St. Xavier's College (Autonomous), Ahmedabad-9
BSc. Biochemistry
Semester I

CORE Paper: Fundamentals of Biochemistry
Course Code: BC 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 biochemistry.

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 eg. 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 Biochemistry 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 Biochemistry, 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 biochemistry 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: Chemistry of life: An introduction

What is biochemistry, development of biochemistry, What is biochemical approach, scope of biochemistry, applications of biochemistry, Biochemical literature (how to conduct a literature search and how to read a research article).

Water: Properties of water, Water a biological solvent, Proton mobility, fitness of the aqueous environment for living organisms, self-ionisation of water: Kw and pKw. Acid base reactions, pH, pOH, pKa, weak and strong acids, physiological importance of pH; Osmosis and Donnan membrane equilibrium.

Buffers: Buffers, buffer action, buffer capacity, Henderson – Hasselbalch equation, its limitations and uses, laboratory use of buffers, physiological importance of buffers in body fluids and tissues.

Measurement of pH: indicators, pH meter, different types of electrodes, advantages and disadvantages of different electrodes, principle, working, application, factors affecting pH determination

Chemical bonding (covalent, ionic, Hydrogen, Van der Waal's, hydrophobic).

Unit 2: Carbohydrates

Introduction, natural occurrence and physiological importance; Classification and structure of carbohydrates: aldose and ketoses, Mono, oligo and polysaccharides, Structure of monosaccharide.

Configuration in sugars, reference carbohydrate, Fischer's projection formula and representation of various sugars, Haworth's representation of cyclic structure. Furanose and pyranose structures and representation of various sugars, Mutarotation, Conformation in sugars: boat and chair forms.

Oligosaccharides – Occurrence, structure, chemical name, function and importance of maltose, sucrose, lactose, cellobiose, trehalose, raffinose.

Polysaccharides – Occurrence, structure, chemical name, functions and importance of starch, glycogen, cellulose, hemicellulose, dextrin, chitin, inulin, dextran, pectin, agar, alginic acid, mannans.

Carbohydrate derivatives of biological importance: Amino sugars, deoxysugars, sugar phosphates, blood group polysaccharides, cell wall polysaccharides, teichoic acids, muramic acids, sialic acid, mucopeptides.

Glycobiology: Glycosaminoglycans - Occurrence, structures and functions of hyaluronic acid, heparin, chondroitin sulphates (A, B and C), glycoproteins and proteoglycans, glycolipids.

Unit 3: Amino acids and Proteins

Introduction, structure and classification of: standard amino acids, introduction to rare amino acids, non-protein amino acids, essential vs Non-essential amino acids, Amino acids as ampholytes and its stereoisomerism.

Chemical reactions of amino acids: Sanger's reaction, Edman's reaction, Nitrous acid reaction, Siegfried's carbamino reaction, Dansyl chloride reaction, oxidative deamination by oxides and ninhydrin.

Proteins: Peptides – structure, formation and characteristics of peptide bond; Classification based on solubility, shape and composition; Functions of proteins; Properties – isoelectric pH , hydration, behaviour in solution, solubility, salting in and salting out, precipitation of proteins by acid reagents, heavy metals, heat, extreme pH changes, denaturation and renaturation of proteins. Structure of proteins – primary, secondary, super secondary, tertiary and quaternary structures; Determination of sequences of proteins; Biological functions of fibrous proteins, keratins, collagen, elastin, globular proteins – hemoglobin, myoglobin, glycoproteins, lipoproteins, nucleoproteins and metalloproteins.

Unit 4: Lipids

Lipids: Introduction, classification of lipids, fatty acids. **S**tructure, properties, functions and importance of saturated, unsaturated, hydroxyl, cyclic, branched chain fatty acids and PUFA;

Physical properties, isomerism, geometrical isomerism, positional isomers, melting point, boiling point, solubility and absorption spectra; Chemical properties: salt formation, detergent, esterification, hydrogenation, halogenations, oxidation, saponification; Chemical constants of fats: saponification value, iodine number, Reichert Meissl number, acetyl number, acid number. Rancidity of fats due to hydrolysis, oxidation and lipolysis, prevention of rancidity; Waxes – natural waxes, properties and importance.

Complex lipids and Sterols: Glycerophospholipids – classification, properties and functions of lecithin, lysolecithin, cephalins, plasmalogens, phosphatidyl serine, phosphatidyl inositol;

Sphingolipids: Classification, properties and functions of cerebrosides, gangliosides; Sulpholipids, gangliosides, proteolipids and prostaglandins;

Structure and properties of sterols; Colour reactions of cholesterol.

Practical Paper: Fundamentals of Biochemistry
Course Code: BC 1502L
No. of Credits: 03
Learning Hours: 60 hrs
Session: 2 hours

Note:

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

Basic Practicals

1. Introduction to Biochemistry Lab. Safety aspects in Biochemical Laboratory.
2. Calibration of instruments and pipettes.
3. Biochemical reagent preparations for various solutions with respect to different Normality, Molarity, % Solutions (W/V), (V/V).
4. Use of microscope and microscopic examination of osazones.
5. Preparation of distilled water.
6. pH measurements***** & numerical based on pH & buffer.
7. Preparation of buffer and its pH determination.

