St. Xavier's College (Autonomous), Ahmedabad-9
Syllabus under Autonomous system for BSc. Biotechnology
(2015-2017)

Includes:
B.Sc. Biotechnology syllabus Sem 1 to 6
Chemistry Sem 1 to 4
Botany Sem 1 to 2
Foundation Sem 1 to 4

St. Xavier's College (Autonomous), Ahmedabad
BSc. Biotechnology
Semester I

Semester I
CORE Paper: Basic Chemistry of Biomolecules
Course Code: BT 1501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying Biotechnology.

By the end of the paper, a student should be able to:

a) Understand the importance of having water as a solvent system in cells
b) Appreciate the importance of bonding and spatial arrangements of molecules for proper functioning and stability.
c) Establish the concept of how proper conformations are needed for optimum functioning of the molecules and thereby the entire cell
d) Appreciate how proteins, carbohydrates, lipids and nucleic acids can contribute to structural integrity of the cell as well as the biochemical reactions.
e) Appreciate how a change in the structure of the molecules can lead to abnormalities, for e.g. A mutated globin results in sickle cell anaemia
f) Understand both the physical as well as chemical properties of these biomolecules, as these properties can be used to carry out various studies.
g) Appreciate experiments carried out by scientists to enable understand the structure of biomolecules, understand their properties, design of experiments to prove the same and analyse the data and give interpretations.

Thus, the knowledge from this course can help in the following:

a) The students could pursue a career in clinical Biotechnology as maintaining levels of these biomolecules in the body are of utmost importance. The decrease or increase in the amount of some of the biomolecules can have clinical significance. For example, increased blood sugar levels are indicative of a person suffering from diabetes mellitus.
b) The students can carry out basic research in Biotechnology, which in turn can be of great help in the medical and diagnostic fields.
c) Students can also go in for Medical Laboratory Technique Courses, opening opportunities in hospitals and pathological laboratories.
d) Basic knowledge of Biotechnology is also required for Nutrition and Dietetics.
e) The understanding of proteins, its study, has opened up the field of Proteomics.
f) Many of the carbohydrates, proteins and lipids discussed have commercial value and thus, find a place in Industrial Biotechnology.

II. Course Content

Unit 1: Basic characteristics of small molecules

Water as solvent for molecules in cell; Bonding: bond angles and lengths; Asymmetry in molecules; Conformations of molecules; Tautomerism and resonance; Forces between molecules and chemical groups; Acids and Bases: Titration curves; pH, its measurement and significance in biological systems; Buffers; Henderson – Hasselbach Equation; Buffering against pH changes in biological systems.

Unit 2: Carbohydrates and Glycobiology

Monosaccharides and Disaccharides: Structures, characteristics, functions and sources; Polysaccharides: Structure and influence of steric factors and hydrogen bonding; Examples of Homo and heteropolysaccharides and their functions in relation to the structures e.g. Starch, cellulose, Glycogen, Pectin, Hemicelluloses etc.; Glycoconjugates: Proteoglycans, Glycoproteins and Glycolipids; Carbohydrates as informational Molecules: Lectin – carbohydrate Interactions.

Unit 3: Amino Acids and Proteins

Structures and classification of amino acids; Uncommon amino acids; Amino acids as acids and bases – titration curves and its ampholytic nature; Peptide bond and its characteristics; Peptides and their ionization behavior; Structure of proteins: Primary structure, Secondary structure, Tertiary structure and Quaternary structure; Amino acid sequencing of proteins and its significance; Use of X – ray crystallography and Mass spectrometry in investigating proteins; Protein denaturation and Folding; Protein functions – Transport: Structure and function relationship of myoglobin and hemoglobin; Complementary interactions between proteins and ligands, e.g. Antigen – antibody interaction,

Unit 4: Lipids and Nucleic Acids

Storage lipids: Structure, characteristics and functions of Fatty Acids, Triacylglycerols; Structural Lipids: Glycerophospholipids, Galactolipids and Sulpholipids, Sphingolipids and Sterols; Lipids as signal molecules; Lipids as cofactors; Lipids as pigments; Lipid extraction methods; Determination of lipid structures; Introduction to lipidomics.

Structures, characteristics and functions of nucleotides; Three dimensional structure of nucleic acids; DNA as a double helical structure; Unusual nucleotides and unusual structures of nucleic acids

Semester I
Practical Paper: Basic chemistry of Biomolecules
Course Code: BT 1501L

No. of Credits: 03
Learning Hours: 60 hrs

1 Session: 2 hours

Lab Sessions

1. Tests for identification of sugars and sugar mixtures
2. Colour reactions for amino acids and peptides
3. Colour reactions of cholesterol
4. Lipid extraction method
5. Determination of iodine number
6. Determination of saponification number
7. Colorimetric estimation of DNA by DPA method
8. Colorimetric estimation of RNA by Orcinol method
9. Colorimetric estimation of Sugar by DNSA method

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Recommended learning Resources

1. Biochemistry, 5th Edition. Garrett and Grisham
2. Biochemistry, 3rd Edition. Matthews, van Holde, and Ahern
3. Biochemistry, 6th Edition. Berg, Tymoczko and Stryer
4. Molecular Cell Biology, 7th Edition. Lodish, et. al.
5. Textbook of Biochemistry with Clinical Correlations, 7th Edition by T. Devlin
6. Biochemistry, 4th edition. Donald Voet and Voet J
7. Harpers review of Biochemistry, 25th Edition. Murray RK, Rodwell VW.
8. Lehninger's Principles of Biochemistry, 5th Edition. Nelson DL and Cox MM
9. Concepts in Biochemistry, 3rd Edition. Rodney Boyer
10. http://en.wikibooks.org/wiki/Biochemistry
11. Introduction to Practical Biochemistry. T. Plummer.

ELECTIVE Paper: Biostatistics
Course Code: EG 1301
No. of Credits: 02
Learning Hours: 30 hrs

Unit 1: Basic concepts in Statistics

Terms and Definitions in Statistics, Population and Sample, Raw Data, Types of variables, Numerical variable (Continuous and discrete), Categorical variables (Nominal and ordinal), Outcome and exposure variables, Display of data for 1 variable, For categorical data: Bar Chart and Pie Chart, For numerical data: Histogram (different shapes) and Frequency Polygon

Unit 2: Central Tendency and Deviations

Measurements of central tendency: Mean, Median, quartiles, percentiles, Mode
Measures of spread: Range, Variance and Standard Deviation and its interpretation
Normal deviation and its characteristics

Unit 3: Probability, Permutations and combinations

Probability: Definition and basic formula, Probability of an event not occurring, Multiplicative rule to calculate the probability of occurrence of both of two events. Independent events, Non-independent events (conditional probability), Additive rule to calculate the probability of occurrence of at least on of two events, Mutually exclusive events, Non-exclusive events, Concept of odds, Applications of probability in biology

Permutations: Definition and basic formula (${}_nP_r = n!/(n-r)!$), Permutations with repetition, Application of permutations in biology (The genetic code), Combinations: Definition and basic formula (${}_nC_r = n!/r!(n-r)!$), Application in biology (pedigree analysis), Problems involving Permutations, Combinations and Probability

Unit 4: Data analysis

Sampling Variation, Population mean and standard error, Concept of Hypothesis test and null-hypothesis, t-test (concept and calculation), ANOVA, One way Anova (concept and calculation), Two way Anova (definition only), SPSS and its application

References

Khan and Khannum. Fundamentals of Biostatistics.
Bala Rastogi. Biostatistics

Semester II
CORE Paper: Cell Biology
Course Code: BT 2501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The basic unit of life is a cell. Therefore, study of its structure and functions gives an insight into an intricately woven network of efficient and coordinated molecular mechanisms that renders a cell fit to not just survive but also to multiply, get differentiated and move around. Understanding various concepts like how cells originated, transport across membranes, transport within cells, cell division, regulation of cell cycle, cell senescence etc. opens up a lot of target areas for drugs and treatment. For example, today there are a lot of drugs that target the ribosomes, which has been possible because its structure and functions has been thoroughly studied.

The course will give a detailed description of

a) The assembly of biomolecules to form a cell, which has been the crux of origin of life and the evolutionary changes thereafter, especially, the role of RNA and genetic changes.
b) The detailed study of membrane biochemistry, transport across membranes and within cells by cytoskeleton
c) Studying the organization of the cell and the structure and functions of various organelles.
d) The structure and function of nucleus, cell division, cell cycle regulation and senescence

By the end of the paper, a student should be able to

a) Understand the evolution of a cell and the role of nucleic acids in evolution
b) Appreciate the importance of semi permeable nature of plasma membrane in maintaining the integrity of a cell.
c) Establish the concept of how proper conformations of lipids and proteins in a membrane are needed for optimum functioning
d) Appreciate how important each organelle is to make cell the basic unit of life – the entire organization within a cell is a perfect example of division of labour with proper coordination and networking.
e) Appreciate how a change in the structure of the molecules can lead to abnormalities, for e.g. Improper glucose transporter can affect blood sugar homeostasis
f) Understand why a cell cycle needs to be regulated and when does a cell need to die.
g) Appreciate experiments carried out by scientists to enable understand the working of a cell, design of experiments to prove the same and analyse the data and give interpretations.

Thus, the knowledge from this course can help in the following:

a) Research in elucidation of molecular mechanisms within a cell
b) Research in cancer biology, tissue engineering, stem cells etc.
c) Drug discovery targeting various anomalies due to malfunction of organelles

II. Course Content

Unit 1: Origin of life and basic structure of cells

Origin of life: Living matter, early history, Chemical evolution, Origin of living systems (molecules to first cell), RNA world, development of metabolic pathways, Central dogma of life, mutation and evolution.

The Cell Theory; Basic structure of cells; Methods used in study of cells; Differences between prokaryotes and eukaryotes; Differences between plants and animal cells; The organization of cells into tissues; Different types of tissues.

Unit 2: Structural Components of Cell

Membrane structure: Singer – Nicholson's Fluid Mosaic Model, Structure and functions of membrane lipids and glycolipids – membrane fluidity and movement, lipid rafts.

Membrane proteins: structure and types; principles of membrane transport, Carrier proteins and active membrane transport, Ion channels

Membrane carbohydrates: Glycocalyx

Cytoskeleton: Nature of cytoskeleton, Intermediate filaments, Microtubules, Cilia and flagella, Actin filaments; Molecular motors associated with cytoskeleton; Role of cytoskeleton in cell – cell interaction, recognition and communication.

Unit 3: Cell Organelles

Detailed structure and functions of: Mitochondria and Chloroplast (Energy Conversions) and the Endosymbiont Theory; Endoplasmic reticulum: Rough and smooth ER; Golgi Apparatus and its role in processing and packaging of biomolecules inside the cells; Ribosomes: its unique structure and functions; Lysosomes and Peroxisomes; Vacuoles in plant cells; Nucleus and transport across the nuclear membrane; Endocytosis and exocytosis.

Unit 4: Cell Cycle and Aging

Cell Cycle: General strategy of cell cycle, Interphase (Different stages) and Mitosis; Generation time; Cell cycle regulation.

The Mechanics of Cell division; Introduction, An overview of different stages in Mitosis, meiosis and cytokinesis; Cell differentiation and its implications

Cell Senescence: Difference between aging and necrosis; Programmed Cell Death

Semester-II
Practical Paper: Basic techniques of cell
Course Code: BT 2502L
No. of Credits: 03
Learning Hours: 60 hrs

Session: 2 hours

1. Use of microscopes and basics staining methods
2. Observing different stages of mitosis
3. Isolation of yeasts from various sources
4. Growth curve studies
5. Effect of temp, pH and carbon source, size of inoculum on growth curve
6. Cell counting and viability studies
7. Methods of cell lysis
8. Total protein content in cells
9. Protein denaturation techniques

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Recommended learning Resources

1. Molecular Cell Biology, 7th Edition. Lodish, et. al.
2. Biochemistry, 4th edition. Donald Voet and Voet J
3. Harpers review of Biochemistry, 25th Edition. Murray RK, Rodwell VW.
4. Lehninger's Principles of Biochemistry, 5th Edition. Nelson DL and Cox MM
5. Biochemistry, 5th Edition. Garrett and Grisham
6. Origin of life on the earth and in the cosmos (2nd ed), Geoffrey Zubay: Academic Press
7. Molecular Biology of the Cell, 5th Edition, Bruce Alberts et. al.
8. Organelle structure and function, David E Sadava, Jones Bartlett publishers.
9. Cytology, P.S. Verma, V.K. Agarval, S. Chand Publications.
10. Cell and Molecular Biology, 8th Edition. De Robertis.
11. Cell and Molecular Biology, Sheeler and Bianchi
12. The Cell: A Molecular Approach, 6th Edition, G.M. Cooper
13. Introduction to Practical Biochemistry. T. Plummer.

Semester –III
CORE Paper: Concepts in Biophysical Chemistry
Course Code: BT 3501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the physical concepts required to study various biochemical aspects.
By the end of the paper, a student should be able to:

a) Understand the basic concepts of physics like adsorption, viscosity, surface tension, absorption of light to be able to apply in understanding concepts in biochemistry
b) Correlate the use of a particular technique to understand a fundamental.
c) Appreciate that the discovery and advancement of biophysics has opened up understanding pathways and mode of actions of various biological systems.
d) Apply the techniques for production, analysis and modifications of biomolecules.
e) Appreciate experiments carried out by scientists to enable understand the use of microbial systems in enhancing the quality of life.

Thus, the knowledge from this course can help in the following:

a) The students could pursue a career in industries that specialize in Instrumentation specifically for Life Science Research and Analysis
b) Avail jobs in Production, Quality Control and Rand D divisions of Pharmaceutical and Biotech companies.
c) The students can carry out basic research in various areas of biology due to their understanding of the techniques
d) Start up companies supplying basic instruments like colorimeters, pH meters, etc.

II. Course Content

Unit 1: Centrifugation and Viscosity

Poiseuille's equation, unit of viscosity, relative viscosity and its determination, factors affecting viscosity, physiological importance
Principle of sedimentation, factors affecting sedimentation
Types of rotors used in centrifuges, separation methods in different rotors
Preparative centrifuges: Differential centrifugation, sub cellular fractionation, density gradient centrifugations; Applications, preparation of gradients, sample collection methods, zonal rotors
Analytical Centrifuges; Ultracentrifugation, working and applications

Unit 2: Adsorption, chromatography and electrophoresis

Principle of adsorption, orientation of molecules on a surface, factors affecting adsorption, application of adsorption

Principle, technique, applications, advantages and disadvantages of: Ion exchange, gel filtration, affinity chromatography. Adsorption chromatography. Thin layer chromatography, reverse phase chromatography, hydrophobic interaction chromatography, HPLC, GLC.

Principle, technique, factors affecting, detection, applications, advantages and disadvantages of:
Gel electrophoresis (PAGE, agarose, starch gel)
Isoelectric focusing, 2-D gel electrophoresis

Unit 3: Colorimeter and Spectroscopy

Beer-Lambert's law, principle, working of single cell and double cell colorimeter.

Principle, working, applications, advantages and disadvantages of spectrophotometers and spectrofluorimeters (expand in detail monochromators, light source)

Principle and applications of NMR, IR spectroscopy and atomic absorption spectroscopy

Unit 4: Advanced Techniques

Radioactive decay, units of radioactivity. Measurement of radioacitivity (Geiger Muller Counter, scintillation counters, autoradiography). Applications of radioactivity and hazards.

Principle and applications of: Fluorescence based techniques (Fluorescent microscopy), Flow cytometry, patch-clamp technique, Freeze fracture technique (Histology), ICP MS, GC MS, LC MS.

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Berg JM, and Tymoczko TJ, Stryer L,: Biochemistry (6^{th} Ed)
2. Daniel, C Harris: Quantitative Chemical Analysis
3. David Freifelder: Physical biochemistry (2^{nd} Ed) WH Freeman, USA)
4. Donald Voet and Voet J: Biochemistry (4^{th} Ed) 2011
5. Ghatak KL: Techniques and methods in Biology. PHI learning Pvt Ltd. 2011

6. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (5th Ed) 2008
7. Oser: Hawks Physiological Chemistry (4th Ed) 1965.
8. Upadhyay and Nath: Biophysical chemistry: Principles and Techniques (3rd Ed)
9. Van Holde KE: Physical Biochemistry. Prentice Hall, NJ.
10. Vogel AI: A text book of quantitative inorganic analysis (3rd Ed), 1975.
11. West and Todd: Text book of biochemistry ((4th Ed) 1970
12. Wharton and McCarty: Experiments and methods in Biochemistry
13. Willard and Merrit: Instrumental methods of analysis (4th Ed) 1971.
14. Wilson K and Walker J: Principles and Techniques of Biochemistry and Molecular Biology (6th Ed) 2006. Cambridge University Press.

