Temperature and Body Fluid Regulation: Homeostasis and Temperature Regulation; The Impact of Temperature on Animal Life; Heat Gains and Losses; Some Solutions to Temperature Fluctuations; Temperature Regulation in Invertebrates, Fishes, Amphibians, Reptiles, Birds and Mammals; Heat Production in Birds and Mammals; Control of Water and Solutes (Osmoregulation and Excretion); Invertebrate and Vertebrate

Excretory Systems; How Vertebrates Achieve Osmoregulation; Vertebrate Kidney Variations; Mechanism in Metanephric Kidney Functions.

Reproduction and Development: Asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction; sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; the human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; the human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.

Descriptive Embryology: Fertilization; embryonic development: cleavage, and egg types; the primary germ layers and their derivatives; echinoderm embryology; vertebrate embryology: the chordate body plan, amphibian embryology, development in terrestrial environments, avian embryology and fate of mesoderm.

Practicals

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of nutritive canal in an invertebrate and a vertebrate representative (Dissection).
3. Study of male reproductive system in an invertebrate and a vertebrate representative (Dissection).
4. Study of female reproductive system in an invertebrate and a vertebrate representative (Dissection).
5. Study of hormonal influence of a reproductive function (Model).

6. Study of preserved advanced stages of avian and mammalian development for amniotic membranes and placenta (Model).

7. Study of stages in the development of an Echinoderm.

8. Study of early stages in the development of a frog, chick and a mammal.

Note: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used.

Year III		
Semester-V		
Course Code	Course Title	Credits
BST-551	Biostatistics	3(3+0)
ZOO-552	Biochemistry	4(3+1)
ZOO-553	Cell & Molecular Biology	4(3+1)
ZOO-554	Zoogeography and Palaeontology	3(2+1)
ZOO-555	Animal Behavior	3(2+1)
	Total Credits	17

BST-551	Biostatistics	3(3+0)
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Course Contents

Introduction and scope: use of statistics in biology. Population and sample: Stages of research,

Types of data: methods of data collection. Data arrangement and presentation, formation of tables and charts.

Measures of central tendency: computation of mean, median and mode from grouped and ungrouped data.

Measures of dispersion: computation of variance, standard deviation, standard error and their coefficients.

Probability rules: Binomial, poissons and normal distributions. Hypothesis testing, Student 't' test, Chi square test,

Handling of multiple samples: Analysis of variance and LSD.

Correlation and regression: Experimental designing, planning of an experiment, replication and randomization.

ZOO-552	Biochemistry	4(3+1)
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Course Contents

Amino acids, peptides and proteins: standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, cytochrome c; Proteins: level of structural organization, example of structural and functional proteins.

Enzymes: Introduction; important characteristics of enzymes; immobilized enzymes; how enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity.

Carbohydrates: Classification, types, important characteristics and structure of carbohydrates; cyclic structure of monosaccharides; cyanohydrin formation; disaccharides their types structure and function; polysaccharides, storage and structural types; structure and major functions of polysaccharides.

Lipids: fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes; structural lipids in membranes; major functions of lipids; lipoproteins, their types and major functions.

Vitamins and cofactors: occurrence, structure and biochemical function of vitamins B complex group.

Metabolism: detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis;

utilization of other carbohydrates in glycolysis phosphorolysis and starch; regulation of glycogen metabolism. Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle; Electron transport and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.

Lipid metabolism: oxidation of fatty acids; digestion, mobilization and transport of fats; biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; betaoxidation; bioenergetics of beta oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex; Ketone bodies their biosynthesis, utilization and role in the tissues; cholesterol metabolism: Steroid hormones.

Nitrogen metabolism: metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle.

Practicals

1. Preparation of standard curve for glucose by ortho-Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of Reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).
7. Determination of pKa values of an amino acid by preparation of titration curves.
8. Biochemical tests for detection of different amino acids.

9. Separation of various protein fractions by precipitation method.
10. Demonstration of differential solubility of lipids in various solvents.
11. Quantitative analysis of phospholipids by estimation of inorganic phosphorous.
12. Quantitative analysis of Amylase activity from blood serum or liver.
13. Study on the effect of temperature on the enzymatic rate of reaction

ZOO-553	Cell & Molecular Biology	4(3+1)
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Course Contents

Introduction to prokaryotic and eukaryotic cells: Plasma membrane, its chemical composition structure and functions of plasma membranes, cell permeability, active transport, endocytosis, phagocytosis.

Cytoskeleton: Microfilaments, Microtubules, Intermediate filaments. Cytoplasmic **Organelles:** Membrane system, structural and functional commonalities. Ultrastructure, chemical composition and functions of Endoplasmic Reticulum and their role in protein synthesis and drug metabolism, Golgi apparatus its role in synthesis of glycoprotein, Mitochondrial respiration and its significance as semi-autonomous organelle; Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, Glyoxysome with reference to glyoxylic acid cycle.

Nucleus: chromatin, heterochromatin, euchromatin, chromosome structure, coiling and nucleosome during different phases of cell cycle.

Replication: mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in Eukaryotes with emphasis on DNA polymerases, concept of replicons etc.,

Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved, RNA splicing, split genes, concept of ribozymes and posttranscriptional processing, RNA transduction, Genetic code, point mutations.

Translation: Specific role of Ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

Practicals

1. Identification of cell organelles
2. Preparation of temporary whole mount.
3. Preparation of permanent whole mount (demonstration)
4. Preparation of human blood smear and identification of Leucocytes.
5. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Squash preparation of onion root tip for mitotic stages.
7. Mounting of polytene chromosome (Drosophila/Chironomous.) Demonstration.
8. Detection and quantitative determination of chromosomal DNA and RNA.
9. Cultural and staining of bacteria and yeast.
10. Separation of different sized DNA fragments on agarose gel.
11. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).

