

PROPOSED B.Sc. (Hons.) BIOTECHNOLOGY SYLLABUS UNDER CBCS

F.Y.B.Sc.:

Semester	Course	Paper code	Paper	Credits		Total Credits
				Theory	Practical	
I	<i>Core</i>	BT DSC 1A	Biochemistry and Metabolism	04	02	06
	<i>Core</i>	BT DSC 2A (Chem)	Chemistry I for Biotechnology (At. Str., Bonding, Gen. Org.)	04	02	06
	<i>Core</i>	BT DSC 3A (Zoo / Bot)	Animal Diversity I/ Plant diversity I	04	02	06
	<i>GE*</i>	BT GEC 1	Generic Elective	04	---	04
	<i>AECC</i>	AECC1	English / Environmental Education	04	---	04
II	<i>Core</i>	BT DSC 1B	General Microbiology	04	02	06
	<i>Core</i>	BT DSC 2B (Chem)	Chemistry II for Biotechnology (Chem. Energetics, Equilibria, Func.Org. Chem)	04	02	06
	<i>Core</i>	BT DSC 3B (Zoo / Bot)	Animal Diversity II / Plant diversity II	04	02	06
	<i>GE</i>	BT GEC 2	Generic Elective	04	---	04
	<i>AECC</i>	AECC 2	English / Environmental Education	04	---	04

Animal Diversity I & II as BT DSC 3A & 3B are for the students of Biotechnology with Biotechnology, Chemistry & Zoology as subject combination.

Plant diversity I & II as BT DSC 3A & 3B are for the students of Biotechnology with Biotechnology, Chemistry & Botany as subject combination.

SEMESTER I

CORE PAPERS

BT DSC 1 A: BIOCHEMISTRY AND METABOLISM

(Credits: Theory-4, Practicals-2)

THEORY

60 periods

UNIT I: Introduction to Biochemistry:

(10 Periods)

A historical prospective: Urey-Miller's experiment.

Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids, Types of proteins and their classification, Forces stabilizing protein structure and shape. Different levels of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins.

Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoproteins and their biological functions.

UNIT II (10 Periods) Lipids:Structure and functions - Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Cholesterol.

Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines, Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA.

UNIT III (20 Periods) Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Michaelis-Menten equation. Factors affecting enzyme activity, Role of: NAD⁺, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate, Vitamin B12, Tetrahydrofolate

UNIT IV

(20 Periods)

Carbohydrates Metabolism: Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis. TCA cycle, Electron Transport Chain, Oxidative phosphorylation. β -oxidation of fatty acids.

PRACTICALS

(15 sessions)

1. Preparation of solutions of different molarity and normality.
2. Preparation of buffers.
3. Principles of Colorimetry: **(i)** Verification of Beer's law **(ii)** To study relation between absorbance and % transmission
4. Estimation of protein by Biuret method.

5. Estimation of protein by Folin Lowry's method
6. Estimation of reducing sugars by DNSA method.
7. To study the effect of pH on the activity of salivary amylase enzyme.
8. To study the effect of temperature on the activity of salivary amylase enzyme.
9. Determination of Km value and Vmax value of acid phosphatase enzyme activity.
10. To study the effect of inhibitor (Inorganic phosphate) on acid phosphatase enzyme activity.
11. Qualitative tests for Carbohydrates.
12. Qualitative tests for lipids.
13. Qualitative tests for proteins.
14. Estimation of blood glucose by glucose oxidase method.
15. Separation of sugars by paper chromatography.

SUGGESTED READING

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co.

BT DSC 2A - CHEMISTRY I FOR BIOTECHNOLOGY

ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC

(Credits: Theory-4, Practicals-2)

THEORY

60 periods

Section A: Inorganic Chemistry-1

(30 Periods)

Atomic Structure:

(14 Periods)

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 , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydrogenic wave functions (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 ml and ms . Shapes of s , p and d atomic orbitals, nodal planes.

Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). 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.

3

Chemical Bonding and Molecular Structure

(16 Periods)

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-Landé 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 anti bonding 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.

Section B: Organic Chemistry-1

(30 Periods)

Fundamentals of Organic Chemistry

(8 Periods)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyper conjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

Stereochemistry

(10 Periods)

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).

Aliphatic Hydrocarbons

(12 Periods)

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

Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe'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 .

4

Reference Books:

- J. D. Lee: *A new Concise Inorganic Chemistry*, E L. B. S. 18
- F. A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley.
- Douglas, McDaniel and Alexander: *Concepts and Models in Inorganic Chemistry*, John Wiley.
- James E. Huheey, Ellen Keiter and Richard Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Publication.
- T. W. Graham Solomon: *Organic Chemistry*, John Wiley and Sons.
- Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry*, Orient Longman.
- E. L. Eliel: *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
- Goa University, Taleigao Plateau, Goa. Page 7
- L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
- R. T. Morrison & R. N. Boyd: *Organic Chemistry*, Prentice Hall.
- Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry*, S. Chand
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CHEMISTRY LAB: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

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 extraelements)
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.

Reference Books:

- Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition. 19
Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960.

BT DSC 3A - ANIMAL DIVERSITY I
(Credits: Theory-4, Practicals-2)

THEORY

60 periods

UNIT I

(15 Periods)

- a) Outline of classification of Non- Chordates upto subclasses. Coelomata, Acoelomata
- b) Protozoa: Locomotion, Reproduction, General features of *Paramoecium* and *Plasmodium*. Pathogenic protozoans
- c) Porifera: General characters, outline of Classification; skeleton, Canal System

UNIT II

(15 Periods)

- a) Coelenterata: General Characters, Outline of classifications Polymorphism, Various types of stinging cells; Metagenesis, coral reefs and their formation.
- b) Platyhelminthes- General Characters; Outline of classification; Pathogenic flatworms: Parasitic adaptations.
- c) Aschelminthes: General features, Outline of classification, Pathogenic roundworms and their vectors in relation to man: Parasite adaptation.

UNIT III

(15 Periods)

- a) Annelida: - General features, Outline of classification, Coelom: Metameric segmentation, General features of Earthworm, Vermicomposting.
- b) Arthropoda: General Features, Outline of Classification; Larval forms of crustacean, Respiration in Arthropoda; Metamorphosis in insects; Social insects; Insect vectors of diseases; Apiculture, Sericulture.

UNIT IV

(15 Periods)

- a) Mollusca : General features, Outline of classification, Shell Diversity; Torsion in gastropoda,
- b) Echinodermata: General features, Outline of Classification Larval forms
- c) Hemichordata: Phylogeny: Affinities of *Balanoglossus*

PRACTICALS

1. Identification and Classification of Any these of the following –

Protozoa-*Amoeba*, *Paramoecium*, *Plasmodium*

Porifera: *Scypha*, *Leucosolenia*, *Euspongia*, *Hylonema*, *Euplectella* Cnidaria: *Medrepora*, *Millepora*, *Physalia*, *Porpita*, *Varella*, *Aurelia*, *Metridium*

Platyhelminthes: *Taenia*, *Fasciola*,

Aschelminthes: *Ascaris*, *Ancylostoma*, *Enterobius*

Annelida: *Pheretima*, *Hirudinaria*, *Chaetopterus*, *Nereis*, *Aphrodite* Arthropoda:

Julus, *Scolopendra*, *Peripatus*, *Carcinus*, *Limulus*, *Lepisma*, *Dragonfly*, *Musca*, *Acheta*

Mollusca: *Pila*, *Unio*, *Mytilus*, *Loligo*, *Sepia*, *Octopus*, *Solen*

Echinodermata: *Asterias*, *Ophiothrix*, *Echinus*, *Holothuria*, *Astrophyton*

Hemichordata: *Balanoglossus*

2. Identification of slides with two points of identification.

Amoeba, *Paramoecium*, *Plasmodium*, L.S. Sponge, Spicules of sponges, L.S. *Hydra*, *Obelia*, Larvae of *Fasciola*, Seta of Earthworm, Nephridia of Earthworm

3. Ecological Note – On any 2 of the specimens in Exercise No 1 Models of dissection of Earthworm, Cockroach. 6

Earthworm: Digestive, Nervous System

Cockroach: Digestive Reproductive, Nervous System

4. Mouth parts of Honey bee (Permanent slides/ Microphotographs/digital sources)

5. Mouth parts of House fly, Mouth parts of Cockroach (Permanent slides/ Microphotographs/digital sources)

6. Appendages of Prawn (mounting should be carried out)

SUGGESTED READING

1. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) *The Invertebrates: A New Synthesis*. III Edition. Blackwell Science.
2. Barrington, E.J.W. (1979) *Invertebrate Structure and Functions*. II Edition. E.L.B.S. and Nelson.
3. Boradale, L.A. and Potts, E.A. (1961) *Invertebrates: A Manual for the use of Students*. Asia Publishing Home.
4. Bushbaum, R. (1964) *Animals without Backbones*. University of Chicago Press.
5. Kent, G.C. and Carr R.K. (2000). *Comparative Anatomy of the Vertebrates*. IX Edition. The McGraw-Hill Companies.

BT DSC 3A PLANT DIVERSITY I

Credits: 4 (Theory): 2 (Practical)

THEORY

60 periods

Unit 1: Algae:

(20 Periods)

General character, classification and economic importance. Life histories of algae belonging to various classes:

Chlorophyceae – *Volvox*, *Oedogonium*

Xanthophyceae – *Vaucheria*

Phaeophyceae – *Ectocarpus*

Rhodophyceae - *Polysiphonia*

Unit 2: Fungi:

(20 Periods)

General characters, classification & economic importance.