Semester -III
CORE Paper: Molecular Biology
Course Code: BT 3502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the importance of Molecular Biology and its implications

By the end of the paper, a student should be able to:

a) Appreciate the experiments carried out by various scientists to prove that DNA is the genetic material,
b) Understand the structure and properties of DNA;
c) Understand the mechanisms of DNA replication, transcription and translation in prokaryotes
d) Comprehend how DNA damage can lead to detrimental effects and how DNA repair systems in the cells try to prevent mutations before being inherited.
e) Understand how cells regulate expression of genes during transcription
f) Appreciate experiments carried out by scientists to enable understand the Central Dogma of life

Thus, the knowledge from this course can help in the following:

a) Enable students to build a career in Genetic engineering, Genomics and proteomics
b) Understanding of molecular mechanisms can enable customizing treatments related to diseases
c) The students can carry out basic research in cell and molecular biology
d) Start up companies based on biologics and molecular medicines

II. Course Content

Unit 1: Basic Concepts in Molecular Biology

Introduction to Molecular Biology; Experiments proving DNA as genetic material: S. F. Griffith's transforming principle, Avery, McLeod and McCarthy's experiment, Roger Heriot's experiments with bacteriophages and Hershey and Chase Experiment; Rosalind Franklin's studies with DNA structure; Chargaff's experiments and Law; Watson – Crick Model; Deviations from Watson – Crick's DNA model; Different forms of DNA;

Physical properties of DNA: Denaturation and Hyperchromic effect, Tm and its significance, Renaturation and hypochromic effect, Cot Curve and its significance; DNA Supercoiling and Topology

Unit 2: DNA Replication, DNA Damage and its Repair

Introduction to DNA replication; Messelson – Stahl's experiment; The basic requirements of DNA replication: Template – primer junction, DNA Polymerases: Structure and Function, Ancillary proteins associated with replication; Mechanism of replication: Initiation, Elongation and Termination; Other modes of replication: Rolling circle mechanism and D – loop mechanism.

Mutations and Types of Mutations; Replication Errors and its Repair; DNA Damage by Chemical Mutagens; DNA damage by physical agents; DNA Repair Mechanisms: Direct Reversal of DNA Damage, Base excision repair and Nucleotide excision repair; Repair by Homologous Recombination

Unit 3: Genetic Code and Transcription

The Genetic Code: Cracking of the code and its triplet nature; Degeneracy and Universality; Initiation and Stop Codons; Wobble's Hypothesis and its significance.

Introduction to Transcription; RNA polymerase: structure and function; Promoters; Transcription Initiation; Transcription elongation and proof reading: Termination of transcription.

Post transcriptional modifications: 5' capping and poly A tailing; RNA splicing: Chemistry of RNA splicing, Spliceosome machinery, Splicing pathways; Concept of Alternate Splicing.

Unit 4: Translation and Regulation of Gene Expression

Introduction to Translation, Roles of messenger RNA, transfer RNA, Aminoacyl tRNA synthetases, and Ribosomes; Mechanism: Initiation of translation, Elongation and Termination; Post translation modifications.

Regulation of Gene Expression: Principles; Regulation of transcriptional initiation: Lac Operon, Arabinose Operon and Tryptophan Operon; Gene Regulation after transcription initiation.

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Berg JM, and Tymoczko TJ, Stryer L,: Biochemistry (6th Edition)
2. Watson, J.D - Molecular Biology of the Gene (5^{th} Edition)
3. De Robertis and De Robertis: Cell and Molecular Biology (8^{th} Edition)
4. Donald Voet and Voet J: Biochemistry (4th Edition) 2011
5. Grisham and Garett: Biochemistry (3rd ed)
6. Benjamin Lewin: Genes IX (2007)
7. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (5th ed) 2008
8. Lodish: Molecular Cell Biology (5^{th} Edition) 2004

Semester -III
ELECTIVE Paper: Hormone Action
Course Code: BT 3601
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the importance of actions of hormones in regulating mechanisms in our body
By the end of the paper, a student should be able to:

a) Classify hormones based on their mode of actions,
b) Understand hormone action based on each mechanism;
c) Explore how hormones like Insulin, glucagon carry out their physiological actions
d) Comprehend how conformational changes play an important role in signal transduction
e) Appreciate experiments carried out by scientists to enable understand the hormone actions

Thus, the knowledge from this course can help in the following:

a) Enable students to correlate physiological functions with regulation by hormones

b) Understanding of molecular mechanisms that can enable developing drugs targeting a particular step
c) The students can understand the implications of disorders related to improper functioning of the hormones
d) Get skills to work in endocrinology labs

II. Course Content

Unit 1: Introduction to Hormones

Chemical nature of hormones; Basic characteristics of hormones; Classification of hormones; Understanding Paracrine action, autocrine action, juxtacrine action and endocrine action with examples; Understanding feedback mechanism of hormones with examples; Differences between steroid hormones and peptide hormones; Importance of hormone – receptor complex.

Unit 2: Class I Hormones and its action

Introduction to Class I hormones; Mode of Action through gene activation and use of intracellular receptors; Understanding the hormone action with examples of glucocorticoid and thyroid hormone – their synthesis and abnormalities associated with its malfunctioning or decreased production.

Unit 3: Class IIa and IIb Hormones and their action

Introduction to Class II a and IIb; Association with membrane receptors coupled to G- protein; Activation of cAMP as a secondary messenger and its cascade mechanism; Understanding the hormone action with example of Glucagon; its physiological action and implications at the body level; Effect of cholera toxin on cAMP levels;
Hormone action through IP3, Calcium and DAG; Example of ACTH, parathyroid hormone and its implications on bone formation.

Unit 4: Hormone action through Receptor Tyrosine Kinase (RTK)

Receptor tyrosine kinase as receptor as well as secondary messenger; Insulin structure, synthesis and its action through Insulin receptor as example of RTK; Physiological action and its implication on the body.

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Berg JM, and Tymoczko TJ, Stryer L,: Biochemistry (6th Ed)
2. Watson, J.D - Molecular Biology of the Gene (5^{th} Ed)
3. De Robertis and de robertis: Cell and Molecular Biology
4. Donald Voet and Voet J: Biochemistry (4th ed) 2011
5. Grisham and Garett: Biochemistry (3rd ed)
6. Benjamin Lewin: Genes
7. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (5th ed) 2008
8. Lodish: Molecular Cell Biology (5^{th} Edition) 2004

Semester - III
Practical Paper: Fundamentals of Biophysical techniques and Molecular Biology
Course Code: BT 3503L
No. of Credits: 2.5
Learning Hours: 60 hrs

Session: 3 hours

Note:

- *Students should learn the principles, theory, protocol and calculations for each experiment.*
- *They should learn about reagent preparations.*

Colorimetric Estimations

1. Estimation of sugar by Folin-Wu method
2. Estimation of protein by Folin-Lowry method

Biophysical methods

3. Measurement of absorption spectra
4. Agarose gel electrophoresis
5. SDS-Poly acrylamide gel electrophoresis
6. Thin layer chromatography
7. Paper chromatography – Ascending
8. Paper Chromatography - Descending
9. Column chromatography
10. Off site visit to Industry

Basic techniques in Molecular Biology

11. Verification of Chargaff's rule by paper/ thin layer chromatography
12. Ultraviolet absorption spectrum of DNA and RNA

13. Determination of DNA concentration by UV absorption method
14. Determination of melting temperature and GC content
15. Isolation of DNA from white blood cells
16. Isolation of RNA from yeast cells

References

1. Oser: Hawk's Physiological Chemistry (14^{th} ed)
2. Plummer: An introduction to Practical Biochemistry, 1988, Tata Mc Graw- Hill education
3. Sheela Sharma: Experiments and Techniques, 2007.
4. Thomas and Schalkhammer: Analytical Biochemistry, 2002
5. Varlery H: Practical Clinical Biochemistry, 1980, Heinemann, London
6. Thimmaiah S R: Standard Methods of Biochemical Analysis, 1999, Klayani Publishers

Semester IV
CORE Paper: Concepts in Microbiology
Course Code: BT 4501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic concepts of microbiology.

By the end of the paper, a student should be able to:

h) Understand the morphology of a prokaryotic cell and the fine structure of its organelles
i) Differentiate between eubacteria, archaebacteria, fungi, algae and viruses and comprehend their economic importance.
j) Appreciate that the discovery and advancement of microscopic techniques has led to revolutionizing the field of microbiology
k) Understand the basic growth requirements of bacteria *in vitro* in order to culture them.
l) Know methodologies to control the growth of microbes by various sterilization techniques and chemotherapeutic drugs. For example: Milk is pasteurized to ensure that its shelf life is long; keeping surgical tools and rooms free of pathogens etc.
m) Appreciate that good bacteria play a major role in industries especially food industries
n) Appreciate how microbes have been a tool to minimise use of chemicals, improvise waste water treatment and decreasing environmental pollution by biodegradation
o) Appreciate experiments carried out by scientists to enable understand the use of microbial systems in enhancing the quality of life.

Thus, the knowledge from this course can help in the following:

g) The students could pursue a career in industries that specialize in synthesis of various chemical components like acetic acid, enzymes, antibiotics, drugs etc.
h) The students can carry out basic research in Microbiology and Biotechnology, which in turn can be of great help in the commercialization of various microbial products.
i) Students can also go in for Medical Laboratory Technique Courses, opening opportunities in hospitals and pathological laboratories.
j) Basic knowledge of microbiology is required for Fermentation Technology which is a basic technology used in many Pharmaceutical and Biotech companies.
k) Explore the field of genetic engineering
l) Entrepreneurial start ups for small scale industries like production of biofertilizers, fermented foods etc.

II. Course Content

Unit 1: Basic structure of microbes

Cell morphology and fine structure of bacteria; Size, shape and arrangement of bacteria; study of organelles: Structure, chemical composition and functions of – cell wall, cell membrane, flagella, mesosomes, fimbriae and pilli, capsules, ribosomes, intracellular inclusions and endospores. Identification of bacteria based on cell morphology and fine structure.

Salient features and economic importance of Archeabacteria, rickettsia, fungi, algae, and viruses

Unit 2: Microscopy

Parts of a compound microscope: condenser, objective, ocular lens systems; Basic principles of image formation; Relationship between magnification and numerical aperture; angular power and resolving power.

Principle, construction, working, limitations and applications of: dark-field microscopy, phase contrast microscopy, fluorescent microscopy, Inverted microscopy and Electron (TEM, SEM) microscopy.

Principle and applications of Confocal microscopy, AFM and Cryoelectric microscopy

Unit 3: Microbial growth, nutrition and control

Control of microorganisms: Definition of terms: sterilization, disinfection, microbicidal, microbiostasis, sepsis and asepsis, antiseptic. Factors affecting; Sterilization and disinfection by physical means: moist, dry heat, radiations and filtration; Sterilization and disinfection by chemical means: characteristics of an ideal antimicrobial agent, phenol coefficient. Mode of action and uses of: halogen and halogen compounds, compounds of heavy metals, phenols and its derivatives, alcohol, detergents. Chemosterilant gases (formaldehyde, ethylene oxide, beta

propiolactone); Chemotherapeutic agents: Mode of action, limitations and uses of: penicillin, streptomycin, tetracyclins, polymixins, choramphenicol, cephamines, sulfa drugs

*Growth and Nutrition***:** Definition and calculation of generation time, Growth curve, diauxic growth curve. Measuring bacterial growth (SPC, serial dilution, direct microscopic count); Effect of various factors on growth and reproduction of bacteria: temperature, osmotic pressure, radiation, hydrostatic pressure, mechanical impact, surface tension (define types based on specific requirement e.g. thermophilic); Cultivation of anaerobes, pure culture isolation and preservation.
Nutritional requirements and broad categories of bacteria (auxotrophs, lithotrophs etc)
Preparation of media, Types of media (Natural, empirical, synthetic, defined, special media)

Unit 4: Applied Microbiology
Microbiology of Milk: pasteurization and sterilization, microbial analysis of milk (SPC, MBRT)
Role of microorganisms in fermented dairy products (butter, cheese, curd and yoghurt)
Microbiology of water and sewage: Definition of potable water, index organisms of fecal contamination and their significance. Microbial analysis of water: SPC, filtration. MTFT, MPN.
Sewage microbiology: BOD and COD- definition and significance. Sewage treatments: Primary, secondary (trickling filters, activated sludge process, oxidation ponds) and advanced treatments. Solids processing. Biofertilizers: Bioremediation and phytoremediation, Soil microbiology.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Atlas R: Microbiology:Fundamentals and Applications (2^{nd} ed)
2. Frobisher, Hinsdill, Crabtree, Goodheart: Fundamentals of Microbiology
3. Pelczar Reid: Microbiology (5^{th} ed)
4. Prescott: General Microbiology.
5. Scheeler and Bianchi: Cell Biology
6. Stainer, Adelber,Ingraham: General Microbiology

Semester -IV
CORE Paper: Recombinant DNA Technology
Course Code: BT 4502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of recombinant DNA technology
By the end of the paper, a student should be able to:

a) Understand the basic tools required in recombinant DNA technology
b) Explore the methods used to study gene location and structure
c) Know the various techniques used to study the gene expression and regulation
d) Understand the techniques used in analyzing transcripts and proteins
e) Understand problems associated with production of recombinant molecules
f) Explore the use of recombinant DNA technology in betterment of the society
g) Appreciate experiments carried out by scientists to enable understand various molecular mechanisms

Thus, the knowledge from this course can help in the following:

a) To chose a career in molecular biology and genetic engineering
b) Exploit the basic understanding of the subject to create something that can help society
c) Equip oneself with skills to grow in the biotech sector
d) Work in biotechnology industries in Research and Development/Production/ Quality Assurance
e) Carry out basic research in understanding many more molecular mechanisms inside a cell

II. Course Content

Unit I: Basic Concepts and Tools of Gene cloning

What is gene cloning and why do we need to clone a gene?; Introduction to recombinant DNA technology: Introduction to vehicles of gene cloning, Handling of DNA, RNA, cDNA and Restriction enzymes, Laboratory requirements, Safety measures and regulations for rDNA work, Choice and selection of the tools and techniques; Purification of DNA from bacterial, plant and animal cells; Manipulation of purified DNA; Introduction of DNA into living cells; Different methods of horizontal gene transfer: Transformation, Conjugation and Transduction.

Unit II: Cloning Vectors and Identification of a clone

Vehicles: Plasmids, Bacteriophages and viruses, Phagemids and Cosmids; Bacterial Artificial Chromosomes; Vectors for yeast and other fungi: 2µ plasmid, YEPs, YIPs, YRPs, and YACs;
To obtain a clone of a specific gene: Direct selection, Selection using hybridization from Genomic DNA library, cDNA library; Probe designing and labeling; Identification of clones using alternative methods

Unit III: Studying gene location and structure

Gene location: Hybridization techniques – Southern blotting; In situ hybridization, FISH, OFAGE.
Studying gene structure; DNA sequencing: Sanger's method of chain termination and Maxam Gilbert's method of chemical degradation; Automated sequencing; Polymerase Chain Reaction and its types; Chemical synthesis of oligonucleotides.