ZOO-554	Zoogeography and Palaeontology	3(2+1)
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Course Contents

(i) Zoogeography: Branches of zoogeography: descriptive, chorology, faunistics, systematic, biocoenotic, causal, ecological, historical, experimental and applied zoogeography.

Animal distribution: cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution and endemic distribution, barriers and dispersal.

Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic regions, Oriental, Ethiopian, Australian, and Neotropical Regions, insular fauna

Palaeogeography: Theories of continental drift and plate tectonics; Pangea.

Zoogeography of Pakistan:

(ii). Paleontology

The Planet Earth: History, age, shells of earth; atmosphere, hydrosphere, biosphere and lithosphere.

Rocks: types; Igneous rocks, sedimentary rocks and metamorphic rocks.

Fossil types and uses of fossils, nature of fossils.

Fossilization: Geological time scale. Pre-Cambrian life. Post Cambrian life, Palaeozoic life, Mesozoic life, Cenozoic life.

Geochronometry: Uranium/Lead dating, radiocarbon dating, methods, index fossils; evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism.

Practicals

1. Study of fauna of various zoogeographical regions.
2. Study of mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4. Study of vertebrate fossils e.g. horse/elephant/camel/bovids.
5. Study and identification of Igneous, Sedimentary and Metamorphic rocks
6. Map work for identification of various zoogeographical regions of the World.

ZOO-555	Animal Behavior	3(2+1)
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Course Contents

Foundations of animal behavior: ethology, classical ethology Development of behavior: innate mechanisms, imprinting

Kinds of behavior: innate, conditioned, complex behaviour patterns, habituation.

Mechanisms of behavior: Nervous system and behavior, hormones and behavior,

Social behavior: agonistic, altruistic, kinship, mating, ritualization, dominance, territoriality

Biological rhythms: circadian clocks, clock genes etc.

Social organization: conflict, sexual behaviour, reproduction and fitness, parental care, social system.

Animal Communication: chemical attraction, in moths, honey bees, communication displays, pheromones etc.

Practicals

1. Locomotory behavior of small animals, earthworm, garden snails etc.
2. Ear pinna reflex responses in domestic cats
3. Preparation of skinner box or maze for study of mouse or rat behavior
4. Mother-pup bond in mice and rats
5. Infant killing behavior
6. Pecking behavior of chickens
7. Hiding behavior of chicks
8. Observation of birds' nests and study of parental behavior
9. Altruistic behavior in monkeys

Semester-VI		
Course Code	Course Title	Credits
ZOO-561	Biological Techniques	3(1+2)
ZOO-562	Evolution & Principles of Systematics	3(2+1)
ZOO-563	Developmental Biology	4(3+1)
ZOO-564	Genetics	4(3+1)
ZOO-565	Synopsis & Research Methodology	2(2+0)
	Total Credits	16

ZOO-561	Biological Techniques	3(1+2)
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Course Contents

Microscopy: Principles of light microscopy. Magnification, Resolution, Contrast. Types of microscopy, Bright field (Compound Microscope), Scanning microscopy, Eyepiece micrometers, Camera Lucida Phase Contrast Dark field Interference microscope, Electron microscope.

Micrometry and Morphometry: Use of stage and ocular micrometer. Calibration of ocular micrometer. Size measurement (length, width, diameter).

Standard system for weight, length, volume: Calculations and related conversions of each:- Metric system- length; surface; weight - Square measures- Cubic measures (volumetric)- Circular or angular measure Concentrations- percent volume; ppt; ppm - Chemical molarity, normality Temperature- Celsius, centigrade, Fahrenheit. Preparation of stock solutions of various strengths

Specimen preparation for optical microscopy: Microtomy: Fixation, embedding, Section cutting (transverse, longitudinal section, mounting and staining. Sections in paraffin and cryosections.

Extraction techniques: Centrifugation, Ultracentrifugation, cell fractionation, filtration, Distillation, Use of Soxhlet and Rotary evaporator for extraction.

Separation Techniques: Chromatography: Principle, applications, types, thin layer, column, gas, ion exchange chromatography. Electrophoresis: Principle, applications, types.

Spectrophotometry: Principle, applications, types, visible spectrum, UV spectrum, atomic absorption.

Basic principles of Sampling and Preservation: Sampling soil organisms, invertebrates, Aquatic animals, Mammals, Estimation of population size, Preservation of dry and wet specimens. Preservation techniques - Taxidermy - Rearing techniques, Laboratory and field.

Practicals

1. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
2. Measurement of cell size: bacterial and eukaryotic
3. Recording of microscopic observations with the help of camera lucida
4. Liquid handling: proper use of pipettes and micropipettes
5. Histological preparations: skeletal muscle, intestine liver and testes
6. Handling of centrifuge machines
7. Thin layer chromatography of amino acids
8. Spectrophotometric estimation of glucose
9. Spectrophotometric estimation of total proteins
10. Preservation of representative animals of various phyla
11. Electrophoretic separation of proteins
12. Electrophoretic separation of DNA

ZOO-562	Evolution & Principles of Systematics	3(2+1)
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(Note: Evolution and Principles of Systematic Zoology 60% and 40% weightage, respectively. Three questions from Evolution and two questions from Systematic will be attempted by the students).

Course Contents

(i). Evolution

The nature and origin of life: Evidences of evolution (molecular, embryological & paleontological).

Theories of Evolution: Theories to explain the diversity of life—Modern synthetic theory, factors initiating elementary evolutionary changes (micro-evolution) by changing gene frequencies, mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.

Role of isolation in evolution: Factors of large evolutionary changes (macro/mega evolution) - allopatry, orthogenesis, adaptive radiation.