Titration Practicals

8. Use of potassium dichromate in the standardization of sodium thiosulphate
9. Estimation of sugar from biological fluid by Cole's method.
10. Water analysis for Hardness*****.

Qualitative analysis

11. Qualitative tests for carbohydrates.

****Note: These will be conducted as a mini project, wherein the students will be asked to check the pH and hardness of different water samples to conclude whether there is a correlation between the two measured parameters and also discuss the results obtained.***

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. 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 Judith
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.

Semester II
CORE Paper: Concepts in Cell Biology
Course Code: BC 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 eg. 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: Nucleic acids and Origin of Life

Introduction to nucleic acids, Composition of DNA and RNA. Nitrogenous bases: structure and properties of normal and rare. Sugars. Nomenclature for writing the structure of nucleic acids. Nucleosides and nucleotides: linkages, different types, naturally occurring, functions.
DNA: Important features of double helix structure.
RNA: Different types, structures, functions and differences and similarities with DNA.

Porphyrins: Introduction, nucleus, classifications, metalloporphyrins.
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. Biological evolution: prokaryotes to eukaryotes; Differences between plant and animal cells; Types of cells.

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
Plant cell wall

Unit 3: Cell Organelles

Detailed structure and functions of: Mitochondria and Chloroplast (Energy Conversions) and the Endosymbiont Theory, Endoplasmic reticulum: Rough and Smooth, Golgi Apparatus, Ribosomes, Lysosomes, Peroxisomes, Nucleus; Endomembrane network system and its importance.

Unit 4: Cell cycle and Cell Senescence

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

Practical Paper: Fundamentals of Biochemistry
Course Code: BC 2502L
No. of Credits: 03
Learning Hours: 60 hrs
Session: 2 hours

Note:

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

Experiments involving titrations

1. Estimation of amino acid by formal titration
2. Use of potassium permanganate in the estimation of Iron.
3. Use of potassium permanganate in the estimation of Oxalate.
4. Use of potassium permanganate in the estimation of Nitrite.
5. Estimation of Calcium from biological fluid. (Serum)

Experiments based on lipids.

6. Determination of Acid number of edible oil.
7. Determination of saponification number of edible oil.
8. Estimation of unsaturated fat by iodine value of oil.

Experiments involving Qualitative Analysis

9. Qualitative analysis by colour reactions of Amino Acids.
10. Qualitative analysis of proteins gelatin, egg albumin by colour reactions and their identification with the help of colour reactions.
    a. Precipitation/ denaturation test for proteins by
    b. Heat
    c. pH (conc. HCl, 5/10 N NaOH, Distilled water)
    d. Acids (TCA and Sulphosalicylic acid).
    e. Heavy metals (Lead, Copper, Zinc, Barium Salts)
11. Analysis of physical property of lipids: Solubility test.
12. Analysis of chemical properties of lipids: colour reactions of cholesterol.

Experiments involving Colorimetric Estimations

13. Use of single cell colorimeter, its construction and operation. (Demo).
14. Estimation of protein by Biuret method.
15. Estimation of DNA by DPA method.
16. Estimation of RNA by Orcinol method.
17. Estimation of Sugars by DNSA method*

18. Permanent slides of

A. Different stages of cell division

a) Prophase

b) Metaphase
c) Anaphase
d) Cytokinesis

B. Different cell types

a) Epithelium
b) Endothelium
c) Muscle cells
d) Nerve cell

Note: This will be conducted as a mini project, wherein the students will be asked to check the sugar content of juices, soft drinks etc. and assess whether the sugar content is in accordance to the amount written on their labels.

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. Videos from American Society of Cell Biology could also be shown to students to imbibe concepts.

IV. Recommended learning Resources

1. Molecular Cell Biology, 7th Edition. Lodish, et. al.
2. Biochemistry, 4th edition. Donald Voet and Voet Judith
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.
14. Practical Biochemistry - Satyanarayan

Semester- III
CORE Paper: Concepts in Microbiology
Course Code: BC 3501
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:

a) Understand the morphology of a prokaryotic cell and the fine structure of its organelles
a) Differentiate between eubacteria, archaebacteria, fungi, algae and viruses and comprehend their economic importance.
b) Appreciate that the discovery and advancement of microscopic techniques has led to revolutionizing the field of microbiology
c) Understand the basic growth requirements of bacteria *in vitro* in order to culture them.
d) 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.
e) Appreciate that good bacteria play a major role in industries especially food industries
f) Appreciate how microbes have been a tool to minimise use of chemicals, improvise waste water treatment and decreasing environmental pollution by biodegradation
g) 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 synthesis of various chemical components like acetic acid, enzymes, antibiotics, drugs etc.
b) 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.
c) Students can also go in for Medical Laboratory Technique Courses, opening opportunities in hospitals and pathological laboratories.
d) Basic knowledge of microbiology is required for Fermentation Technology which is a basic technology used in many Pharmaceutical and Biotech companies.
e) Explore the field of genetic engineering
f) 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- III
CORE Paper: Biophysical Chemistry
Course Code: BC 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 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 (6th Ed)
2. Daniel, C Harris: Quantitative Chemical Analysis
3. David Freifelder: Physical biochemistry (2nd Ed) WH Freeman, USA)
4. Donald Voet and Voet J: Biochemistry (4th 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
Practical Paper: Fundamentals of Biophysical techniques and Microbiology
Course Code: BC 3503L
No. of Credits: 3
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
8. Column chromatography
9. Off site visit to Industry

