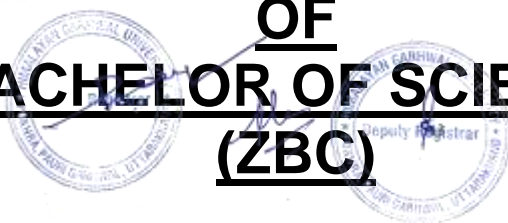


HIMALAYAN GARHWAL UNIVERSITY **UTTARAKHAND**



STUDY AND EVALUATION SCHEME **OF** **BACHELOR OF SCIENCE** **(ZBC)**



Marks Evaluation **B.Sc. (ZBC) Semester – I**

S.No.	Subject Code	Subject Name	Effetive Teaching			Cre dits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	ZBC101	English Communication	2	-	-	2	30	70	100
2	ZBC102	Animal Diversity	3	1	-	4	30	70	100
3	ZBC103	Organic Chemistry & Inorganic Chemistry	3	1	-	4	30	70	100
4	ZBC104	Biodiversity (Microbes, Algae, Fungi and Archegoniate)	3	1	-	4	30	70	100
5	ZBC P12	Animal Diversity-Lab (Practical)	-	-	4	-	15	35	50
6	ZBC P13	Organic Chemistry & Inorganic Chemistry –Lab (Practical)	-	-	4	-	15	35	50
7	ZBC P14	Biodiversity (Microbes, Algae, Fungi and Archegoniate)-Lab (Practical)	-	-	4	-	15	35	50
Total			11	3	12	20	170	380	550

B.Sc. (ZBC) Semester – II

S.No.	Subject Code	Subject Name	Effective Teaching			Credits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	ZBC201	Environmental Science	2	-	-	2	30	70	100
2	ZBC202	Comparative Anatomy and Developmental Biology	3	1	-	4	30	70	100
3	ZBC203	Chemical Energetics, Equilibria & Functional Group Organic	3	1	-	4	30	70	100

		Chemistry-I							
4	ZBC204	Plant Ecology and Taxonomy	3	1	-	4	30	70	100
5	ZBC P22	Comparative Anatomy and Developmental Biology-Lab (Practical)	-	-	4	-	15	35	50
6	ZBC P23	Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I-Lab (Practical)	-	-	4	-	15	35	50
7	ZBC P24	Plant Ecology and Taxonomy-Lab (Practical)	-	-	4	-	15	35	50
Total			11	3	12	20	170	380	550

B.Sc. (ZBC) Semester – III

S.No.	Subject Code	Subject Name	Effetive Teaching			Cre dits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	ZBC301	(Skill Enhancement Course-I) SEC-I	2	-	-	2	30	70	100
2	ZBC302	Physiology and Biochemistry	3	1	-	4	30	70	100
3	ZBC303	Solutions, Phase Equilibria, Conductance, Electrochemistry & Functional Group Organic Chemistry-II	3	1	-	4	30	70	100
4	ZBC304	Plant Anatomy and Embryology	3	1	-	4	30	70	100
5	ZBC P32	Physiology and Biochemistry-Lab	-	-	4	-	15	35	50
6	ZBC P33	Solutions, Phase Equilibria, Conductance, Electrochemistry & Biomolecules-Lab	-	-	4	-	15	35	50
7	ZBC P34	Plant Anatomy and Embryology-	-	-	4	-	15	35	50

		Lab							
Total			11	3	12	20	170	380	550

B.Sc. (ZBC) Semester – IV

S.No.	Subject Code	Subject Name	Effetive Teaching			Cre dits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	Elective	(Skill Enhancement Course-2) SEC-2	2	-	-	2	30	70	100
2	ZBC402	Genetics and Evolutionary Biology	3	1	-	4	30	70	100
3	ZBC403	Chemistry of s- and p- block elements, States of matter & Chemical Kinetics	3	1	-	4	30	70	100
4	ZBC404	Plant Physiology and Metabolism	3	1	-	4	30	70	100
5	ZBC P42	Genetics and Evolutionary Biology-Lab	-	-	4	-	15	35	50
6	ZBC P43	Chemistry of s- and p- block elements, States of matter & Chemical Kinetics-Lab	-	-	4	-	15	35	50
7	ZBC P44	Plant Physiology and Metabolism-Lab	-	-	4	-	15	35	50
Total			11	3	12	20	170	380	550

B.Sc. (ZBC) Semester – V

S.No.	Subject Code	Subject Name	Effective Teaching			Credits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	Elective	(Skill Enhancement Course-3) SEC-3	2	-	-	2	30	70	100
2	Elective-1 (DSE)	Discipline Specific Elective-1 (DSE-1)	3	1	-	4	30	70	100

3	Elective-2 (DSE)	Discipline Specific Elective-2 (DSE-2)	3	1	-	4	30	70	100
4	Elective-3 (DSE)	Discipline Specific Elective-3 (DSE-3)	3	1	-	4	30	70	100
5	Elective (Lab)	Discipline Specific Elective-1 (DSE-1) Lab	-	-	4	-	15	35	50
6	Elective (Lab)	Discipline Specific Elective-2 (DSE-2) Lab	-	-	4	-	15	35	50
7	Elective (Lab)	Discipline Specific Elective-3 (DSE-3) Lab	-	-	4	-	15	35	50
Total			11	3	12	20	170	380	550

B.Sc. (ZBC) Semester – VI

S.No.	Subject Code	Subject Name	Effetive Teaching			Cre dits	Evaluation Scheme		
			L	T	P		Internal Assessment	End Term	Total Marks
			Hours/Week						
1	Elective	(Skill Enhancement Course-4) SEC-4	2	-	-	2	30	70	100
2	Elective-1 (DSE)	Discipline Specific Elective-1 (DSE-1)	3	1	-	4	30	70	100
3	Elective-2 (DSE)	Discipline Specific Elective-2 (DSE-2)	3	1	-	4	30	70	100
4	Elective-3 (DSE)	Discipline Specific Elective-3 (DSE-3)	3	1	-	4	30	70	100
5	Elective (Lab)	Discipline Specific Elective-1 (DSE-1) Lab	-	-	4	-	15	35	50
6	Elective (Lab)	Discipline Specific Elective-2 (DSE-2) Lab	-	-	4	-	15	35	50
7	Elective (Lab)	Discipline Specific Elective-3 (DSE-3) Lab	-	-	4	-	15	35	50
Total			11	3	12	20	170	380	550

Skill Enhancement Course (any four) (Credit: 02 each) - SEC 1 to SEC 4

SEMESTER-III (SEC-1: Opt any one)

SEC 301- Pisci-Culture

SEC 302- Fuel

SEC 303- Biofertilizers

SEMESTER-IV (SEC-2: Opt any one)

SEC 401- Poultry Farming
SEC 402- Basic Analytical Chemistry
SEC 403- Herbal Technology

SEMESTER-V (SEC-3: Opt any one)

SEC 501 — Apiculture
SEC 502 — Pharmaceutical Chemistry
SEC 503 — Plant Diversity and Human Welfare

SEMESTER-VI (SEC-4: Opt any one)

SEC 601- Sericulture
SEC 602- Chemistry of Cosmetics & Perfumes
SEC 603- Mushroom Culture Technology

Discipline Specific Elective papers (Credit: 06 each) opt any three subject from Vth sem & VIth Sem :

SEMESTER-V

DSE 501: Molecular Biology
DSE 502: Polymer Chemistry
DSE 503: Economic Botany and Biotechnology
DSE 504: Reproductive Biology
DSE 505: Applications of Computer in Chemistry

SEMESTER-VI

DSE 601: Immunology
DSE 602: Instrumental Methods of Chemical Analysis
DSE 603: Cell and Molecular Biology
DSE 604: Genetics and Plant Breeding
DSE 605: Green Chemistry

SEMESTER-I

ZBC101: English Communication

(Credits 2)

Unit 1: Theory of communication, types and modes of communication

Introduction. Definitions and function of communication, Need for effective communication, Process of communication, Barrier to communication, Kinds of

communication: intrapersonal, personal, group and mass verbal and non—verbal communication.

Unit 2: Listening and speaking skills

Types of listening, developing effective listening skills, Academic listening (Lectures), Listening to talks and presentation, Monologue, dialogue, group discussion, miscommunication, interview, public speech, Pronunciation, accent and intonation and rhythm.

Unit 3: Reading skills

Skimming, scanning, summary, paraphrasing, comprehension.

Introductory English Grammar

Parts of Speech, Tenses, punctuation, Common errors in English.

Unit 4: Writing Skills: Social and Official Correspondence

Enquiries complaints and replies, Letters to the editor, Social appeals in the form of letter/pamphlets, Standard business Letter, Email drafting and etiquettes, preparing agenda and writing minutes for meetings

Unit 5: Career skills

Job application, Cover letters, Bio-data, CV and Resume and effective profiling, Mock interviews Group discussions.

Suggested Readings:

1. Prasad, P. The functional Aspects of Communication Skills, Delhi.
2. Sen, Leena. Communication Skills, Prentice Hall of India, New Delhi.
3. McCarthy, Michael L English Vocabulary in Use, Cambridge University Press.
4. Rajinder Pal and Prem Lata. English Grammar and Composition, Sultan Chand Publication

ZBC102: Animal Diversity

(Credits 4)

Unit 1 : Kingdom Protista

General characters and classification up to classes; Locomotory Organelles and locomotion in Protozoa. Phylum Porifera: General characters and classification up to classes; Canal System in Sycon. Phylum Cnidaria: General characters and classification up to classes; Polymorphism in Hydrozoa.