Modern concept of Natural Selection: Levels of selection, selection patterns, laboratory and field example regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regression and extinction, Batesian mimicry, Mullerian mimicry, Sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory, Recapitulation theory, Trend and rates in evolution.

(ii). Systematic Zoology

Importance and applications of systematics: Taxonomy in Animal science, systematics as a profession and its future perspectives.

History of taxonomy: systematics, basic terminology of systematics, theories of biological classifications.

Taxonomic characters: Kinds and weightage, microtaxonomy, taxonomic categories: specific category, infraspecific category, higher categories; Species concept.

Typological species concept: Nominalistic species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation, Taxonomic

procedures, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.

Systematics publications: International code of zoological nomenclature; its objective, principles, interpretation, application of important rules, with reference to: Zoological nomenclature, law of priority and validity of names.

Practicals

1. Study of preserved invertebrate species and their classification upto class level.
2. Collection, preservation and identification of common species with the help of keys.
3. Preparation of keys for the identification of specimens.
4. Methods of statistical analysis of samples from populations T-test, Analysis of variance etc.

ZOO-563	Developmental Biology	4(3+1)
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Course Contents

Introduction: Principal features of development, origin of sexual reproduction, developmental patterns; Spermatogenesis; Oogenesis.

Fertilization: Recognition of sperm and egg, fusion of gametes, activation of egg metabolism, rearrangement of egg cytoplasm.

Cleavage: Patterns of embryonic cleavage, mechanism of cleavage.

Gastrulation: Fate maps, gastrulation in sea urchin, amphibians, birds and mammals.

Early Vertebrate Development: Neurulation, ectoderm, mesoderm and endoderm.

Cellular Basis of Morphogenesis: Differential cell affinity, cell adhesion molecules.

Mechanism of Cellular Differentiation: RNA processing, translational regulation of developmental process, cell-fate by progressive determinants, autonomous cell specification by cytoplasmic determinants, establishment of body axes and mechanism of teratogenesis; Secondary Induction.

Organogenesis: A brief account; Origin and migration of germ cells in vertebrates. Factors controlling growth and oncogenesis. Post embryonic Development and metamorphosis Hormones as mediators of development; Regeneration in vertebrates.

Practicals

1. Study of the structure of gametes in some representative cases, i.e. frog, fish, fowl and a mammal.
2. Study of cleavage and subsequent development from prepared slides and/or whole mounts in various animals i.e., frog, chick etc. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions.
3. Preparation and study of serial sections of frog or chick embryos.
4. Application of microsurgical techniques on chick embryos In vitro.
5. Preparation and staining of histological slides.

ZOO-564	Genetics	4(3+1)
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Course Contents

Classical Genetics: Scope and importance of genetics, gene concept; classical and modern),

Multiple Alleles: blood groups and coat color in rabbits.

Chromosomal Basis of Inheritance: interaction of genes, changes in chromosomal number, euploidy, aneuploidy, polyploidy; structural changes, insertion, deletion (Cri du chat syndrome), duplication and translocation

Pedigree Analysis: Normal human chromosome complement; Karyotyping.

Sex-determination and Sex-linkage: Sex determination in animals and humans, linkage, recombination and chromosome mapping in eukaryotes.

Molecular Genetics: Elements of genetic engineering; genetic basis of diseases, like cancer, genetic control of animal development. Human Genetics; Single and Multifactorial Disorders: Autosomal anomalies, Pseudoautosomal genes, (eg. Down syndrome, Edwards syndrome and), Single gene disorders Gene mutation and disorders; autosomal single gene disorders (Sickle cell anemia, brachydactyly; inborn errors of metabolism such as Phenylketonuria, alkaptonuria). Definition - characteristics crisscross inheritance. Polygenic traits-Cleft lip and cleft palate, Sex-linked Chromosomal anomalies: Klinefelters syndrome, and Turners syndrome.

Sex-influenced inheritance: Hemophilia, muscular dystrophy, color blindness.

Prenatal Diagnosis: Amniocentesis and choriovillous sampling - Ultrasound scanning and Fetoscopy. Genetic counselling, Eugenics and Euthenics.

Population Genetics: Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis.

Practicals

1. Mitosis (Onion root tips.)
2. Meiosis (Grass hopper testes)
3. Blood groups.
4. Salivary gland Chromosomes of *Drosophila melanogaster*
5. General morphology of *Drosophila melanogaster*
6. Human Pedigree analysis problems
7. Human Genetics problems
8. Probability problems. Tossing of coins. X² test
9. Study of transformed bacteria on the basis of antibiotic resistance.

ZOO-565	Synopsis & Research Methodology	2(2+0)
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Course Contents

Significance: objectives of research, Types of research, Research approaches,

Research process: steps involved in research process, (Survey, Observation, case study, experimental, historical and comparative methods)

Data: Types of Data, Data collection, processing, analysis, Review of literature, Research problem, Hypothesis.

Bioethics: Ethical, legal, social and scientific issues in Biological Research.

Plagiarism:

Funding Sources: A brief idea about the funding agencies such as HEC, PSF, USAID etc.

Writing of Research Proposal: Thesis/Report and Research Paper: Footnotes and Bibliography.

Year -IV		
Semester-VII		
Course Code	Course Title	Credits
ZOO-671	Environmental Biology	4(3+1)
ZOO-672	Animal Physiology	4(3+1)
ZOO-673	Parasitology I	4(3+1)
ZOO-674	Wildlife	2(2+0)
ZOO-675	Entomology	3(2+1)
	Total Credits	17

ZOO-671	Environmental Biology	4(3+1)
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Course Contents

Energy: laws of thermodynamics, primary and secondary productions, trophic levels and energy variation with increasing trophic levels, energy flow, food chains and food webs.