Basic techniques in Microbiology

10. Introduction to stains and staining procedures
11. Monochrome staining(Positive and negative)
12. Gram staining
13. Capsule staining
14. Metachromatic granules staining
15. Spore staining(optional)
16. Methylene blue reduction test
17. Antibiotic assay by agar cup method
18. Antibiotic assay by disc/ditch method
19. Identification of microorganisms and Fermentation tests for microorganisms
20. Study of growth characteristics of microorganisms*
21. Alcohol fermentation by yeast*

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
2. Thomas and Schalkhammer: Analytical Biochemistry, 2002
3. Varley H: Practical Clinical Biochemistry
4. Wharton and McCarty: Experimental methods in Biochemistry
5. Willard and Merrit: Instrumental methods of analysis.
6. Seeley HW and Van Denmark PJ: Microbes in Action
7. Wistreich GA and Lechman MD: Laboratory Exercise in Microbiology

Semester IV
CORE Paper: Molecular Physiology
Course Code: BC 4501
No. of Credits: 04
Learning Hours: 60 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to understand the molecular mechanisms of physiological functions of the body.
By the end of the paper, a student should be able to:

a) Understand that physiological functions of cells are aided and regulated by signal molecules likes hormones, owing to its specificity and transduction mechanisms, which in turn become a target for treatment of various ailments
b) Understand the molecular mechanisms involved in blood clotting, production of erythrocytes, leucocytes and thrombocytes. This also gives an insight into molecular mechanisms that could be induced to enhance production of cells *in vitro*.
c) Understand the underlying mechanisms involved in movement of different muscle types to facilitate specific functions.
d) Appreciate the importance of secretions and absorption in the body to aid digestion, circulation and excretions. The mechanisms involved will also enable comprehend what happens when there is any defect in any of the steps.
e) Appreciate experiments carried out by scientists to enable understand the basic concepts involved in signalling, transport, regulation and movement.

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

a) An ability to carry out basic research in understanding various physiological actions in cells.
b) Work in research institutions, hospitals which are involved in finding molecular targets to treat diseases.
c) Opportunities to work in companies that are into discovery of drugs that target cells at the molecular level for therapeutics
d) Work as skilled technicians in pathological laboratories, blood banks and hospitals.

II. Course Content

Unit 1: Hormone signaling mechanisms

Classification of hormones, Characteristics of hormones; Hormone receptors;

Mode of action of hormones: cAMP, calcium, IP_3, DAG, receptor kinases, cGMP, NO and gene activation; Regulation by feedback mechanisms e.g. Thyroid hormones, TSH and TRH;

Synthesis and regulation of Insulin, glucagon, thyroid hormone, estrogen, and growth hormone.

Unit 2: Circulatory and Respiratory System

Hematopoeisis: Erythropoesis, Thrombocyte formation and leucopoesis.

Hemostasis: Vasoconstrictions, Platelet plug formation, Clot – Clotting factors; intrinsic and extrinsic pathways for blood clotting. Clot retraction.

Role of surface tension in inhalation; (Theory of surface tension and its measurement); Role of hemoglobin in oxygen transport, dissociation curve of oxyhemoglobin and its significance. Bohr's effect, transport of oxygen and carbon dioxide, chloride shift.

Various buffer systems of the blood, acid base balance, factors affecting acid-base balance. Acidosis and alkalosis, Role of lung and kidney in regulation of acid base balance.

Unit 3: Muscle movement in body systems

Excitation and contraction of muscles – molecular organization of muscle, proteins of contractile element; their organization and role in contraction; Energy for contraction .

Theories of contraction; Hormonal regulation.

Cardiac physiology- circulation, electrophysiology of heart. Measurement of blood pressure, hypo and hypertension.

Regulation of striated and smooth muscle movement in the GI tract for propulsion and mixing.

Unit 4: Secretions and Absorption

Salivary secretions and its regulation, gastric secretions and its regulation, pancreatic secretions and its regulation; Biliary secretions and its regulation; Secretions of the small intestine and its regulation; Absorption processes in the small intestine and large intestine; Transport of nutrients after absorption; Examples of disorders due to anomalies in regulation.

Functions of glomerular membrane and glomerular filtration rate (GFR), selective reabsorption and secretion, active passive transport of various substances (sugars, amino acids, urea and creatinine), mechanism of urine formation; Role of hormones in regulation.