Unit 2: Phylum Platyhelminthes

General characters and classification up to classes; Life history of Taenia solium. Phylum Nematelminthes: General characters and classification up to classes; Life history of Ascaris lumbricoides and its parasitic adaptations. Phylum Annelida: General characters and classification up to classes; Metamerism in Annelida.

Unit 3: Phylum Arthropoda

General characters and classification up to classes; Vision in Arthropoda, Metamorphosis in Insects. Phylum Mollusca: General characters and classification up to classes; Torsion in gastropods.

Unit 4: Protochordates

General features and Phylogeny of Protochordata. Agnatha: General features of Agnatha and classification of cyclostomes up to classes. Pisces: General features and Classification up to orders; Osmoregulation. Amphibia: General features and Classification up to orders; Parental care.

Unit 5 Reptiles

General features and Classification up to orders; Poisonous and non-poisonous snakes, Biting mechanism in snakes. Aves: General features and Classification up to orders; Flight adaptations. Mammals: Classification up to orders; Origin of mammals.

Suggested Readings:

1. Barnes, R.D. (1982). Invertebrate Zoology, V Edition. Holt Saunders International Edition.
2. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. and Spicer, J.L. (2002). The Invertebrates: A New Synthesis, III Edition, Blackwell Science
3. Barrington, E.J.W (1979). Invertebrate Structure and Functions. II Edition, E.L.B.S. and Nelson
4. Young, J. Z. (2004). The Life of Vertebrates. III Edition. Oxford university press.
5. Pough H. Vertebrate life, VIII Edition, Pearson International.
6. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and Bartlett Publishers Inc.
7. Kotpal, Agrawal & Khetrapal: Modern Text-book of Zoology, Invertebrates. Rastogi, 1976.

ZBC103: Organic Chemistry & Inorganic Chemistry . Hydrocarbons

(Credits 4)

Unit I : Inorganic Chemistry-I

Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time Independent Schrodinger equation and meaning of various terms in it. Significance of Ψ and Ψ^2 Schrodinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Shapes of s, p and d atomic orbitals nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals Anomalous electronic configurations.

Unit 2 : Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding Energy considerations in ionic bonding. Lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born—Lande equation for, calculation of lattice energy. Born—Haber cycle and its applications, polarizing power and polarizability. Fajan's rules. Ionic character in covalent compounds, bond moment, dipole moment, and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and, ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals; nonbonding combination of orbitals MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO'. comparison of VB and MO approaches.

Unit 3 :Organic Chemistry-I Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Unit 4 : Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis trans nomenclature; CIP Rules: R/S (for upto 2 chiral carbon atoms) and E/Z Nomenclature (For upto two C=C systems).

Unit 5: Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to the student in context to their structure.

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolb's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis—addition (alk. KMnO_4) and trans—addition (bromine), Addition of HX (Markownikoff's and anti—Markownikoff's addition), Hydration, Ozonolysis, oxymercuration demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO_4 , ozonolysis and oxidation with hot alk. KMnO_4 .

Suggested Readings:

1. J. D. Lee: A new Concise Inorganic Chemistry, E. L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexander: Concept and Models in Inorganic Chemistry, John Wiley.
4. James S. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T.W. Graham Solomon: organic Chemistry, John Wiley and Sons.
6. Peter Sykes; A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
7. E.L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. L.L. Finar: Organic Chemistry (Vol. I & II) E. L. B. S

ZBC104: Biodiversity(Microbes, Algae, Fungi and Arthropods) (Credits 4)

Unit 1: Microbes

Viruses — Discovery, general structure, replication (general account), DNA virus (Tphage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance; Bacteria— Discovery, General characteristics and cell structure; Reproduction — vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 2: Algae

General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following : Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia. Economic importance of algae

Unit 3:Fungi

Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True

Fungi- General characteristics, ecology and significance, life cycle of Rhizopus (Zygomycota) Penicillium, Alternaria (Ascomycota), Puccinia, Agaricus (Basidiomycota); Symbiotic Associations-Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit 4: Introduction to Archegoniate

Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Bryophytes

General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of Marchantia and Funaria. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of Sphagnum.

Unit 5:

Pteridophytes

General characteristics, classification, Early land plants (Cooksonia and Rhynia).. Classification (up to family), morphology, anatomy and reproduction of Selaginella, Equisetum and Pteris. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.

Gymnosperms

General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of Cycas and Pinus. (Developmental details not to be included). Ecological and economical importance.

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi.
 - a. 2nd edition;
2. Tortora, G.J., Funke, B.R., Case, CL. (2010). Microbiology: An Introduction, Pearson a. Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan a. Publishers Pvt. Ltd., Delhi.
4. Vashishta, P.C., Sinha, A.K, Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
5. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd a. Publishers, New Delhi, India.

ZBC P12: Animal Diversity—Lab

(Credits 2)

Kingdom Protista: Amoeba, Euglena, Plasmodium, Paramecium

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

Phylum Cnidaria: Obelia, Physalia, Aurelia, Tubipora, Metridium

Phylum Platyhelminthes: Taenia solium and Study of its life history stages

Phylum Nematelminthes: Male and female Ascaris lumbricoides

Phylum Annelida: Aphrodite, Nereis, Pheretima, Hirudinaria

Phylum Arthropoda: Palaemon, Cancer Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis

Phylum Mollusca: Chiton, Dentalium, Pita, Lnio, Loligo, Sepia, Octopus Phylum

Echinodermata: Pentaceros, Ophiura, Echinus, Cucurnaria and Antedon

Protochordata: Balanoglossus, I-Ierdmania, Branchiostoma, Agnatha: Petromyzon

Pisces: Sphyrna, Pristis, Torpedo, Labeo, Exocoetus, Anguilla,

Amphibia: Ichthyophis / Ureotyphlus, Salamandra, Bufo, Hyla

Reptilia: Chelone, Hem idactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gáivalis Key for Identification of poisonous and non-poisonous snakes

Ayes: Study of six common birds from different orders

Mammalia: Sorex, , Bat, Funambulus, Loris, An “animal album” containing photographs, cut outs, with appropriate write up about the above mentioned taxa. Different taxa / topics may be given to different sets of students for this purpose.

These need riot be repeated as drawings by the album maker.

ZBC P13: Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons Lab (Credits 2)

Section A: Inorganic Chemistry — Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO_4 .
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO_4 .
4. Estimation of Fe (II) ions by titrating it with $\text{K}_2\text{Cr}_2\text{O}_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $\text{Na}_2\text{S}_2\text{O}_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).
2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given).
 - (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
 - (b) Identify and separate the sugars present in the given mixture by paper chromatography.

Suggested Readings:

1. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
2. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
3. Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall, 5th edition.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman.

ZBC P14: Biodiversity (Microbes, Algae, Fungi and Archegoniate)-Lab (Credits 2)

1. EMs/Models of viruses — T-Phage and TMV, Line drawing/Photograph of Lytic and
2. J.vsogenic Cycle.
3. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary
4. Fission; Conjugation; Structure of root nodule.

5. Gram staining
6. Study of vegetative and reproductive structures of Nostoc, Chlamydomonas (electron micrographs), Oedogonium, Vaucheria, Fucus* and Polysiphonia through temporary preparations and permanent slides. (* Fucus - Specimen and permanent slides)
7. Rhizopus and. Penicillium: Asexual stage from temporary mounts and sexual structures through permanent slides.
8. Alternaria: Specimens/photographs and tease mounts.
9. Puccinia: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
10. Agaricus: Specimens of button stage and full grown mushroom; Sectioning of gills of
11. Agaricus.
12. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
13. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
14. **Marchantia**- morphology of thallus, w.m. rhizoids and scales, vs. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
15. **Funaria**- morphology, w.m. leaf rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
16. **Selaginella**- morphology, w.m. leaf with ligule, t.s. stem; w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
17. **Equisetum**- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s. rhizome (permanent slide).
18. **Pteris**- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
19. **Cycas**- morphology (coralloid roots, bulbil leaf), t.s. coralloid root, t.s. rachis, vs. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
20. **Pinus**- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

SEMESTER II

ZBC201: Environmental Science

(Credits 2)

Unit I

Introduction to Environmental Sciences Multi-disciplinary nature of Environmental Sciences; Scope and importance; Concept of sustainability and sustainable development. Ecosystems: What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystem: a. Forest ecosystem b. Grassland ecosystem c. Desert ecosystem d. Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 2

Natural Resources: Renewable and Non-renewable Resources ' Land resources and land use change; Land degradation, soil erosion and desertification. ' Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and Over exploitation of surface and grounds water, flood, droughts, conflicts over water(international and interstate).Energy resources, renewable and non renewable energy resources, use of alternate energy sources, growing energy needs, case studies.

Unit 3

Environmental Pollution a Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution ' Nuclear hazards and human health risks Solid waste management: Control measures of urban and industrial waste. Pollution case studies.