Biogeochemical cycle: nitrogen, phosphorus, sulphur, water, carbon, nutrient.

Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire.

Global ecosystems: (atmosphere, hydrosphere, lithosphere, ecosphere). An overview of ecosystem with special reference to ecological niche: basic concepts and types. Major ecosystem of world: Marine, Estuarine, Freshwater, Wetlands, Tundra, Forest, Grassland, Desert and Agricultural ecosystems.

Population ecology: basic population characters, growth and growth curves, population dynamics and regulations.

Community ecology: basic concepts, community analysis, ecotones, inter-population interactions.

Applied Ecology: resources and their ecological management (mineral, agricultural desalination and weather modification, forest and range management, landscape and land use);

Pollution: (definition, types, cost, origin and management); water (sources, domestic and industrial pollution, heavy metals); air (sulphur dioxide, nitrogen oxide, carbon monoxide, ozone, smog and PAN, MTBE & CFCs); land pollution (pesticides, bacterial toxins, synthetic hormones); noise pollution.

Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, Koyota protocol, desertification, deforestation, exotic and invasive species, radioactivity leakage, environmental laws).

Practicals

1. Measurement of environmental factors on land, water and air.
2. Study of different ecosystems: pond, agricultural or grassland, forest.
3. Community analysis through different sampling techniques (quadrat, Transect),
4. Population studies mark and recapture method, statistical analysis of field data.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project
10. Development of an ecological management plan of some selected area.

ZOO-672	Animal Physiology	4(3+1)
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Course Contents

Central themes in Physiology: Homeostasis, Concepts of conformity and regulation; physiological adaptations.

Membrane Physiology: Ionic distribution across membrane, Resting membrane potentials: Electrogenic ion pump, Donnan equilibrium, Ion channels

Nerve and Muscle Physiology: Action potentials in neurons; Electrical and chemical synaptic transmission; Neurotransmitters; Excitatory and inhibitory postsynaptic potentials; tetany; Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction: sarcoplasmic reticulum and role of calcium, muscle action potentials, isometric and isotonic contraction, leverage factor, muscle fatigue.

Receptors Physiology: Receptor types: Mechanoreceptors, Olfactory and taste receptors, Photoreceptors, Photochemistry and Phototransduction; acoustico-lateralis system, Cutaneous receptors, electro-receptors. Sensory transduction, coding and adaptations. Range fractionation.

Endocrine Physiology: Gland types; Hypothalamus, Pituitary, Thyroid, Parathyroid, Pineal, Pancreatic Islets, Gastric glands, Adrenal, Ovary, Testis and Placenta; Overview of hormones; types, peptide and steroid hormones, chemistry, synthesis and roles. Hormone receptors and signal transduction. Feedback mechanisms.

Cardiovascular Physiology: Electrical activity of heart: Autorythmicity, Electrocardiography, Kymography; Hemodynamics, Relationship between blood flow, pressure and resistance. Control of cardiac activity, cardiac output and peripheral circulation.

Respiratory Physiology: Respiratory epithelia, gas exchange in gills and lungs; Transport of O₂ and CO₂, Structure of alveoli, lung volumes and capacities, surfactants, control of breathing; hypoxia; Hypercapnia etc., air breathing in divers.

Renal Physiology: Osmoregulation: Osmoregulation in aquatic and terrestrial animals; Kidney and Vertebrate nephron as osmoregulatory and excretory organ: Glomerular filtration, Tubular absorption and secretion; Nitrogenous waste products; Patterns of nitrogenous excretion and their phylogenetic significance.

Physiology of Digestion: Physiologic anatomy of digestive tract (mammalian model), Regulation of digestive secretions; Absorption of water, ions and nutrients; Potential

and Movements in gastrointestinal tract; Control of motility. Deglutition, Peristalsis, Absorption, Assimilation and defecation.

Temperature Regulation: Temperature classification of animals; Temperature relation of ectotherms in freezing and cold and warm and hot environment; Costs and benefits of ectothermy; Temperature relations of heterotherms and endotherms; Dormancy: Sleep, Torpor, Hibernation and Estivation.

Practicals

1. Determination of haemoglobin content, haematocrit and cell counting.
2. Preparation of blood smears.
3. Nerve muscle preparation, Muscle twitch, Comparison of muscle and nerve irritability, effect of stimulus strength, effect of stimulus frequency (tetany), effect of load or stretch, effect of prolonged activity (fatigue), neuromuscular fatigue, stimulation of motor points in human.
4. Recording of action potential by oscilloscope and demonstration of its various features. Experiments to demonstrate characteristic of reflex arc. Experiment in human (students themselves) to demonstrate some aspect of sensory physiology.
5. Normal cardiac activity, effect of temperature, effect of drug, heart block, tetanization of heart. Measurement of blood pressure.
6. Oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer), heart rate, blood pressure glycemia altered by exercise.
7. Effect of insulin on glycemia, study of stages in estrous cycle.

ZOO-673	Parasitology I (Protozoology, Pathology and Immunology)	4(3+1)
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Course Contents:

Protozoology

Systematic, geographical distribution, habitats, biology, pathogenesis, important symptoms, mode of transmission laboratory methods of diagnosis, and control of protozoa of medical and veterinary importance.

Pathology and Immunity

The cell and cell injury and its relationship to disease. Acute and chronic inflammations, wound healing, disorders of growth, benign and malignant tumors in case of infections immunity, and hypersensitivity in case of parasitic diseases.

Practical

A study of parasitic Protozoa of medical veterinary importance with special reference to differential morphological features. Preparation of permanent mounts of parasitic Protozoa. Examination of human feces and from domesticated animals by using standard laboratory techniques. Techniques and study of blood parasite study of different types of pathological tissues from prepared slides.