Unit IV: Gene Expression and Regulation

Transcript analysis; Studying gene expression; Regulation of gene expression; Studying translated product of the gene; Studying protein – protein interactions; Expression vectors; Promoters used in expression vectors; Cassettes and gene fusions; Problems associated with production of recombinant protein in E.*coli;* Production of recombinant protein by eukaryotic cells like yeast and fungi; Study of protein functions by *in vitro* mutagenesis

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.
Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Molecular Biology of the Gene (2008) 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York).
2. Gene Cloning and DNA Analysis (2010) 6th ed., Brown, T.A., Wiley-Blackwell Publishing (Oxford, UK)
3. Principles of Gene Manipulation and Genomics (2006) 7th ed., Primrose, S. B., and Twyman, R. M., Blackwell publishing (Oxford)
4. Molecular Biotechnology: Principles and Applications of Recombinant DNA (2010) 4th ed., Glick B.R., Pasternak, J.J. and Patten, C.L., ASM Press (Washington DC)

Semester -IV
Practical Paper: Fundamentals of Microbiology and recombinant DNA Technology
Course Code: BT 4503L
No. of Credits: 2.5
Learning Hours: 60 hrs

Session: 3 hours

Note:

- *Students should learn the principles, theory, protocol and calculations for each experiment.*
- *They should learn about reagent preparations.*

Basic techniques in Microbiology

1. Introduction to stains and staining procedures
2. Monochrome staining(Positive and negative)
3. Gram staining
4. Capsule staining
5. Metachromatic granules staining
6. Spore staining(optional)
7. Methylene blue reduction test
8. Antibiotic assay by agar cup method
9. Antibiotic assay by disc/ditch method
10. Identification of microorganisms and Fermentation tests for microorganisms
11. Study of growth characteristics of microorganisms*
12. Alcohol fermentation by yeast*
13. Total plate count

Basic techniques in recombinant DNA technology

14. Genomic DNA isolation from bacteria
15. Plasmid DNA isolation
16. Assessment of quality and quantity of DNA
17. Agarose gel electrophoresis to visualize DNA
18. Restriction digestion
19. DNA ligation
20. DNA transformation
21. PCR (Demonstration)

Note: These will be conducted as a mini project, wherein the students will be asked to check the growth characteristics of microorganisms under static and aerated conditions; under

different temperature and pH conditions. Production of alcohol by yeasts from different food sources.

References

1. Plummer: An introduction to Practical Biochemistry, 1988, Tata Mc Graw- Hill education
2. Thomas and Schalkhammer: Analytical Biochemistry, 2002
3. Varley H: Practical Clinical Biochemistry, 1980, Heinemann, London
4. Wharton and McCarty: Experimental methods in Biochemistry; Macmillan, New York. Whistler, R. L. (1964)
5. Seeley HW and Van Denmark PJ: Microbes in Action
6. Wistreich GA and Lechman MD: Laboratory Exercise in Microbiology; 1973, Glencoe Press, New York, Beverly Hills
7. Sambrook J, Fritsch E F, Maniatis T: Molecular Cloning (A Laboratory Manual: 3 Volumes), 2nd Edition, 1989, Cold Spring Harbour Lab

Semester -IV
ELECTIVE Paper: Nutrition
Course Code: BT 4601
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the importance of Nutrition and its biochemical implications

By the end of the paper, a student should be able to:

a) Understand simple concepts related to Nutrition like balanced diet, RDA etc.,
b) Appreciate the correlation between food and energy requirements and utilization;
c) Understand why the body requires carbohydrates, lipids and proteins in specific quantities and how its deficiency or excess can lead to disorders
d) Appreciate the contribution of minerals, trace elements and vitamins to the well being of humans.
e) Appreciate experiments carried out by scientists to enable understand the requirement of different molecules by the body

Thus, the knowledge from this course can help in the following:

a) Enable students to build a career as a nutritionist
b) Find employment as dieticians in hospitals, health care agencies.
c) The students can carry out basic research in nutrition based projects
d) Start up companies supplying basic health supplements

II. Course Content

Unit 1: Introduction and Energy Metabolism:

Introduction: Introduction to nutrition science: current trends in nutrition, nutrition in India: RDA, balanced diet, assessment of nutritional status; Introduction to concept of nutraceuticals

Energy metabolism: Energy molecules, energy value of foods (gross and physiological fuel value), units of energy; Determination of energy value of foods by direct and indirect calorimetry; Determination of energy expenditure: direct and indirect methods, RQ and its significance; Total energy requirements, factors affecting it. BMR: definition, measurements, and factors affecting it; SDA of foods; Food habits of people and relate it to balanced nutrition

Unit 2: Nutritional and Physiological Functions of Carbohydrates, Proteins, Lipids.

Carbohydrates: Nutritionally important carbohydrates, function of carbohydrates, carbohydrate loading, lactose intolerance; Dietary fibres: role in human nutrition; Ethyl alcohol; Dental caries., Probiotics and Prebiotics

Lipids: Animal and vegetable lipids in diet; Fatty acids: essential fatty acids, PUFA/P/S ratio;

Fats: storage (adipose tissue), transport, mobilization, ketosis, function and requirements; Obesity; Differentiated crops with high oil content

Proteins: Source of dietary proteins, nitrogen balance; Quality of proteins: complete, incomplete proteins, supplementary values, Indices: BV, NPU, PER, PDCASS, digestibility, NDpV; Biotechnological interventions to increase protein content and essential amino acids content.

Unit 3: Minerals and Trace Elements

Essentiality, classification and functions of minerals; Calcium, Phosphorus, iron, iodine, selenium, zinc, fluorine.

Dietary sources; Absoption, transport, storage, excretion, malnutrition and toxicity of each of the above.

Diseases associated with deficiency of minerals and trace elements

Unit 4: Vitamins

Water soluble vitamins: Occurrence/ Dietary sources; Biochemical functions; recommended dietary allowances; assimilation; and deficiency

Fat soluble vitamins: Occurrence/ Dietary sources; Biochemical functions; recommended dietary allowances; assimilation and deficiency.

Golden Rice: an example of fortified food by biotechnology intervention

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II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. B. Srilakshmi: Dietetics
2. B. Srilakshmi: Nutrition Science
3. Christopher Haslett: Davidson's principles and Practice of medicine (18^{th} ed) 1999. Churchill Livingston.
4. Guthrie
5. Guyton A: Text book of Medical Physiology (10^{th} ed).
6. Murray H et al: Harper's Biochemistry (25^{th} ed) 2000.
7. Rang HM and Dale MM: Rang and Dale's pharmacology (6^{th} ed) 2007, Churchill Livingston Elsevier.

Semester - V
CORE Paper: Metabolism
Course Code: BT 5501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Metabolism and its importance in the proper functioning of each cell.
By the end of the paper, a student should be able to:

a) Understand simple concepts related to metabolism,
b) Appreciate the correlation between energy molecules, reducing equivalents and pathways;
c) Understand anabolic and catabolic pathways of carbohydrates
d) Understand catabolic pathways of proteins and nucleic acids and comprehend how any defect in a pathway could lead to diseases.
e) Appreciate experiments carried out by scientists to enable understand the pathways and cycles of metabolism

Thus, the knowledge from this course can help in the following:

a) Give a basic understanding of clinical aspects of Metabolism
b) Discover drugs related to metabolic disorders
c) Work in industries related to diagnostics
d) Carry out basic research in understanding aspects of metabolism that are still not clear

II. Course Content

Unit 1: Introduction to Metabolism and Metabolism of Carbohydrates

Introduction to Metabolism, general features of metabolism, difference between anabolic and catabolic pathways, Experimental Approach to Metabolism, Glycolysis and its energetic and regulation, fates of pyruvate, Feeder pathways, gluconeogenesis, difference between glycolysis and gluconeogenesis, reciprocal regulation of Glycolysis & Gluconeogenesis, Glycogen degradation, synthesis and regulation, difference between glycogenolysis and glycogenesis, glycogen storage diseases, Cori cycle, Alternate pathways of carbohydrate metabolism, their regulation and significance.

Unit 2: Metabolism of Proteins

Over view of the fate of carbon skeletons of amino acids, Amino acids as synthetic molecules: Gamma-Glutamyl cycle, Creatine metabolism, Porphyrin metabolism, Transamination, oxidative deamination, Non-oxidative, decarboxylation, glucose alanine shuttle; Urea cycle, its regulation, energetics and significance; Uric acid formation.

Unit 3: Metabolism of Lipids

Introduction, Lipoprotein metabolism, mobilization of fat, β-Oxidation of saturated, unsaturated and odd chain fatty acids, energetics and regulation, alpha and omega oxidation, Ketone bodies synthesis and utilization, FA synthesis, steps, stoichiometry, regulation, Desaturation and elongation of FA, comparison of synthesis and oxidation

Unit 4: Energy Metabolism linked to Electron Transport System

PDH Complex, TCA Cycle, Energetics, Regulation, Anapleurotic & Amphibolic reactions, Glycerol Phosphate And Malate- Aspartate Shuttle, ETC, Uncouplers and Inhibitors of ETC, various hypotheses for ATP Production, Oxidative Phosphorylation, Binding Change Hypothesis, P/O Ratio, Regulation of oxidative phosphorylation.

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Berg JM, and Tymoczko TJ Stryer L,: Biochemistry (8th ed), (2015).WH Freeman Publishers
2. Bhagvan NV: Medical Biochemistry (4th ed) Bartlett Publishers.
3. Donald Voet and Voet J: Biochemistry (4th ed) 2011, Wiley Publications.
4. Grisham and Garett: Biochemistry (3rd ed), Pearson-Thomson publishers
5. Jeoffrey Zubay: Principles of Biochemistry, McGraw Hill Publications, (1996).
6. Murray RK, Rodwell VW: Harpers review of Biochemistry (25th ed), (2000).
7. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (6th ed) 2008.
8. Metzler: Biochemistry (2nd ed), Academic Press, 2004

Semester V
CORE Paper: Enzymology
Course Code: BT 5502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Enzymology and its importance in the proper functioning of each cell.
By the end of the paper, a student should be able to:

a. Understand the structures and functions of enzymes and its classification
b. Relate the parameters associated with enzyme activity
c. Understand mechanisms of catalysis and the involvement of various cofactors and coenzymes in the process;
d. Know concepts on how to purify a protein using various techniques
e. Understand how the rate of reaction of an enzyme is affected by physical and chemical factors
f. Differentiate between regulatory enzymes and non regulatory enzymes through kinetic studies
g. Appreciate experiments carried out by scientists to enable understand the pathways and cycles of metabolism

Thus, the knowledge from this course can help in the following:

a. Use concepts of purification of enzymes in industries
b. Study different molecules that can modify enzyme activity
c. Gain basic technical knowledge required in laboratories
d. Work in industries related to enzymes
e. Carry out basic research in purifying and characterizing enzymes to establish an application in industry or research

II. Course Content

Unit 1: Introduction to enzymes

Historical development of enzymology, Nature of enzymes, Other forms of enzymes: Abzymes, Ribozymes, Synzymes, Extremozymes; Classification of enzymes with examples, Concept of Holoenzymes, cofactors and coenzymes; Enzyme mechanism and activation, various models of enzyme specificity.

Unit 2: Reaction mechanism

Purification of enzymes – precipitation (salting in and out, organic solvents, acid and base), isolation (chromatography and electrophoresis), Enzyme units, fold purification; Characterization of enzymes: Solubility studies, Enzyme assays, Factors affecting enzyme activity; Mechanism of bi substrate reaction, Cleland's notion.

Unit 3: Kinetics and Regulation

Kinetics of enzyme activity, Michaelis Menten equation, importance of Km and Vmax, Regulation of enzyme activity at gene level, Inhibition of enzyme: Allosteric regulation and covalent modification, Zymogens, Isoenzymes, Feedback regulation; Kinetics of enzyme inhibition.

Unit 4: Metabolic Engineering

Importance of metabolic engineering; Need for pathway synthesis (bioproduction), Scope and future of metabolic engineering; Methods for metabolic characterization: genome, transcriptome, proteome, metabolome, fluxome. Regulation of enzyme activity versus regulation of enzyme concentration; Regulation of metabolic networks; Regulation of at the whole cell level; Metabolic control analysis, The theory of flux balances (Cell Capability Analysis, Genome Scale Flux Analysis), Examples of applications of flux analysis, Experimental Determination Method of Flux Distribution with Isotope Labeling

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. G. Stephanopoulos, A. Aristidou and J. Nielsen, Metabolic Engineering Principles and

2. Methodologies, Academic Press, 1998.
3. S. Y. Lee and E. T. Papoutsakis, Metabolic Engineering, Marcel Dekker, New York,
4. 1999.
5. David Fell, Understanding the Control of Metabolism, Portland Press, London, 1997.
6. R. Heinrich and S. Schuster, The Regulation of Cellular Systems, Chapman & Hall, 1996.
7. E. O. Voit, Computational Analysis of Biochemical Systems, Cambridge University
8. Press, 2000.
9. Enzyme Technology by Palmer
10. Biochemical Engineering by James M. Lee, Prentice Hall (1992).
11. Design and Analysis of Immobilised Enzyme Flow Reactors" by W.R. et. al.
12. Enzymes in Food Processing by Gerald Reed, Academic presses

Semester V
CORE Paper: Immunology
Course Code: BT 5503
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Immunology and its important applications.

By the end of the paper, a student should be able to:

a) Understand the immune system of our body, the different organs and cells that enable us to fight viruses and pathogens,
b) Understand the significance of antigen and antibody interactions and use this specificity for various applications;
c) Understand underlying mechanisms allowing the immune cells and molecules to kill the pathogens just like an army defends ones country
d) Fathom what would happen if the mechanisms sensitize our body such that it proves detrimental to our own system eg. Asthmatic attacks
e) Appreciate that a natural phenomenon can be used a s a basis to producing vaccines, which have been responsible for eradication of diseases like small pox and now polio
f) Appreciate experiments carried out by scientists to enable understand the mechanisms underlying immune responses

Thus, the knowledge from this course can help in the following:

a) Working towards developing vaccines against many diseases
b) Use immune molecules or cells for diagnosis and therapy especially for cancer

c) Work in laboratories specifically using immune techniques like Radioimmunoassay, ELISA etc.
d) Carry out basic research in understanding still unexplored areas of immunology

II. Course Content

Unit 1: Introduction to immunology

Historical perspective and terminologies, Innate immune response and its role in protection, Adaptive immune response - Humoral and cellular component of immune response, complement system, cytokines, interferons; Innate v/s Adaptive immune response, hematopoiesis, Cells and organs of the immune system (primary and secondary lymphoid organ).

Unit 2: Antigen and antibodies

Characteristics of antigen, antigen and immunogen, Epitopes, Haptens, adjuvants, Structure, Function and classification of immunoglobulins; Antigen antibody reactions, agglutination and precipitation, complement fixing test, ELISA, RIA, Immunoflourescence.

Unit 3: Antigen processing and Presentation

Major Histocompatability Molecules, Organization of MHC genes, Structure and function of MHC gene product, T-cell maturation, activation and differentiation, B-cell maturation, activation and differentiation.

Unit 4: Diseases related to immune system

Immune Response against Infectious diseases: Bacterial, Viral and Protozoan infection, Immuno deficiency diseases (like SCID, AIDS), Autoimmune diseases: Organ specific disease (eg. Myasthenia gravis), and systemic autoimmune diseases (eg. Rheumatism), Hypersensitive reactions, Transplantation immunology: Graft rejection, Evidences and mechanism, prevention of graft rejection and Immunosuppressive drugs.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.
Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A., W.H Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-

8590-0.
2. Immunology: A Short Course (2009) 6th ed., Coico, R and Sunshine, G., John Wiley& sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
3. Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowat, A., and Weaver, C.T., Garland Science (London & New York), ISBN: 978-0-8153-4243-4.
4. Immunology: Jan Klain, Blackwell Scientific Publishers
5. Immunology: Ivan Roitt, (10^{th} ed), Blackwell Scientific Press, 2010.

Semester V
CORE Paper: Environmental Biotechnology
Course Code: BT 5504
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Environmental Biotechnology and its important applications.
By the end of the paper, a student should be able to:

a) Understand the importance of requirement of alternate fuels and its production
b) Appreciate the reclamation of contaminated water and soil by bioremediation
c) Understand how microbes are able to degrade xenobiotics
d) Understand how microbes enable assimilability of nutrients
e) Understand using biological systems to recover trace elements, to control growth of weeds, pests etc.
f) Clean the environment by waste water and solid waste management

Thus, the knowledge from this course can help in the following:

a) Carry out research to enable reclamation of polluted soil, water to maintain the natural flora and fauna
b) Develop biosensors or technology to assess levels of pollutants
c) Develop technology to increase production and use of biofuels
d) Understand carbon credit and its effect on the environment
e) Work to develop better policies for environment conservation

II. Course Content

Unit I: Alternative fuels

Introduction to Environmental Biotechnology; Biofuels – definition, benefits and prospects; Biogas production using methanogenic bacteria; Microbial hydrogen gas production; Ethanol production and its use as fuel, eg. Gasohol; Cellulose degradation for combustible fuel; Photosynthetic pigments as solar energy convertors; Plant based petroleum industry.