Unit 4

Environmental Policies & Practices Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture Environment Laws: Environment Protection Act 1986; Air (Prevention & Control of Pollution) Act 1981; Water (Prevention and control of Pollution) Act 1974; Wildlife Protection Act 1972; Forest Conservation Act 1980. International agreements: Montreal protocol, Kyoto protocol and Convention on Biological Diversity (CBD). Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Unit 5

Human Communities and the Environment .Human population growth: Impacts on environment, human health and welfare. a Resettlement and rehabilitation of project affected persons; case studies. Disaster management: floods, earthquake, cyclones and landslides. Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan, \$ Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

Unit 6

Field work Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc. Visit to a local polluted site--Urban/Rural/industrial/Agricultural.. Study of common plants, insects, birds and basic principles of identification. 'Study of simple ecosystems-- pond, river, lake, forest patch, grassland, Delhi Ridge, etc.

Suggested Readings:

1. Carson, R 2002. Silent Spring. Houghton Mifflin Harcourt
2. Gadgil, M., & Guha, R. 1993, This Fissured Land: An Ecological History Of India, Univ. of California Press.
3. Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.
4. Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.

COMPARATIVE ANATOMY**Unit 1**

Integumentary System: Derivatives of integument w.r.t. glands and digital tips. Skeletal System: Evolution of visceral arches. Digestive System: Brief account of alimentary canal and digestive glands. Respiratory System; Gills, lungs, air sacs and swim bladder.

Unit 2

Circulatory System: Evolution of heart and aortic arches. Urinogenital System: Succession of kidney, Evolution of urino-genital ducts. Nervous System: Comparative account of brain. Sense Organs: Types of receptors.

DEVELOPMENTAL BIOLOGY**Unit 3: Early embryonic development**

Gametogenesis: Spermatogenesis and oogenesis in mammals, vitellogenesis in birds.

Fertilization: external (amphibians), internal (mammals), blocks to polyspermy; Early development of frog and humans (structure of mature egg and its membranes, patterns of cleavage, fate map, upto formation of gastrula); types of morphogenetic movements; Fate of germ layers; Neurulation in frog embryo.

Unit 4: Late embryonic development

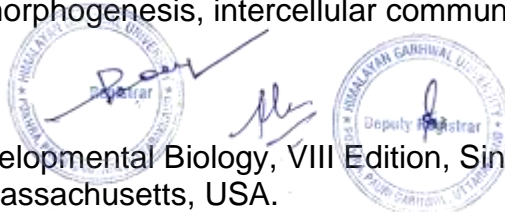
Implantation of embryo in humans, Formation of human placenta and functions, other types of placenta on the basis of histology; Metamorphic events in frog life cycle and its hormonal regulation.

Unit 5: Control of Development

Fundamental processes in development (brief idea) Gene activation, determination, induction, Differentiation, morphogenesis, intercellular communication, cell movements and cell death.

Suggested Readings:

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Carlson, Bruce M (1996). Patten's Foundations of Embryology, McGraw Hill, Inc.
4. Kardong, K.V. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
5. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
6. Weichert C .K and William Presch (1970). Elements of Chordate Anatomy, Tata McGraw Hills Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons.



9.. Walter, H.E. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House.

ZBC203: Chemical Energetics, Equilibria & Functional Organic Chemistry
(Credits 4)

Physical Chemistry-I

Unit 1: Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics, Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature — Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG° , Le Chatelier's principle.

Relationships between K_p , K_e and K_x for reactions involving ideal gases.

Ionic Equilibria :Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts — applications of solubility product principle.

Organic Chemistry-2

Unit 3: Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Unit 4: Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1 S_N2 and S_Ni) Reactions,

Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides Preparation: (Chloro, bromo. and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$)

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, Benzyl, vinyl and aryl halides.

Unit 5

Alcohols, Phenols and Ethers (Upto 5 Carbons)

Alcohols: Preparation: Preparation of 1°, 2° and 3° alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions; With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO₄, acidic dichromate, conc. HNO₃) Oppeneauer oxidation Diols:

(Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben—Hoesch Condensation, Schotten — Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde

Preparation: from acid chlorides and from nitriles.

Reactions — Reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test.

Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation.

Clemensen reduction and Wolff Kishner reduction. Meerwein-Ponndorf Verley reduction.

Suggested Readings:

1. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
2. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient a. Longman.
3. I.L Finar: Organic Chemistry (Vol 1 & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
5. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
6. G. M. Barrow: Physical Chemistry Tata McGraw-Hill. (2007).
7. G. W. Castellan: Physical Chemistry 4th Edn Narosa (2004).
8. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Learning a. India Pvt. Ltd., New Delhi (2009).
9. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
10. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York a. (1985).

ZBC204: Plant Ecology and Taxonomy

(Credits 4)

Unit 1: Introduction

Ecological factors

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Plant communities

Characters; Ecotone and edge effect; Succession; Processes and types.

Unit 2: Ecosystem

Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous

Phytogeography

Principle biogeographical zones; Endemism.

Unit 3: Introduction to plant taxonomy

Identification, Classification, Nomenclature. Taxonomic hierarchy Ranks, categories and taxonomic groups

Identification

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

Taxonomic evidences from palynology, cytology, phytochemistry and molecular data.

Unit 4: Botanical nomenclature

Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Classification

Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).

Biometrics, numerical taxonomy and cladistics

Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Unit 5: Taxonomy, important distinguishing characters, classification, and economic importance of the following families:

Ranunculaceae, Papaveraceae, Caryophyllaceae, Malvaceae, Rutaceae, Fabaceae, Apiaceae, Solanaceae, Apocyanaceae, Asclepidiaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Poaceae.

ZBC P22: Comparative Anatomy and Developmental Biology — Lab (Credits 2)

COMPARATIVE ANATOMY

1. Osteology:

- a Disarticulated skeleton of fowl and rabbit
- b. Carapace and plastron of turtle /tortoise.
- c.. Mammalian skulls: One herbivorous and one carnivorous animal,

2. Frog - Study of developmental stages- whole mounts and sections through permanent slides — cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.

3. Study of the different types of placenta- histological sections through permanent slides or photomicrographs

4. Study of placental development in humans by ultrasound scans.

5. Examination of gametes - frog/rat - sperm and ova through permanent slides or photomicro graphs

Unit 3: Early embryonic development

Fertilization: external (amphibians), internal (mammals), blocks to polyspermy; Early development of frog and humans (structure of mature egg and its membranes, patterns of cleavage, fate map, upto formation of gastrula); types of morphogenetic movements; Fate of germ layers; Neurulation in frog embryo.

Implantation of embryo in humans, Formation of human placenta and functions, other types of placenta on the basis of histology; Metamorphic events in frog life cycle and its hormonal regulation.

Fundamental processes in development (brief idea) Gene activation, determination, induction, Differentiation, morphogenesis, intercellular communication, cell movements and cell death.

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
4. Carlson, Bruce M (1996). Patten's Foundations of Embryology, McGraw Hill, Inc.
5. Kardong, KV. (2005) Vertebrates' Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.
7. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.
8. Weichert C .K and William Presch (1970). Elements of Chordate Anatomy, Tata McGraw Hills Hilderbrand, M and Gaslow G.E. Analysis of Vertebrate Structure, John Wiley and Sons.
- 9.. Walter, RE. and Sayles, L.P; Biology of Vertebrates, Khosla Publishing House

Thermochemistry

- ## Ionic equilibria

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

Preparation of buffer solutions:

Sodium acetate-acetic acid

Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and
2. distillation
3. Criteria of Purity: Determination of melting and boiling points.
- 4 Preparations: Mechanism of various reactions involved to be discussed.
5. Recrystallisation, determination of melting point and calculation of quantitative
6. yields to be done.
 - (a) Bromination of Phenol/Aniline
 - (b) Benzoylation of amines/phenols
 - (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone *

ZBC P24: Plant Ecology and Taxonomy-Lab (Credits 2)

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates,
3. sulphates, organic matter and base deficiency by rapid field test.
4. Comparison of bulk density, porosity and rate of infiltration of water in soil of three habitats.
- 5 (a) Study of morphological adaptations of hydrophytes and xerophytes (four each).
(b) Study of biotic interactions of the following: Stem parasite (Cuscuta), Root parasite (Orobanchaceae), Epiphytes, Predation (Insectivorous plants)
6. (Orobanchaceae), Epiphytes, Predation (Insectivorous plants)
7. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed)
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law
9. Study of vegetative and floral characters of the following families (Description, VqS. flower, section of ovary, floral diagrams, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae -Brassica, Alyssum or Iberis; Asteraceae -Sonchus/Oxalis, Vernonia/Ageratum, Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae -Asphodelus / Lilium / Allium.
10. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label
11. Taxonomic treatment of plant species belonging to families mentioned in the syllabus.
12. Study of taxonomic terminology



Suggested Readings

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). Plant Systematics Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & LBH Pvt. Ltd., New Delhi. 3rd edition.

SEMESTER-III

ZBC302: Physiology and Biochemistry

(Credits 4)

A. PHYSIOLOGY

Unit 1. Nerve and muscle

Structure of a neuron, Resting membrane potential, Graded potential, Origin of Action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction

Unit 2 Digestion

Digestion in different segments of the alimentary canal; Absorption of carbohydrates, proteins, lipids

Unit 3. Respiration: Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood.