ZOO-674	Wildlife	2(2+0)
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Course Contents

Wildlife: Animal occurrence, protection, needs of animals, maintenance, and the habitat.

Techniques: Ground and aerial tracking, GPS, radiotelemetry, maps etc.

Wildlife Conservation: Philosophy and significance, Biodiversity and sustainability of wildlife.

Wildlife Agencies: National and International agencies involved in conservation and management of wildlife. International conventions, agreements.

Wildlife of Pakistan: identification, distribution, status, conservation and management (population estimate technology) of fishes, reptiles, birds and mammals of major importance in Pakistan.

Wildlife rules and regulations in Pakistan: Sanctuaries, Game Reserves and National Parks in Pakistan. Endangered species of Pakistan.

(Note: The teacher is suggested to provide blank maps of Pakistan in the theory class to the students to indicate the distribution of the animals. Similar blank maps should be attached with the question paper, if distribution of animals is asked from the student in the theory paper).

ZOO-675	Entomology	3(2+1)
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Morphology and Physiology:

An introduction of Entomology with a brief description of different classes of Arthropods. Complete morphology of an insect. Anatomy and Physiology of various systems with special reference to digestive, nervous, circulatory, respiratory, excretory and reproductive system. Development and metamorphosis. Hibernation and diapause.

Taxonomy and Ecology

Classification of insects up to orders. Insect ecology with special reference to factors effecting the population, population estimations. Insect societies.

Practicals

1. Dissection of various insects, to expose their internal anatomy.
2. Preparation of mouth parts, antennae, wings, legs and genitalia of different insects.
3. To study the whole mounts of Collembola, silverfish, thrips, aphids, lice and fleas.
4. Preparation of killing bottles, preservation, pinning and setting of insects.
5. Study of metamorphosis and different types of insects' larvae and pupae, life history of an insect.
6. Classification and identification of insects.

Semester-VIII		
Course Code	Course Title	Credits
ZOO-681	Bioinformatics	3(2+1)
ZOO-682	Research Thesis/ Project/ Internship or Special Paper	4(0+4) or 4(3+1)
ZOO-683	Applied Fisheries	4(3+1)
ZOO-684	Applied Entomology	3(2+1)
ZOO-685	Parasitology II	3(2+1)
	Total Credits	17

ZOO-681	Bioinformatics	3(2+1)
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Course Contents

Introduction to BI: What is BI; history of BI; Uses of BI (Protein, Gene); comparison of BI with experimental tools.

Basic principles of computing in bioinformatics: Basic acquisition and database: DDBJ, NCBI and EMBL

Short introduction to DNA, RNA and protein: amino acids, sequence; analyzing Protein sequence using BI tools; sequence-structure function.

Retrieving protein sequences from database (FASTA): Alignment of protein\ nucleotide sequences (BLAST, CLUSTALW); Computing physicochemical parameters of proteins (eg. PROTPARAM); Predicting elements of secondary structure of proteins (eg. PSSP); Retrieval, understanding and predicting 3D structure of protein from sequence; PTMs (eg NETPHOS etc.)

Enzyme classification: retrieval databases

Short introduction to DNA/RNA: structure, genetic code; analyzing the DNA/RNA sequence by the use of BI tools Retrieving the DNA sequence from database; Computing the sequence Identifying restriction sites; Predicting elements of DNA/RNA secondary structure; Computing the optimal alignment between two or more DNA sequences

PRIMER designing for PCR (PRIMER3+, PRIMER-BLAST, OLIGO-CALC etc.)

Short introduction to proteomics and genomics, and the role of bioinformatics in the pharmaceutical industry.

Practicals

- Retrieval of FASTA sequence
- Determination of proteins physical and chemical parameters
- Finding similar sequences for protein and DNA

- Multiple alignment
- Predicting proteins secondary structure
- Predicting RNA secondary structure
- Predicting protein PTM
- Finding protein families
- Determination of gene location on chromosome
- SNPs
- Primer design

ZOO-683	Applied Fisheries	4(3+1)
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History and significance of aquaculture; Study of management techniques and habitat improvement; Designing, construction, fertilization, manuring, stocking and harvesting of a fish pond; Study of native and exotic fishes of Pakistan; Shellfish and fin fish; Fishing gears and crafts/nets used in Pakistan; Fish ways; construction and importance. Bye products of fish industry; Methods of processing fish such as drying, salting smoking, curing, freezing etc; Study of fish parasites, common diseases and enemies of fishes. Pollution and its effect on fish population; Methods of population estimation by direct count, catch effort, mark re-capture method, tagging of fish; Artificial propagation induced spawning techniques; Marketing strategies; transport of fish and seed; Major problems of fishermen in Pakistan;

Practical

- Collection and identification of common zooplanktons
- Study of gut contents of fish
- Statistical analysis of fish growth, length-weight relationship
- Study of farm fishes of KPK
- Visit to a fish farm/hatchery to study installations/methods of breeding
- Prepared slides of fish parasites
- Analysis of physical properties (temperature, light, colour, turbidity, conductivity etc.) and chemical properties (pH, oxygen, carbon dioxide, salinity, dissolved solids/salts) of water;
- General methods of age growth studies; reading of age from scales, opercula, otolith and back calculation from bones;
- Study of larvae, fry and fingerlings of a common fish, regulation of fishing, enactment of fishery legislation.

ZOO-684	Entomology II: (Applied Entomology and Pest Management)	3(2+1)
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Course Contents:

Applied Entomology:

Principles of apiculture, sericulture and lac culture. Study and identification of pests of agriculture, stored grain and households. General characteristics, life cycles and habits of insects of medical and veterinary importance. Study of various insect-borne diseases.