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. Best and Taylor: Physiological basis of Medical practice

2. Bhagavan NV: Medical Biochemistry (4th ed), Jones and Bartlett Publishers
3. Charterjee: Human Physiology Vol. 1 and 2.
4. Chatterjee and Shinde: Text book of Medical Biochemistry
5. Das AK: Human Physiology
6. Ganong WF: Review of Medical Physiology (12th ed). Lange Medical Publishers
7. Guyton AG and Hall JE: Text book of Medical Physiology (11th ed) Harcourt Asia.
8. Murray RK, Granner DK, Mayes PA and Rodwell, VW: Harper's Biochemistry (25th ed) 2000, Prentice Hall publishers.
9. Sherwood: Human Physiology (5th ed) 2004
10. Talwar PC: Text book of Biochemistry and Human Physiology
11. Tortora G and Grabowski SR: Principles of Anatomy and Physiology (10th ed) 2003. John Wiley and sons.

Semester- IV
CORE Paper: Nutrition
Course Code: BC 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 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

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.

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

Proteins: Source of dietary proteins, nitrogen balance; Quality of proteins: complete, incomplete proteins, supplementary values, Indices: BV, NPU, PER, PDCASS, digestibility, NDpV.

Unit 3: Minerals and Trace Elements

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

Dietary sources; Absorption, 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.

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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.

Practical Paper: Nutrition and Heamatology
Course Code: BC 4503L
No. of Credits: 3
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.*

Nutrition

1. Estimation of Iron by KSCN method
2. Estimation of Magnesium
3. Estimation of Calcium
4. Estimation of Vitamin C*
5. Measurement of obesity indices*
6. Interpretation of Lipid Profile Indices*
7. Tests for Food adulteration*

Urine Analysis

8. Physical parameters of Urine
9. Normal chemical constituents of Urine
10. Detecting abnormal and pathological constituents of Urine

Basic hematology

11. Red blood cell count
12. White blood cell count
13. Differential counting
14. Estimation of Hb by Sahli's method
15. Determination of ESR
16. Determination of PCV

17. Determination of bleeding time, clotting time and blood group

Note: These will be conducted as a mini project, wherein the students will be asked to, i) determine the Vitamin C content from different food sources; ii) Comment on the obesity indices of subjects of different age groups and correlate the same with lifestyle and diet; iii)Analyze the lipid profile of various subjects; iv) Food adulterations as mini projects

References

1. Oser: Hawk's Physiological Chemistry (14th ed)
2. Plummer: An introduction to practical Biochemistry
3. Sheela Sharma: Experiments and Techniques, 2007.
4. Thomas and Schalkhammer: Analytical Biochemistry, 2002
5. Varlery H: Practical Clinical Biochemistry
6. Whatton and McCarty: Experimental methods in Biochemistry

Semester V
CORE Paper: Metabolism-I
Course Code: BC 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 how metabolism is regulated by enzymes and hormones
d) Understand anabolic and catabolic pathways of carbohydrates
e) Understand catabolic pathways of proteins and nucleic acids and comprehend how any defect in a pathway could lead to diseases.
f) 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 biochemistry
b) Discover drugs related to metabolic disorders
c) Basic technical knowledge required in pathological laboratories
d) Work in industries related to diagnostics
e) Carry out basic research in understanding aspects of metabolism that are still not clear

II. Course Content

Unit 1: Introduction to Metabolism

Introduction to Metabolism, Terms, Overall view of Metabolism, general features of metabolism, Chemical basis of high standard energy of hydrolysis of ATP, other phosphorylated compounds and thioesters, NAD and NADH, common regulatory mechanisms in metabolic pathways, genetic control of enzyme synthesis, regulation of the activity of enzymes, Hormones and regulatory cascades, difference between anabolic and catabolic pathways, Experimental Approach to Metabolism.

Unit 2: Metabolism of Carbohydrates

Glycolysis, energetics, regulation of glycolysis, fates of pyruvate, Feeder pathways, Glycogen degradation, Glycogen synthesis, Regulation of glycogen metabolism, difference between glycogenolysis and glycogenesis, glycogen storage diseases, Gluconeogenesis, reciprocal regulation of Glycolysis & Gluconeogenesis, difference between Glycolysis & Gluconeogenesis, Cori cycle, Alternate pathways, PPP and regulation and significance.

Unit 3: Metabolism of Proteins

Over view of the fate of carbon skeletons of amino acids, Gamma-Glutamyl cycle, Transamination, oxidative deamination, Non-oxidative, glucose alanine shuttle decarboxylation, Urea cycle , its regulation, energetics, and significance; Uric acid formation, Creatine metabolism, Disorders of amino acids metabolism, cell surface glycoproteins and membrane skeleton proteins

Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

Unit 4: Metabolism of Nucleic acids

Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism, Disorders of purine and pyrimidine metabolism: Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

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 (7th ed), (2012).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)
9. Dee Unglaub Silverthron: Human Physiology an integrated approach (5th ed), Pearson – Benjamin Cummngs (2010).

CORE Paper: Molecular Biology-I
Course Code: BC 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 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.

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

CORE Paper: Enzymology
Course Code: BC 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 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 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

History, general characteristics, nomenclature, IUB enzyme classification, significance of numbering system. Definitions with examples; holoenzyme, apoenzyme, cofactors, coenzymes, activators, inhibitors.