Unit 4. Excretion; Structure of nephron, mechanism of Urine formation

Unit 5. Cardiovascular system

Blood: Composition, Hemostasis, Heart structure, Origin and conduction of the cardiac impulse, cardiac cycle

Unit 6. Reproduction and Endocrine Glands

Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle; Structure and function of pituitary, thyroid, parathyroid, pancreas and adrenal

SUGGESTED READINGS

1. Tortora, G.J. & Derrickson, B.H. (2009). Principles of Anatomy and Physiology, 12th edn., John Wiley & Sons, Inc.
2. Widmaier, E.P., Rafferty, H. & Strang, K.T. (2008) Vander's Human Physiology, 10th edn., McGraw Hill
3. Guyton, A.C. & Hall, J.E. (2011) Textbook of Medical Physiology, 12th edn., Harcourt Asia Pvt Ltd & W.B. Saunders Company
4. Nielson: Animal Physiology, Cambridge.
5. Textbook of Physiology by A K Jaiswal; APC New Delhi
6. Animal Physiology and related Biochemistry, H R Singh and N. Kumar SL, Nagin Chand and Co, Delhi

B. BIOCHEMISTRY

Unit 7. Carbohydrate Metabolism

Glycolysis, Krebs Cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogen metabolism, Review of electron transport chain

Unit 8. Lipid Metabolism

Biosynthesis and β oxidation of palmitic acid

Unit 9. Protein metabolism

Transamination, Deamination and Urea Cycle

Unit 10 Enzymes

Introduction, Mechanism of action, Kinetics, Inhibition and Regulation

SUGGESTED READINGS

1. Berg, J. M, Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. WH Freeman and Co.
- 2; Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009) . Principles of Biochemistry. IV Edition. W.H Freeman and Co.
3. Murray, FL K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry. XXVIII Edition. Lange Medical Books/Mc Graw-Hill

ZBC303: Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry—II (Credits 4)

Section A: Physical Chemistry2

Solutions

Thermodynamics of ideal solution: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius — Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $\text{FeCl}_3\text{-H}_2\text{O}$ and Na-K only).

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation thermodynamic properties: ΔG , ΔH and ΔS from EMF data.

Calculation of equilibrium constant from EMF data, Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry-3

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and Alkaline hydrolysis of esters.

Reactions: Hell — Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): Upto. 5 carbons

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann-Brown reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2 , Schotten — Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: Preparation: from aromatic amines.

Reactions: conversion to benzene, phenol, dyes.

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of $-\text{COOH}$ group, acetylation of $-\text{NH}_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edman degradation (N-terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-'-Hill (2007).
2. G. W Castellan: Physical Chemistry 4th Ed. Narosa (2004).
3. J. C. Kotz, P. M. Treichel, I it Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
- 5 R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co: New York (1985).
6. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W.H. Freeman.
10. Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman

ZBC304: Plant Anatomy and Embryology

(Credits 4)

Unit 1:

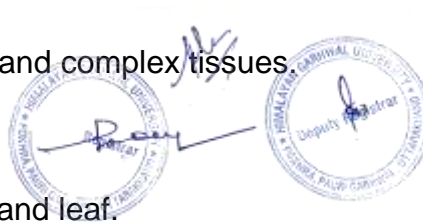
Meristematic and permanent tissues

Root and shoot apical meristems; Simple and complex tissues

Unit 2:

Organs

Structure of dicot and monocot root stem and leaf.



Secondary Growth

Vascular cambium — structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Unit 3:

Adaptive and protective systems

Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Unit 4:

Structural organization of flower

Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Pollination and fertilization

Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit5:

Embryo and endosperm

Endosperm types, structure and functions; Dicot and monocot embryo; Embryoendosperm relationship.

Apomixis and polyembryony

Definition, types and practical applications.

ZBC P32: Physiology and Biochemistry-Lab

(Credits 2)

A. PHYSIOLOGY

1. Preparation of hemin and hemochromogen crystals
2. Examination of permanent histological sections of mammalian pituitary, thyroid, parathyroid, pancreas, adrenal,
3. Examination of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage

B. BIOCHEMISTRY

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

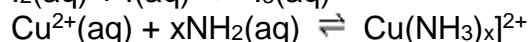
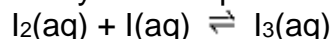
ZBC P33: Solutions, Phase Equilibrium, Conductance, Electrochemistry & Biomolecules Lab

(Credits 2)

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:



Phase equilibria

- a. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
- b. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
- c. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

b. Conductance

1. Determination of cell constant

- II Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid,
 III Perform the following conductometric titrations:
 i. Strong acid vs. strong base ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

- i. Strong acid vs. strong base
- ii. Weak acid vs. strong base
- iii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

I Systematic Qualitative Organic Analysis. of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
- 3 Titration curve of glycine
4. Action of salivary amylase on starch•
- 5 Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing/nonreducing sugar.

Reference Books:

1. A.L Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
- 2 F.G. Mann & B.L. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960
3. B.D. Khosla: Senior Practical Physical Chemistry, K Chand & Co.
4. Ahluwalia, V.I.C. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

ZBC P34: Plant Anatomy and Embryology-Lab

(Credits 2)

Practical

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs)
3. Stem: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
4. Root: Monocot: Zea mays; Dicot: Helianthus; Secondary: Helianthus (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (Nerium oleander); Hydrophyte (Hydrilla stem).
7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circumscissile, amphitropous/campylotropous.

9. Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (Permanent slides/photographs).
10. Ultrastructure of mature egg apparatus cells through electron micrographs.
11. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
12. Dissection of embryo /endosperm from developing seeds.
13. Calculation of percentage of germinated pollen in a given medium.

Suggested Readings

1. Bhojwani, SS. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas
2. Publication House Pvt. Ltd. New Delhi. 5th edition,
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

SEMESTER.- IV

ZBC402: Genetics and Evolutionary Biology

(Credits 4)

A. GENETICS

Unit 1.Introduction to Genetics

Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information.

Unit 2.Mendelian Genetics and its Extension

Principles of Inheritance, Chromosome theory of inheritance, Pedigree analysis, Incomplete dominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Polyotropy, Environmental effects on phenotypic expression, sex linked inheritance, extrachromosomal inheritance involving mitochondria and chloroplast.

Unit 3.Linkage, Crossing. Over and Chromosomal Mapping

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics — an alternative approach to gene mapping.

Unit 4. Mutations

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy; Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations

Unit 5. Sex Determination

Chromosomal mechanisms, dosage compensation

Unit 6. Quantitative Genetics

Quantitative and multifactor inheritance, Transgressive variations, Heterosis

SUGGESTED READINGS

1. Gardner, E.J., Simmons, MJ., Snustad, D.P. (2008). Principles of Genetics. VIII Edition. Wiley India.

2. Snustad, D.P., Simmons, Mi. (2009). Principles of Genetics. V Edition. John Wiley and Sons inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. Introduction to Genetic Analysis. IX Edition; W. H. Freeman and Co.
6. P S Verma and V K Agrwal (2010) Cell biology, genetics, molecular biology and Evolution. S Chand & Company.

B. EVOLUTIONARY BIOLOGY

Unit 1: History of Life: Major Events in History of Life

Unit 2: Introduction to Evolutionary Theories: Lamarckism, Darwinism, Neo-Darwinism:

Unit 3: Direct Evidences of Evolution: Types of fossils, Incompleteness of fossil record, Dating of fossils, Phylogeny of horse

Unit 4: Processes of Evolutionary Change: Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection

Unit 5: Species Concept: Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric).

Unit 6: Evolution above species level: Macro-evolutionary Principles (example: Darwin's Finches)

Unit 7: Extinction: Mass extinction (Causes, Names of five major extinctions, K-T extinction in detail), Role of extinction in evolution

SUGGESTED READINGS

1. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Hall, B. K. and Hallgrinsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
4. Campbell, N. A. and Reece J. B. (2011). Biology. IX Edition, Pearson, Benjamin, Cummings.
5. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
6. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley.

ZBC403: Chemistry of S- and P-Block Elements, States of Matter & Chemical Kinetics (Credits 4)

General Principles of Metallurgy

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon as reducing agent.

Hydrometallurgy, Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn): electrolytic, oxidative refining, Kroll process, Parting process, van Arkel-de Boer process and Mond's process.

s- and p-Block Elements

Periodicity in s- and p-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity (Pauling, Mulliken, and Alfred-Rochow scales). Allotropy in C, S, and P.

Oxidation states with reference to elements in unusual and rare oxidation states like carbides and nitrides), inert, pair effect, diagonal relationship and anomalous behaviour of first member of each group.

Compounds of s- and p-Block Elements

Hydrides and their classification (ionic, covalent and interstitial), structure and properties with respect to stability of hydrides of p- block elements.

Concept of multicentre bonding (diborane).

Structure, bonding and their important properties like oxidation/reduction, acidic/basic nature of the following compounds and their applications in industrial, organic and environmental chemistry.

Hydrides of nitrogen (NH_3 , N_2H_4 , N_3H , NH_2OH) Oxoacids of P, S and Cl.

Halides and oxohalides: PCl_3 , PCl_5 , SOCl_2 and SO_2Cl_2

Section B: Physical Chemistry-3 (30 Lectures) Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation, van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2 .

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation — derivation not required) and their importance.