Pest management

The principles of pest control/management viz., physical, mechanical, culture, legislative biological, genetic, chemical and integrated control. Relative merits of various types of insect control. Pest's management practices in Pakistan- oriental review.

Practical: Applied Entomology

Collection, identification and preservation of different pests and other insects of medical and veterinary importance. Study of sericulture and apiculture. Operation of various types of sprayers. Dusters, fumigation emulsions. Preparation of insecticide emulsions in different concentration. The record of laboratory and fieldwork will be maintained and presented at the time of examination.

ZOO-685	Parasitology II (Helminthology)	3(2+1)
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Course contents: Basic principles and concepts in Parasitology, Taxonomy, etiology, biology, epidemiology, pathology and pathogenesis, diagnosis, life cycle, control and treatment of **Digenetic Trematodes:** *Schistosoma mansoni*, *S.japonicum*, *S.haematobium*, *Fasciola hepatica*, *Fasciolopsis buski*, *Paragonimus westermani*, *Colanorchis sinensis*, *Heterophyes heterophyes*, **Monogenetic trematodes:** *Dactylogyrus vastator*, *Gyrodactylus*, **Cestodes:** *Diphyllobothrium latum*, *Taenia saginata*, *T.solium*, *Echinococcus granulosus*, *Hymenolepis nana*, *Dipylidium caninum*, **Nematodes:** *Trichuris trichiura*, *Trichenella spiralis*, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Necator americanus*, *Ascaris lumbricoides*, *Toxocara canis*, *Enterobius vermicularis*, *Wuchereria bancrofti*, *Brugia malayi*, *Onchocerca volvulus*, *Loa loa* and *Dracunculus medinensis*.

Practicals

- Stage and ocular micrometry for measurement of helminths.
- Preparation of temporary and permanent mounts of parasites from the following animals: a. Fish b. Frog/toad c. Fowl/Pigeon d. Rat/Mouse.
- Study of helminths from prepared slides.
- Study of eggs / larvae from feces and prepared slides.
- Diagnosis of medically important parasites in fecal specimen by using: Tillman's centrifugation technique, by Lugol's iodine staining technique

**List of Optional /
Special Subjects
for
BS and MSc
Zoology**

List of Optional/Elective/Special papers for BS 8th semester and MSc 4th semester students

Course Category	Course Title	Credits
Special Paper I	Ichthyology	4(3+1)
Special Paper II	Ornithology	4(3+1)
Special Paper III	Immunology	4(3+1)
Special Paper IV	Fish Farming	4(3+1)
Special Paper V	Mammalogy	4(3+1)
Special Paper VI	Endocrinology	4(3+1)
Special Paper VII	General Microbiology	4(3+1)
Special Paper VIII	Herpetology	4(3+1)
Special Paper IX	Reproductive Biology	4(3+1)
Special Paper X	Biotechnology	4(3+1)

Ichthyology	4(3+1)
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Course Contents:

Systematic position of fish in animal kingdom, External features of fish, Fish muscular system, locomotion and energetics of swimming. Physiology of respiration and air breathing among fishes. Cardiovascular system, blood and its circulation and hydromineral balance: Osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance. Digestion and control of gastro-intestinal motility in fish. Physiology of gas bladder: Use of gas by the fish as a source of static lift. Gas in the gas bladder: Loss, retention and secretion of gas. Process of aestivation in fish. Control of kidney function in fish. Sensory system and communication in fish: Acoustico-lateralis system, sound reception and production.

Practicals

1. Study of classification of fishes and some selected fish species

2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological and economic importance of fishes
6. Study of ornamental fishes
7. Field visits to fish hatcheries

Ornithology	4 (3+1)
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Course Contents:

Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species; evolution of birds; biology of fossil birds; archaeopteryx, archaeornithes, neoornithes; morphology and surface anatomy of bird, and development structure of feathers, plumage; structure of bones; basic embryology of birds; internal anatomy of birds; systems physiology; blood circulatory, cardiovascular physiology, heart, blood cells and hemodynamics; respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption; urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste; digestive system, anatomy, guts and feeding strategies; morphological and physiological adaptations of birds to flying, kinds of flight, mechanisms of aerodynamics; reproductive organs anatomy and physiology, egg laying and breeding seasons; bird migration, song production, bird behavior, courtship, mating, egg incubation strategies, brood parasitism; predator-prey relationship; homing behavior; learning, imprinting; nest building; bird parasite; endangered species of birds; bird conservation and sanctuaries. Introduction, evolution, geographical distribution. Classification Characteristics of birds, external features, identification of sex and age, reproduction and development, behavior (migration, territoriality), populations and their regulation. Anatomical, physiological adaptations to their environment, reproductive strategies, food/feed, communication (vocal, behavioral). Anatomy & physiology of game and predatory species. Birds of Pakistan: Aquatic, Forest and Game birds and birds of prey. Birds as pests.

Practicals

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, other available birds
3. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
4. Study of gut contents of birds to understand feeding habits
5. Incubation of chicken eggs to learn avian embryogenesis
6. Bird stuffing and preservation of eggs

7. Identification of bird species through feathers and egg shells, beak and claw structures
8. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
9. Bird watching and preparation of ethograms
10. Study of Predator-prey relationship among birds
11. Study of Brood parasitism
12. Study of flying mechanics through models

Immunology	4 (3+1)
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Course Contents

Immunology: Immunobiology, Immunophysiology, Immunopathology. Immunity: Natural and acquired immunity, Active and passive immunity. Antigens and elicitation of immune responses: antigens and their types, antigenicity and immunogenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens, genetic constitution of individuals and route of administration. Immunoglobulins: Synthesis of antibodies, Theories of antibodies synthesis. Detection and application of antigen-antibody reactions: in vivo and in vitro reactions.