Units of enzyme activity, Definition of IU, Katal, enzyme turn over number abd specific activity.

Metallo-enzymes, isoenzymes, monomeric and oligomeric enzymes and multi-enzyme complexes.

Unit 2: Enzyme catalysis

Role of cofactors in enzyme catalysis: NAD/NADP, FMN/FAD, coenzyme A, biotin, cobamine, TPP, pyridoxal phosphate, terahydoxy folate.

Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase and lysozyme.

Enzyme specificity and active-site.

Unit 3: Enzyme Purification

Need for purification and general outline of purification scheme, Purification table, methods for protein determination, purification methods with respect to source, principle, isolation and extraction method, efficiency with examples and advantages or disadvantages during use. Methods to check enzyme purity such as ultracentrifugation, electrophoresis & solubility.

Methodology, sampling & continuous methods with examples, advantages, disadvantages of: (a) Spectrophotometric method (b) Spectrofluorometric method (c) Electrochemical methods (d) Polarimetric method, and (e) Manometric method; Handling of enzymes, Enzyme assays.

Unit 4: Enzyme Kinetics

Factors affecting enzyme activity: enzyme concentration, substrate concentration, pH and temperature.

Derivation of Michaelis-Menten equation for uni-substrate reactions. Km and its significance. Line Weaver-Burk plot, Eadie - Hoofstie Plot and Hanes plot. Bi-susbtare reactions - brief introduction to sequential and ping-pong mechanism with examples.

Kinetics of zero and first order reactions; Significance and evaluation of energy of activation and free energy.

Reversible and irreversible inhibition, competitive, non-competitive and un-competitive inhibition, determination of Km and Vmax in presence and absence of inhibitors. Allosteric enzymes – regulation and kinetics.

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. M. Dixon, E. C. Webb, C.J.R Thorne and K.F. Tipton (1979) *Enzymes.* 3rd Edition, Longmans, Green & Co., London, and Academic Press, New York.
2. Price NC and Stevens L: Fundamentals of Enzymology, (1999) 3rd Edition, Oxford University Press, USA
3. Foster R L: The nature of enzymology, Wiley (1980)
4. Palmer T: Understanding Enzymes (1995), 4th Edition, Ellis Horwood Ltd
5. Palmer T: Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, Horwood Series (2001)
6. Conn and Stumpf: Outlines of Biochemistry (2009), 5th Edition, John Wiley and Sons
7. Nelson DL and Cox MM: Lehninger's Principles of Biochemistry (2014), 6th Edition, W. H. Freeman

CORE Paper: Applied Biochemistry
Course Code: BC 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 applications of metabolic reactions, enzymes and fermentation

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

a) Understand how understanding of biochemistry of various processes enable applying to diagnostics, analysis and therapy,
b) Understand how enzymes are used at an industrial level;
c) Understand how simple fermentation processes yield economically important products
d) Understand upstream and downstream processing
e) Study various products obtained by fermentation
f) Appreciate experiments carried out by scientists to enable practical applications of theory

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

a) Give a basic understanding of clinical aspects of biochemistry and its use in diagnosis
b) Discover drugs related to metabolic disorders
c) Start small scale industries using microbes and enzymes
d) Work in industries related to fermentation

II. Course Content

Unit 1: Clinical Biochemistry

Biochemical tests in clinical medicine: uses; criteria for selecting a method for biochemical analysis; enzymes as diagnostic tool; isoenzymes and their diagnostic importance; methods for the detection of isoenzymes; organ function tests: clinical presentation and diagnosis of the diseases of liver and kidney; bilirubin metabolism and hyperbilirubinaemia; acid base disorders. Use of glucose oxidase in enzyme electrodes.

Tumour markers, Bone markers, Cardiac markers, liver markers.

Unit 2: Industrial application of enzymes

Immobilization of enzymes and their applications; Production of glucose from starch, cellulose and dextran; Use of lactase in dairy industry; Production of glucose-fructose syrup from sucrose; Use of proteases in food, detergent and leather industry.

Unit 3: Fermentation Technology

Introduction to fermentation; Types of fermentation: Biomass, Microbial enzymes, metabolites, recombinant products and transformation processes; Media for industrial fermentation- carbon source, nitrogen source, micronutrients, oxygen requirement; Sterilization- types and methods; inoculum development; downstream processing-harvesting cells, product recovery-extracellular and intracellular.:

Unit 4: Fermentation in Industry

Products of microbial origin: citric acid, glutamic acid, lysine, alcohol, protease, lipase, pectinase, xanthan.
Products of algal origin: Carragenan, asthaxanthin, anti coagulants, anti HIV compounds.
Microorganisms as source of nutrition, energy and fuel.