Temperature dependence of these distributions, Most probable, average and root mean square velocities (no derivation) Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of

interfacial angles, Law of rational indices. Miller indices. X—Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half—life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw--Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
1. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
5. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S
7. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
8. D. F Shriver and P. W. Atkins: Inorganic Chemistry, Oxford University Press.

ZBC404: Plant Physiology and Metabolism

(Credits 4)

Unit 1:

Plant—water relations

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2:

Mineral nutrition

Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

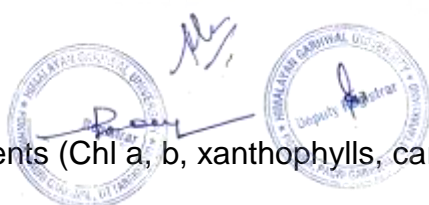
Translocation in phloem

Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.

Unit 3:

Photosynthesis

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II,



reaction center; antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 4:

Respiration

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit5:

Enzymes

Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Nitrogen metabolism

Biological nitrogen fixation; Nitrate and ammonia assimilation.

Plant growth regulators

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Plant response to light and temperature

Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

ZBC P42: Genetics and Evolutionary Lab

(Credits

2)

A. GENETICS

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

B. EVOLUTIONARY BIOLOGY

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

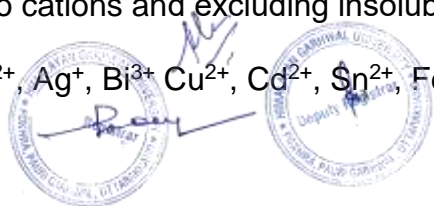
ZBC P43: Chemistry of S and P-Block Elements, States of Matter & Chemical Kinetics. Lab

(Credits 2)

Section A: Inorganic Chemistry

Semi-micro qualitative analysis using H₂S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the 'following:

Cations : NH₄⁺, Pb²⁺, Ag⁺, Bi³⁺, Cu²⁺, Cd²⁺, Sn²⁺, Fe³⁺, Al³⁺, Co²⁺, Cr³⁺, Ni²⁺, Mn²⁺, Zn²⁺, Ba²⁺, Sr²⁺, Ca²⁺, K⁺



Anions : CO_3^{2-} , S^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$, NO_3^- , CH_3COO^- , Cl^- , Br^- , I^- , NO_3^- , SO_4^{2-} , PO_4^{3-} , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, F^-

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

- Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
- Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

- Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
- Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions

- Initial rate method: Iodide-persulphate reaction
- Integrated rate method:
 - Acid hydrolysis of methyl acetate with hydrochloric acid.
 - Saponification of ethyl acetate:
 - Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Reference Books:

- A.I. Vogel, Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- Al. Vogel, Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

ZBC P44: Plant Physiology and Metabolism-Lab

(Credits 2)

Practical

- Determination of osmotic potential of plant cell sap by plasmolytic method.
- To study the effect of two environmental factors (light and wind) on transpiration by excised twig
- Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
- Demonstration of Hill reaction.
- Demonstrate the activity of catalase and study the effect of pH and enzyme concentration.
- To study the effect of light intensity and bicarbonate ion concentration on O_2 evolution in photosynthesis.
- Comparison of the rate of respiration in any two parts of a plant.
- Separation of amino acids by paper chromatography.

Demonstration experiments (any four)

- Bolting.
- Effect of auxins on rooting.

3. Suction due to transpiration.
- 4 R.Q.
5. Respiration in roots.

Suggested Readings

1. Taiz, L., Zeiger, B., (2010), Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, NY., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology A Laboratory Manual. Narosa Publishing House, New Delhi.

Skill Enhancement Course (any four) (Credit: 02 each) SEC I to SEC 4

(One each 3rd, 4th, 5th and 6th semester)

SEMESTER-III (Opts any one) (SEC-1)

(Elective paper) SEC301: Pisciculture

(Credits 2)

Unit 1: Scope of Aquaculture. Importance of cultivable fresh Water, marine ornamental species.

Unit 2: Fish farm Maintenance — Farm management technique, water quality, temperature and accessories in Farm management viz Aerator, Filter, paddler

Unit 3: Fish culture technique, Monoculture, Polyculture and monosex culture, Induced fish breeding, Integrated fish farming

Unit 4: Fish nutrition and fish formulations live fish live .fish transport.

Unit 5: Prevention and control of fish diseases.

(Elective paper) SEC302: Fuel Chemistry

(Credits 2)

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

Coal: Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal.Coal gas, producer gas and water gas- composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Petroleum and Petrochemical Industry: Composition of crude petroleum, Refining and different types of petroleum products and their applications.

Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels.

Petrochemicals: Vinyl acetate, Propylene oxide; Isoprene, Butadiene, Toluene and its derivatives Xylene.

Lubricants: Classification of lubricants, lubricating oils (conducting and non-conducting) Solid and semisolid lubricants, synthetic lubricants.

Properties of lubricants (viscosity index, cloud point, pour point) and their determination.

Reference Books:

- a. E. Stocchi: Industrial Chemistry, Vol -1, Ellis Horwood Ltd. UK.
- b. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- c. B.K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

(Elective paper) SEC303: Biofertilizers

(Credits 2)

Unit 1:

General account about the microbes used as biofertilizer — Rhizobium — isolation, identification, mass multiplication, carrier based inoculants, Actinorrhizal symbiosis.

Unit 2:

Azospirillum: isolation and mass multiplication — carrier based inoculant, associative effect of different microorganisms. Azotobacter: classification, characteristics — crop response to Azotobacter inoculum, maintenance and mass multiplication.

Unit3:

Cyanobacteria (blue green algae), Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla in rice cultivation.

Unit 4:

Mycorrhizal association, types of mycorrhizal association, taxonomy, occurrence and distribution, phosphorus nutrition, growth and yield — colonization of VAM — isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit 5:

Organic farming — Green manuring and organic fertilizers, Recycling of biodegradable municipal, agricultural and Industrial wastes — biocompost making methods, types and method of vermicomposting — field Application.

Suggested Readings

1. Dube, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Ernakulam Publication, New Delhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vyas, S.C, Vyas, S. and Modi, H.A. 1998 Bio-fertilizers and organic Farming Akta Prakashan, Nadiad

SEMESTER IV (Opt. any one) (SEC-2)

(Elective paper) SEC401: Poultry Farming

(Credits 2)

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

Unit 2: Classification of Fowls based on their use : Meat type such as Broilers, Egg type such as White Leghorn and Commercial layers, Dual purpose varieties, Game and Ornamental purpose varieties.

Unit 3: Feeding Poultry — Management of Egg Layers — Management of Broilers in large scale farms.

Unit 4: Poultry diseases Viral, Bacterial, Fungal, Protozoan and Parasitic Lice etc., Prevention and precautions during vaccination.

Unit 5: Management of a modern Poultry Farms — Progressive plans to promote Poultry as a Self-Employment venture.

(Elective paper) SEC402: Basic Analytical Chemistry

(Credits 2)

Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature.

Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil: Composition of soil, Concept of pH and $pT-1$ measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

- a. Determination of pH of soil samples
- b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

- a. Determination of pH , acidity and alkalinity of a water sample.
- b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.

- a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
- b. Analysis of preservatives and colouring matter.

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

- a, Paper chromatographic separation of mixture of metal ion (Fe and Al).
- b. To compare paint samples by TLC method.

Ion-exchange: Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function



- a. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
- b. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration,

Suggested Applications (Any one):

- a. To study the use of phenolphthalein in trap cases.
- b. To analyze arson accelerants,
- c. To carry out analysis of gasoline.

Suggested Instrumental demonstrations;

- a. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
- b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
- c. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Reference Books:

1. Willard, H. H. Instrumental Methods of Analysis, CBS Publishers.
2. Skoog & Lerry. Instrumental Methods of Analysis, Saunders College Publications, New York. III
3. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed, Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. Quantitative Chemical Analysis, W, H. Freeman.
5. Dean, J. A. Analytical chemistry Notebook, McGraw Hill.
6. Day, R. A, & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry I' Ed., W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel; A. I. Vogel's Qualitative Inorganic Analysis 7th ,Ed., Prentice Hall.
10. Vogel, A. I. Vogel's Quantitative Chemical Analysis Ed., Prentice Hall.

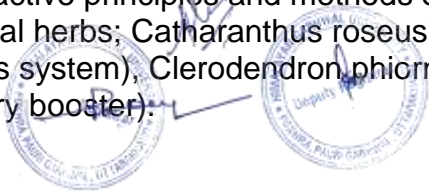
(Elective paper) SEC403: Herbal Technology

(Credits 2)

Unit 1: Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Ayurveda/Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.

Unit 2: Pharmacognosy - systematic position and medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.

Unit 3: Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; Catharanthus roseus (cardiotonic), Withania somnifera (drugs acting on nervous system), Clerodendron phicnoides (antirheumatic) and centella asiatica (memory booster):



Unit 4: Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation
- Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds)

Unit 5: Medicinal plant banks micro propagation of important species (Withania somnifera, neem and tulsi- Herbal foods-future of pharmacognosy)

Suggested Readings

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and LC.Chopra, 1956. C.S.I.R, New Delhi.
2. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International Book Distributors.
3. Herbal plants and Drugs Agnes Arber, 1999, Mangal Deep Publications.
4. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994. Oxford IBH publishing Co.
5. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi,
6. Principles of Ayurveda,. Anne Green, 2000. Thomsons, London.
7. Pharmacognosy, Dr.C.K.Kokate et al. 1999. Nirali Prakashan.