Monoclonal antibodies: Importance, synthesis, isolation and applications Major histocompatibility complex: types and importance, diversity in MHC proteins. Cellular basis of immune response: Origin of lymphocytes, Primary and secondary lymphoid organs, Specific response of individual lymphocytes to antigenic stimulation, Histological features of immune response. Hypersensitivity: Immediate hypersensitivity (anaphylaxis, antibody dependent cytotoxicity, Immune-complex mediated disease and stimulatory hypersensitivity), Delayed type or cell mediated hypersensitivity. Immunological tolerance and autoimmunity: Tolerance, autoimmune diseases and types, factors responsible for autoimmunity. Transplantation immunology, Tumor immunology, Immunity against infectious diseases, Immuno deficiency diseases, Immunity and malnutrition. Immunization; Immunization procedures, Vaccines and their types.

Practicals

1. Study of different types of leucocytes in: Blood, Bone marrow, Spleen and Thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbent assay (ELISA).

5. Isolation of lymphocytes and resetting technique.
6. Antigen-antibody reaction by agglutination and precipitation reaction.
7. Antigen antibody reaction by using adjuvant.
8. Diagnosis of typhoid fever by Widal test.
9. Visit to pathological laboratory and report writing.

Fish Culture or Farming	4 (3+1)
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Course Contents

Aims and evolution of fish culture. Pond fish culture: Planning and construction of fish pond, water quality criteria, conditions suitable for fish culture, biological production cycle of fish pond. Culturable fishes of Pakistan. Fertilization of fish pond: Organic and inorganic fertilizers. Artificial feeding in fish culture: Fish feeding methods, different components of fish feed, composition of commonly available feed ingredients, preparation and feed storage methods. Integrated fish farming: Concepts and practices. Fish enemies. Fish diseases and remedial measures. Fish hatchery management. Fishing gears, pre- and post-harvesting care of fish, maintenance of fish catch quality during transportation, storage and marketing. Fish processing technology.

Practicals

1. Uses of different organic and inorganic fertilizers in fish ponds
2. Identification of various fishes
3. Study of morphological characters and identification of cultureable fish species
4. Practical demonstration of induced fish breeding

Mammalogy	4 (3+1)
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Course Contents

Introduction to mammalogy. History of mammalogy. Mammalian phylogeny. Dental and cranial characteristics. Evolution of viviparity. Biogeography: Mammalian radiation, biogeography of mammals of Pakistan. Food and feeding: Stenophagy and euryphagy. Population regulation: Natality, mortality, immigration, emigration, population size, mean crowding, population modeling, Signaling: Types and evolution, communication and social organization. Mammalian Adaptations: Molecular basis of torpor, aestivation, hibernation, acoustic orientation (echolocation). Home range and territoriality. Predation: Predator-prey co-evolutionary race.

Practicals

1. General survey of mammalian species (Visits to zoological museums and zoos and field study)
2. Study of techniques for the collection of mammals, their identification and systematic relationships
3. Comparative study of mammalian skeleton
4. Dissection of a rabbit or rat to expose its different systems

General and Comparative Endocrinology	4 (3+1)
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Course Contents

An overview of general concepts and principles of endocrinology: The endocrine system; Type of hormones; Endocrine and nervous system relationship; General principles in function, interaction, nature, synthesis, transport of hormones; General concept of feedback, biorhythms, pathology and assessment of endocrine function; Evolution of endocrine system. Hypothalamus and pituitary: Hypothalamic hormones: Origin, chemistry and actions; Anterior pituitary & hormones: Hypothalamic pituitary regulation, General chemistry, Physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormone family, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: Release, regulation and actions of vasopressin and oxytocin. Thyroid gland: Anatomy and histology of gland; Formation and secretion of thyroid hormones; Thyroid hormones in peripheral tissues, Regulation and factors affecting thyroid function. Calciotropic and Mineral Metabolism Hormones: Chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols; Homeostasis of calcium, phosphate and magnesium. Pancreatic Hormones and Regulatory Peptides of the Gut: Anatomy and histology for sources of the hormones; Chemistry, physiological roles and mechanism of action of insulin and glucagon; Physiological roles of gut peptides. Adrenal Medulla and Catecholamines: Chromaffin cell and organization; Structure of adrenal medulla; Biosynthesis, storage, release and metabolism; Adrenergic receptors. Adrenal Cortex: Steroid biochemistry; Physiological actions of corticoid hormones; Regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids. Testes: Androgenic tissue: Structure and chemistry; Transport, metabolism and mechanism of action. Ovaries: Ovarian hormones: Steroid biochemistry and biosynthesis; Transport, metabolism and mechanism of action. Endocrinology of Pregnancy: Hormones in conception and implantation; Hormonal actions and adaptation in pregnancy and parturition. Endocrinology of Lactation: Hormones in lactation. Endocrinology of Heart, Kidney, Immune system: Growth and pineal gland. Functional diversity of hormones in vertebrates; Overview of endocrine mechanisms in invertebrates.

Practicals

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc;
2. Histological and ultra-structure features of endocrine glands;
3. Experiments to demonstrate physiological roles of hormones of different endocrine glands;
4. Experiments to demonstrate regulation of hormones' releases.
5. Experiments to demonstrate functional diversity of hormones in different vertebrates.
6. Experiments on endocrine mechanism in vertebrates.

General Microbiology	4(3+1)
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Course Contents

The beginnings of Microbiology: Discovery of the microbial world; Discovery of the role of microorganisms in transformation of organic matter, in the causation of diseases, development of pure culture methods. The scope of microbiology.