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. Stanbury P., Whitaker and Hall. Principles of Fermentation Technology. Second Edition
2. Palmer T: Understanding Enzymes. Horwood Publishers. 2001
3. Muray-Moo Young. Comprehensive Biotechnology. Elsevier. 2004

Subject Elective Paper: Research methodology and Biostatistics.
Course Code: BC 5401
No. of Credits: 02
Learning Hours: 30 hrs

I. Course Overview & Course Objectives

The main objective of the course will be to build the basic foundation for doing research and to give general overview of the field of intellectual properties. It explains the importance of planning and development in research, designing and implementation of methodology to maintain quality of research.
It explains the concepts and rational behind data analysis. Students will be introduced to basic statistical methods to help prove hypotheses and validate data.

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

a) Develop most appropriate research strategy.
b) Know and use different methods and strategy for research.
c) Know basics of Statistics,
d) Analyse and interpret experimental results

.

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

a) The students can carry out quality research in Biochemistry, which in turn can be of great help to the society.
b) The students are able to carry out significant research.
c) The students could pursue a career in Biostatistics

II. Course Content

Unit 1: Research methodology : an introduction

Meaning of research, objectives of research, types of research, research approaches, significance of research, research methods versus methodology, research process and criteria of good research.

Defiling research problem, selecting the problem, necessity of defining the problem, technique involved in defining a problem.

Unit 2: Research Designs, interpretation and report writing

Research designs: Meaning of research designs, need for research designs, features of good designs, Important concepts of good designs, differential research designs, and basic principles of experimental designs.

Interpretation and report writing: Meaning and need to interpret, techniques of interpretation, precaution in interpretation. Significance of report writing, Layout and types of report, precautions for writing reports.

Unit 3: 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

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 4: 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

References:

1. Fundamentals of Biostatistics , 2006 – Bernard A Rosner
2. Fundamentals of Biostatistics, Khan and Khanum
3. Methods in Biostatistics, 2010, B.K. Mahajan
4. Fundamentals of Biostatistics, 2009 , V.B. Rastogi

Practical Paper: Clinical Biochemistry, Molecular Biology , Enzymology
Course Code: BC 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.*

Clinical Experiments

1. Estimation of blood glucose by Arsenomolybdate.
2. Estimation of blood urea.
3. Estimation of serum uric acid.
4. Estimation of serum creatinine.
5. Estimation of glucosamine
6. Estimation of serum phosphorus

Enzyme practicals

7. Assay of salivary amylase.
8. Effect of pH on enzyme activity
9. Effect of enzyme concentration on enzyme activity
10. Effect of substrate concentration on enzyme activity
11. Effect of a competitive inhibitor on enzyme activity
12. Extraction and partial purification of an enzyme (amylase/peroxidase)

Liver Function Tests

13. Assay of serum transaminases – SGOT

14. Assay of Serum transaminases - SGPT.
15. Estimation of Alkaline Phosphatase

Molecular biology practicals

16. Verification of Chargaff's rule by paper/ thin layer chromatography
17. Ultraviolet absorption spectrum of DNA and RNA
18. Determination of DNA concentration by UV absorption method
19. Determination of melting temperature and GC content

Fermentation Experiments

20. Estimation and recovery of citric acid.

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. Varley H: Practical Clinical Biochemistry, 1980, Heinemann, London
6. Thimmaiah S R: Standard Methods of Biochemical Analysis, 1999, Klayani Publishers

Semester VI
CORE Paper: Metabolism-II
Course Code: BC 6501
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 breakdown and synthesis of fatty acids and its regulation,
b) Link the various pathways and cycles that contribute to synthesis of ATP, which in turn would be used up for various synthetic pathways, thereby establishing ATP cycle.
c) Understand and compare the roles of mitochondria and chloroplast in ATP synthesis.

d) Understand metabolism in different conditions, in different tissues, and how intermediates connect several metabolic pathways, thus, relating a single pathway to various metabolic disorders
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 biochemistry
b) Discover drugs related to metabolic disorders
c) Basic technical knowledge required in pathological laboratories
d) Work in industries related to diagnostics
e) Carry out basic research in understanding aspects of metabolism that are still not clear

II. Course Content

Unit 1: Metabolism of Lipids

Introduction, Lipoprotein metabolism, mobilization of fat, β-Oxidation of saturated, unsaturated and odd chain fatty acids, energetic 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

Biosynthesis of membrane lipids**:** TG & PL synthesis, Sphingolipids and glycolipids synthesis, lipid storage diseases, role of liver and adipose tissue in lipid metabolism.

Unit 2: Energy Metabolism linked to Electron Transport System

PDH Complex, TCA Cycle, Energetics, Regulation, Anapleurotic & Amphibolic reactions, Glyoxalate Cycle

Mitochondria, Glycerol Phosphate And Malate- Aspartate Shuttle, ETC, Inhibitors of ETC various hypotheses for ATP Production, Oxidative Phosphorylation, Binding Change Hypothesis, P/O Ratio, Regulation of oxidative phosphorylation, Uncouplers & Inhibitors, mitochondrially mediated diseases.

Unit 3: Photosynthesis

Structure of Chloroplast, light absorption, , photosynthetic pigments, light harvesting systems of plants and microbes, , molecular architecture of Photosystem I and Photosystem II, Z-scheme of photosynthetic electron flow, General features of photophosphorylation, Photo inhibition. Evolution of oxygenic photosynthesis. Calvin-Benson cycle, regulation of Calvin cycle, photorespiration, C4 and CAM pathways.