Life histories of Fungi:

Mastigomycotina - *Phytophthora*

Zygomycotina - *Mucor*

Ascomycotina - *Saccharomyces*

Basidiomycotina - *Agaricus*

Deutromycotina - *Colletotrichum*

Unit 3: Lichens:

(10 Periods)

Classification, general structure, reproduction and economic importance. Plant diseases:

4 of 36

Causal organism, symptoms and control of following plant diseases.

Rust & Smut of Wheat.

White rust of Crucifers. Late blight of Potato. Red rot of Sugarcane.

Citrus Canker.

Unit 4: Bryophytes:

(10 Periods)

General characters, classification & economic importance.

Life histories of following:

Marchantia.

Funaria.

PRACTICALS:

1. Comparative study of thallus and reproductive organs of various algae mentioned in theory (1P)
2. Comparative study of vegetative and reproductive parts of various fungi mentioned in theory. (1P)
3. Study and section cutting and lactophenol mount of plant disease materials studied in theory. (1P)
4. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*. (1P)
5. Lichens: Study of growth forms of lichens (Crustose, foliose and fruticose). (1P)
6. Mycorrhiza: ectomycorrhiza and endomycorrhiza – (slide preparation/Photographs). (2P)
7. *Riccia*: morphology and T. S. of thallus, W. M. rhizoids and scales, V. S. thallus through gemma cup, W. M. gemmae (all permanent slides), V. S. antheridiophore, archegoniophore, L. S. sporophyte (all permanent slides). (1P)
8. *Anthoceros*: morphology and T. S. of thallus and sporophyte. Sporophyte (permanent slides). (1P)
9. *Marchantia* / *Funaria*: morphology, W. M. leaf, rhizoids, sporophyte (permanent slides); permanent slides showing antheridial and archegonial heads, L. S. capsule and protonema. (1P)
10. Herbarium preparation of algae. (1P)

11. Conservation of at least one species of alga and bryophyte in the botanical garden ('Ex-situ' conservation/ Preparation of a Conservatory). (1P)
12. Preparation of spawn for Oyster mushroom cultivation. (1P)
13. Culturing of Mucor and Aspergillus. (2P)

SUGGESTED READINGS

- Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press Pvt. Ltd. Delhi. 2nd edition.
- Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
- Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw Hill, Delhi.
- Agrios, G.N. 1997 Plant Pathology, 4th edition, Academic Press, U.K. John Wiley and Sons (Asia) Singapore.
- Bold, H.C. & Wayne, M.J. 1996 (2nd Ed.) Introduction to Algae.
- Lee, R.E. 2008. Phycology, Fourth Edition, Cambridge University Press, USA.
- Sambamurty 2008 A Textbook of Bryophytes, Pteridophytes, Gymnosperms and Paleobotany. IK International Publishers.
- Shaw, A.J. and Goffinet, B. 2000 Bryophyte Biology. Cambridge University Press.
- Van den Hoek, C.; Mann, D.J. & Jahns, H.M. 1995. Algae: An introduction to Phycology. Cambridge Univ. Press.
- Vander-Poorteri 2009 Introduction to Bryophytes. COP.
- Webster, J. and Weber, R. 2007 Introduction to Fungi. 3rd edition, Cambridge University Press, Cambridge.
- Wickens, G.E. 2004 Economic Botany: Principles and Practices, Springer. Kuwer Publishers, Dordrecht, The Netherlands

SEMESTER II

CORE COURSES

BT DSC 1B - GENERAL MICROBIOLOGY

(Credits: Theory-4, Practicals-2)

THEORY

60 Periods

UNIT I

(10 periods)

Fundamentals, History and Evolution of Microbiology.

Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria.

Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells,

Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

UNIT II

(10 periods)

Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

UNIT III

(20 periods)

Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria.

Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways

Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

UNIT IV

(20 periods)

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents

Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal.

Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria.

Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

PRACTICALS

(15 sessions)

1. Isolation of bacteria & their biochemical characterization IMViC.(02)
2. Study of colony characteristics of bacteria.
3. Staining methods: simple staining,
4. Gram staining,
5. Spore staining,
6. Capsule staining
7. Hanging drop.
8. Preparation of media & sterilization methods(02)
9. Methods of Isolation of bacteria from different sources.(02)
10. Determination of bacterial cell size by micrometry.
11. Enumeration of microorganism - total & viable count.(02)

SUGGESTED READING

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). *Introductory Mycology*. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7th edition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). *Introductory Phycology*. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). *Microbiology*. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). *General Microbiology*. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9 th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY I
(Credits: Theory-4, Practicals-2)**THEORY****60 Periods****Section A: Physical Chemistry-1****(30 Periods)****Chemical Energetics****(10 Periods)**

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.

Chemical Equilibrium:**(8 Periods)**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G_0 , Le Chatelier's principle. Relationships between K_p , K_c and K_x for reactions involving ideal gases.

Ionic Equilibria:**(12 Periods)**

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.

Section B: Organic Chemistry-2**(30 Periods)**

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

Aromatic hydrocarbons**(8 Periods)**

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).

Alkyl and Aryl Halides**(8 Periods)**

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN_1 , SN_2 and SN_i) 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: KNH₂/NH₃ (or NaNH₂/NH₃).

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

Alcohols, Phenols and Ethers (Upto 5 Carbons)

(14 Periods)

Alcohols: Preparation: Preparation of 1^o, 2^o and 3^o 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.

Reference Books:

T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons.*

Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry, Orient Longman.*

I.L. Finar: *Organic Chemistry (Vol. I & II), E. L. B. S.*

R. T. Morrison & R. N. Boyd: *Organic Chemistry, Prentice Hall.*

Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry, S. Chand.*

G. M. Barrow: *Physical Chemistry Tata McGraw-Hill (2007).*

G. W. Castellan: *Physical Chemistry 4th Edn. Narosa (2004).*

J. C. Kotz, P. M. Treichel & J. R. Townsend: *General Chemistry Cengage Learning, India Pvt. Ltd., New Delhi (2009).*

B. H. Mahan: *University Chemistry 3rd Ed. Narosa (1998).*

R. H. Petrucci: *General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).*

CHEMISTRY LAB: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3 , NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH .

Ionic equilibria

pH measurements

- a) 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.
- b) Preparation of buffer solutions:
 - (i) Sodium acetate-acetic acid
 - (ii) Ammonium chloride-ammonium hydroxide

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

Section B: Organic Chemistry

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

SUGGESTED READING

A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.

F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).

B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

BT DSC 3B - ANIMAL DIVERSITY II

(Credits: Theory-4, Practicals-2)

THEORY

60 Periods

UNIT I: Proto-chordates, Pisces and Amphibia

(20 Periods)

Proto-chordates: Outline of classification, General features and important characters of Herdmania, Branchiostoma

Origin of Chordates

Cyclostomata- General features, Classification

Pisces: General features, Migration in Pisces, Outline of classification

Amphibia: General features, Classification, Origin, Parental care, Neoteny and Paedogenesis

UNIT II: Reptilia, Aves and Mammalia

(20 Periods)

Reptilia: General features Classification, Origin

Aves: General features, Classification, Origin, flight- adaptations, migration, Flightless birds or ratitae, Beak and feet in birds.

Mammalia: General features, Classification, Origin, dentition, Aquatic and flying mammals

UNIT III: Mammalian Anatomy

(10 Periods)

Anatomy of various systems of mammals: Integumentary- Epidermal derivatives and their modifications, Dermal derivatives

Respiratory systems- types of gills, swim bladder, lungs and air ducts, Anatomy of Eye and Ear.

UNIT IV: Anatomy of vertebrates

(10 Periods)

Anatomy of mammals – Circulatory system- anatomy of Heart, Aortic arches, Kidney and urinogenital system, anatomy of kidney and nephron,

Autonomic Nervous system in Mammals

PRACTICAL

Protochordata - Study of specimens: Balanoglossus, Herdmania, Branchiostoma, Salpa, Doliolum, Oikopleura, Botryllus

Agnatha -Study of specimens: Petromyzon, Myxine

Fishes - Study of specimens: Scoliodon, Rhinobates, Sting ray, Echeneis, Anguilla, Hippocampus, Antennarius, Clarius, Ophiocephalus, , Anabas,

Amphibia - Study of specimens: Ichthyophis/Ureotyphlus, , Bufo, Hyla, Alytes, Salamandra

Reptilia - Study of specimens: Chelone, , Hemidactylus, Varanus, Uromastix, Chamaeleon, , Draco, Pit viper, Naja,. Key for Identification of poisonous and non-poisonous snakes

Aves -Study of six common birds from different orders. Types of beaks and feet and feathers

Mammalia - Sorex, Bat, rat, rabbit.

I. Identification & Classification upto order of the following: Proto-chordata: *Salpa, Doliolum, Herdmania, Branchiostoma*

Cyclostomata: *Myxine, Petromyzon*

Chondrichthyes: *Scoliodon, Zygyra, Pristis, Trygon, Raja*, Osteichthyes: *Labeo, Mystus, Catla, Hippocampus, Anabas, Echeneis, Lophius, Polypeterus*

Amphibia: *Rana, Hyla, Amblystoma, Necturus, Proteus*.