SEMESTER V(Opt. any one) (SEC-3) (Elective paper) SEC501: Apiculture

(Credits 2)

Unit 1 : History - Biology and classification of honey bees, species of honey bees, Social organization of honey bee colony.

Unit 2: Bee hive — Flora for apiculture — Selection of bees for apiculture, Method of bee Keeping — Indigenous method of Extraction of honey

Unit 3: Modern method of apiculture — Appliances for modern method. Diseases of Honey bee and control measures.

Unit 4: Products of bee keeping : Honey Bee wax— Honey : Production, Chemical composition — Economic importance of Honey bee wax.

Unit 5: Bee enemies — Bee keeping industry — Recent efforts — Modern method in employing honey bees for cross pollination in horticultural gardens.

(Elective paper) SEC502: Pharmaceutical Chemistry Drugs & Pharmaceuticals

(Credits 2)

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, antiinflammatory agents (Aspirin, paracetamol, ibuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazole, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glycerol trinitrate), antileprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Fermentation

Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

Practicals

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

Reference Books:

1. G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. Hakishan, V1K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. William O. Foye, Thomas L., Lemke, David A. William: Principles of Medicinal Chemistry, B.I, Waverly Pfl Ltd. New Delhi.

(Elective paper) SEC503: Plant Diversity and Human Welfare (Credits 2)

Unit 1:

Plant diversity and its scope- Genetic diversity, Species diversity, Plant diversity at the ecosystem level, Agrobiodiversity and cultivated plant taxa, wild taxa. Values and uses of Biodiversity: Ethical and aesthetic values, Precautionary principle, 'Methodologies for valuation, Uses of plants, Uses of microbes.

Unit 2:

Loss of Biodiversity: Loss of genetic diversity, Loss of species diversity, Loss of ecosystem diversity, Loss of agrobiodiversity, Projected scenario for biodiversity loss, Management of Plant

Biodiversity: Organizations associated with biodiversity management Methodology for execution IUCN, UNEP, UNESCO, WWF, NBPGR; Biodiversity legislation and conservations, Biodiversity in formation management and communication.

Unit 3:

Conservation of Biodiversity: Conservation of genetic diversity, species diversity and ecosystem diversity, In situ and ex situ conservation, Social approaches to conservation, Biodiversity awareness programmes, Sustainable development.

Unit 4:

Role of plants in relation to Human Welfare; (a)

Cereals- Wheat, Rice Pulses- A general account Fruits- A general account Alcoholic beverages.

Unit 5:

Role of plants in relation to Human Welfare; (b)

Importance of Forestry its utilization and commercial aspects, Wood, Ornamental plants of India.

Suggested Readings

- 1 Krishnamurthy, K.V. (2004). An Advanced Text Book of Biodiversity — Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi

SEMESTER-VI (SEC-4: Opt any one)

(Elective paper) SEC601 Sericulture (Credits 2)



Unit 1: Classification of commercial varieties of mulberry. Mulberry plantation establishment and cultivation practices.

Unit 2: Diseases of mulberry fungal, bacterial, viral and Nematode diseases, Deficiency diseases and their remedial measures.

Unit 3: Silkworm rearing operations — Chawki rearing and Late age rearing techniques.

Unit 4: Physical and commercial characters of Cocoons. Reeling operations; Importance of by-products of Sericulture.

Unit 5: Economics of Sericulture — Future and progress of Sericulture Industry in India. Prospects of Sericulture as Self-Employment venture.

(Elective paper) SEC602 Chemistry of Cosmetics & Perfumes (Credits 2)

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practicals

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

Reference Books:

- E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
- P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
- BK. Sharma: Industrial Chemistry, God Publishing House, Meerut.

(Elective paper) SEC603- Mushroom Culture Technology (Credits 2)

Unit 1:

Introduction history. Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms. Types of edible mushrooms available in India *Volvarela volvacea*, *Pleurotus citrinopileatus*, *Agaricus bisporus*.

Unit 2:

Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels; inoculation hook, inoculation loop, 16w cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag.

Unit 3:

Pureculture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production.

Unit 4:

Storage and nutrition : Short-term storage (Refrigeration - upto 24 hours) Long term Storage (canning, pickles, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content Vitamins.

Unit 5:

Food Preparation: Types of foods prepared from mushroom. Research Centres - National level and Regional level. Cost benefit ratio - Marketing in India and abroad, Export Value.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore -560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol I & Vol. II.

Discipline Specific Elective papers (Credit: 06 each) opt any three subject from Vth sem & VIth Sem:

SEMESTER-V

(Elective paper) DSE501: Molecular Biology

(Credits 4)

Unit 1:

DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication.

Unit 2:

DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

Unit 3:

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains

Unit 4:

Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

Unit 5: Regulation of gene expression and translation

Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics. Ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Fidelity of translation, Inhibitors of translation. , Posttranslational modifications of proteins.

SUGGESTED READINGS

1. Friefelder: Molecular Biology. Narosa Publ, House.
2. De Robertis- Cell and Molecular Biology
3. Alberts et. al.: Molecular Biology of the cell, Garland Publ, New York.
4. Verma, P.S. and Agrwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)

DSE P51: Molecular Biology-Lab

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA. from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity

(Elective paper) DSE502 Polymer Chemistry

(Credits 4)

Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular force and chemical bonding in polymers, Texture of Polymers.

Functionality and its importance:

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems.

Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Nature and structure of polymers-Structure Property relationships.

Determination of molecular weight of polymers (M_n , M_w etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.
Polydispersity index.

Glass transition temperature (T_g) and determination of T_g , Free volume theory, WLF equation, Factors affecting glass transition temperature (T_g).



Polymer Solution — Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers:

polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers, Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

Reference Books:

- Seymour's Polymer Chemistry, Marcel Dekker, Inc.
- G. Odian: Principles of Polymerization, John Wiley.
- F.W. Billmeyer: Text Book of Polymer Science, John Wiley.
- P. H. Plesch: Polymer Science & Technology, Tata McGraw-Hill.

DSE P52: Polymer Chemistry-Lab

(Credits 2)

1. Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
 - a. Purification of monomer
 - b. Polymerization using benzoyl peroxide (BPO)/ 2,2'-azo-bis-isobutyronitrile (AIBN)
2. Preparation of nylon 66/6
 1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
 - a. Preparation of IPC /
 - b. Purification of IPC
 - c. Interfacial polymerization
 3. Redox polymerization of acrylamide.
 4. Precipitation polymerization of acrylonitrile
 5. Preparation of urea-formaldehyde resin
 6. Preparations of novalac resin/resold resin.
 7. Microscale Emulsion Polymerization of Poly (methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry: (a) Polyacrylamide aq. NaNO₂ solution (b) (Poly vinyl pyrrolidone (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.

5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

at least 7 experiments to be carried out.

Reference Books:

- Malcolm P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed.
- Harry R. Ailcock Frederick W. Lampe and James B. Mark Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
- Fred W. Billmeyer, Textbook of Polymer Science, ed. Wiley-Interscience (1984)
- Joel R. Fried Polymer Science and Technology, 2nd ed. Prentice-Hall (2003) Petr Munk and Tejraj M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
- U H. Sperling, Introduction to Physical. Polymer Science, 4th ed. John Wiley & Sons (2005)
- Malcolm P. Stevebs, Polymer Chemistry; An Introduction, 3rd ed. Oxford University Press (2005)
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

(Elective paper) DSE503: Economic Botany and Biotechnology

(Credits 4)

Unit 1:

Origin of Cultivated Plants

Concept of centres of origin, their importance with reference to Vavilov's work

Unit 2:

Cereals

Wheat and Rice -Origin, morphology, uses.

Legumes

General account with special reference to Gram and soybean

Unit 3:

Spices

General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses)

Beverages

Tea (morphology, processing, uses)

Unit 4:

Oils and Fats

General description with special reference to groundnut

Fibre Yielding Plants



General description with special reference to Cotton (Botanical name, family, part used, morphology and uses)

Unit 5:

Introduction to biotechnology Plant tissue culture

Micropropagation ; haploid production through androgenesis and gynogenesis; brief account of embryo & endosperm culture with their applications

Recombinant DNA Techniques

Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Molecular diagnosis of human disease, Human gene Therapy.

DSE P53: Economic Botany and Biotechnology-Lab .

(Credits 2)

Practical

1. Study of economically important plants : Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture,
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGFA and PAGE.

Suggested Readings

- 1 Kochhar, S. L. (2011) . Economic Botany in the Tropics, MacMillan Publishers India Ltd. New Delhi. 4th edition.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
3. Glick, B.A., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of, recombinant DNA. ASM Press, Washington.

(Elective paper) DSE 504: Reproductive Biology

Unit 1 : Reproductive Endocrinology

Gonadal hormones and mechanism of hormone 'action, steroids, glycoprotein hormones, and prostaglandins, hypothalamo — hypophyseal — gonadal axis, regulation of gonadotrophin secretion in male and female; Reproductive System: Development and differentiation of gonads, genital ducts, external genitalia, mechanism of sex differentiation.