Unit II: Biodegradation and Bioremediation

Xenobiotic degradation – pesticide degradation, herbicide degradation etc. by microbes; Vermicompost; Biological approaches to solving Air pollution problems; Biosensors; Bioremediation and phytoremediation; Bioleaching: Enrichment of ores by microorganisms; Wasteland reclamation; Use of microbes to decolorize dyes; Plastic degradation

Unit III: Biofertilizers and biocontrol agents

Plant growth promoting rhizobacteria; Biofertilizers: Nitrogen fixing microorganisms (symbiotic and non-symbiotic free living) enriching the soil with assimilable nitrogen; Phosphate solubilizers; IAA producers; Bacteria and viruses as biocontrol agents and biopesticides; Biological control of phytopathogens using fungi and bacteria, Development of biofertilizers and commercialization; Development of disease resistant transgenic plants as Biopesticides, thuringiensis toxin as a natural pesticide, Bt plants etc. Engineered mosquitoes to fight Zika virus, Engineered fish

Unit IV: Waste-water treatment & Solid waste management

Biotechnological interventions in waste-water treatment: Primary, secondary and tertiary treatments; Bioreactors – Rotating Biological Contactors (RBC), Biological filters- fluidized bed reactors, inverse fluidized bed biofilm reactor, Sewage Sludge management. Tertiary treatment- Removal of suspended solids, micro straining, removal of dissolved solids, adsorption on activated carbon, solvent extraction, ion exchange, reverse osmosis

Solid waste management: Types of domestic solid wastes, collection and transportation, characteristics of solid waste, segregation; types of disposal methods- sanitary land fill, incineration, composting, and organic fertilizer, recovery of energy from solid wastes.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Sayler, G. S., Fox, R., & Blackburn, J. (Eds.). (2013). **Environmental biotechnology for waste treatment** (Vol. 41). Springer Science & Business Media.
2. Wang, L. K., Ivanov, V., Tay, J. H., & Hung, Y. T. (Eds.). (2010). **Environmental biotechnology** (Vol. 10). Springer Science & Business Media.
3. Kaushik, G. (Ed.). (2015). **Applied Environmental Biotechnology: Present Scenario and Future Trends**. New Delhi: Springer India.

4. Wainwright, M. (2012). **An introduction to environmental biotechnology.** Springer Science & Business Media.
5. Glazer. Microbial Biotechnology

Semester V
ELECTIVE Paper: Genetics
Course Code: BT 5401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Genetics and role of genes in developmental biology

By the end of the paper, a student should be able to:

a) Understand the concepts behind deviations from Mendel's Laws
b) Understand the structure of chromosomes and related inheritance to chromosomes;
c) Understand the concept of gene linkage and significance of gene mapping
d) Appreciate how evolution and population genetics go hand in hand
e) Appreciate the concept of maternal inheritance
f) Carry out pedigree analysis to study genetics of diseases
g) Look at the correlation of gene expression and development of an organism
h) Appreciate experiments carried out by scientists to enable understand genetics

Thus, the knowledge from this course can help in the following:

a) Explore career options in cytogenetics and genetic counselling
b) Work in laboratories dealing with prenatal genetic diagnosis of disorders
c) Work in clinical embryology field
d) Carry out basic research in understanding still unexplored areas of genetics

II. Course Content

Unit 1: Mendelian Genetics and deviations from Mendel's laws

Introduction to genetics; Mendelian Genetics: History of Mendelian genetics, First Law of Inheritance, Second Law of Inheritance, Test Cross and Back cross and their significance.

Deviations: Incomplete Dominance, codominance, overdominance; Multiple alleles: ABO blood group and incompatibility, Rh incompatibility; Epistasis: Dominant and Recessive epistasis with examples; Non epistatic inter allelic gene interactions; Gene Lethality

Unit 2: Chromosomal basis of genetics

Chromosomal theory of inheritance and inheritance patterns (Pedigree analysis); Sex linkage, non-disjunction as proof of chromosomal theory of inheritance; Chromosomes: Chemical composition and structural organization of chromatids; Centromeres and Telomeres; Chromatin and nucleosome organization: eu- and heterochromatin; Special banding patterns in human chromosomes; Chromosomal aberrations: structural and numerical; Evolution of wheat, cotton and rice; Linkage and crossing over; Gene mapping; Interference and coincidence in prokaryotes and eukaryotes;

Unit 3: Bacterial Genetics

Conjugation, Transduction and Transformation; Isolation of auxotrophs and replica plating; Induced mutations in microbes, plants and animals and its economic benefits; Analysis of mutations in biochemical pathways: one gene – one enzyme hypothesis

Unit 4: Population genetics and Extrachromosomal Inheritance

Extrachromosomal inheritance; Mitochondrial equilibrium and evolution; Evolution of chloroplast DNA and its inheritance; Examples of maternal inheritance

Population genetics: Hardy Weinberg theory, Factors affecting Hardy Weinberg theory, Gene and genotypic frequencies; Introduction to the concept of Epigenetics; Evolutionary genetics

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Genetics (2012) 6th ed., Snustad, D.P. and Simmons, M.J., John Wiley & Sons.(Singapore)
2. Genetics - A Conceptual Approach (2012), 4th ed., Pierce, B.A., W.H. Freeman & Co. (New York)
3. An Introduction to Genetic Analysis (2010), 10th ed., Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J., W.H. Freeman & Company (New York)
4. Robert J. Brooker. Genetics: Analysis and Principles. 5th Edition. (2015) McGraw Hill Publications.

5. Terry Brown. Introduction to Genetics: A molecular approach. Garland Science
6. M.W. Strickberger. Genetics. 3rd Edition. MacMillan Publications

Practical Paper: Fundamentals of Enzymology, Immunotechnique and Environmental Biotechnology
Course Code: BT 5505L
No. of Credits: 2.5
Learning Hours: 60 hrs
Session: 3 hours

Note:

- *Students should learn the principles, theory, protocol and calculations for each experiment.*
- *They should learn about reagent preparations.*

Enzyme practicals

1. Assay of salivary amylase.
2. Effect of pH on enzyme activity
3. Effect of enzyme concentration on enzyme activity
4. Effect of substrate concentration on enzyme activity
5. Effect of a competitive inhibitor on enzyme activity
6. Extraction and partial purification of an enzyme (amylase/peroxidase)

Liver Function Tests

7. Assay of serum transaminases – SGOT
8. Assay of Serum transaminases - SGPT.
9. Estimation of Alkaline Phosphatase

Immunological Tests

10. Ouchterlony Double Radial Immunodiffusion
11. Mancini Single Radial Immunodiffusion.
12. Demonstration of Enzyme linked immunosorbent assay
13. Antibody structure and binding: computer based study

Environmental Biotechnology

14. Estimation of total hardness of water samples
15. Determination of pH, carbonates and nitrates in soil
16. Estimation of Dissolved oxygen and Biological oxygen demand*
17. Estimation of chemical oxygen demand
18. Bioremediation*

** These could be done as mini projects and in groups. The BOD levels of various industrial (dye) effluents can be checked and its bioremediation could be carried out by isolating cultures growing on dye fortified media and then using a few select isolates for its bioremediation.*

References

1. Oser: Hawk's Physiological Chemistry (14^{th} ed)
2. Plummer: An introduction to Practical Biochemistry, 1988, Tata Mc Graw- Hill education
3. Sheela Sharma: Experiments and Techniques, 2007.
4. Thomas and Schalkhammer: Analytical Biochemistry, 2002
5. Varlery H: Practical Clinical Biochemistry, 1980, Heinemann, London
6. Thimmaiah S R: Standard Methods of Biochemical Analysis, 1999, Klayani Publishers

Semester VI
CORE Paper: Plant Biotechnology
Course Code: BT 6501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic concepts of Plant Biotechnology and look at its applications.

By the end of the paper, a student should be able to:

a) Understand the concept of *in vitro* micropropagation and its various techniques
b) Understand the various mechanisms of transfer of desired DNA into plant cells
c) Appreciate the benefits of protoplast isolation and fusion
d) Understand the benefits of somaclonal variations in crop improvement
e) Know the basic experimental designs required for a successful transfer of plantlets from labs to farms
f) Understand the importance of secondary metabolites and their production for commercial use
g) Appreciate use of bioreactors, details of designs of bioreactors for large scale production of useful products

Thus, the knowledge from this course can help in the following:

a) Contributing towards developing high yielding and good quality crops to meet demands of the farmers and population

b) Contributing towards developing plants for bioremediation and sustaining in stressed climatic conditions
c) Start small scale companies with products that can cater to the agricultural sector
d) Carry out basic research in developing new products
e) Work in institutions and industries contributing to agribiotech sector

II. Course Content

Unit 1: Introduction to plant tissue culture

Principles of plant tissue culture, cell totipotency and cyto-differentiation, Laboratory setup of plant tissue culture, sterilization techniques and instruments used, culture condition and explants selection, Media preparation and components of media, Role of growth hormone in plants and its application in tissue culture.

Unit 2: Techniques used in plant tissue culture

Callus culture, Single cell culture, Protoplast isolation, culture and fusion, haploid culture: Anther culture, pollen culture, ovule culture, Triploid plant production: endosperm culture, Somatic embryogenesis, Somaclonal variation, Synthetic seeds, Generating Virus free plants, Plant breeding techniques, Conservation of plants (need of conservation of plant, liquid nitrogen, seed bank, gene bank etc)

Unit 3: Genetic engineering of plants

Transformation of gene, vector mediated and non-vector mediated methods of transformation, Hairy root culture, Varieties included for crop improvement, selection of desired variety, Recombinant products by plant tissue culture, Introduction to Genome Editing and Genome Selection.

Unit 4: Plant Secondary metabolites

Introduction to secondary metabolites, role of secondary metabolites in plants, commercial use of secondary metabolites, Role of elicitors in production of secondary metabolites; Strategies of large scale production of secondary metabolites; Use of bioreactors and its types

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Plant Tissue Culture, Theory and Practice, Rev Ed.,S. S. Bhojwani, M.K. Razdan
2. Biotechnology, B.D. Singh
3. Introduction to Plant Biotechnology, 3rd Ed., H. S. Chawla
4. Plant Tissue Culture, development and Biotechnology, Edited by Robert N. Trigiano and Dennis J Gray.
5. Plant Propagation: Principles and Practices – Hartmann, H.T and Kester D. E.

Semester VI
CORE Paper: Animal Biotechnology
Course Code: BT 6502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts of Animal Biotechnology and its applications

Thus, the knowledge from this course can help in the following:

a) Understanding the concept of growing animal cells *in vitro*
b) Understand the importance of specifications in design of laboratory and working to avoid contamination
c) Appreciate how transfection studies enable production of cloned products necessary for medical and pharmaceutical applications
d) Appreciate experimental designs by scientists to develop techniques for production of vaccines, monoclonal antibodies etc.
e) Appreciate how animal cell culture has been instrumental in basic research

Thus, the knowledge from this course can help in the following:

a) Become a skilled personnel in animal cell culture
b) Work in biotech and pharmaceutical industries that commercialize cloned products such as erythropoietin, factor VIII etc
c) Carry out basic research in understanding mode of action of drugs, chemicals etc
d) Work in clinical research laboratories
e) Work in hospitals involved in research especially cancer research

II. Course Content

Unit I: Basics of Animal Cell Culture and types of animal cell culture
Terms and definitions; History of development of cell culture; Laboratory set up; Sterilization and maintenance of cultures; Simulating natural conditions for growth of animal cells; Significance of media components. Anchorage dependence and contact inhibition. Types of Animal cell culture; Organ culture; Primary explant cultures; Secondary cultures and Established

cell lines; commonly used cell lines: origin and characteristics; Growth kinetics and cells in culture; 3 – D culture

Unit II: Specialized techniques

Transfection in animal cells; Expressing cloned products in animal cells: The need to express in animal cells, Production of special secondary metabolites/ products (insulin, growth hormone, interferon, t – plasminogen activator, factor VIII etc), processing of chosen protein; Growth of cells in suspension and bioreactors for large scale culture of cells; Stem cell culture, Embryonic stem cell culture and its applications, Transplantation of cultured cells; somatic gene therapy, ethical issues in relation to animal biotechnology.

Unit III: Vaccines, transgenic animals and tissue engineering

Transgenic animals: Mice, Sheep, Fish; use and applications.
Production and applications of monoclonal antibodies;
Production of vaccines using animal cell culture: Polyclonal, monoclonal antibodies and humanized vaccines, recombinant vaccines, DNA vaccines.
Tissue engineering: Elementary idea of tissue engineering, Artificial skin, artificial cartilage.

Unit IV: Applications in research

Conservation of endangered species by use of biotechnology and molecular markers for the live stock; Study of toxicity of drugs and chemical constituents using animal cell lines;
Understanding metabolic pathways, cell signaling, apoptosis, cell division processes etc.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.
Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. M Butler. Animal Cell Culture and Technology.
2. Freshney's Culture of Animal Cells
3. Biotechnology – B.D. Singh
4. Ashish S. Verma et al. Animal biotechnology: Models in discovery and Translation. AP Publications.

Semester VI
CORE Paper: Fermentation Biotechnology
Course Code: BT 6503
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the concepts and importance of Fermentation technology

Thus, the knowledge from this course can help in the following:

a) Understand the growth parameters of microbes *in vitro* and their optimization for large scale production
b) Sterilization processes needed for fermentation technology
c) Appreciate the basic design of fermentors
d) Comprehend the requirement of processing and recovery of pure products.
e) Understand different industrial applications of fermentation

Thus, the knowledge from this course can help in the following:

a) Developing a skill base for working in industries like pharmaceuticals, food industries etc.
b) Begin entrepreneurial set up for products based on fermentation
c) Developing efficient methods for product recovery
d) Exploring to address problems associated with current products and improvise on them

II. Course Content

Unit 1: Upstream processing

The types of fermentation processes. Microbial growth kinetics- Batch culture, continuous culture, fed-batch culture. Isolation and improvement of industrially important micro-organisms.

Media for fermentation- types, Carbon sources, nitrogen sources, growth factors, oxygen requirements, antifoams and medium optimization.

Sterilization: Types, Batch sterilization-design and scale up, continuous sterilization- design and scale up, filter sterilization- media, air.

Basic design of a fermentor; Inoculum development

Unit 2: Downstream Processing

Downstream processing: Introduction; Importance; Processes: Removal of insolubles, Product isolation, Product purification and Product polishing. Quality Control and Assurance, Regulatory policies.

Unit 3: Food products

Production and recovery of citric acid, glutamic acid, lysine, flavoring agents, mushrooms, SCP. Industrial production and applications of proteases, lipases and amylases. Processes involved in beer, wine and fruit juice production.

Unit 4: Industrial applications

Immobilization of enzyme and cells for industry. Production of industrial solvents – alcohol, acetone. Production of polysaccharides – xanthan gum, carragenan, anti-coagulants and anti-HIV agents.

Production of Bio-plastics.

Products of medicinal importance; biotransformation of steroids; Asthaxanthin

IV. Recommended learning Resources

1. Practical Biochemistry, Wilson and Walker, Latest edition
2. Microbial Biotechnology, Glazer, 2nd edition
3. Principles of Fermentation, Whittaker
4. El – Mansi et al. Fermentation Microbiology and Biotechnology. 3rd Edition. CRC Press (2012)
5. Murray Moo Young. Advances in Biotechnology: Fermentation Products. Volume 3. Pergamon Press.
6. D. A. Mitchell et al. Solid state fermentation Bioreactors: Fundamentals of Design and Operation. (2006). Springer Publications

Semester VI
Practical Paper: Fundamentals of Plant and Animal biotechnology, and Fermentation biotechnology
Course Code: BT 6503L
No. of Credits: 2.5
Learning Hours: 60 hrs
Session: 3 hours

Note:

- *Students should learn the principles, theory, protocol and calculations for each experiment.*
- *They should learn about reagent preparations.*

Basic techniques in plant tissue culture

1. Study of laboratory equipments
2. Stocks and Media preparation
3. Sterilization techniques in plant tissue culture
4. Explant selection, treatment and inoculation
5. Subculture of initiated cultures
6. Acclimatization of cultures
7. Extraction of proteins from plants and its estimation
8. Extraction of DNA/RNA from plants and its estimation
9. Estimation of peroxidase in plant extracts

Basic techniques in animal biotechnology

10. Laboratory set up of animal cell culture
11. Demonstration of use of Biosafety Cabinet
12. Media preparation and sterilization by membrane filtration
13. Peripheral Blood Lymphocyte Culture
14. Cell suspension studies using cell lines

Basic techniques in fermentation biotechnology

15. Production of citric acid using Aspergillus in batch cultures
16. Effect of pH on citric acid production
17. Effect of temperature on citric acid production
18. Strain improvement

References

1. Plummer: An introduction to Practical Biochemistry, 1988, Tata Mc Graw- Hill education
2. Thomas and Schalkhammer: Analytical Biochemistry, 2002
3. Varley H: Practical Clinical Biochemistry, 1980, Heinemann, London
4. Wharton and McCarty: Experimental methods in Biochemistry; Macmillan, New York. Whistler, R. L. (1964)
5. Seeley HW and Van Denmark PJ: Microbes in Action
6. Wistreich GA and Lechman MD: Laboratory Exercise in Microbiology; 1973, Glencoe Press, New York, Beverly Hills
7. Sambrook J, Fritsch E F, Maniatis T: Molecular Cloning (A Laboratory Manual: 3 Volumes), 2nd Edition, 1989, Cold Spring Harbour Lab

Semester VI
ELECTIVE Paper: Entrepreneurship and Bioinformatics
Course Code: BT 6601
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the importance of Bioinformatics and nuances of entrepreneurship.