Reptiles: *Hemidactylus*, *Calotes*, *Draco*, *Phrynosoma*, *NajaVipera*,
Bungarus Aves: *Columba*, *Alcedo*, *Passer*

Mammalia: *Ornithorhynchus*, *Macropus*, *Didelphes*, *Dasyopus*

2. An Ecological Note on any one of the specimens in Experiment 1

3. Identification of the following slides: Slides of *Salpa*, *Doliolum*, Spicules of *Herdmania*, Tadpole of Frog

4. Preparation of a permanent mount of Placoid scales,

5. Identification of endoskeletons of frog and rabbit.

SUGGESTED READING

1. Hall B.K. and Hallgrimsson B. (2008). Strickberger's Evolution. IV Edition. Jones and, Bartlett Publishers Inc.

2. Kardong, K.V. (2005) Vertebrates Comparative Anatomy, Function and evolution. IV Edition., McGraw-Hill Higher Education.

3. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

4. Weichert, C.K. (1970). Anatomy of Chordate. McGraw Hill.

5. Young, J.Z. (2004). The life of vertebrates. III Edition. Oxford university press.

BT DSC 3B Plant diversity II
Credits: 4 (Theory): 2 (Practical)

THEORY	(60 periods)
Unit 1: Pteridophytes	(12 periods)
General characteristics, classification, Early land plants (Cooksonia and Rhynia). Classification (up to family), morphology, anatomy and reproduction of Psilotum, Selaginella, Equisetum and Pteris. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.	
Unit 2: Gymnosperms	(10 periods)
General characteristics, Classification (Coulter & Chamberlain), morphology, anatomy and reproduction of Cycas, Pinus and Gnetum. (Developmental details not to be included). Ecological and economical importance.	
Unit 3: Introduction to plant taxonomy	(4 periods)
Identification, Classification, Nomenclature.	
Unit 4: Identification	(8 periods)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access.	
Unit 5:	(6 periods)
Taxonomic evidences from palynology, cytology, photochemistry and molecular data.	
Unit 6: Taxonomic hierarchy	(2 periods)
Ranks, categories and taxonomic groups.	
Unit 7: Botanical nomenclature	(6 periods)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.	
Unit 8: Classification	(10 periods)
Types of classification - artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series); study of families: Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae.	
Unit 9: Biometrics, numerical taxonomy and cladistics	(2 periods)
Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).	
PRACTICALS: (1P is for 2 hrs)	
1. Psilotum – morphology, W. M. Synangium, T. S. Stem. (2P)	
2. 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).(2P)	
3. 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).(2P)	
4. 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). (2P)	

5. Cycas - morphology (coralloid roots, bulbil, leaf), T. S. coralloid root, T. S. rachis, V. S. leaflet, V. S. microsporophyll, W. M. spores (temporary slides), L. S. ovule, T. S. root (permanent slide). (2P)
6. 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. and R. L. S. stem (permanent slide). (3P) .
7. Study of vegetative and floral characters of the following families (Description, V.S.flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Asteraceae, Solanaceae, Lamiaceae, Liliaceae and Poaceae (Any two locally available plants per family). (10P)
8. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book). (2P)
9. Field Botany. (5P)

SUGGESTED READINGS:

1. Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta, S. Chand. Delhi, India.
2. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad.
4. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A. 5. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3 rd edition.

GENERIC ELECTIVE

GENERIC ELECTIVES FLOATED BY DCT'S DHEMPE COLLEGE OF ARTS & SCIENCE, MIRAMAR, GOA

Semester I: BT GE 1: Food Science & Nutrition
Semester II: BT GE 2: Entrepreneurship Development

BT GE 1: FOOD SCIENCE & NUTRITION

Credits: 04

Total: 60 periods

OBJECTIVE:

1. To acquire knowledge of various concepts of Food Science – its facts and principles
2. To understand the composition of food.

COURSE CONTENT:

Unit I:

1. Role of nutrition in health– An overview (02 periods)

- I. Concept of nutrition
- II. Significance & functions of food

2. Introduction to Nutrition and Food Science (20 periods) Facts and Principles, Detailed study of foodstuffs, Composition and nutritive value, Processing, Classification, Digestibility, Storage, their importance in the diet & their recommended daily intake :

Milk, Eggs, Meat, Poultry, Fish and shell fish, Vegetables, Fruits, Fats, Oils and nuts

Role of water: Role of water in the body, Water and Electrolyte balance **(03 periods)**

Unit II:

Macro & Micronutrients

3. Macronutrients: Carbohydrate, Proteins & Fats - Their Classification, Functions , Digestion and absorption, Sources , Requirements, Deficiency and related diseases (08 periods)

4. Micronutrients – Their Classification, Functions, Digestion and absorption, Sources, Requirements , Deficiency and related diseases, & role of antioxidants (12 periods)

- I. Minerals: a) Macro: i. Calcium ii. Phosphorus iii. Sodium iv. Potassium
b) Micro: i. Iron ii. Iodine iii. Zinc
- II. Vitamins –a) Fat soluble –A, D, E, K
b) Water Soluble - B Complex , Vitamin C

Unit III:

5. A brief Introduction to Energy: (04 periods)

- I. Balance; underweight, overweight, obesity
- II. Factors determining energy requirements

6. Meal Planning (07 periods)

- I. Factors affecting meal planning
- II. Balanced Diet
- III. RDA and Dietary guidelines for Indians, ICMR, 2010
- IV. Food exchange list, its usage

V. Basic steps in planning a meal.

7. Recent advances in Nutrition

(04 periods)

I. Nutritional labelling

II. Functional foods-Antioxidants, Probiotics, Nutraceuticals, Phytonutrients

REFERENCES:

1. Chaddha and Pulkeet Mathur, Nutrition a lifecycle approach, recent edition
2. B. Srilakshmi, Food Science, New Age International, recent edition
3. Sunetra Rody, Food Science & Nutrition, Oxford University Press, recent edition

BT GEC 2 -

ENTREPRENEURSHIP DEVELOPMENT

Credits: 04

Total: 60 periods

UNIT I INTRODUCTION

(10 periods)

Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

UNIT II ESTABLISHING AN ENTERPRISE

(12 periods)

Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

UNIT III FINANCING THE ENTERPRISE

(15 periods)

Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

UNIT IV MARKETING MANAGEMENT

(13 periods)

Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management, Costing and Books of Accounts.

UNIT V ENTREPRENEURSHIP AND INTERNATIONAL BUSINESS

(10 periods)

Meaning of International business, Selection of a product, Selection of a market for International business, Export financing, Institutional support for exports.

Project Report on a selected product should be prepared and submitted.

GENERIC ELECTIVES FLOATED BY ST. XAVIER'S COLLEGE, MAPUSA, GOA

Semester I: BT GE 1: Research Methodology
Semester II: BT GE 2: Entrepreneurship Development

BT GE 1: RESEARCH METHODOLOGY

Credits: 04

Total: 60 periods

Unit 1: Basic concepts of research

(10 periods)

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; Quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices

(12 periods)

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases. Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations

(6 periods)

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems

(6 periods)

History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit 5: Methods to study plant cell/tissue structure

(6 periods)

Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

Unit 6: Plant microtechniques

(12 periods)

Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and fluorochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

Unit 7: The art of scientific writing and its presentation

(8 periods)

Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright - academic misconduct/plagiarism.

PRACTICAL

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.

Suggested Readings

1. Dawson, C. (2002). Practical research methods.UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

ABILITY ENHANCEMENT COMPULSORY COURSE

AECC 1

ENGLISH COMMUNICATION

60 periods

1. Introduction: Theory of Communication, Types and modes of Communication

2. Language of Communication:

Verbal and Non-verbal

(Spoken and Written)

Personal, Social and Business

Barriers and Strategies

Intra-personal, Inter-personal and Group communication

3. Speaking Skills:

Monologue

Dialogue

Group Discussion

Effective Communication/ Mis-Communication

Interview Public Speech

4. Reading and Understanding

Close Reading

Comprehension

Summary Paraphrasing

Analysis and Interpretation

Translation (from Indian language to English and vice-versa) Literary/Knowledge Texts

5. Writing Skills

Documenting

Report Writing

Making notes

Letter writing

Recommended Readings:

1. *Fluency in English* - Part II, Oxford University Press, 2006.

2. *Business English*, Pearson, 2008.

3. *Language, Literature and Creativity*, Orient Blackswan, 2013.

4. *Language through Literature* (forthcoming) ed. Dr. Gauri Mishra, DrRanjanaKaul,DrBratiBiswas

Learning Objectives: The course envisages that all the under graduates coming out of our University system are aware of our natural resources, ecosystems and their linkages to society, livelihood, environment and conservation. This theoretical learning shall be supported by the actual field visits.

SECTION – A Natural Endowments: Status, Issues, concerns and responses

Unit 1: The Multi-Disciplinary Nature of Environmental Studies (2 periods)

Definition, Scope and Importance; need for public awareness.