Microbial evolution, systematics and taxonomy; Characterization and identification of microorganisms. Nomenclature and Bergey's manual. Viruses: Bacteriophages and phages of other protests. Replication of bacteriophages. Viruses of animals and plants; History, structure and composition; classification and cultivation of animal viruses. Effects of virus infection on cells. Cancer and viruses. Morphology and fine structure of bacteria: Size, shape and arrangement of bacterial cells, Flagella and motility, Pili, Capsules, sheaths, Prosthecae and stalks, structure and chemical composition of cell wall, cytoplasmic membrane, protoplasts, spheroplasts, the cytoplasm, nuclear material. The Cultivation of Bacteria: Nutritional requirements, nutritional types of bacteria, bacteriological media, physical conditions required for growth, choice of media, conditions of incubation. Reproduction and growth of bacteria: Modes of cell division, New cell formation, Normal growth cycle of bacteria, synchronous growth, continuous culture, quantitative measurement of bacterial growth; Direct microscopic count, Electronic enumeration of cell numbers, the plate count method, Membrane-filter count, Turbidimetric method, Determination of nitrogen content, Determination of the dry weight of cells, The selection of a procedure to measure growth, Importance of measurement of growth. Pure cultures and cultural characteristics: Natural microbial populations, selective methods; Chemical methods, Physical methods, Biological methods, Selection in nature, Pure cultures; Methods of isolating pure cultures, Maintenance and preservation of pure cultures, Culture collections, Cultural characteristics; Colony characteristics, Characteristics of broth cultures. Eukaryotic Microorganisms: Algae: Biological and economic importance of algae; Characteristics of algae; Lichens. Fungi: Importance of fungi; Morphology; Physiology and reproduction, Cultivation of fungi. Economic importance of protozoa. Prokaryotic diversity Bacteria: Purple and green bacteria; cyanobacteria, prochlorophytes, chemolithotrophs, methanotrophs and methylotrophs, sulfate and

sulfur-reducing bacteria, homoacetogenic bacteria, Budding and appendaged bacteria, spirilla, spirochetes, Gliding bacteria, Sheathed bacteria, Pseudomonads, Free living aerobic nitrogen fixing bacteria, Acetic acid bacteria, Zymomonas and Chromobacterium, Vibrio, Facultatively aerobic Gram-negative rods, Neisseria and other Gram-negative cocci, Rickettsias, Chlamydias, Gram-positive cocci, Lactic acid bacteria, Endospore forming Gram-positive rods and cocci, Mycoplasmas, High GC Gram-positive bacteria; Actinomycetes, Coryneform bacteria, propionic acid bacteria, Mycobacterium, Filamentous Actinomycetes. Prokaryotic Diversity: Archaea: Extremely Halophilic archaea, Methane producing archaea: Methanogens, Hyperthermophilic archaea, Thermoplasma.

Practicals

1. Preparation of culture media
2. Pure culturing and cultivation of bacteria
3. Simple, Gram, endospore, capsular, flagellar and acid fast stainings of different genera of bacteria \ Vital staining and microscopic observations of protozoa
4. Cultivation methods of fungi
5. Isolation of bacteriophages

Reproductive Biology	4(3+1)
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Introduction: Overview of structure, at different levels, of reproductive systems and developments in gametes formation.

Sex Determination and Differentiation: Molecular aspects and chemical messengers in differentiation.

Hypothalamic-Hypophyseal-Gonadal axis in Reproduction: Hormonal and neuronal factors and their interactions in ovarian, testicular and other reproductive target functions. The interactions in developments in estrous and menstrual cycles. The interactions in transitions from childhood to reproductive and post-reproductive states.

Reproductive Behaviors: Endocrine basis of communication in reproduction and aggression; Pheromones in mammalian reproduction; Rhythms in Reproduction.

Pregnancy: Hormonal mechanism in fertilization, zygote transport and implantation. Placental steroid and polypeptide hormones; Recognition and maintenance of pregnancy; Maternal metabolism in gestation, Hormonal mechanism in parturition.

Lactation: Hormonal mechanism in lactation; Lactogenesis, Galactopoiesis, Milk ejection.

Reproductive Senescence: Hormonal and metabolic aspects in menopause; Mechanisms in males.

Fertility Control Mechanisms: Hormonal contraceptives; Rhythmic methods, Immunologic techniques and other fertility control procedures in women; complications in their uses; Fertility control in men and search for male contraceptive.

Practicals

Study of male and female reproductive tract. Histology of segments of male and female reproductive tracts. Recognition of spermatogonial cells, ovarian follicles and corpus luteum in gonads. Study of hormonal mechanisms in super ovulation and implantation; Tests for pregnancy recognition; Experiments on role of gonads in maintenance of accessory sex gland in males and target structures in females. Study of fertility control procedures in populations.

Biotechnology	3-1
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Introduction to Biotechnology

History, importance and application of Biotechnology

Introduction to recombinant DNA technology

Restriction of endonucleases, classification of restriction enzymes, restriction and modification systems. Nomenclature of restriction enzymes, cutting and joining of DNA, recombinant DNA and gene cloning, restriction mapping.

Animal Biotechnology

Stem cells concepts and applications, Transgenic Animals, Gene therapy, Vaccine production

Microbial Biotechnology

Plants Biotechnology: Transgenic Plants, Vaccine production in plants. Bioethics

Techniques in Biotechnology

Gel electrophoresis, Hybridization techniques (southern blotting, northern blotting, western blotting), polymerase chain reaction (PCR), sequencing techniques and cDNA libraries construction.

Practicals

Bacterial cell culture, pure culture isolation and selection. DNA/ RNA extraction from animal tissues. Plasmid DNA isolation from Bacterial cell. Polymerase Chain Reaction (PCR). Gel electrophoresis.