Thus, the knowledge from this course can help in the following:

a) The basic requirements needed to start a small scale company and the importance of market and product anlaysis before launching a product
b) The characteristics of an entrepreneur and how to write a business proposal
c) To understand the basics of bioinformatics and importance of database maintenance
d) To appreciate the various software developed for database management, retrieval and analysis
e) To appreciate the various applications of Bioinformatics especially in drug designing, speciation, study of phylogenetic trees and evolution etc.

Thus, the knowledge from this course can help in the following:

a) Develop skills to use software related to bioinformatics
b) To be able to work in companies especially involved in drug development
c) Sow the seeds of entrepreneurship in students

II. Course Content

Unit 1: Entrepreneurship

Starting an enterprise: Entrepreneur, Stages in setting up an enterprise: Business idea, Setting up a business plan: Executive summary, Vision statement, Mission statement, Product offering and SWOT analysis, Management team, Marketing: Analysis of the market and competition – Market research, Choosing target market, Marketing strategy: 4P strategy, Financial planning: Balance sheet, Profit and loss statement, Breakeven analysis, Sources of capital; Intellectual Property rights

Unit 2: Basics of Bioinformatics

Portraying Bioinformatics as modern hybrid of biology and computer informatics, Goals, Scope, Applications and Limitations, Introduction to Biological Databases, Types of Databases, Biological Databases, Pitfalls of Biological Databases, Information Retrieval from Biological Databases

Unit 3: Basic operations of Bioinformatics

Pairwise and Multiple Sequence Alignment, Basic Local Alignment Search Tool (BLAST), FASTA, Sequence Homology versus Sequence Similarity Sequence Similarity versus Sequence Identity, Methods, Scoring Matrices (DOT Matrix, BLOSUM (Introduction),PAM matrix (INTRO)], Database, Similarity Searching, Unique Requirements of Database Searching

Unit 4: Application and essential tools of Bioinformatics

General and Phylogeny tools: BIO EDIT, TREEVIEW, MEGA, RASMOL, DRUG DESIGNING [DRUG BANK tool (to be taught in UNIT 2 for this)], PRIMER DESIGNING (Theoretical and by using Primer 3) NEB-CUTTER

II. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group projects. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

Emphasis will be given to systematic designing of experiments in the laboratory sessions.

IV. Recommended learning Resources

1. Xiong, J. (2006). Essential bioinformatics. Cambridge University Press. [Primary Book]
2. Dan E Krane and M. L Raymer. Fundamental Concepts of Bioinformatics. Pearson Publications. 2003
3. S. G. Sandhu. Bioinformatics and its applications. Neha Publishers. 2013
4. B.M. Purohit. Modern Entrepreneurship Development. Neha Publishers. 2013
5. Lall and Taylor. Entrepreneurship Development, Neha Publishers. 2014

Semester I
Foundation course: English
Course Code: EN 1101
No. of Credits: 2
Leaning Hours: 30

Prescribed text: **Insights: A course in English Literature and Language by K.Elango**
Unit 1:
Unit 1 A and B (part)
Unit 2:
Unit 2B (part) and C

Semester II
Foundation Course: English
Course Code: EN 2101
No. of Credits: 2
Leaning Hours: 30

Prescribed text: **Insights: A course in English Literature and Language by K.Elango**
Unit 1:
Unit 4 A, B and C
Unit 2:
Unit 5 A and C and Unit VII A,B,C

Semester III
Foundation course: English
Course Code: EN 3101
No. of Credits: 2
Leaning Hours: 30

Learning Objectives

- To explore and understand the practices in India
- To be able to develop a stream of thoughts and opinions based on the reading
- To be able to explain and present ideas on the matter
- Building confidence in group discussion and presentations

Text: "Untouchable" by Mulk Raj Anand

Learning Results

- The text will help them build a perspective
- It will give them an image of the practices that are still prevalent in the country
- The presentations on the chapters from the novel will help build self confidence

Semester IV
Course Code: EN 4101
No. of Credits: 2
Leaning Hours: 30

Learning Objectives

- To be able to enunciate one's thoughts and opinions firmly
- To understand a topic at hand from several angles through various characters
- To be able to justify one's stand on a matter with logical and valid argument

Text: "Tara" by Mahesh Dattani

Learning Results

- The play will help the students understand gender bias
- Each character's take on the issue at hand will expose them to several opinions
- It will teach them to respect each opinion and build their own
- Role play reading of the text in class will build interactive sessions when each student is asked to defend the character s/he represents

CORE: BOTANY

Semester I
Core Courses: Botany
Course Code: BO 1501
No. of Credits: 04
Leaning Hours: 30
Learning Hours: 60 hrs

Learning Objectives:

The students will be able to:

1. Understand the morphology, structure and importance of the organisms
2. State the meaning of scientific terms
3. Differentiate between various groups of Algae, Fungi, Bryophytes and Pteridophytes.
4. Understand the morphology, structure and functions of various parts of plants.
5. Learn the taxonomical terminology and understandthe meaning of the same.
6. Learn anatomical structure and function of various tissues.
7. Acquainted with basic concepts of Ecology and Environment.
8. Able to understand the interactions taking place in the Ecosystems and the flow of energy.
9. Able to appreciate the diversity of Ecosystems.
10. The students will be able to understand:
11. The structure, composition and role of DNA and RNA.
12. The mechanism, role and importance of fundamental processes of replication and protein synthesis.

Unit-1 Plant diversity: Study of lower plants

Algae

1. Occurrence and thallus organization.
2. Modes of reproduction.
3. General account of Chlorophyta.
4. Type studies: Distribution, life cycle and systematic position of Spirogyra.
5. Economic importance of Algae (as food, fodder and fertilizer).

Fungi

1. Thallus organization in Fungi.
2. Mode of nutrition in Fungi.
3. Modes of reproduction.
4. Type studies: Distribution, life cycle and systematic position of Mucor.
5. Economic importance of Fungi (as food and medicine).

Bryophyta

1. General characters of Bryophytes.
2. Type studies: Distribution, life cycle and systematic position of Riccia.

Pteridophyta

1. General characters of Pteridophytes.

2. Type studies: Distribution, life cycle and systematic position of Nephrolepis.

Unit-2 Morphology of angiosperms
Morphology andanatomy of angiosperms

1. Leaf.
2. Simple and Compound leaves.
3. Types of Leaf incisions. Leaf margin. Leaf tip.
4. Phyllotaxy.
5. Bracts- Scaly, Involucral, Foliaceous, Petaloid and Spathe.
6. Flower- Complete, incomplete, actinomorphic, zygomorphic, irregular.
7. Inflorescence- Racemose, Cymose and special kinds.
8. General characters and functions of various kinds of plant tissues:
    a. Meristematic tissues.
    b. Simple tissues.
    c. Complex tissues.

Unit-3 Plants and environment

1. Introduction, Scope and Branches of Ecology
2. Ecosystems:
   Kinds of Ecosystem: Natural, Artificial
   Structure and Functions of Ecosystems
   Ecological Pyramids, Productivity of an Ecosystem, Energy flow in an Ecosystem
   Biogeochemical Cycles-Carbon, Nitrogen, Phosphorus, Sulfur, Components of
   Freshwater Ecosystem (Pond) Components of Terrestrial Ecosystem (Grassland)
   Food chain and food web.
3. Biotic Factors:
   Symbiosis: Mutualism, Proto-cooperation, Commensalism
   Antagonism: Predation, Parasitism, Antibiosis, Competition, Saprophytism
4. Concept of Sustainable Biodiversity:
   Case study: The Messenger Pigeon gone forever

Unit-4 Genetics and Molecular biology

1. DNA and RNA Composition and Structure
2. Watson and Crick's model of DNA
3. Types of RNA
4. DNA Replication
5. Genetic code
6. Protein Synthesis
7. Regulation of gene expression in prokaryotes – Operon concept

Reference Books

1. Smith, Gilbert M; Cryptogamic Botany Algae & Fungi Volume 1; 2nd edition; McGraw-hill Book Comp. Tokyo, 1955.

2. Vasishtha B.R. And Sinha A. K. - Botany for degree students Part 1 ALGAE; S. Chand & Company Ltd, 1st edition, revised 2005.
3. Vasishtha B.R. And Sinha A. K. - Botany for degree students Part 2 FUNGI; S. Chand & Company Ltd, 1st edition, revised 2005.
4. Alexopoulos, Constantine J.;Mims, Charles W; Introductory Mycology; 3rd edition; New Delhi: Wiley Eastern Limited, 1983.
5. Webster, J.1985. *Introduction to Fungi*.Cambridge University Press.
6. Smith, Gilbert M; Cryptogamic Botany Bryophyta&Pteridophyta Volume 2; 2nd edition; McGraw-hill book Comp. Tokyo, 1955.
7. Parihar, N.S.; Pteridophytes: An introduction to Embryophyta, Vol.II; 4th edition; Allahabad: Central Book Depot, 1962.
8. Kar, Ashok Kumar;Gangulee, Hirendra Chandra; College botany: Volume II; 2nd edition; Kolkata: New Central Book Agency (P) Ltd, 1989, 2006.
9. Sporne, K.K. 1991. *The Morphology of Pteridophytes.*B.I. Publishing Pvt. Ltd. Bombay.
10. Singh V., Pande P.C., Jain D.K.; A Textbook of Botany, 4th Edition; Rastogi publications, 2013.
11. Dutta, A.C.; A Class-book of Botany; 15th edition; Calcutta: Oxford University Press, 1976.
12. Sivarajan, V.V.; Introduction to the principles of plant taxonomy; 2nd edition; Cambridge: Cambridge University Press, 1991.
13. Subramanian, N.S.; Modern plant taxonomy; New Delhi: 1st edition; Vikas Publishing House Pvt. Ltd., 1995.
14. Lawrence, George H.M.; Taxonomy of Vascular Plants; 1st edition; New Delhi: Oxford & IBH Publishing Co., 1967.
15. Sharma, O.P.; Plant Taxonomy; 1st edition, reprint; New Delhi: Tata McGraw-Hill Publishing Co. Ltd., 1993(2002)
16. Esau, Katherine; Anatomy of seed plants; 2nd edition; New York: John Wiley & Sons, 1977.
17. Gangulee, H.C.,Das, K.S., Dutta C.T.; College Botany Vol I.; Kolkatta: New Central Book Agency, 2002.
18. 8.Naik, V.N. 1984. *Taxonomy of Angiosperms;* New Delhi:Tata McGraw - Hill Publishing Co. Ltd., 1984.
19. Fahn, A; Plant anatomy; 4th edition. Indian reprint; New Delhi: Aditya Books (P) Ltd., 1990(1997).
20. Eames, Arthur J.;MacDaniels, Laurence H.; An introduction to plant anatomy; 2nd edition. Reprint; New Delhi: Tata McGraw-Hill Publishing Company Limited, (1978, 2004).
21. Tayal M.S.; Plant Anatomy; Rastogi publications, 1983.
22. J. D. Watson, T. A. Baker, S. P. Bell, A. Gann, M. Levine, R. Losick; Molecular Biology of the Gene, 5th Edition; Pearson Education, 2004.

23. Lewin, B..GenesVIII;NewYork:Oxford University Press, 2000.
24. Alberts, B., Bray,D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D.; Molecular Biology of the Cell.NewYork:Garland Publishing, Inc..
25. Wolfe, S.L.;Molecular and Cellular Biology. California, USA: Wadsworth Publishing Co., 1993.
26. Kleinsmith, L.J. and Kish, V.M.;Principles of Cell and Molecular Biology,2nd Ed.,.New York, USA:Harper Collins College Publishers, 1995.
27. Subrahmanyam, N.S.;Sambamurty, A.V.S.S.; Ecology; 1st edition; New Delhi: Narosa Publishing House, 2000.
28. Sharma, P.D.; Ecology and Environment; 7th edition; Meerut:Rastogi Publishers, 1998.
29. Odum, E.; Barrick M.; Barrett G.; Fundamentals of Ecology, 5th edition; New Delhi: Cengage Learning India, Pvt. Ltd., 1971.
30. Miller, G. Tyler; Textbook of Ecology, New Delhi: Cengage Learning India**,**2009.

Semester I
Core Courses: Basic Botany Practicals-I
Course Code: BO 1502L
No. of Credits: 2
Learning Hours: 60 hrs

1. Study of Algae- ***Spirogyra***
    a. Mounting- Thallus, conjugation types
    b. Permanent slides - Thallus and conjugations
2. Study of Fungi- ***Mucor***
    a. Specimen- Bread/ Roti with Mucor
    b.Mounting- Reproductive structure- spores, sporangia
    c. Permanent slides- Mucor sporangia, Zygospores
3. Study of Bryophytes-***Riccia***
    a. Specimen - Thallus with Sporophyte
    b. Permanent slides – Thallusv.t.s.,thallus with Antheridia and Archegonia
4. Study of Pteridophytes- ***Nephrolepis***
    a. Specimen- Sporophytic plant
    b. Mounting- Ramenta, Hydathode, Sporangia
    c. Permanent slides- Prothallus with Antheridia and Archegonia; T.S. leaflet passing through sorus
5. Study of morphological characters of Leaf, bracts,flower and inflorescence (as per theory syllabus).
6. Study of various types of Simple tissues from Sunflower and Cucurbita stems (T.S. and L.S.) through fresh material and permanent slides.Study of complex tissues through maceration.
7. Study of Biotic Factors- examples of Symbiosis and Antagonism (through charts / models / specimens)
    a. Ecological Pyramids (Number, Biomass and Energy).
    b. Ecosystems: Pond and Grassland.

c. Symbiosis- Root nodules, Lichen
d. Protocooperation- Hermit crab and Fierasfer fish
e. Antagonism- Cuscuta, Loranthes, Viscum, Utricularia, Nepenthes, Drosera

8. Detailed study of Genetic Codes.
9. Study of structure of Nucleic acids (DNA, RNA) through charts or models- Watson & Crick Model.
10. DNA Replication and Protein Synthesis through charts or models.

Project

The PROJECT will be on Plant Morphology. Students will study the morphological characters present in living plant specimens from the field. These are to be presented as an individual project which may contain pressed plant materials/original photographs/ original drawings presented in a creative manner.

Semester – II
Botany: Basics of Botany-II
Course Code: BO 1503
No. of Credits: 04
Learning Hours: 60 hrs

Learning Objectives:

The students will learn:

1. The life cycle of individuals belonging to Gymnosperms, Dicotyledons and Monocotyledons.
2. The taxonomical terminology and understand the meaning of the same.
3. To differentiate between Gymnosperms, Dicotyledons and Monocotyledons.
4. Understand the morphology, structure and functions of various parts of plants.
5. Learn the taxonomical terminology and understand the meaning of the same.
6. Learn about various classification systems and the basis of classification of these systems.
7. Learn various plant families and their economic importance.
8. And differentiate between the physiological processes and their importance.
9. The factors which affecting flowering in plants.
10. The respiratory process in the presence of light.
11. Able to understand use of plant resources for food and medicine.
12. Able to understand basic concepts of gardening, including types of gardens and garden plants.
13. Acquainted with the latest technological developments in the field of Biotechnology and plant tissue culture.