Unit 2: Natural Resources: (8 periods)

Renewable and Non-Renewable resources: natural resources and associated problems

- a) Forest Resources: use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.
 - b) Water Resources: use and over-exploitation of surface and ground water; floods, droughts, conflicts over water, dams-benefits and problems.
 - c) Mineral Resources: use and exploitation, environmental effects of extracting and using mineral resources; case studies related to mining and its effect on siltation and loss of biodiversity.
 - d) Food Resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity; case studies.
 - e) Energy Resources: growing energy needs, renewable and non-renewable energy sources, use of alternative energy sources, case studies
 - f) Land Resources: land as a resource, land degradation, man-induced landslides, coastal erosion, soil erosion and desertification.
- Role of an individual in conservation of natural resources.
 - Equitable use of resources for sustainable lifestyles.

Unit 3: Ecosystems (6 periods)

Concept of an ecosystem, structure and functions of ecosystems; producers, consumers and decomposers, energy flow in the ecosystem, ecological succession, food chains, food webs and ecological pyramids. Introduction, types, features, structure and functions of the following ecosystems: forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystem (ponds, streams, lakes, rivers, oceans, coastal zone, estuaries).

Unit 4: Biodiversity and its Conservation (8 periods)

Introduction, definition, genetic, species and ecosystem diversity; bio-geographical classification of India; value of biodiversity - consumptive use, productive use, social, ethical, aesthetic and option values; biodiversity at global, national, regional and local levels; India as a mega-diversity nation; hotspots of biodiversity; threats to biodiversity - habitat loss, poaching of wildlife, man-wildlife conflicts, bio-invasion, and over exploitation; endangered and endemic species of India (at least 5 examples of animals and plants each); conservation of biodiversity- in-situ and ex-situ conservation, role of biotechnology in conservation of biodiversity.

Unit 5: Field visit to different ecosystems/Landscapes and to learn biodiversity (6 periods)

Visit to a local area to document environmental assets - river/ forest/ grassland/ hill/ mountain; study of common plants, insects, birds; study of simple ecosystems-pond/ river/ hill slopes, etc. A report of field

visit(s) to be maintained.

SECTION – B Socio-economic dimensions of Environment

Unit 6: Environmental Pollution

(7 periods)

Definition, causes, effects and measures to control air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards; waste – types, causes, effects; waste management –solid, sewage and effluents; measures to control industrial and urban wastes; role of an individual in prevention of pollution; pollution case studies (Bhopal gas tragedy and mining); disaster mitigation and management-floods, droughts, earthquakes, landslides, cyclones, Tsunami.

Unit 7: Social issues and the Environment

(8 periods)

From unsustainable to sustainable development; urban problems related to energy; water conservation, rainwater harvesting, watershed management; resettlement and rehabilitation of people - problems and concerns, case studies; environmental ethics - issues and concerns; climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies; wasteland reclamation; consumerism and associated waste products; Objectives and scope of Environment (Protection) Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Forest Conservation Act, Wildlife Protection Act, Forest Rights Act and Biodiversity Act; Issues involved in enforcement of environmental legislation; public awareness.

Unit 8: Human Population and the Environment

(5 periods)

Population growth, variation among nations; population explosion - Family Welfare Programme; environment and human health; human rights; value education; HIV/AIDS; women and child welfare; role of Information Technology in environment and human health; case studies.

Unit 9: Tourism and Environment

(4 periods)

Definition and typology of tourism; mass tourism and environment - aspects of degradation and exploitation, physical and social impacts; examples at local, regional, national and international levels. Sustainable tourism.

Unit 10: Field visit local polluted / waste treatment site(s)

(6 periods)

Visit to a local polluted site - urban/rural/ industrial/ agricultural and waste treatment plant(s)/sustainable tourism site(s). A report of field visit to be maintained.

Recommended Readings

1. Agarwal K.C. (2001): Environmental Biology, Bikaner, Nidi
2. Bharucha E.: The Biodiversity of India, Ahmedabad, Mapin
3. Bharucha E.: Textbook of Environmental Studies. Orient BlackSwan
4. Brunner R.C. (1989): Hazardous Waste Incineration, New York, McGraw-Hill
5. Chatwal G.R. & Sharma H. (2005): A Textbook of Environmental Studies, Mumbai, Himalaya
6. Clark R.S.: Marine Pollution, Oxford, Clarendon
7. Cunningham W.P., Cooper T.H., Gorani E. & Hepworth M.T. (2001): Environmental Encyclopaedia, Mumbai, Jaico.
8. De A.K.: Environmental Chemistry, Wiley
9. Desai R.J. (2003): Environmental Studies, Mumbai, Vipul, Goa University, Taleigao Plateau, Goa
Page 3
10. Gleick H.P. (1993): Water in Crisis, Stockholm Env. Institute, OUP
11. Hawkins R.E.: Encyclopaedia of Indian Natural History, Mumbai, BNHS

12. Heywood V.H. & Watson R.T. (1995): Environment Protection and Laws, Mumbai, Himalaya
13. Jadhav H. & Bhosale V.M. (1995): Environment Protection and Laws, Mumbai, Himalaya
14. McKiney M.L. & Schoel R.M. (1996): Environment Science, Systems and Solutions, Web Enhanced Edition.
15. Mhaskar A.K.: Matter Hazardous, Techno-Science Publications
16. Miller T.G. Jr.: Environmental Science, Wadsworth
17. Odum E.P. (1971): Fundamentals of Ecology, Philadelphia, W.B. Saunders
18. Rao M.N. & Datta A.K. (1986): Waste Water Treatment, Oxford & IBH
19. Santra S.C. (2004): Environmental Science, Kolkata, Central Book Agency
20. Sharma B.K. (2001): Environmental Chemistry, Meerut, Goel Publishing House
21. Townsend C., Harper J. & Begon M.: Essentials of Ecology, Blackwell Science
22. Trivedi R.K.: Handbook of Environmental Laws, Rules, Guidelines, Compliances and, Standards, Vol.1 & 2, Enviro Media.
23. Trivedi R.K. & P.K. Goel: Introduction to Air Pollution, Techno-Science Publications
24. Wagner K.D. (1998) Environmental Management, Philadelphia, W.B. Saunders

Magazines

Down to Earth, Centre for Science & Environment
Survey of the Environment published by The Hindu

E- resource

<http://www.ugc.ac.in/oldpdf/modelcurriculum/env.pdf>

S.Y.B.Sc.

Semester	Course	Paper code	Paper	Credits		Total Credits
				Theory	Practical	
III	<i>Core</i>	BT DSC 1C	Cell Biology	04	02	06
	<i>Core</i>	BT DSC 2C (Chem)	Chemistry III for Biotechnology	04	02	06
	<i>Core</i>	BT DSC 3C (Zoo. / Bot.)	Mammalian Physiology / Plant Physiology & metabolism	04	02	06
	<i>SEC</i>	BT SEC1	Urban Gardening	03	01	04
IV	<i>Core</i>	BT DSC 1D	Plant Physiology & metabolism /Mammalian Physiology	04	02	06
	<i>Core</i>	BT DSC 2D (Chem)	Chemistry IV for Biotechnology	04	02	06
	<i>Core</i>	BT DSC 3D (Zoo. / Bot.)	Genetics	04	02	06
	<i>SEC</i>	BT SEC 2	Bakery	03	01	04

***Mammalian Physiology as BT DSC 1D is for the students of Biotechnology with Biotechnology, Chemistry & Botany as subject combination.**

***Plant Physiology as BT DSC 1D is for the students of Biotechnology with Biotechnology, Chemistry & Zoology as subject combination.**

SEMESTER III

CORE COURSES

BT DSC 1 C

CELL BIOLOGY

THEORY

60 periods

UNIT I

(12 periods)

Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport, Cell wall Ultrastructure & Function.

UNIT II

(13 periods)

Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules, Microfilaments, Intermediate filaments. Endoplasmic reticulum: Structure, function including role in protein segregation. Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT III

(15 periods)

Lysosomes: Vacuoles and micro bodies: Structure and functions Ribosomes: Structures and function including role in protein synthesis. Mitochondria: Structure and function, Genomes, biogenesis. Chloroplasts: Structure and function, genomes, biogenesis Nucleus: Structure and function, chromosomes and their structure. Cell cycle: Mitosis & Meiosis

UNIT IV

(20 periods)

Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction. Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

PRACTICALS

(15 sessions)

1. Study the effect of temperature on semi permeable membrane.
2. Study the effect of organic solvents on semi permeable membrane
3. Demonstration of dialysis.
4. Study of plasmolysis and de-plasmolysis.
5. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source. (2)
6. Study of structure of a Prokaryotic cell
7. Study of structure of a Eukaryotic cell
8. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes. (4)
9. Study of Mitosis & Meiosis using Permanent / Temporary slides
10. Localisation of Mitochondria by Janus Green stain
11. Cytochemical staining of DNA.

SUGGESTED READING:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.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.

BT DSC 2 C - CHEMISTRY III FOR BIOTECHNOLOGY

SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II

(Credits: Theory-04, Practicals-02)

Theory

60 Periods

Section A: Physical Chemistry-2

(30 Periods)

Solutions

(6 periods)

Thermodynamics of ideal solutions: 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

(8 periods)

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, FeCl₃-H₂O and Na-K only).

Conductance

(8 periods)

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

(10 periods)

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 of 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

(30 periods)

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

Carboxylic acids and their derivatives

(6 periods)

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

(6 periods)

Amines (Aliphatic and Aromatic): (Upto 5 carbons)

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

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO₂, 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

(6 periods)

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of –NH₂ group, complexation with Cu²⁺ ions, ninhydrin test.

Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & Activating groups and Merrifield solid-phase synthesis.

Alkaloids

(4 periods)

Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Terpenes

(4 periods)

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α -terpineol.

Pharmaceutical Compounds

(4 periods)

Structure and Importance, Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

Reference Books:

- G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
- G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
- J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
- R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
- Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

- Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
- Berg, J. M., Tymoczko, J. L. & Stryer, L. Biochemistry 7th Ed., W. H. Freeman

CHEMISTRY III LAB: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method: $I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$
 $Cu^{2+}(aq) + xNH_3(aq) \rightleftharpoons [Cu(NH_3)_x]^{2+}$ Phase equilibria

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

Conductance

IV. Determination of cell constant

V. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

VI. Perform the following conductometric titrations:

v. Strong acid vs. strong base

vi. Weak acid vs. strong

base Potentiometry

Perform the following potentiometric titrations:

v. Strong acid vs. strong base

vi. Weak acid vs. strong base

vii. 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

- Separation of amino acids by paper chromatography
- Determination of the concentration of glycine solution by formylation method.
- Titration curve of glycine

Reference Books:

- A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.

- F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
- B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
- Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

BT DSC 3 C - MAMMALIAN PHYSIOLOGY

(Credits: Theory-04, Practicals-02)

THEORY

60 Periods

UNIT I: Digestion and Respiration

(15 Periods)

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice

Respiration: Exchange of gases, Transport of O₂ and CO₂, Oxygen dissociation curve, Chloride shift.

UNIT II: Circulation

(10 Periods)

Composition of blood, Plasma proteins & their role, blood cells, Haemopoiesis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT III: Muscle physiology and osmoregulation

(15 Periods)

Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction.

Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT IV: Nervous and endocrine coordination Reproduction

(20 Periods)

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, salutatory conduction, Neurotransmitters

Mechanism of action of hormones (insulin and steroids)

Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions. Anatomy of human male reproductive system, structural and functional aspects of testis (in brief). Onset of puberty. Anatomy of the female reproductive system in brief, estrous cycle, menstrual cycle in relation to ovarian cycle and menopause. Methods of fertility control- mechanical, chemical and surgical.

PRACTICALS

1. Finding the coagulation time of blood
2. Demonstration of action of salivary enzyme
3. Mounting of haemin crystals
4. Separation of lipids by Thin layer Chromatography
5. Estimation of blood cholesterol.
6. Detect the presence of Albumin, sugar, uric acid, ketone/ acetone bodies, chlorides, phosphates, calcium, bilirubin from urine sample. (2)
7. Permanent slides of Transverse section of mammalian gonads

8. Measurement of blood pressure and determination of pulse rate in Man
9. Effect of osmolarity on RBC
10. Determination of ESR
11. Study of ECG using recorded graph
12. Diffusion of glucose through intestine
13. Study of any five clinical conditions associated with hypo/hyper active endocrine glands using photographs (Gigantism, dwarfism, acromegaly, cretinism, myxedema, Graves' disease, cushion's disease) (2)

SUGGESTED READING

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Herculat Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley&sons, Inc.

BT DSC 3 C- Plant Physiology and Metabolism
(Credits: Theory-4, Practical-2)

THEORY

60 periods

Unit 1: Plant-water relations

(8 periods)

Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition

(6 periods)

Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.

Unit 3: Nutrient Uptake

(8 periods)

Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.

Unit 4: Translocation in the phloem

(8 periods)

Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators

(6 periods)

Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of flowering

(6 periods)

Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Unit 7: Phytochrome ,cryptochromes and phototropins

(6 periods)

Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.

Unit 8: Photosynthesis

(8 periods)

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 9: Nitrogen metabolism

(4 periods)

Biological nitrogen fixation; Nitrate and ammonia assimilation.

PRACTICAL

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.

3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf.
4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces).
6. To study the phenomenon of seed germination (effect of light).
7. To study the effect of different concentrations of IAA on *Avena* coleoptile elongation (IAA Bioassay).
8. To study the induction of amylase activity in germinating barley grains.
9. Demonstration of Hill reaction.
10. To study the effect of light intensity and bicarbonate concentration on O₂ evolution in photosynthesis.
11. Comparison of the rate of respiration in any two parts of a plant.
12. To demonstrate suction due to transpiration.
13. Fruit ripening/Rooting from cuttings (Demonstration)
14. Bolting experiment/*Avena* coleoptile bioassay (demonstration).
15. Demonstration of Respiration in roots.

SUGGESTED READINGS

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.

SEMESTER IV
CORE COURSES

BT DSC 2 D - CHEMISTRY IV FOR BIOTECHNOLOGY

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

(Credits: Theory-04, Practicals-02)

Theory:	60 Periods
Section A: Inorganic Chemistry 2	(30 periods)
Acids and Bases	(6 Periods)
Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.	
Chemistry of s and p Block Elements	(10 Periods)
Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial.	
Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.	
Noble Gases	(6 Periods)
Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF ₂ , XeF ₄ and XeF ₆ ; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF ₂). Molecular shapes of noble gas compounds (VSEPR theory).	
Inorganic Polymers	(4 Periods)
Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.	
Bio-Inorganic Chemistry	(4 Periods)
A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na ⁺ , K ⁺ and Mg ²⁺ ions: Na/K pump; Role of Mg ²⁺ ions in energy production and chlorophyll. Role of Ca ²⁺ in blood clotting, stabilization of protein structures and structural role (bones).	
Section B: Physical Chemistry-3	(30 Periods)
Kinetic Theory of Gases	(10 periods)
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. Vander 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 CO₂. 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

(4 periods)

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

(6 periods)

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

(10 periods)

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:

* G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).

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

CHEMISTRY IV LAB

CHEMISTRY OF S- AND P-BLOCK ELEMENTS, STATES OF MATTER & CHEMICAL KINETICS

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 : CO₃²⁻, S²⁻, SO₃²⁻, S₂O₃²⁻, NO₃⁻, CH₃COO⁻, Cl⁻, Br⁻, I⁻, NO₂⁻, SO₄²⁻, PO₄³⁻, BO₃³⁻, C₂O₄²⁻, F⁻

(Spot tests should be carried out wherever feasible)

Preparation of Aluminium potassium sulphate KAl(SO₄)₂.12H₂O (Potash alum) or Chrome alum.

Section B: Physical Chemistry

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

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

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

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

(III) Chemical Kinetics

Study the kinetics of the following reactions.

3. Initial rate method: Iodide-persulphate reaction

4. Integrated rate method:

c. Acid hydrolysis of methyl acetate with hydrochloric acid.

d. Saponification of ethyl acetate.

e. Compare the strengths of HCl and H₂SO₄ by studying kinetics of hydrolysis of methyl acetate

Reference Books:

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

BT DSC 3 C- GENETICS
(Credits: Theory-04, Practicals-02)

Theory:

60Periods

UNIT I-

(15 Periods)

Overview of Mendelian genetics, its modifications, Sex determination and linkage

Introduction: Historical developments in the field of genetics. Mendelian genetics: Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity. Epistasis and Hypostasis- Multiple alleles with example, Multiple genes with example Sex determination and sex linkage - Sex determination in Drosophila, Insects, Honeybee, Bonelia, Turtle, Birds and Man. Barr bodies, dosage compensation, genetic balance theory, sex influenced dominance, sex limited gene expression, sex linked inheritance.

UNIT II Chromosomal structure, Linkage and crossing over

(15 Periods)

Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes. Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition –unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, repetitive transposed sequences, repetitive multiple copy genes, noncoding DNA.

Genetic organization of prokaryotic genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III Gene mutations

(15 Periods)

Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), spontaneous mutation and induced mutation, Types of mutagens-physical, Chemical and Biological. Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, Chromosomal aberrations in human beings, abnormalities– Aneuploidy and Euploidy, Chromosome and gene mutations: Definition and types of mutations, causes of mutations, s, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression,

UNIT IV Human genetics

(15 Periods)

Eugenics, Pedigree construction and analysis (Inheritance pattern of sex linked, autosomal dominant and recessive traits), Inheritance of human traits- Brown eyes, polydactyl, Diabetes insipidus, sickle cell anaemia. Study of Human chromosomal disorders: Down's syndrome, Klinefelter's syndrome, Turner's syndrome, Philadelphia syndrome. In breeding and out breeding, applications and evolutionary significance.

Evolution and population genetics:, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

PRACTICALS

1. Problems in Genetics through beads / seeds mixtures. Monohybrid and Dihybrid ratios. (2)
2. Problems in Genetics on multiple alleles and Quantitative inheritance (multiple genes). (2)
3. Problems on Mendelian Genetics
4. Chromosome mapping using point test cross data
5. Study of polyploidy in onion root tip by colchicine treatment.
6. Study of phenotypic characters in *Drosophila* (Body colour, Wing pattern and Eye colour).
7. Determination of sex by Barr body method.
8. Karyotyping Analysis in Humans from Printed material. (2)
 - a. Normal male or female
 - a. Klinefelter's Syndrome
 - b. Turner's Syndrome
 - c. Down's Syndrome
 - d. Philadelphia
9. Determination of allelic frequency of the following Mendelian Human traits- (2)
Tongue Rolling, Ear lobes, Widow's peak, Clasp of hand, Thumb crossing pattern, Folding of arms, Hitch-hiker's thumb.
10. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
11. Preparation of Polytene chromosome slide

SUGGESTED READING

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX 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. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

SKILL ENHANCEMENT COURSES

SKILL ENHANCEMENT COURSES FLOATED BY DCT'S DHEMPE COLLEGE OF ARTS & SCIENCE, MIRAMAR, GOA

Semester I: BT SEC 1: Urban Gardening
Semester II: BT SEC 2: Bakery

BT SEC 1- URBAN GARDENING (Credits: Theory-03, Practicals-01)

THEORY **45 periods**

UNIT I **3 periods**

Introduction to Urban Farming, its status and potential in India and Goa

UNIT II **12 periods**

Study different kinds of plants and their role in our lives, Uses of plants for creating an ambience, adding colour, beauty; providing shade/cooling; protecting from dust; removing odours, toxins ; yielding flowers, fruits, nuts, berries, tubers, spices, flavours, etc; preventive and therapeutic medicinal value of plants, their root systems, their requirement for nutrition, water and light.