Unit 2: Functional anatomy of male reproduction

Outline and histological of male reproductive system in rat and human; Testis: Cellular functions, germ cell, stem cell renewal; Spermatogenesis: kinetics and hormonal regulation; Androgen synthesis and metabolism; Epididymal function and sperm maturation; Accessory glands functions; Sperm transportation in male tract

Unit 3: Functional anatomy of female reproduction

Outline and histological of female reproductive system in rat and human; Ovary:

folliculogenesis,. ovulation, corpus luteum formation and. regression; Steroidogenesis and secretion of ovarian hormones; Reproductive cycles (rat and human) and their regulation, changes in the female tract; Ovum transport in the fallopian tubes; Sperm transport in the female tract, fertilization; Hormonal control of implantation; Hormonal regulation of gestation, pregnancy diagnosis, foeto — maternal relationship; Mechanism of parturition and its hormonal regulation; Lactation and its regulation

Unit 4: Reproductive Health

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

SUGGESTED READINGS

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

DSE P 54: Reproductive Biology-Lab

(Credits 2)

1. Study of animal house: set up and maintenance of animal house, breeding techniques, care of normal and experimental animals.
2. Examination of vaginal smear rats from live animals.
3. Surgical techniques: principles of surgery in endocrinology. Ovaryectomy, hysterectomy, castration and vasectomy in rats.
4. Examination of histological sections from photomicrographs/ permanent slides of rat/human: testis, epididymis and accessory glands of male reproductive systems; Sections of ovary, fallopian tube, uterus (proliferative and secretory stages), cervix and vagina.
5. Human vaginal exfoliate cytology.
6. Sperm count and sperm motility in rat
7. Study of modern contraceptive devices

(Elective paper) DSE 505; Applications of Computers in Chemistry

(Credits 4)

Basics:

Constants, variables, bits, bytes, binary and ASCII formats, arithmetic expressions, hierarchy of operations, inbuilt functions. Elements of the BASICS language. BASIC keywords and commands. Logical and relative operators. Strings and graphics. Compiled versus interpreted languages. Debugging. Simple programs using these concepts. Matrix addition and multiplication. Statistical analysis.

Numerical methods:

Roots of equations: Numerical methods for roots of . equations: Quadratic formula, iterative method, Newton-Raphson method, Binary bisection and Regula-Falsi.

Differential calculus: Numerical differentiation.

Integral calculus: Numerical integration (Trapezoidal and Simpson's rule), probability distributions and mean values.

Simultaneous equations: Matrix manipulation: addition, multiplication. Gauss-Siedal method. In terpo lati on, extrapolation and curve fitting: Handling of experimental data.

Conceptual background of molecular modelling: Potential energy surfaces. Elementary ideas of molecular mechanics and practical MO methods.

Reference Books:

1. Harris, D. C. Quantitative Chemical Analyses. 6th Ed., Freeman (2007) Chapters 3-5.
2. Levie, R. de, Hrnnv to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages.
3. Noggle, J. H. Physical chemistry on a Microcomputer. Little Brown & Co. (1985).
4. Venit, S .M. Programming in BASIC: Problem solving with1 structure and style. Jaico Publishing House: Delhi (1996).

DSE P55: Applications of Computers in Chemistry-Lab (Credits 2)

Computer programs based on numerical methods for

1. Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid).
2. Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations).
3. Numerical integration (e.g. entropy enthalpy change from heat capacity data), probability distributions (gas kinetic theory) and mean values.
4. Matrix operations. Application of Gauss-Siedel method in colourimetry.
5. Simple exercises using molecular visualization software.

Reference Books:

- McQuarrie, D. A. Mathematics for Physical Chemistry University Science Books (2008).
- Mortimer, R. Mathematics for Physical Chemistry. 3rd Ed. Elsevier (2005).
- Steiner, E. The Chemical Maths Book Oxford University Press (1996). Yates, P. Chemical Calculations. 2nd Ed. CRC Press (2007).
- Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007) Chapters 3-5.
- Levie, R. de, How to use Excel in analytical chemistry and in general scientific data analysis, Cambridge Univ. Press (2001) 487 pages
- Noggel, J. H. Physical Chemistry on a Microcomputer. Little Brown & Co. (1985).
- Venit, S.M. Programming in BASIC: 'Problem solving with structure and style. Jaico

SEMESTER-VI

(Elective paper) DSE601: Immunology (Credits 4)

Unit 1: Overview of the immune system- Introduction to basic concepts in immunology, components of immune system, principles of innate and adaptive immune system

Unit 2: Cells and organs of the immune system- Haematopoiesis, cells of immune system and organs (primary and secondary lymphoid organs) of the immune system

Unit 3: Antigens- Basic properties of antigens, B and T cell epitopes, haptens and adjuvants

Unit 4: Antibodies- Structure, classes and function of antibodies, monoclonal antibodies, antigen antibody interactions as tools for research and diagnosis

Unit 5: Working of the immune system I- Structure and functions of MHC, exogenous and endogenous pathways of antigen presentation and processing

Unit 6: Working of immune system II- Basic properties and functions of cytokines, types and functions of complement system

Unit 7: immune system in health and disease I- Hypersensitivity: types and functions, introduction to concepts of autoimmunity and immunodeficiency

Unit 8: Immune system in health and disease II- Infectious agents and how they cause diseases, course of adaptive response to infection, general introduction to vaccines

SUGGESTED READINGS

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., Kuby, J. (2006). VI Edition. Immunology. W.H. Freeman and Company.
2. Delves, P. J., Martin, S. J, Burton, D. R, Roitt, I.M. (2006). XI Edition. Roitt's Essential Immunology, Blackwell Publishing.

DSE P 61: Immunology-Lab

(Credits 2)

1. Study of lymphoid organs (by slides or micrographs)
2. ABO blood group determination *
3. Ouchterlony's double diffusion assay
4. Preparation, cell count and percentage viability of spleenocytes
5. Enzyme linked immunosorbent assay (DOT-ELISA)
6. Demonstration of immunoelectrophoresis

(Elective paper) DSE602: Instrumental Methods of Chemical Analysis

(Credits 4)

Introduction to spectroscopic methods of analysis:

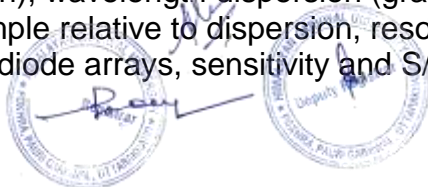
Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

Molecular spectroscopy: -

Infrared spectroscopy;

Interactions with molecules: absorption and scattering, Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution advantages of Fourier Transform (FTIR). Samples and results expected. Applications: issues of quality assurance and quality control, Special problems for portable instrumentation, and rapid detection.

U V-Visible Near IR — emission, absorption, fluorescence and photoacoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photo multipliers, diode arrays, sensitivity and S/N), Single and Double Beam



instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoacoustic, fluorescent tags).

Separation techniques

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

Immunoassays and DNA techniques

Mass spectroscopy: Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, 'fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

Elemental analysis:

Mass spectrometry (electrical discharges).

Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

Electroanalytical Methods: Potentiometry & Voltammetry

Radiochemical Methods

X-ray analysis and electron spectroscopy (surface analysis)

Reference books:

- Principles of Instrumental Analysis - 6th Edition by Douglas A Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).
- Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.
- PAW. Atkins: Physical Chemistry.
- G.W. Castellan: Physical Chemistry.
- C.N. Banwell: Fundamentals of Molecular Spectroscopy.
- Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
- W.J. Moore: Physical Chemistry.

DSE P62: Instrumental Methods of Chemical Analysis-Lab

(Credits 2)

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.

3. Titration curve of an amino acid.
 4. Determination of the void volume of a gel filtration column.
 5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
 6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
 7. IR Absorption Spectra (Study of Aldehydes and Ketones)
 8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
 9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
 10. Separation of Carbohydrates by HPLC
 11. Determination of Caffeine in Beverages by HPLC
 12. Potentiometric Titration of a Chloride-Iodide Mixture
 13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
 14. Nuclear Magnetic Resonance -
 15. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
 16. Use of "presumptive tests" for anthrax or cocaine
 17. Collection, preservation, and control of blood evidence being used for DNA testing
 18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
 19. Use of sequencing for the analysis of mitochondrial DNA. Laboratory analysis to confirm anthrax or cocaine
 21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
 22. Detection of illegal drugs or steroids in athletes
 23. Detection of pollutants or illegal dumping
 24. Fibre analysis
- At least 10 experiments to be performed.*

Reference Books:

- Principles of Instrumental Analysis - 6th Edition by Douglas A. Skoog, F. James Holler, and Stanley Crouch (ISBN 0-495-01201-7).
- Instrumental Methods of Analysis, 7th ed, Willard, Merritt, Dean, Settle.

(Elective paper) DSE603: Cell and Molecular Biology

(Credits 4)

Unit 1:

Techniques in Biology

Principles of microscopy; Light Microscopy; Phase contrast microscopy; Fluorescence microscopy; Confocal microscopy; Sample Preparation for light microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM); Sample Preparation for electron microscopy; X-ray diffraction analysis.

Unit 2:

Cell as a unit of Life

The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape Eukaryotic Cell components.