Unit-1: Gymnosperms

1. General characters of Gymnosperms: occurrence, morphology and reproduction.
2. *Cycas*: Occurrence, distribution, taxonomic position, morphology, reproduction

and life history of the genus (excluding anatomy),

Angiosperms

1. General characters of Dicotyledons and Monocotyledons.
2. Sunflower and Maize: Occurrence, distribution, taxonomic position, morphology, reproduction and life history of the genus (excluding anatomy).

Unit-2 Morphology and taxonomy of angiosperms

Morphology of angiosperms

1. Stipules: types and modifications.
2. Types of placentation.
3. Types of aestivation.

Taxonomy of angiosperms

1. Introduction to systems of classification—Artificial, Natural and Phyllogenetic.
2. Bentham and Hooker's system of classification.
3. Study of the following families.

   Dicotyledons- Polypetalae – *Malvaceae*
   Dicotyledons- Gamopetalae- *Convolvulaceae*
   Dicotyledons- Apetalae- *Nyctaginaceae*
   Monocotyledons- *Amaryllidaceae*

Unit-3 Plant physiology

1. Plant-Water Relations:
   a. Water Potential
   b. Diffusion,
   c. Imbibition,
   d. Osmosis,
   e. Plasmolysis
2. Physiology of Flowering:
   a. Role of temperature in flowering (Vernalization)
   b. Role of light in flowering (Photoperiodism)
3. Respiration
   a. Outline of Respiratory metablosim.
   b. Glycolytic pathway.
   c. Oxidative Pentose Phosphate Pathway.
   d. Anaerobic respiration.
   e. Tricarboxylic Acid Cycle.
   f. Respiratory Chain.
   g. Significance of ATP.
   h. Chemiosmotic theory.

Unit-4 Plant resources, Gardening and Biotechnology

1. **Plant resources:** Botanical name, common name, family, useful part, brief description, important chemical constituents if any, climate and cultivation (only for cereals, pulses and oil seeds) and uses of the following plants:
   a. Cereals- Wheat, Rice
   b. Pulses- Gram

c. Medicinal plants- Ginger, Aloe, Neem and Ashwagandha

2. Gardening:

a. Introduction, Uses of gardens.

b. Types of gardens (Kitchen garden, water garden, rock garden and terrace garden)

b. Garden Operations- digging, planting

c. Identification of common plants for different garden location. (Minimum 5 plants for each location): paths, avenue, hedges and flower beds.

3. Biotechnology:

a. Introduction, Brief History, Scope and Types of Plant Biotechnology.

b. Plant Tissue Culture – Tools & Technique; Applications

Reference Books:

1. Chamberlain, Charles Joseph;Coulter, John Merle; Morphology of Gymnosperms; 2nd edition; Allahabad: Central Book Depot, 1964.
2. Chamberlain, Charles Joseph; Gymnosperms: structure and evolution; 2nd edition; New York: Dover Publications, Inc., 1966.
3. Bhatnagar, S.P.;Moitra, A.;Gymnosperms. ., New Delhi: New Age International Pvt. Ltd., 1996.
4. Raghavan, V.;Developmental Biology of Flowering plants; New York: Springer - Verlag, 1999.
5. VasishtaP.C.,; Botany for degree students- Vol. V, Gymnosperm; Delhi: S. Chand, 1983.
6. Chopra G.L., Nagin S.; Gymnosperm; Jullundhar:S. Nagin& Co., 1978.
7. Dutta, A.C.; A Class-book of Botany; 15th edition; Calcutta: Oxford University Press, 1976.
8. Sivarajan, V.V.; Introduction to the principles of plant taxonomy; 2nd edition; Cambridge: Cambridge University Press, 1991.
9. Subramanian, N.S.; Modern plant taxonomy; New Delhi: 1st edition; Vikas Publishing House Pvt. Ltd., 1995.
10. Lawrence, George H.M.; Taxonomy of Vascular Plants; 1st edition; New Delhi: Oxford & IBH Publishing Co., 1967.
11. Sharma, O.P.; Plant Taxonomy; 1st edition, reprint; New Delhi: Tata McGraw-Hill Publishing Co. Ltd., 1993(2002)
12. Esau, Katherine; Anatomy of seed plants; 2nd edition; New York: John Wiley & Sons, 1977.
13. Gangulee, H.C.,Das, K.S., Dutta C.T.; College Botany Vol I.; Kolkatta: New Central Book Agency, 2002.
14. 8.Naik, V.N. 1984. *Taxonomy of Angiosperms;* New Delhi:Tata McGraw - Hill Publishing Co. Ltd., 1984.
15. Noggle, Ray G.;Fritz, George J.; Introductory plant physiology; 2nd edition; New Delhi: Prentice-Hall Of India Private Limited, 1991.
16. Sinha, B.K.;Pandey, S.N.; Plant Physiology; 1st edition; New Delhi: Vikas Publishing House Pvt. Ltd., 1981.

17. Verma, V.; Textbook of plant physiology; New Delhi:Ane Books India, 2007.
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19. Devlin, Robert M.;Witham, Francis H.; Plant Physiology; 4th edition, Indian reprint; Delhi: CBS Publishers & Distributors, 1986(2001).
20. Kochhar, P.L.; A textbook of Plant Physiology; 7th edition; Delhi:Atma Ram & Sons, 1964.
21. Verma S. K. Textbook of Plant physiology and Biochemistry ; 4th editon; S. Chand & Company Ltd, 2003.
22. Salisbury, Frank B.;Parke, Robert V.; Vascular plants: form and function; London: Macmillan & Co Ltd, 1964.
23. Sinha, R.K.; Modern plant physiology; 2nd edition; New Delhi:Narosa Publishing House, 2004.
24. Ganguly A.K., Kumar N.C.; General Botany, Vol II, Part II: Introduction to plant physiology; 7th Edition; Emkay Publications, 1990.
25. Verma V.; Text Book of Economic Botany; Delhi: Ane Books, 2009.
26. Kochhar S.L., Elbaum L., Einstein E.; Economic Botany in the Tropics; Pan MacMillan, 2012.
27. Hill A.F.; Economic Botany, 2nd Edition; New York:McGraw -Hill, 1992.
28. Samba MurtyA.V.S.S.,SubramanyamN.S.; Economic Botany of Crop Plants; Asia tech Publishers, 2000.
29. Mukherjee D., Bose T.K.; Percy Lancaster's Gardening in India;India Book House Pvt Ltd., 1997.
30. FutehallyLaeeq; Gardens, 2nd Edition; New Delhi: National Book Trust, 1990.
31. Satyanarayana U.; Biotechnology; Books and Allied (P) Ltd, 2005.
32. Gupta P.K.;Elements of Biotechnology; Rastogi Publications, 2009.
33. Narayanaswamy S.; Plant cell and tissue culture; Tata McGraw Hill, 2011.
34. Bhojwani, S.S.; Plant Tissue Culture: Theory and Practical (a revised edition). New York, USA: Elsevier Science Publishers, 1990.
35. IgnacimuthuS.; Basic Biotechnology; Tata McGraw Hill, 1995.
36. Dubey, R.C.; Text Book of Biotechnology; S.Chand Ltd, 2001.

Semester II
Core Courses: Basic Botany Practicals-II
Course Code: BO 2504L
No. of Credits: 2
Learning Hours: 60 hrs

1. Study of Gymnosperms- Life-History of ***Cycas***
   a. Specimen- Cycas whole plant, coralloid roots, compound leaf, male cone, Megasporophyll and ovules
   b. Mounting – Cycas microspores
   c. Permanent slides- TS Microsporophyll, LS Ovule
2. Study of Angiosperm: Life-History of **Sunflower**
   a.Specimens – Whole plant, Inflorescence, Ray floret and Disc floret.
   Life-History of **Maize**
   a. Specimen – Whole plant, Inflorescence, Seed.
   b. Slides – LS of Seed
3. Study of Plant Morphology:
   a. Types of placentation.
   b. Types of aestivation.
   c. Types of Stipules.
1. Study of Plant families- *Malvaceae, Convolvulaceae, Nyctaginaceae*and*Amaryllidaceae*-Classification with reasons, identifying characters, floral formula and floral diagrams, habit, sketch, androecium, gynoecium and TS of ovary; 3-4 botanical and common names of examples.
4. Plant Physiology: Experiments (to be individually performed)for-
   a. Diffusion-experiment to show diffusion of gases.
   b. Imbibition- Demonstration of Endosmosis, exosmosis in grapes
   c. Osmosis- Potato osmoscope
   d. Plasmolysis- Tradescantia leaf

Demonstration experiments-
   a. Anaerobic respiration.
   b. Kuhne's tube.
   c. Release of CO_2 in anaerobic respiration.
5. Economic Botany- Study of plants as per theory syllabus.
6. Study of Garden tools as per theory syllabus through charts- Scissors, Hoe, Hose, Clippers, Watering can, Sprinkler.
7. Study of any five Avenue trees, five ornamentals and five foliage plants of your area through fresh specimen and herbaria.
8. Plant Tissue Culture:
   a) Laboratory design
   b) Laminar Air Flow, Autoclave, pH meter, oven, digital balance

Project: Study the Career opportunities available in any of the branches of Biology which you have studied in Semesters I and II. Local, State, National and International level.

Semester I
CORE Paper: General Chemistry (Theory)
Course Code: CH 1501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:

a) To learn preparations reactions and properties of alkane, alkene and alkynes.
b) To learn estimation of nitrogen and molecular weight determination of organic acids and bases
c) To learn basics of selected organic reactions and mechanisms
d) To understand the atomic structure
e) To learn the applications of wave mechanics
f) To understand the nature of chemical bonding and different geometrical shapes of inorganic molecules based on V B and VSEPR theories.
g) To learn fundamentals of thermodynamic chemistry and Chemical kinetics.

Thus, the knowledge from the course can help in the following:

a) Basic knowledge of chemistry is important for higher study in the subject.
b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.
c)Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content
Unit-1 Organic Chemistry-I

Alkane

Methods of formation:-Wrutz reaction, Corey–House Synthesis (*Gilmanreagent*) Hydrolysis of R-Mg-X, Decarboxylation of carboxylic acids and Kolbe electrolysis. Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity(with Energy considerations), Nitration of alkane (only reaction).

Alkene

Methods of Preparation:- Dehydration of alcohols (with mechanism), regioselectivity in alcohol dehydration, dehalogenation, dehydrogenation, dehydrohalogenation of alkyl halides, The Saytzeff rule, Hofmann elimination (Only introduction, without mechanism).Mechanisms involved in hydrogenation, electrophilic andfree radical additions, Markownikoff's rule, peroxide effect, hydroboration-oxidation,and oxymercuration-reduction.Epoxidation, ozonolysis,

hydration, hydroxylation and oxidation with $KMnO_4$and OsO_4.Polymerization of alkenes, substitution at the allylic and vinylic positions ofalkenes.

Alkynes

Methods of Preparation: Dehydrohalogenation, dehalogenation, Acidity of Alkynes (Na, Ag,Cu), Mechanism of electrophilic and nucleophilicaddition reactions, hydroboration-oxidation, metal-ammonia and metal reductions (cis and trans), and polymerization.

Unit-2 Organic Chemistry-II

Quantitative Analysis and Determination of Molecular Formula:

Determination of Nitrogen by Kjeldahl's method and Kjeldahl's method modified with boric acid. Molecular weight of organic acid by Ag-salt method and organic base by Chloroplatinate method, Numerical based on empirical and molecular formula.

Fundamentals of Organic Reactions

Curved arrow notation, drawing electron movements with arrows, half-headed and double-headed arrows, type of reagent (electrophile, nucleophile,free radical), Reactive intermediates - carbocations, carbanions, free radicals, carbenes, nitrenes and arynes (only one example).

Types of reaction, Addition(electrophilic, nucleophilic, free radical addition, Substitution reaction: S_N^1 and S_N^2nucleophilic substitutions with mechanism. Elementary treatment of (free radical substitution reaction (*cf.* Alkane), Electrophilic substitution reaction (*cf.* Nitration),Elimination reaction: E1 and E2 reactions, Rearrangement reactions, Inter and intramolecular rearrangement.1,2- rearrangement, pericyclic reaction, olefin metathesis (one example of each)

Unit-3 Inorganic Chemistry

Atomic Structure and ware Mechanics:

Idea of de–Broglie's matter wave (dual nature) and Heisen Berg's uncertainty principle Schrodinger wave equation, Normalized and Orthogonal wave, quantum numbers and their significance, radial and angular wave functions, shapes ofs, p and d orbitals and characteristics. Variation of orbital energies with atomic number and energy level diagram.

Chemical Bonding

I) Ionic bonding:

a) Lattice energy:-Definition, Born–Lande equation (derivation not required), factor's affecting lattice energy, Solvation energy and solubility of ionic solid , covalent nature of ionic compound, Polarizing power and Polarisability of ions, Fajan's rule.

II) Covalent boning:

a) Valance bond theory and its Limitations

b) Various types of hybridization and shapes of simple inorganic molecules and ions (such as NH_3, H_3O^+ , SF_4 ,SF_6,PCl_5 , ClF_3 , I_3^-, NH_4^+ , BF_4^-, XeF_4 , XeF_6) byValence Shell Electronpair Repulsion (VSEPR) Theory.

Unit-4 Physical Chemistry

Thermodynamics

Limitations of first law and need for the second law, Entropy- its physical significance, entropy of gas and calculation of entropy for different processes. Entropy change during phase change, entropy of mixing of ideal gases, entropy change in reversible and irreversible process.

Chemical kinetics

Derivation of second order rate reaction constant for (a=b) and (a≠b). Derivation of third order equation (a=b=c),Determination of half life time for the 2^{nd} and 3^{rd} order reaction. Kinetics of opposing and consecutive reaction.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books: CH1501: General Chemistry

1. "Elements of Quantum Mechanics" by Michael D. Fayer, Oxford University Press, Indian Edition.
2. "Concise Inorganic Chemistry" by J. D. Lee, 5/E, Oxford University Press, Indian Edition.
3. "Basic Inorganic Chemistry" by F. A. Cotton and G. Wilkinson, Wiley Publication.
4. "Inorganic Chemistry" by Shriver & Atkins, 4/E, Oxford University Press, Indian Edition.
5. "Introductory Quantum Chemistry" by A. K. Chandra, 4/E, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. "Organic Chemistry" by G. Marc Loudon, 4/E, 2010, Oxford University Press, Indian Edition,
7. "Organic Chemistry" by Robert Thornot Morrison, Robert Neilson Boyd, 6/E, 1992, Prentice Hall of India Pvt Ltd, New Delhi.
8. "Text book of Organic Chemistry" by P. L. Soni and H. M. Chawla, 26/E, 1995, Sultan Chand & Sons Publication, New Delhi.
9. "Text book of Organic Chemistry" by P. S. Kalsi, 1999, MacMillan of IndiaPvt. Ltd.
10. "Organic Chemistry" by Bhupinder Mehta, Manju Mehta, Prentice Hall of India Pvt. Ltd, New Delhi.

11. "Elements of Physical Chemistry" by Peter Atkins & Julio De Paula, 5/E, Oxford University Press, Indian Edition.
12. "Physical Chemistry" by P. W. Atkins, 7/E, 2002, Oxford University Press, IndianEdition.
13. "Physical Chemistry" by W. J. Moore, 1996, 6/E, MacGraw Hill Publication.
14. "Principle of Physical Chemistry" by Puri, Sharma & Pathania, 41/E, Vishal Publishers.
15. "Essentials of Physical Chemistry" by Bahl & Tuli. 22/E, S.Chand publication New Delhi
16. "Advanced Physical Chemistry" by Gurdeep Raj, 19/E, Goel Publishing House Meerut.