Study of specific vegetable, fruit & flowering plants, their light and water requirements, maturity indices, harvesting and post-harvest treatment

UNIT III **10 periods**

Study of plant spacing and planting methods, Water holding capacity of different soils, Saturation, Field Capacity and Wilting Point. Improvement of WHC.

UNIT IV **20 periods**

Panchagavya, Sanjivani, Beej Amrut solutions, their efficacy, application and uses, Advantages of organic or jaiwik agriculture for better quality/flavour of food, longer shelf life of fruits, vegetables, herbs and flowers and for human health and well-being, Sources of seeds, plants and garden inputs including tools and equipment, Beneficial and Effective Micro-organisms [E.M.] solutions, their efficacy, dilutions, application and uses, Innovations like vertical gardening, sub-surface irrigation, hydroponics

PRACTICAL

1. Study of plants with respect to requirement of water [including xerophytes, cacti and succulents, epiphytes], preparation of pot with appropriate soil mix or other media.
2. Study of plants with respect to requirement of light or shade [including orchids, anthurium, fruit/vegetable plants, cacti and succulents] including selection of appropriate light filters like shade-nets, curtains, etc
3. Study of plants with respect to nutrient requirement [including orchids, anthurium, fruit/vegetable plants, cacti and succulents] and preparation of pot with appropriate mix of manures, PSB, *Rhizobium*, VAM, etc.
4. Study of specific vegetable crops, their light and water requirements, harvesting and PHT [Okra/Bhendi, Legumes, Solanaceous crops, Cucurbits etc]
5. Study of specific fruit plants, their light and water requirements, harvesting and PHT [Banana, Mango, Guava, etc]
6. Study of specific flowering plants, their light and water requirements, harvesting and PHT [Gladioli,

Anthurium, Orchids, Chrysanthemums, Roses, etc]

7. Preparation of Effective Micro-organisms [E.M.] solutions and their dilution without plasmolysis.
8. Preparation of Panchagavya, Sanjivani, BeejAmrut, etc
9. Determination of available soil moisture at Field Capacity in different soils. Improvement of WHC using compost, coco-peat or clay
10. Study of shelf life in conventionally grown and organically grown fruits and vegetables/ herbs in different kinds of packaging [polythene, butter paper, brown paper, newsprint bags, etc] and different storage conditions [ambient, refrigeration, etc]
11. Study of shelf life in conventionally grown and organically grown flowers in different kinds of packaging [polythene, butter paper, brown paper, newsprint bags, etc] and different storage conditions [ambient, refrigeration, etc]. Extension of vase-life of flowers with additives
12. Using plants for creating an ambience, adding colour, beauty; providing shade/cooling, removing odors, toxins as specimen plants and by massing or clusters. Study of plants in a local garden
13. Transect walk across the campus to evaluate and understand the role of plants therein; Discussion based on the observations.
14. Calculation of space requirement for plants based on recommended spacing, design and layout for home garden
15. Field visit to a nursery, KVK or institute

SUGGESTED READING

1. Braganza, Miguel ,2015. **Growing Organically**. Botanical Society of Goa, Panaji-Goa. Pp 60
2. Kumar N. (2014). **Introductory Horticulture**. Rajalaxmi Publications, Pune-Maharashtra
3. Natrajan , K. 2009 Panchagavya. Organic Farming Association of India, Mapusa-Goa
4. Chadha K. L. (2008) **Handbook of Horticulture** I.C.A.R., Delhi.
5. Figueiredo , Nelson. 2000. **Integrated Pest Management**. Agriculture Officers' Association. Panaji-Goa. Pp 159
6. Singh, Ranjit.1992. **Fruits**. National Book Trust. New Delhi. Pg 221
7. Alvares, .. Claude (Ed.) 2009. Organic Farming Source Book . Other India Press. Mapusa-Goa.

BT SEC 2- BAKERY
(Credits: Theory-03, Practicals-01)

THEORY **45 periods**

Unit I: Introduction to baking **(4 periods)**

Introduction to baking; what is baking; baking v/s cooking; types of baking; science in baking; fermentation principles.

Unit II: History of Baking **(6 periods)**

The origin of baking; baking in the Middle Ages -the Egyptians, the Romans, the Europeans, Ginger Bread Merchants, Open Air Café; Baking in the 15th – 19th centuries; Modern baking and technology; history of baking timeline.

Unit III: Baking tools **(15 periods)**

Measuring tools; mixing bowls; wooden spoons; rubber scrapper; flour sifter; spatulas; rolling pin; baking pans- types; cookie sheets; bread knife; kitchen shears; grater or shredder; weighing scale; cookie cutter; pastry blender; pastry brush; pastry wheel; cooling rack; wire whisk; decorating/ pastry tips; pastry bag/piping bag; parchment paper; oven thermometer; cake turntable; cake stand with tier; double boiler

Unit IV: Baking equipments **(9 periods)**

Baking equipment- ovens (deck ovens, rack ovens, mechanical ovens, convection ovens, wood fire oven); Mixers (stand mixer, hand mixer); upright freezer; mechanical dough cutter; blenders; food processor

Unit V: Ingredients and Their Effects **(11 periods)**

Flours (bread flour, cake flour, all-purpose flour, whole wheat, wheat germ, rye flour, oat flour, corn flour, rice flour, triticale, potato starch flour, soy flour); sweeteners (sucrose, fructose, honey, molasses, saccharin, aspartame); salt, leavening agents (baking soda, baking powder, yeast); fats (shortening, butter, margarine, reduced fat substitutes, oil); eggs; liquids (water, milk, butter milk, cream, juice)

PRACTICALS

1. Bread – Grissini, Clover Leaf rolls, Baguette, Brioche (4)
2. Welsh Cheesecake pastry, Strawberry biscuit, Swiss tarts (3)
3. Muffins – Choco chip, Chocó lava (1)
4. Cake (red velvet/chocolate/ribbon/vanilla) (4)
5. Chocolate Doughnuts
6. Apple crumble pie, banoffe pie, serradura (2)

SKILL ENHANCEMENT COURSES FLOATED BY ST. XAVIER'S COLLEGE, GOA

Semester I: BT SEC 1: Urban Gardening

Semester II: BT SEC 2: Basics of Forensic science

BT SEC 2- BASICS OF FORENSIC SCIENCE

(Credits: Theory-03, Practicals-01)

THEORY

45 periods

Unit I

(15 Periods)

Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths.

Unit II

(13 Periods)

Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.

Unit III

(08 Periods)

Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification,

Unit IV

(09 Periods)

Principle of DNA fingerprinting, application of DNA profiling in forensic medicine, Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber security.

PRACTICALS

1. Documentation of crime scene by photography, sketching and field notes.
2. a. Simulation of a crime scene for training.
b. To lift footprints from crime scene.
3. Case studies to depict different types of injuries and death.
4. Separation of nitro compounds (explosives)/ ink samples by thin layer chromatography.
5. Investigate method for developing fingerprints by Iodine crystals.
6. PCR amplification on target DNA and DNA profiling,
7. E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Recovering deleted evidences, Password Cracking

SUGGESTED READING

1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001). _
3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002). _
4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific

- and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005). _
5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997). _
 6. R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004). _
 7. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton (2013). _

T.Y.B.Sc.

Semester	Course	Paper code	Paper	Credits		Total Credits
				Theory	Practical	
V	<i>Core</i>	BT DSC 5	Plant Biotechnology	04	02	06
	<i>Core</i>	BT DSC 6	Bio-analytical Tools	04	02	06
	<i>Core</i>	BT DSC 7	Molecular Biology	04	02	06
	<i>DSE</i>	BT DSE1	Biostatistics and Bioinformatics	03	01	04
	<i>DSE</i>	BT DSE2	Food Biotechnology	03	01	04
VI	<i>Core</i>	BT DSC 8	Bioprocess Technology	04	02	06
	<i>Core</i>	BT DSC 9	Immunology	04	02	06
	<i>Core</i>	BT DSC10	Environmental Biotechnology	04	02	06
	<i>DSE</i>	BT DSE 3	Animal Biotechnology	03	01	04
	<i>DSE</i>	BT DSE 4	PROJECT	---	---	04

T.Y.B.Sc.