Unit 4: Integration of metabolism

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), Role of Hormones (Glucagon, Epinephrine, Insulin) in Fuel Metabolism, tissue specific metabolism (brain, muscle, and liver), Metabolic adaptations in well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis, Metabolic homeostasis during exercise, cardio vascular response.

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 (7th ed), (2012).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 (5th ed), (2013) 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 D E: Biochemistry (2nd ed) (2003), Elsevier
9. Dee Unglaub Silverthron: Human Physiology an integrated approach (5th ed), Pearson – Benjamin Cummings (2010).

Semester VI
CORE Paper: Molecular Biology-II
Course Code: BC 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 molecular biology and its techniques.
By the end of the paper, a student should be able to:

a) Understand complex mechanisms like homologous recombination and transposition and look at the importance of these in the cells.
b) Understand the basic tools required in recombinant DNA technology
c) Know the various techniques in molecular biology and their applications
d) Explore the use of recombinant DNA technology in betterment of the society
e) 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 1: Basic techniques of Molecular Biology

Separation of DNA and RNA molecules according to size using electrophoresis and centrifugation; Purification of genomic DNA from various sources: Bacteria, plant cells and animal cells; Quantification and assessment of purity of DNA using UV spectrophotometer; Purification of plasmid; Purification of phage DNA: Lambda and M13.

Unit 2: Homologous Recombination and Transposition

Introduction to homologous recombination, Models for Homologous Recombination: The Holliday Model, The Double – Strand Break Repair Model; Homologous Recombination protein machines; Site specific recombination

Introduction to Transposition; Classes of Transposable elements (DNA Transposons, Retrotransposons) and their mechanisms (Cut and Paste Mechanism, Copy and Paste Mechanism); Maize elements in Barbara McLintoc's studies;

Unit 3: Basic tools used in recombinant DNA Technology

Basic concepts of gene cloning; The range of manipulative enzymes; Cutting and ligation of DNA; Introduction to Vectors; Types of Vectors (M13, lambda phage, pBR322 and pUC 8), and its use in cloning; Host organisms used in cloning; Introduction of vectors into host organisms by transformation using physical and chemical methods; Different methods of horizontal gene transfer: Transformation, Conjugation and Transduction.

Unit 4: Specialized Techniques used in Molecular Biology

Construction of genomic library and cDNA library; Identification of clones in DNA library using the concept of hybridization; Chemical synthesis of oligonucleotides; Polymerase Chain Reaction and its types; Blotting Techniques: Southern, Northern, and Western; DNA Sequencing methods: DNA sequencing: Sanger's method of chain termination and Maxam Gilbert's method of chemical degradation; DNA Fingerprinting and its application.

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
9. TA Brown. Gene Cloning and DNA Analysis (6^{th} Edition), Wiley- Blackwell

Semester VI
CORE Paper: Immunology
Course Code: BC 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 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, Innate, Acquired, organs and cells of Immune system

Introduction, organs of immune system (primary and secondary), cells of immune system (B,T, Null cells, mononuclear cell, granulocytes, mast cells, dendritic cells). Innate immunity (anatomic barriers, physiological barriers, endocytic and phagocytic barriers, barriers created by the inflammatory response), Acquired immunity, connections between innate and adaptive immunity, cell adhesion molecules, chemokines, leukocyte extravasation, localized and systemic response, self versus non – self.

Unit 2: Ag, Ab, Ag-Ab interaction and experiments, Hybridoma technology

Immunological properties of antigen, factors that influence immunogenicity, Haptens, B and T cell epitopes, antigenicity, mitogens.

Structure and functions of antibody, antigenic determinants on Ig, Isotypes of Ig, Ig super family. Ag-Ab interactions, affinity, avidity, precipitations reactions, agglutination reactions, RIA, ELISA, Western Blotting, Immuno fluorescence, Hybridoma technology and its uses, engineered mAbs.

Unit 3: MHC, Ag processing & presentation, T & B cell response, Complement system

Structure and functions of Class I and II MHC, role of APC, Ag processing (endocytic and cytosolic pathways), Ag presentation

Activation, maturation and differentiation of T cell receptors, Humoral response, Activation, maturation and differentiation of B cells

Complement components, classical and alternate pathways, MAC and its regulation, consequences of complement activation, complement deficiencies.

Unit 4: Immune response: Tolerance, hypersensitivity, cytokines and Vaccines

Regulation of immune responsiveness, tolerance, hypersensitivity reactions (Type I, II, III, IV), Properties of cytokines, receptors of cytokines, role in inflammatory response, active and passive immunization (whole organism vaccines, purified macromoleucles as vaccines, recombinant antigen and vector as vaccines, synthetic peptide, anti-idiotype vaccines).

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. 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 Klein, Blackwell Scientific
5. Immunology: Ivan Roitt, (10^{th} ed), Blackwell Scientific Press, 2010.