B Sc. Semester I
Practical Paper: General Chemistry
Course Code: CH 1502L
No. of Credits: 03
Learning Hours: 60 hrs

1. Volumetric Analysis (Acid and Base)

a) Preparation and Standardization of NaOH and HCl
b) Succinic Acid ---------NaOH
c) Oxalic Acid ---------- NaOH
d) (Hydrated and/or Anhydrous)
e) Na_2CO_3(Anhydrous)------HCl

2. Inorganic Qualitative Analysis (Two Radicals) (Minimum Eight Salts)

a) Water Soluble and Insoluble Inorganic salts of following cations and anions:
b) Cations: K^+, NH_4^+ , Mg^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+},Cr^{3+}, Zn^2+, Mn^{2+}, Co^{3+}, Pb^{2+}, Cu^{2+}.
c) Anions: S^{2-}, SO_4^{2-} , CO_3^{2-} , PO_4^{3-} , CrO_4^{2-} , Cl^-, Br^-, I^- , NO_3^- , O^{2-}

3. Inorganic Preparation of

a) Ferrous ammonium sulphate
b) $Na_2S_2O_3$,
c) Potash Alum

VI. Reference books: CH 1502L: Chemistry (Practicals)

1. "Vogel's Textbook of Quantitative Chemical analysis" Revised by G. H. Jeffery, J. Bassett, J.Mendham & R. C. Denney, 5/E , ELBS (English Language Book Society) Longman.
2. "Analytical Chemistry" by Dhruba Charan Dash, PHI Learning Private Ltd, 2011 NewDelhi..
3. "Analytical Chemistry" by Gary D. Christian , 4/E, John Wiley & Sons.

4. "Advanced Practical Inorganic Chemistry" by Gurdeep Raj, 9/E, Goel Publishing House, Meerut.
5. "Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis", 5/E, Orient Longman Ltd.

Semester II Chemistry
CORE Paper: General Chemistry (Theory)
Course Code: CH 2501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:

a) To understand the concept of isomerism and represent the structure of organic compounds.

b) To understand general characteristics of transition metal elements, electronic configuration and their properties.

c) To learn rules and nomenclature of co-ordinated compounds, Werner's theory of co-ordination compounds and types of isomerism in co-ordination compounds.

d) To understand the nature of bonding in co-ordination compounds and application of co-ordination compounds in our day to day life.

e) To learn about fundamental chemistry of Ionic equilibrium and Catalysis

f) To understand some of the basics of analytical chemistry

g) To apply theoretical concepts in order to solve numerical problems.

Thus, the knowledge from the course can help in the following:

a) Basic knowledge of chemistry is important for higher study in the subject.

b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.

c) Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content

Unit-1 Organic Chemistry

Stereochemistry of organic compounds

Optical isomerism — elements of symmetry, molecular chirality, enantiomers, stereogeniccentre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogeniccentres, diastereomers, threo and erythrodiastereomers, meso compounds, resolution of enantiomers, inversion, retention and racernization.

Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature.

Geometric isomerism — determination of configuration of geometric isomers.E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.
Conformational isomerism — Difference between configuration and conformation. conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives (only one example). Newman projection and Sawhorse formulae, Fischer and flying wedge formulae.

Unit-2 Inorganic Chemistry

Transition Metals

Characteristic properties of 3d elements, Ionic radii, oxidation states, complexation tendency, Magnetic behavior and electronic spectral properties, Spectrophotometric estimation of metal ions.

Co-ordination compounds

a)Werner's theory, nomenclature, chelates

b)Valence Bond theory of co-ordination compounds, stereochemistry of numbers 4, 5 and 6.

c) Various types of isomerism in co-ordination complexes.

Unit-3 Physical Chemistry

[Prerequisites or topics for Self Study:- Electrolytes, introduction to electrolytic conducatance, definitions and units of basic terms: electrical conductance, specific conductance, molar conductance , cell constants and degree of dissociation.

1. Ionic equilibrium

Definition ionic equilibrium, Ostwald's dilution law and its limitations, ionic product of water (K_w), pH scale, hydrolysis reaction and relations between K_w , K_a, K_b , and$K_h$for all types of salts, Buffer solution (Handerson- Hasselbalch equation), buffer capacity. Indicator theories- Oswald's and modernquinonoid theory.

2. Catalysis

Characteristics of catalysis, Types of catalysis, homogeneous and heterogeneous catalysis, enzyme catalyzed reaction and derivation mechanism.

Unit-4 Analytical Chemistry

[*Prerequisites or topics for Self Study:- Fundamental terms and definitions of analytical chemistry]*

General Introduction of analytical chemistry

Introduction, Types of titrations. Requirements for titrimetric analysis. Concentration systems: molarity, formality, normality, wt% ppm, milliequalence and millimoles-problems. Primary and secondary standards, criteria for primary standards. preparation of standard solutions, standardization of solutions. Limitation of volumetric analysis, endpoint and equivalence point.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books: CH 2501: General Chemistry(Theory)

1. "Elements of Quantum Mechanics" by Michael D. Fayer, Oxford University Press, Indian Edition,
2. "Concise Inorganic Chemistry" by J. D. Lee, 5/E, Oxford University Press, Indian Edition.
3. "Basic Inorganic Chemistry" by F. A. Cotton and G. Wilkinson, Wiley publication.
4. "Inorganic Chemistry" by Shriver & Atkins, 4/E, Oxford University Press, Indian Edition.
5. "Introductory Quantum Chemistry" by A. K. Chandra, 4/E, Tata MacGraw Hill Publishing Company Limited New Delhi.
6. "Organic Chemistry" by G. Marc Loudon, 4/E, 2010, Oxford University Press, Indian Edition.
7. "Organic Chemistry" by Robert Thornot Morrison, Robert Neilson Boyd, 6/E, 1992, Prentice Hall of India Pvt Ltd, New Delhi.
8. "Text book of Organic Chemistry" by P. L. Soni and H. M. Chawla, 26/E, 1995, Sultan Chand & Sons Publication, New Delhi.
9. "Text book of Organic Chemistry" by P. S. Kalsi, 1999, MacMillan of India Pvt. Ltd.
10. "Organic Chemistry" by Bhupinder Mehta, Manju Mehta, Prentice Hall of India Pvt.Ltd, New Delhi.
11. "Elements of Physical Chemistry" by Peter Atkins & Julio De Paula, 5/E, Oxford University Press, Indian Edition.
12. "Physical Chemistry" by P. W. Atkins, 7/E, 2002, Oxford University Press, Indian Edition.
13. "Physical Chemistry" by W. J. Moore, MacGraw Hill Publication, 1996, 6/E.
14. "Principle of Physical Chemistry" by Puri, Sharma &Pathania, 41/E, Vishal Publishers.
15. "Essentials of Physical Chemistry" by Bahl&Tuli. 22/E, S. Chand publication New Delhi .
16. "Advanced Physical Chemistry" by Gurdeep Raj, 19/E, Goel Publishing House, Meerut.

B Sc Semester II
Paper: Chemistry (Practicals)
Course Code: CH 2502L
No. of Credits: 03
Sessions: Two X 2 hrs

1. Volumetric Analysis:-

Redox Titrations:-

a) $KMnO_4$…… $FeSO_4.7H_2O$

b) $K_2Cr_2O_7$……$FeSO_4(NH_4)_2SO_4.6H_2O$

Complexometric Titration by EDTA:-

a) Estimation of Ca^{+2} / Mg^{+2}…….. EDTA

Iodimetry Titration $Na_2S_2O_3$----------I_2

2. Organic Spotting:- (06 Solids and 04 Liquids).

List organic compounds having different mono functional groups:

Solids:Acids:

a) Benzoic acid b) Oxalic acid

c) Succinic acid

Phenols:

a) β-Napthol b) α-Napthol

c) Resorcinol d) Phenol

Neutral:

a) Urea b) Thiourea

c) Benzamide d) Napthalene

Liquids:

a) Aniline b) Nitrobenzene

c) Benzaldehyde d) Ethanol

e) Ethylacetate f) Chloroform

g) Chlorobenzene h) Acetone

VI. Reference books: CH 2502L Chemistry (Practicals)

1. "Vogel's Textbook of Quantitative Chemical analysis" Revised byG. H. Jeffery, J. Bassett,J. Mendham & R. C. Denney, 5/E, ELBS (English Language Book Society) Longman.
2. "Analytical Chemistry" by DhrubaCharan Dash, PHI Learning Private Ltd, 2011,New Delhi,
3. "Analytical Chemistry" by Gary D. Christian, 4/E, John Wiley & Sons.
4. "Comprehensive Practical Organic Chemistry – Qualitative Analysis" by V. K. Ahluwalia, Sunita Dhingra, First Indian Reprint 2010, University Press (India) Private Limited, Hyderabad,
5. "Organic Analytical Chemistry theory and Practice" by Mohan Jag, Narosa.

CORE Paper: Organic Chemistry (Theory)

Course Code: CH 3504

No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:
(a) To learn basic aspects of Green Chemistry.

(b) To learn electrophilic aromatic substitution and polynuclear hydrocarbons

(c) To learn basics of selected heterocyclic compounds and β -dicarbonyl compounds

(d) To understand the chemical reactivity and molecular Structure in context of acid- base properties

Thus, the knowledge from the course can help in the following:
(a) Basic knowledge of green chemistry is important for higher study in the subject.
(b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.
(c) Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content

Unit 1
[Prerequisites or topics for Self Study :- Basic terms related to Green chemistry chemistry]Self-study (B) :- Basic terms related to Reagents, catalysts, green solvents, green processes chemistry]

Unit 1 Selected Topics in Green Chemistry
[A] Fundamentals of green chemistry

Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts.

[B] Green reagents, catalysts, solvents and Comparative study of green processes

Green reagent: dimethyl carbonate, Green catalysts: Acid catalysts, phase transfer catalysts-Tetra-n-butyl, Green solvents**:** supercritical carbon dioxide, solid supported synthesis, Comparison of traditional processes versus green processes in the syntheses of Ibuprofen, adipic acid

Unit 2

[Prerequisites or topics for Self Study (A):- Fundamentals and definitions related to Electrophilic aromatic Substitution][Self-study (B):- Fundamentals and definitions related to Polynuclear hydrocarbon.]

[A] Electrophilic aromatic Substitution

Introduction, effect of substituent groups, determination of orientation and relative reactivity, classification of substituent groups, electrophilic substitution (ES) reactions. (Nitration, Sulfonation, Halogenation, Friedel Craft alkylation and acylation), Orientation in mono and disubstituted benzene.

[B] Polynuclear hydrocarbon

Nomenclature, structure and synthesis of Naphthalene and its derivatives. Reactions (oxidation, reduction and electrophilic substitution reaction (ESR)) of naphthalene. Preparation and reactions of anthracene and phenanthrene.

Unit 3

[Prerequisites or topics for Self Study (A):- Basic terms related to Heterocyclic Compounds][Self-study(B) :- Fundamentals and definitions related to β -dicarbonyl compounds.]

[A] Heterocyclic Compounds

Introduction, Three and four membered ring with one hetero atom: Preparation of azirine (Neber rearrangement), oxirane (oxidation of alkenes), azitidine (cyclization of γ haloalkylamines), Five membered ring with one hetero atom: Structure and preparation of Pyrrole (Knorr synthesis, Paal Knorr synthesis, Hantzsch synthesis), Furan (synthesis from carbohydrates, Paal-Knorr synthesis) and Thiophene (Paal-Knorr synthesis, Hinsberg method); Nitration, sulfonation, halogenations and Friedel Crafts reaction for pyrrole, furan and thiophene, Six membered ring with one heteroatom: Structure and preparation of pyridine(Hantzsch synthesis, cyclization of acetylene with hydrogen cyanide) and piperidine (from 1,5 diamine hydrochloride salt); Nitration, sulfonation, halogenations and Chichibabin reaction for pyridine, Five and six membered rings with two heteroatoms: Preparation of Pyrazoles(From1,2 dicarbonyl compound with hydrazine) and Pyrimidines (From 1,3 dicarbonyl compound with amidines)

[B] β -dicarbonyl compounds

Introduction, synthesis of Ethyl acetoacetate (EAA) and Diethylmalonate. Acidic and ketonic hysrolysis of β-dicarbonyl compounds. Synthetic applications of β -dicarbonyl compounds. (i) Crotonic acid from EAA (ii) Valeric Acid from diethyl malonate

Unit 4 Chemical Reactivity and Molecular Structure: (Acid- Base Properties)

[Prerequisites or topics for Self Study: Basic terms related to chemical reactivity and molecular structure and acid- base concepts.]

Acid-Bases, scale of acidity-basicity, Resonance effect, drawing of structures and the condition for resonance, Effect of change of hybridization on acidity and basicity, Inductive and electronic effects, steric effect and hydrogen bonding, Lewis acid and bases, Keto – enol tautomerism . Difference between resonance and tautomerism.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books:

(1) "Organic Chemistry" by Robert Thornot Morrison and Robert Neilson Boyd,Prentice Hall of India Pvt Ltd, New Delhi, Sixth Edition, 1992.

(2) "Organic Chemistry", by Bhupinder Mehta, Manju MehtaPrentice Hall of India Pvt Ltd, New Delhi, 2005.

(3) "Organic Chemistry", by James B Hedrickson Donald J. Cram and George S. Hammond, Mc-Graw-Hill Kogakusha,Ltd., Third Edition.

(4) "Advance Organic Chemistry", by Arun Bahl, B. S. Bahl, S. Chand & Company Ltd., New Delhi, First Edition, 2003.

(5) "Organic Chemistry", by I. L. Finar, Pearson Education Pet Ltd, New Delhi, First Edition, 2002.

(6) "Organic Chemistry", by G. Marc Loudon, Oxford University Press, Forth Indian edition, 2010.

(7) "Text book of Organic Chemistry" by P.S.Kalsi, , MacMillan of India Pvt. Ltd., 1999.

(8) "Text book of Organic Chemistry" by P.L. Soni and H.M. Chawala, Sultan Chand & Sons Publication, New Delhi, 26th Edition, 1995.

(9) "Green Chemistry: An Introductory Text", by Mike Lancaster, RSC Publishing, Cambridge, UK, 2nd Edition, 2010

(10) "New trends in green chemistry" by V. K. Ahluwalia, M. Kidwai, Anamay Publishers, New Delhi, (2004)

(11) "Green Chemistry: Environmentally Benign Reactions", Editor: V. K. Ahluwalia, University of Delhi, India Publication 2007.

(12) "Green Chemistry: Greener Alternatives to Synthetic Organic Transformations" by V.K. Ahluwalia, Narosa Publishing House, 2011

(13) "Green Chemistry: Environmentally Benign Reactions" by V. K. Ahluwalia, Ane Books India, 2011

(14) "Heterocyclic chemistry" by Raj K. Bansal, New Age International (P) Ltd Publishers, Fourth Edition, 2008.

(15) "Heterocyclic Chemistry in Drug Discovery", Edited by Jie Jack Li (Editor), Wiley Publishers, New Jersey 2013.

Semester -III
CORE Paper: Physical Chemistry (Theory)
Course Code: CH 3502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:
(a) To learn various aspects of thermodynamics and chemical kinetics.

(b) To learn understand some of the concepts of electrochemistry and phase rule

(c) To learn basics of adsorption and colloids
(d) To understand the polymer chemistry and nuclear chemistry
Thus, the knowledge from the course can help in the following:
(a) Basic knowledge of chemistry is important for higher study in the subject.
(b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.
(c) Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content

Unit 1
[Prerequisites or topics for Self Study (A): Fundamentals and definitions related to Thermodynamics] [Self-study(B) :- Basic terms related to Chemical Kinetics.]

(A) Thermodynamics

Physical significance of entropy; Entropy change during phase change - solid to liquid and liquid to vapor; Entropy of mixing of ideal gases; Entropy change in reversible and irreversible process; Work and free energy functions; Helmoltz function and variation of free energy change with temperature and pressure; Gibbs Helmoltz equation, derivation. Numericals based on theory.

(B) Chemical Kinetics

Theories of reaction rates: Collision theory of bimolecular gaseous reactions and Activated Complex theory of bimolecular reactions; Effects of temperature on reaction rates; Derivation of Arrhenius equation.

Unit 2

[Prerequisites or topics for Self Study (A):- Basic terms related to Electrochemistry [Self-study (B):- Fundamentals and definitions related to Phase Rule]

(A) Electrochemistry

Transport number; Determination of transport numbers by moving boundary method; Conductometric titrations: Principle and advantages; Titration of Strong acid against strong base (HCl vs NaOH); Titration of Weak acid against strong base (CH_3COOH vs NaOH); Titration of Strong acid against weak base (HCl vs NH_4OH); Titration of very weak acid against strong base (H_3BO_3 vs NaOH); Titration of mixture of acids against strong base (HCl + CH_3COOH vs NaOH); Activity and activity coefficient; Ionic strength.