SEMESTER V

CORE COURSES

BT DSC 5- PLANT BIOTECHNOLOGY (Credits: Theory-04, Practicals-02)

THEORY
periods

60

UNIT I

(20 periods)

Introduction & history of plant tissue culture. Importance of plant tissue culture. In vitro culture techniques: Sterilization methods, Culture media – composition, types of media and role of hormones in in-vitro culture. Inoculation, Incubation and Acclimatization. Cryo and organogenic differentiation, Types of culture: Callus, Seed, Embryo, Organs, single cell and suspension Protoplast culture. Micro propagation Axillary bud proliferation, Meristem and shoot tip culture, bud culture, organogenesis, embryogenesis, advantages and disadvantages of micro propagation.

UNIT- II

(10 periods)

In vitro haploid production: Androgenic methods: Anther culture, Microspore culture androgenesis Significance and use of haploids, Ploidy level and chromosome doubling, diploidization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

UNIT – III

(20 periods)

Protoplast Isolation and fusion: Methods of protoplast isolation, Protoplast development, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation- Nomenclature, methods, application and disadvantages. Plant transformation using *Agrobacterium tumefaciens*, Production of secondary metabolites using plant tissue

culture

UNIT - IV

(10 periods)

Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria. Applications of Plant Biotechnology-Improved crop varieties- High yield, Insect resistance, drought and salt tolerance, edible vaccines

PRACTICALS

1. Preparation of simple growth nutrient (Knop's medium), full strength, half strength, solid and liquid. (2)
2. Preparation of complex nutrient medium (Murashige & Skoog's medium) (1)
3. To select, sterilize and prepare an explant for culture. (2)
4. Effect of growth hormones in callus induction (2).
5. To demonstrate various steps of Micropropagation (4).
6. Protoplast isolation (2)
7. To set up single cell suspension culture and to check cell viability (2)

SUGGESTED READING

1. KalyanKumarDe:PlantTissueCulture;1992.NewCentralBookAgency(P)Ltd., Calcutta.
2. Narayanswamy S;PlantCellandTissueCulture;1994.TataMcGraw-HillPublishing CompanyLtd.NewDelhi.
3. S.P.Misra:PlantTissueCulture;2009.AneBooksPvt.Ltd.,NewDelhi.
4. ChawlaH.S.;IntroductiontoPlantBiotechnology;2002.SciencePublishersInc. USA
5. K.G.Ramawat:PlantBiotechnology;S.Chand& CompanyLtd.,NewDelhi,2004
6. Jha&Ghosh:PlantTissueCulture;UniversitiesPressPvt.Ltd.,Hyderabad,2005.
7. PrakashandArora:CellandTissueCulture;5thed2005AnmolPublicationsPvt.Ltd., NewDelhi.
8. KumarU;MethodsInPlantTissueCulture.2011.Agro-Bios.India
9. S.S.Purohit,PracticalPlantBiotechnology,7thed,2009. StudentEdition.

BT DSC 6 - BIO-ANALYTICAL TOOLS

(Credits: Theory-04, Practicals-02)

THEORY periods

60

UNIT I (10 periods)

Simple microscopy, phase contrast microscopy, fluorescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy. Introduction to mass spectrometry.

UNIT II (15 periods)

Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared), centrifugation: principle of centrifugation, centrifugal force and sedimentation rate, differential and density gradient centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

UNIT III (15 periods)

Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV (20 periods)

Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno-electrophoresis, isoelectric focusing, Southern Blotting, Northern Blotting and Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

PRACTICAL

1. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.
2. Fluorimetry demonstration video.
3. Demonstration of Column Chromatography
4. Separation of amino acids by paper chromatography
5. Separation of plant pigments by paper chromatography
6. To identify lipids in a given sample by TLC.
7. Gel filtration chromatography (Demonstration)
8. Native gel electrophoresis of proteins
9. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
10. Immunoelectrophoresis
11. Southern and Western Blotting (Video or Demonstration) (2)
12. DNA elution from Agarose gel (2)
13. Visit to a R&D section of pharmaceutical industry for demonstration of new analytical instruments

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons, Inc.
2. De Robertis, E.D.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.

BT DSC 7- MOLECULAR BIOLOGY
(Credits: Theory-04, Practicals-02)

THEORY

60 periods

UNIT I: DNA structure and replication

(15 periods)

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

UNIT II: DNA damage, repair and homologous recombination

(10 periods)

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

UNIT III: Transcription and RNA processing

(10 periods)

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

UNIT IV: Regulation of gene expression and translation

(15 periods)

Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl-tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptide

UNIT V: Recombinant DNA technology

(10 periods)

Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT- (Reverse transcription) PCR. Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants

PRACTICAL

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from plant cells
3. Isolation of chromosomal DNA from bacterial cells.
4. Isolation of nuclei and chromatin.
5. Plasmid DNA isolation by alkaline lysis
6. Restriction digestion of DNA
7. Making competent cells

8. Transformation of competent cells.
9. Demonstration of Ames test or reverse mutation for carcinogenicity
10. UV survival curve for E. coli
11. Preparation of Polytene chromosomes from Drosophila larva
10. Titration of phages P1 and λ , studying plaque morphology
12. Chemical mutagenesis and isolation of auxotrophic mutants.
13. Isolation of RNA from bacterial cells
14. Isolation of RNA from plant cells
15. Estimation of RNA by orcinol method.

SUGGESTED READING

1. Lewin B. Genes XI. 2007. Jones and Bartlett Publishers
2. Nelson D.L. and Cox M.M. 2000. Lehninger Principles of Biochemistry (3rd Edition). Worth Publishers, New York, USA.
3. Gerald Karp, Harris D. Cell and Molecular Biology – Concepts and Experiments. 2008. John Wiley & Sons Inc, New York.
4. Robertis E.D.P., Robertis E.M.F., Cell Biology and Molecular Biology, 8th edition, 1998. Sauder College.
5. Watson J.D., Hopkins N.H. et al. Molecular Biology of the Gene. (2008). Garland Publishing (Taylor & Francis Group), New York & London.

DISCIPLINE SPECIFIC ELECTIVES

BT DSE 1- BIOSTATISTICS AND BIOINFORMATICS

(Credits: Theory-03, Practicals-01)

THEORY

45 periods

UNIT I

(10 periods)

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis. Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

UNIT II

(10periods)

Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA), Correlation and Regression. Emphasis on examples from Biological Sciences

UNIT III

(15periods)

History of Bioinformatics. The notion of Homology. Sequence Information Sources: EMBL, GENBANK, Entrez, Unigene, Protein Information Sources: PDB, SWISSPROT, TREMBL,. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry. Introduction to protein structure. Protein Data Bank (PDB) data format and visualization of protein structure. Protein-Protein and Protein-Ligand interaction visualization

UNIT IV

(10 periods)

Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis. Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identification tools. SNP (Single Nucleotide Polymorphism) and other mutation databases.

PRACTICALS

1. Based on graphical Representation
2. Based on measures of Central Tendency
3. Based on measures of Dispersion
4. Based on Distributions Binomial Poisson Normal
5. Based on t test
6. Based on z - test
7. Based on Chi-square test
8. Based on Regression and Correlation
9. Sequence information resource
10. Understanding and use of various web resources: EMBL, Genbank, Entrez,
11. Understanding structural data: Exploring Protein Data Bank (PDB), Visualizing protein structures

with RasMol or PyMOL.

12. Understanding and use of various web resources: Unigene, Protein information resource (PIR)
13. Understanding and using: PDB, Swissprot (UniProt), TREMBL
14. Using various BLAST options and interpretation of results.
15. Multiple sequence alignment using ClustalW.

SUGGESTED READING

- 1) Rastogi S.C., Mendiratta N. & Rastogi P., Bioinformatics: Concepts, Skills and Applications. 2004, CBS publishers.
- 2) David W. Mount, Bioinformatics - sequence and Genome analysis; (2004), CBS Publishers and Distributors.
- 3) Ignacimuthu S., Basic Bioinformatics. 2005. Narosa Publishing House, New Delhi.
- 4) Chikhale N.J., Gomase V.S., Bioinformatics: Theory and Practice, 2007, Himalaya Publishing House, New Delhi.
- 5) Xiong, Jin, Essential Bioinformatics, 2006, Cambridge University Press

BT DSE 2- FOOD BIOTECHNOLOGY

(Credits: Theory-03, Practicals-01)

THEORY	45 periods
UNIT I: Microbiology of food	3 periods
<ul style="list-style-type: none">• History of Microorganisms in food• Role and significance of microorganisms in foods.	
UNIT II: Food Technology and Diseases	10 periods
<ul style="list-style-type: none">• Intrinsic and extrinsic factors responsible for food spoilage• Microorganisms involved in food spoilage: fruits, vegetables, meat, eggs, bread• Food Borne diseases. <ol style="list-style-type: none">1. Food poisoning: (Bacterial Toxin Botulism and Staphylococcal toxin) Fungal Toxins: Aflatoxin.2. Food borne Infections: Gastroenteritis and Salmonellosis	
UNIT III: Milk technology and Diseases	5 periods
<ul style="list-style-type: none">• Sources of contamination• Different microorganisms implicated in spoilage• Milk borne diseases: Listeriosis and Scarlet fever• Grading of milk by dye reduction test - MBRT and Resazurin	
UNIT IV: Detection of food spoilage	7 periods
<ul style="list-style-type: none">• Methods of detection of food spoilage: <ol style="list-style-type: none">1. Traditional approaches: SCP, Breeds smear, identification of specific organisms by using selective and differential media.2. New approaches: use of gene probes, RDT, Bioluminescence.	
UNIT V: Food preservation	12 periods
<ul style="list-style-type: none">• Preservation by Drying: Solar drying, mechanical drying, salting, smoking).• Preservation at High temperature: concept of TDP and TDT. <p>Pasteurization (LTHT, HTST,UHT processes; efficiency of pasteurization phosphatase test, canning, Hurdle Technology.</p> <ul style="list-style-type: none">• Preservation at low temperature: Freezing,• Preservation by use of additives: Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants.• Preservation by radiation: UV, ionizing radiations, gamma and cathode rays, microwave processing.• Other methods: Hydrostatic pressure cooking, modified atmosphere. <p>Fermentation technology</p> <ul style="list-style-type: none">• Fermented Food: Process, microbiology involved and changes during fermentation of - Fermented food: sourkraut, Milk products: yogurt	
UNIT VI: Microorganisms as source of food and enzymes	3 periods
<ul style="list-style-type: none">• Nutritive value and use of <p>-Mushroom (production done in industrial)</p> <p>-SCP eg. Spirullina</p> <ul style="list-style-type: none">• Enzymes and its application in food industry	

UNIT VII: Food quality assurance

5 periods

• Food safety: HACCP System to food protection, Responsibility for food safety.