Semester VI
CORE Paper: Genetics
Course Code: BC 6504
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 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; 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; 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 3: 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; Pedigree analysis; Introduction to the concept of Epigenetics; Evolutionary genetics

Unit 4: Principles of development

Introduction to development biology: Anatomical approaches to understand development of an organism like comparative embryology, evolutionary embryology, medical embryology, and mathematical models of developmental biology.

Life cycles and development patterns: The Evolution of Developmental Patterns in Unicellular protists. Multicellularity: The Evolution of Differentiation, Developmental Patterns among the metazoan.

Genes and development: The Embryological Origins of the Gene Theory, Evidence for Genomic Equivalence, Differential Gene Expression, Determining the Function of Genes during Development, Identifying the Genes for Human Developmental Anomalies.

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.

III. 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)

Semester VI
Subject Elective Paper: Model Organisms
Course Code: BC 6401
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 having a model organism to study the basic metabolic and molecular pathways, to understand responses of systems to external stimuli or environment, to enable research oriented towards understanding basics as well as looking at applications etc. The features and characteristics that are needed to make use of an organism for various studies are of prime importance. In future, many more such model organisms could be developed to unravel the mysteries of life.

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

a) Highlight basic characteristics required in a model organism.
b) Design experiments using these model organisms.
c) Appreciate the concepts that have become clear because of research carried out using these model organisms

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

a) Defining a problem and explore using model organisms to seek for a solution, thus looking at research as a career option
b) Enable use of these model organisms to develop products for the market, by beginning a start up company

II. Course Content

Unit 1: Bacteriophage and *E.coli*

Bacteriophages: Basic features, types and its life cycle, Assays of phage growth, Phage Crosses and Complementation Tests, Use as vectors; Advantages and disadvantages.
Bacteria: Basic features, growth and basic requirements, *E.* coli: the most commonly used bacteria, Whole genome sequencing and transcriptional profiling, cytological analysis, biochemical analysis studies, BACs; Advantages and disadvantages.

Unit 2: Yeast and *Arabidopsis thaliana*

Yeast: unicellular eukaryote, basic features, variations in size and multiplication, small characterized genome, use in rDNA technology, plasmids and YACs, its feasibility for studying mutations; Advantages and disadvantages.

Arabidopsis thaliana: Basic characteristics and growth pattern; Attributes of Arabidopsis as a model genetic system; DNA transformation studies; developmental analysis by using fluorescent markers; Advantages and disadvantages

Unit 3: *C. elegans and Drosophila*

C. elegans: Basic characteristics and rapid life cycle, Well studied lineages, Drug toxicity studies and cognitive functions; Discovery of cell death pathway and RNAi; Advantages and disadvantages.

Drosophila: Basic characteristics and rapid life cycle, first genome maps, genetic mosaics, ease of creating mutants, ease of creating transgenic fruitflies; Advantages and disadvantages.

Unit 4: *Mus musculus* and zebrafish

Mus musculus: Life cycle and basic characteristics; embryonic development dependence on stem cells; creating transgenic mice; knockout mice; homologous recombination studies; epigenetic inheritance; Advantages and disadvantages.

Zebrafish: Life cycle and basic features; developmental studies due to its regenerative properties; mutations in genes; study of human diseases especially tuberculosis; Imaging studies using fluorescence; Advantages and disadvantages.

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.

III. Recommended learning Resources

1. Genetics (2012) 6th ed., Sinustad, 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. Watson, J.D - Molecular Biology of the Gene (5^{th} Ed)
5. Lodish: Molecular Cell Biology (5^{th} Edition) 2004

Semester VI
Practical Paper: Biochemistry, Molecular Biology, Immunology and Genetics
Course Code: BC 6505L
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.*

Biochemistry Experiments

1. Estimation of A/G ratio and its significance
2. Protein estimation by Bradford Assay
3. Estimation of Bilirubin
4. Estimation of Serum iron
5. Estimation of serum magnesium
6. Lipid Profile analysis (Case studies)
7. Isolation of cholesterol from egg yolk and its estimation.
8. Isolation of lecithin, identification by TLC, and its estimation.
9. Isolation of chloroplasts from spinach
10. Estimation of chlorophyll
11. Estimation of photosynthetic activity.
12. Estimation of nitrate reductase

Molecular biology practicals

13. Diauxic growth curve effect (Regulation of gene expression)
14. Isolation of DNA from WBCs and comment on purity
15. Effect of inhibitors on protein synthesis

Immunological Tests

16. Ouchterlony Double Radial Immunodiffusion
17. Mancini Single Radial Immunodiffusion.
18. Demonstration of Enzyme linked immunosorbent assay
19. Antibody structure and binding: computer based study

Genetics practicals

20. Study of abnormal human karyotype (Dry Lab)
21. Pedigree analysis (Dry Lab)
22. Population genetics studies (Case study: Blood groups in population)

23. e – PCR: computational study

References

1. Oser: Hawk's Physiological Chemistry (14^{th} ed)
2. Plummer: An introduction to Practical Biochemistry
3. Sheela Sharma: Experiments and Techniques, 2007.
4. Thomas and Schalkhammer: Analytical Biochemistry, 2002
5. Varley H: Practical Clinical Biochemistry