(B) Phase Rule

Theoretical derivation of phase rule; One component system : water system and sulphur system; Condensed phase rule; Silver – lead (Ag-Pb) system; Zn-Cd system, Freezing mixture (salt-H_2O) system, Congruent melting point.

Unit 3

[Prerequisites or topics for Self Study (A):- Various fundamental aspects of Adsorption][Self-study (B):- Basic terms related to Colloids]

(A) Adsorption

Definition of terms, Types of adsorption (physical, chemical and their difference), Types of adsorption isotherms (5 types), Derivation of Freundlich adsorption isotherm, Derivation of Langmuir adsorption isotherm, Applications of adsorption.

(B) Colloids

Colloidal Systems; Preparation of Colloidal Solutions; General Properties of Colloidal Systems; Properties of hydrophobic Colloidal Systems.

Unit 4

*[Prerequisites or topics for Self Study (A):- Fundamentals and definitions related to***) *Polymer Chemistry][Self-study(B) :- Various fundamental aspects of Nuclear Chemistry.]*

(A) Polymer Chemistry

Definition: Monomer, Polymer, Polymerization, Classification of Polymers; Chain polymerization:Free radical and Ionic polymerization [cationic and anionic], Co-ordination polymerization, Step polymerization: Polycondensation and Polyaddition and Ring Opening Polymerization.

(B) Nuclear Chemistry

Particle acceleration –linear accelerator, Cyclotron, Geiger-Muller counter, proportional counter, scintillation counter.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books: CH 3502: Physical Chemistry (Theory)

(1) "Principles of physical chemistry",by B.R. Puri, L.R. Sharma, Madan S. Pathania, Vishal publishing-Jalandhar, 44th Edition, 2010-2011.

(2) "Thermodynamics for chemistry" by S. Glasstone, Affiliated East-West Press Pvt. Ltd,New Delhi.

(3) "An introduction to electrochemistry", by S. Glasstone, Affiliated East-West press Pvt. Ltd, New Delhi.

(4) "Essential of physical chemistry", B.S.Bahl, G.D.Tuli and Arun Bahl, S.Chand-New Delhi, Reprint, 2006.

(5) "Polymer chemistry", by V.R. Gowarikar, New Age International(P) Ltd, Fifteen Reprint, Sep.,1999.

Semester - III

Paper: Inorganic & Physical Chemistry (Practicals)

Course Code: CH 3503L

No. of Credits: 2.5

Sessions: Two X 3 hrs

II. Course Content

[A] Inorganic Mixture

Semi micro method of analysis of inorganic mixture containing four radicals

(excluding phosphate, arsenite, arsenate and borate)

Minimum eight mixtures should be performed.

Mixture may be water soluble, or partly water soluble, or insoluble in water

[B] Physical Experiment

1. To determine the relative strength between HCl and H_2SO_4 by studying hydrolysis of methyl acetate.
2. To determine the temperature coefficient and energy of activation of hydrolysis of methyl acetate catalyzed by acid.
3. To study the adsorption of an organic acid by Animal Charcoal. (Acetic acid /Oxalic acid).
4. Conductometric titration.

    (i) Strong acid Strong Base (HCl, NaOH)
    (ii) Weak acid Strong base (CH_3COOH, NaOH)
    (iii) Mixture of acids Strong base (HCl + CH_3COOH, NaOH)

5. To determine specific refraction and molar refraction of liquid A,B and its Mixture
6. To determine absolute viscosities of liquid A, B and its Mixture

III. Teaching methodologies: Practical work, problem solving, and group discussion etc.

IV. Reference books:

(1) "Textbook of Quantitative chemical Analysis", by Vogel's Pearson Education Ltd. Sixth Edition, 2008.

(2) "Qualitative Inorganic Analysis", by Vogel's Pearson Education Ltd. Seventh Edition, 2009.

(3) "Advanced Inorganic Chemistry", by Gurdeep Raj, Goel Publishing House, Meerut, Volume –I, 24th Revised Edition,1998.

(4) "Advance Physical Practical Chemistry", by J .B.Yadav , Goel Publishing House, Meerut

(5) "Experiments in Physical Chemistry",by P.H.Parsania, Neminath Printers Rajkot First Edition 2004.

(6) "Practical Physical Chemistry", by A.M.. James and F.E.Prichard Longman Group Limited London Third Edition Reprinted 1979.

Semester IV
CORE Paper: Inorganic Chemistry (Theory)
Course Code: CH 4501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:
(a) To learn wave –mechanics and terms related to wave –mechanics.
(b) To learn various aspect of coordination chemistry.
(c) To learn basics of coordination compounds
(d) To understand the Chemical Bonding
(e) To learn organometallic chemistry and applications of catalysis
Thus, the knowledge from the course can help in the following:
(a) Basic knowledge of chemistry is important for higher study in the subject.
(b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.
(c) Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content

Unit 1 Wave Mechanics (15L)[14 marks]
[Prerequisites or topics for Self Study: Various fundamental aspects and definitions related Wave –Mechanics]

Basic postulates of quantum mechanics (Postulates 1,2,3 and 4); Setting up of operators: commutator; Particle in a box (One dimensional); Zero potential energy; Characteristics of the wave functions; Electron in a ring.

Unit 2 Coordination Compounds (15L)[14 marks]
[Prerequisites or topics for Self Study (A):- Basic terms related to Crystal Field Theory] [Self-study(B) :- Fundamentals and definitions related to Coordination Chemistry]

[A] Crystal Field Theory (8L) [8 marks]

Crystal Field Theory ,Orientation of d-orbitals and Crystal Field Splitting of Energy levels; Crystal Field Splitting in Octahedral complexes; Crystal Field Stabilization

Energy (CFSE); Crystal Field Splitting in Tetrahedral Complexes; Crystal Field Splitting in Tetragonal and square Planar Complexes; Magnetic Properties of Metal Complexes and Crystal Field Theory; Factors influences the magnitude of Crystal Field Splitting; Color of Transition Metal Complexes; Crystal Field Effects on Ionic Radii; Crystal Field Effects on Lattice Energies; Jahn- Teller Effect.

[B] Coordination Chemistry (7L) [6 marks]

Coordination Chemistry: Lability, inertness, Stability, Instability, reaction, kinetics and mechanism, Trans effect and Influence

Unit 3 Chemical Bonding (15L)[14 marks]

[Prerequisites or topics for Self Study (A):- Fundamentals and definitions related to Chemical Bonding]

Introduction of AO's, MO's, Molecular orbital Theory; LCAO Molecular Orbital Theory; Energy Level Diagram for Molecular Orbitals; Mixing of Orbitals; Filling up of Molecular Orbitals; MO diagram of Heteronuclear Diatomic molecules (HF, HCl); Molecular orbitals of Polyatomic Species (BeH_2, CO_2, NH_3) (Excluding Walsh diagram); M.O. Theory of $[Co(NH_3)_6]^{3+}$ and $[CoF_6]^{3-}$; Molecular orbital or Band Theory for metals.

Unit 4

[Prerequisites or topics for Self Study (A):- Basic terms related to Organometallic Chemistry]
[Self-study(B) :- Various fundamental aspects and applications of Catalysis]

[A] Organometallic Chemistry (8L)[8 marks]

Introduction, Bonding: Stable electron configurations, electron count preference,
Electron counting and oxidation states.
Ligands: Carbon monoxide, Phosphines, hydrieds and dihydride complexes, n'-Alkyl, alkenyl, alkynyl, and Aryl ligands.
Types of organometallic reactions.

[B] Catalysis (7L)[6 marks]

General principle, The language of catalysis, hydrogenation of alkene. Heterogeneous catalysis: surfaces four interactions with adsorbates.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books:

(1) "Advanced Inorganic Chemistry", by Gurdeep Raj, Goel Publishing House, Meerut, Volume –I, 24th Revised Edition,1998.

(2) "Modern Inorganic Chemistry', by R.D. Madan, S. Chand & Co. Ltd., New Delhi, 2nd Edition, 2006.

(3) "Concise Inorganic Chemistry", by J.D. Lee, Wiley India Publication, 5th Edition, 1996, Reprint 2011.

(4) "Selected Topics in Inorganic Chemistry", by W.V. Malik, G.D. Tuli, R.D. Madan, S.Chand & Co. Ltd., New Delhi, 7th Edition, 2007.

(5) "Introductory Quantum Chemistry", by A.K. Chandra, Tata- McGraw Hill Pub. Co. Ltd., New Delhi, 4th Edition.

(6) "Principles of Inorganic Chemistry", by Puri, Sharma, Kalia, Milestone Publishers & Distributors, New Delhi, 3rd Edition, 2006.

(7) "Quantum chemistry", by R.K.Prasad, New Age International (P) Ltd., Publishers, 4th Edition, 2010.

(8) "Shriver & Atkins' Inorganic Chemistry", Peter Atkins, Tina Overton, Jonathan Rourke, Mark Weller, Fraser Armstrong, Oxford University Press, 2011.

(9) "Inorganic Chemistry", by Catherine E Housecroft and Alan G Sharpoe, 2nd edn.

Semester -IV
CORE Paper: Analytical Chemistry (Theory)
Course Code: CH 4502
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for studying chemistry.
By the end of the paper, a student should be able to:

(a) To learn basic concepts of acid-base titration and Precipitation Titration

(b) To learn basics of Complexometric and Redox Titrations

(c) To learn basic concepts of gravimetric analysis

(e) To learn basic concepts of Solvent Extraction Separation and Organic reagents used in quantitative Analysis.

Thus, the knowledge from the course can help in the following:

(a) Basic knowledge of chemistry is important for higher study in the subject.
(b) The students could pursue a career in chemistry, Industrial chemistry and Post-graduation in the field of Chemistry.
(c) Various aspects of organic , inorganic and physical chemistry can help for the research specialization at higher study.

II. Course Content

Unit 1 Acid Base and Precipitation Titrations (15L)[14 marks]

[Prerequisites or topics for Self Study(A): Fundamentals and definitions related to qualitative and quantitative analysis e.g. Theory of acid-base titration] [Self-study(B) :- Basic terms related to Precipitation Titration]

[A] Theory of acid-base titration: (8L)[[8 marks]

Theory of acid-base titration ,Ways of locating the end point of an acid-base titration, Titration of strong acid with strong base, Titration of weak acid with strong base, Titration of weak base with strong acid, Titration of weak base with weak acid, Factors determining the exact form of a pH curve.

[B] Precipitation Titration (7L) [6 marks]

Titration curves, Feasibility, Indicators, Mohr, Volhard and Fajans' Methods, Factors affecting solubility

Unit 2 Complexometric and Redox Titrations (15L)[14 marks]

[Prerequisites or topics for Self Study(A): Fundamentals and definitions related to Complexometric titrations] [Self-study(B) :- Fundamental aspects of Redox titration]

[A] Complexometric Titration (8L) [8 Marks]

Theory of complexometric titration involving EDTA, Study of EDTA complex formation taking disodium salt of EDTA and effect of pH, Ways of locating the end point, Estimation of calcium and magnesium by complexometric titration by EDTA.

[B] Redox titration (7L)[6 marks]

Theory of redox titration, study of redox titration by electrochemical potential method, Ways of locating the end point for redox titration

Unit 3 Gravimetric analysis (15L)[14 marks]

[Prerequisites or topics for Self Study (A):- Fundamentals and definitions related to gravimetric analysis]

Introduction, Precipitation, Digestion, Filtration, Washing of the precipitate, Drying and/or incineration of the precipitate, Weighing, Gravimetric factors, Specific and selective precipitation, Organic precipitants, Masking or sequestering agent, Problems involved in precipitation gravimetry.

Unit 4 Solvent Extraction and Organic reagents (15L)[14 marks]

[Prerequisites or topics for Self Study(A): Fundamentals and definitions related to Solvent Extraction Separation] [Self-study(B) :- Fundamental aspects of Organic reagents used in quantitative Analysis]

[A] Solvent Extraction Separation (8L) [8 Marks]

Principles of solvent extraction, choice of solvent, distribution coefficient, distribution ratio, percentage, (%) extraction. The extraction process, solvent extraction of metals, selective extraction and separation efficiency.

[B] Organic reagents used in quantitative Analysis (7L)[6Marks]

Separation of methods with 8-Hydroxy Quinoline, Cupferron, DMG and *N*-benzoyl-*N*-phenylhydroxylamine.

III. Teaching methodologies: Apart from the conventional black board teaching, other modes of teaching that will be adopted are power points, problem solving, and group discussion. Assignments will be designed such that students inculcate the habit of reading reference books and science journals. The use of smart boards for teaching will also be promoted to enable more interaction based teaching.

IV. Reference books

(1) "Analytical Chemistry", by Dhruba Charan Dash, PHI Learning Pvt. Ltd., New Delhi, 2011.

(2) "Quantitative Analysis", by R.A.Day, A.L.Underwood, Prentice-Hall of India Pvt.Ltd., New Delhi, 2004. (Sixth edition)

(3) "Analytical Chemistry", by Gary D. Christian, John Wiely & Sons, INC, New York, 1994. (Fifth edition)

(4) "Analytical Chemistry An Introduction", by Douglas A. Skoog, Donald M. West, F.James Holler, Saunders College Publishing, Harcourt Brace College Publishers,

Philadelphia, 1994. 6th edn.

(5) "A Textbook of Analytical Chemistry",by Y.Anjaneyulu, K.Chandrasekhar, Valli Manickam, Pharma Book Syndicate, Hyderabad, India, 2006.

(6) "Instrumental Methods of analysis" by H. H . Willard, L. L. Mirrit, J.A. Dean, CBS Publications

(7) **"**Solvent extraction in Analytical Chemistry" by G.H. Morrison, F. Frieiser, John Wiley & Sons, NY.

(8) "Quantitative Chemical Analysis" by Daniel C. Harris, W H Freeman, New York.

(9) "Ion exchange and solvent extraction of metal compounds' by Y. Macros, A.S.Kertes, Wiley, Interscience.

Semester –IV
Paper: Organic and Analytical Chemistry (Practicals)
Course Code: CH 4503L
No. of Credits: 2.5
Sessions: Two X 3 hrs

II. Course Content

[A] Organic Spotting and Estimation

Organic spotting minimum eight compounds (5 solids and 3 liquids)

Acids: Salicylic acid, Cinnamic acid, Anthranilic acid, Sulfanilic acid

Phenols: m-Nitrophenol, p-Nitrophenol, α- Naphthol ,β-Naphthol

Bases: m and p – Nitroanilines, p-Toludine

Neutral : Solids:- Acetanilide, Glucose

Liquids:- Methanol Acetophenone, Carbon tetrachloride (CCl_4), Methylacetate

Estimations: (1) Glucose

(2)Acetamide

(3)Phenol/Aniline

[B] Volumetric and Gravimetric Analysis

Volumetric Analysis :

(a) Nitrite by back titration.

(b) Determination of the available cholrine in Hypochorates

(b) Estimation of Ni by using EDTA , $MgCl_2$ (Back Titration)

Gravimetric Analysis :

(a) Fe as Fe_2O_3

(b) Ba as $BaSO_4$

(c) Al as Al_2O_3

III. Teaching methodologies: Practical work, problem solving, and group discussion etc.

IV. Reference books:

(1) "Elementary Practical Organic Chemistry Part-II, Qualitative Organic Analysis", by I Vogel, CBS Publishers & Distributers, New Delhi, Second Edition, 2004.

(2) "Elementary Practical Organic Chemistry Part III Quantitative Organic Analysis", by I Vogel, CBS Publishers & Distributers, New Delhi, Second Edition, 2004.

(3) "Comprehensive Practical Organic Chemistry – Qualitative Analysis", by V.K. Ahluwalia, Sunita Dhingra, University Press (India) Private Limited, Hyderabad, First Indian Edition, 2010.

(4) "Organic Analytical Chemistry theory and Practice", by Mohan Jag, Narosa Publication, New Delhi, 2003.

(5) "Advanced Practical Organic Chemistry",by J Leonard, B Lygo, G Procter, Stanley Thornes (Publishers) Ltd., First Indian Edition, 2004.

(6) "Analytical Chemistry : Practice", by John H. Kennedy, Saunders College Publishing, New York, Second Edition, 1990.

(7) "Quantitative Analysis", by R.A.Day, A.L.Underwood, Prentice-Hall of India Pvt.Ltd., New Delhi, Sixth Edition, 2004.

(8) "Analytical Chemistry", by Gary D. Christian, John Wiely & Sons, INC, New York, Fifth Edition, 1994.