Pros and Cons of GM foods

PRACTICALS:

1. Dye reduction tests (MBRT)
2. Dye reduction tests (Resazurin)
3. SPC
4. Breed's smear
5. Plating on selective media
6. Efficiency of pasteurization: Phosphatase test
7. Determination of TDP and TDT
8. Microbiology of food: Microbial examination of spoilt food on selective media.
9. MIC of preservatives (Sugar, NaCl, Na-benzoate and K - metabisulfite) (4)
10. Estimation of shelf-life of packaged food stuff
11. Mushroom production
12. Field trip to a dairy industry

SUGGESTED READING

1. Jay, James M., Loessner, Martin J., Golden, David A. Modern Food Microbiology, 2005
2. M. R. Adams, M. O. Moss, Food Microbiology, Royal Society of Chemistry, 2008 –
3. Frazier, Food Microbiology, Tata McGraw-Hill Education, 1950
4. Bibek Ray, Arun Bhunia, Fundamental Food Microbiology, Fifth Edition
5. Banwart, George, Basic Food Microbiology, (1989)

BT DSC 8: BIOPROCESS TECHNOLOGY

(Credits: Theory-04, Practicals-02)

THEORY

60 periods

UNIT I

(10 periods)

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. (Historical contributions), Basic principle components of fermentation technology. Types of microbial Culture and its growth kinetics– Batch, Fedbatch and Continuous culture.

UNIT II

(20 periods)

Design of bioprocess vessels- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in production processes. Principles of upstream processing – Media preparation, Inocula development and sterilization.

UNIT III

(15 periods)

Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control.

UNIT IV

(15 periods)

Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of penicillin/ streptomycin, ethanol/ wine, amylase, lactic acid and Single Cell Proteins.

PRACTICALS

1. Bacterial growth curve. (Batch Fermentation)
2. Bacterial growth curve. (Fed Batch Fermentation)
2. Calculation of thermal death point (TDP) of a microbial sample.
3. Production and analysis of ethanol. (2)
4. Production and analysis of amylase. (2)
5. Production and analysis of lactic acid. (2)
6. Isolation of industrially important microorganism from natural resource. (2)
7. Bioassay of Penicillin
8. MIC: penicillin
9. MIC: streptomycin
10. Industrial visit to a Bioprocess facility.

SUGGESTED READING

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

BT DSC 9 – IMMUNOLOGY
(Credits: Theory-04, Practicals-02)

THEORY

60 periods

UNIT I

(20 periods)

Immune Response - An overview, components of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell receptor genes by somatic recombination.

UNIT II

(15 periods)

Regulation of immunoglobulin gene expression – clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

UNIT III

(15 periods)

Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing.

Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS. Types of Hypersensitivity

UNIT IV

(10 periods)

Vaccines & Vaccination – adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics – RIA, ELISA.

PRACTICALS

1. Blood Grouping
2. Preparation of serum
3. Differential leucocytes count
4. Total leucocytes count
5. Total RBC count
6. Haemagglutination inhibition assay
7. Simple Immunodiffusion
8. Double immunodiffusion test using specific antibody and antigen. (3)
9. Demonstration of ELISA
10. Pregnancy test
11. WIDAL test (Qualitative)
12. Countercurrent Electrophoresis
13. Haemoglobin estimation by Sahli's haemocytometer

SUGGESTED READING

1. Roitt and Roitt, Essential Immunology. 1994. Blackwell Science, Oxford Blackwell Scientific Publications.
2. Kuby J., Immunology, 5th Edition, 2005. W.H. Freeman and Company, New York.
3. Rastogi V.B., Genetics. 2000. S. Chand Publishers, New Delhi.
4. Weir D.M., 1986. Handbook of Experimental Immunology - Vol I & II.

THEORY**60 periods****Unit 1:Environment****(4 periods)**

Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.

Unit 2: Environmental problems**(6 periods)**

Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.

Unit 3:Microbiologyof waste water treatment**(8 periods)**

Aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, upflow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.

Unit 4:Xenobiotic compounds**(10 periods)**

Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates).Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation.

Unit 5: Role of immobilized cells/enzymes in treatment of toxic compounds**(6 periods)**

Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.

Unit 6: Sustainable Development**(8 periods)**

Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.

Unit 7: International Legislations, Policies for Environmental Protection**(6 periods)**

Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report 75 (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.

Unit 8: National Legislations, Policies for Pollution Management**(6 periods)**

Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

Unit 9: Public Participation for Environmental Protection**(6 periods)**

Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada BachaoAndolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.

PRACTICALS

1. Determination of Total Suspended Solids (TSS) of water sample.
2. Determination of Total Dissolved Solids (TDS) of water sample.
3. Determination of DO of Water Sample
4. Calculation of BOD of water sample.
5. Calculation of COD of water sample.
6. Determination of Presence of coliforms in water
7. Bacterial Examination of Water by MPN Method.
8. Determination of total alkalinity of water.
9. Detection of chlorine in water.
10. Isolation of xenobiotic degrading bacteria
11. Determination of acidity of water.
12. Determination of salinity of water
13. Determination of nitrates in water
14. Determination of calcium in water
15. Determination of phosphorus in water

SUGGESTED READING

- 1) Chatteji A.K., Introduction to Environmental Biotechnology. 2nd ed, 2009. Prentice Hall of India Pvt. Ltd. New Delhi 110001,
- 2) Jogdand B.N., Environmental Biotechnology (Industrial Pollution Management). 2008. Himalaya Publishing House, Mumbai.,
- 3) Agarwal S.K., Environmental Biotechnology. 2009. APH Publishing Corporation New Delhi.
- 4) Indu Shekar Thakur, Environmental Biotechnology: Basic concepts and applications. 2006. I.K. International Pvt. Ltd. New Delhi.
- 5) Singh B.D., Biotechnology. 3rd edition, 2008. Kalyani Publishers.
- 6) Murugesan A; G., Rajakumari C., Environmental science and Biotechnology: theory and techniques. 2006. MJP publishers, Chennai.
- 7) Santra S.C., Environmental Science. 2001. New central book agency (P) ltd. Calcutta.
- 8) Anjaneyula Y., Introduction to environmental Science. 2005. BS publications

DISCIPLINE SPECIFIC ELECTIVES

BT DSE 3- ANIMAL BIOTECHNOLOGY

(Credits: Theory-03, Practicals-01)

THEORY

45 PERIODS

UNIT I

(10 periods)

History and Scope of animal tissue culture, Requirements for animal cell culture technology (washing room, media prep, sterilization room, inoculation and culture room, equipment, culture vessels)

Culturing of cells (basic techniques, cell lines and maintenance, types of culture, transformed and normal cells) ,Cell growth (cell cycle, synchronization, apoptosis)

UNIT II

(10 periods)

Gene transfer methods in Animals Introduction to transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect. Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis.

UNIT III

(15 periods)

Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications.

UNIT IV

(10 periods)

Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.

PRACTICALS

1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization (2)
2. Sources of contamination and decontamination measures.
3. Preparation of serum from animal blood for cell culture.
4. Preparation of Hanks Balanced salt solution
5. Preparation of Minimal Essential Growth medium
6. Isolation of lymphocytes for culturing
7. Establishing primary culture (monolayer)
8. Observation of cell culture (chick embryo)
9. Sub culturing of monolayer culture.
11. DNA isolation from animal tissue
12. Quantification of isolated DNA.
13. Resolving DNA on Agarose Gel.
14. Viability study of cell using trypan blue.

SUGGESTED READING

1. Mathurshivangi, Animal cell & tissue culture, (2009), Agrobios (India),
2. Masters John, Animal cell culture - A practical approach. 2000. OUP Oxford publishers
3. Butterworth-Heinemann, in vitro cultivation of animal cells, 2007
4. Das H.K., Textbook of Biotechnology, 2007. Wiley India, New Delhi
5. Sudhagangal, Principles and practice of animal tissue culture. 2007.

6. Freshney Ian, Animal Cell Biotechnology (5th Edition) 2005. Wiley, John & sons
7. Gupta P.K., Elements of Biotechnology - (1st Edition - 2000). Rastogi Publications.

BT DSE 4

PROJECT