Cell Organelles

Mitochondria: Structure; marker enzymes, composition; Semiautonomous nature; Symbiont hypothesis; Proteins synthesized within mitochondria; mitochondrial DNA Chloroplast Structure, marker enzymes, composition; semiautonomous nature, chloroplast DNA.

ER, Golgi body & Lysosomes: Structures and roles,

Peroxisomes and Glyoxisomes: Structures, composition, functions in animals and plants and biogenesis.

Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief).

Unit 3:

Cell Membrane and Cell Wall

The functions of membranes; Models of membrane structure; The fluidity of membranes; Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall, Cell Cycle

Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.

Unit 4:

Genetic material

DNA: Miescher to Watson and Crick- historic perspective, Griffith's. and Avery's transformation experiments, Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material.

DNA replication (Prokaryotes and eukaryotes): bidirectional replication, semi-conservative, semi discontinuous RNA priming, θ (theta) mode of replication, replication of linear, ds- DNA, replicating the 5 end of linear chromosome including replication enzymes.

Unit 5:

Transcription (Prokaryotes and Eukaryotes)

Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.

Regulation of gene expression

Prokaryotes: Lac operon and Tryptophan operon ; and in Eukaryotes.

DSE P63: Cell and Molecular Biology-Lab

(Credits 2)

Practical

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. Study of the photomicrographs of cell organelles
3. To study the structure of plant cell through temporary mounts.
4. To study the structure of animal cells by temporary mounts-squamous epithelial cell and nerve
5. Preparation of temporary mounts of striated muscle fiber
6. To prepare temporary stained preparation of mitochondria from striated muscle cells / cheek epithelial cells using vital stain Janus green.
7. Study of mitosis and meiosis (temporary mounts and permanent slides).

8. Study the effect of temperature, organic solvent on semi permeable membrane.
9. Demonstration of dialysis of starch and simple sugar.
10. Study of plasmolysis and deplasmolysis on Rhoeo leaf.
11. Measure the cell size (either length or breadth/diameter) by micrometry.
12. Study the structure of nuclear pore complex by photograph (from Gerald Karp) Study of special chromosomes (polytene & lampbrush) either by slides or photographs..
13. Study DNA packaging by micro graphs.
14. Preparation of the karyotype and ideogram from given photograph of somatic metaphase chromosome.

Suggested Readings

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, ED.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C. Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

(Elective paper) DSE604: Genetics and Plant Breeding

(Credits 4)

Unit 1:

Heredity

1. Brief life history of Mendel
2. Terminologies
3. Laws of Inheritance
- 4 Modified Mendelian Ratios: 2:1-lethal Genes; 1:2:1- Co- dominance, incomplete dominance; 9:7; 9:4:3; 13:3; 12:3:1.
5. Chi Square
6. Pedigree Analysis
7. Cytoplasmic inheritance: Shell Coiling in Snail, Kappa particles in Paramecium, leaf variegation in Mirabilis jalapa, Male sterility.
8. Multiple allelism
9. Pleiotropism
10. Chromosome theory of Inheritance.

Unit 2:

Sex-determination and Sex-linked Inheritance

Linkage and Crossing over

Linkage: concept & history, complete & incomplete linkage, bridges experiment, coupling & repulsion, recombination frequency, linkage maps based on two and three factor crosses. Crossing over: concept and significance, cytological proof of crossing over.

Unit 3:

Mutations and Chromosomal Aberrations

Types of mutations, effects of physical & chemical mutagens. Numerical chromosomal changes: Euploidy, Polyploidy and Aneuploidy; Structural chromosomal changes: Deletions, Duplications, Inversions & Translocations.

Unit 4:

Plant Breeding

Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

Methods of crop improvement

Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants — Procedure, advantages and limitations.

Quantitative inheritance

Concept, mechanism, examples. Monogenic vs polygenic Inheritance.

Unit 5:

Inbreeding depression and heterosis

History, genetic basis of inbreeding depression and heterosis; Applications.

Crop improvement and breeding

Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

(Elective paper) DSE P64: Genetics and Plant Breeding-Lab (Credits 2)

Practical

1. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square.
2. Chromosome mapping using point test cross data.
3. Pedigree analysis for dominant and recessive autosomal and sex linked traits.
4. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 13:3, 15:1, 12:3:1, 9:3:4).
5. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs.
6. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
7. Hybridization techniques - Emasculation, Bagging (For demonstration only).
8. Induction of polyploidy conditions in plants (For demonstration only).

Suggested Readings

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Klug WS, Cummings MR, Spencer, C., Palladino, M (2011). Concepts of Genetics, 10th Ed. Benjamin Cummings
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
5. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning.

6. Singh, B.D. (2005). Plant Breeding: Principles and Methods Kalyani Publishers. 7th edition.
- 7' Chaudhari, H. IC. (1984). Elementary Principles of Plant Breeding. Oxford — IBH. 2nd edition.
8. Acquaah, O. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

(Elective paper) DSE605: Green Chemistry

(Credits 4)

Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples; Designing a Green; Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials' used in the process into the final products (Atom Economy); Prevention / minimization of hazardous/ toxic products; designing safer chemicals — different basic approaches to do so; selection of appropriate auxiliary substances (solvents, separation agents), green solvents, solventless processes, immobilized solvents and ionic liquids; energy requirements for reactions use of microwaves, ultrasonic energy; selection of starting materials; avoidance of unnecessary derivatization — careful use of blocking/protecting groups; use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; designing of biodegradable products; prevention of chemical accidents; strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

Examples of Green Synthesis/ Reactions

1 Green Synthesis of the following compounds: adipic acid, catechol, BHT, methyl methacrylate, urethane, aromatic amines (4-aminodiphenylamine), benzyl bromide, acetaldehyde, disodium iminodiacetate (alternative to Strecker synthesis), citral, ibuprofen, paracetamol, furfural.

2. Microwave assisted reactions in water: Hofmann Elimination, Hydrolysis (of benzyl chloride, benzamide, n-phenyl benzamide, methylbenzoate to benzoic acid), Oxidation (of toluene, alcohols).

Microwave assisted reactions in organic solvents: Esterification, Fries rearrangement, Orthoester Claisen Rearrangement, Diels-Alder Reaction, Decarboxylation.

Microwave assisted solid state reactions: Deacetylation, Deprotection. Saponification of esters, Alkylation of reactive methylene compounds, reductions, synthesis of nitriles from aldehydes; anhydrides from dicarboxylic acid; pyrimidine and pyridine derivatives; 1,2-dihydrotri azine derivatives; benzimidazoles.

3. Ultrasound assisted reactions: Esterification, saponification, substitution reactions, Alkylations, oxidation, reduction, coupling reaction, Cannizzaro reaction, Strecker synthesis, Reformatsky reaction.

4. Selective methylation of active methylene group using dimethylcarbonate: Solid-state polymerization of amorphous polymers using diphenylcarbonate; Use of "Clay", a nonmetallic oxidative reagent for various reactions; Free Radical Bromination; Role of Tellurium in organic syntheses; Biocatalysis in organic syntheses.

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; oncovalent derivatization; Green chemistry in sustainable development.

Reference Books:

- V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
- P.T. Anastas & K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
- A.S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
- M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
- M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

DSE P65: Green Chemistry-Lab

(Credits 2)

1. Safer starting materials

The Vitamin C clock reaction using Vitamin C tablets, tincture of iodine, hydrogen peroxide and liquid laundry starch.

- Effect of concentration on clock reaction
- Effect of temperature on clock reaction. (if possible)

2. Using renewable resources

Preparation of biodiesel from vegetable oil.

3. Avoiding waste

Principle of atom economy.

Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.

Preparation of propene by two methods can be studied

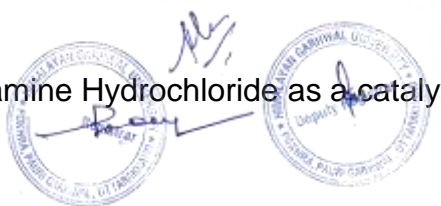
(I) Triethylamine ion + OH \rightarrow propene + trimethylpropene + water

(11) 1 propanol $\xrightarrow{\text{H}_2\text{SO}_4/\Delta}$ propene + water

The other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

4. Use of enzymes as catalysts

Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide
Alternative Green solvents



5. Diels Alder reaction in water

Reaction between furan and maleic acid in water and at room temperature rather than in benzene and reflux.

6. Extraction of D-limonene from orange peel using liquid CO₂ prepared from dry ice.

7. Mechanochemical solvent free synthesis of azomethines

8. Co-crystal controlled solid state synthesis (C^2S^3) of N-organophthalimide using phthalic anhydride and 3—aminobenzoic acid.

Alternative sources of energy

9 Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).

10. Photoreduction of benzophenone to benzopinacol th the presence of sunlight.

Reference Books:

- Anastas, P.T & Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press (1998).
- Kirchoff', M. & Ryan, MA. Greener approaches to undergraduate chemistry experiment. American Chemical Society, Washington DC (2002).
- Ryan, MA. Introduction to Green Chemistry, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. Real world cases in Green Chemistry, American Chemical Society (2008).
- Cann, M. C. & Thomas, P. Real world cases in Green 'Chemistry, American Chemical Society (2008).
- Pavia, D. L. Lamponan, G. H. & Kriz, G.S. W B Introduction to organic laboratory

