

UGC

**UGC  
MODEL  
CURRICULUM**

**BIOCHEMISTRY**



**UNIVERSITY GRANTS COMMISSION**  
NEW DELHI

**2001**

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## FOREWORD

Renewing and updating of the Curriculum is the essential ingredient of any vibrant university academic system. There ought to be a dynamic Curriculum with necessary additions and changes introduced in it from time to time by the respective university with a prime objective to maintain updated Curriculum and also providing therein inputs to take care of fast paced development in the knowledge of the subject concerned. Revising the Curriculum should be a continuous process to provide an updated education to the students at large.

Leaving a few, there have been many universities where this exercise has not been done for years together and it is not uncommon to find universities maintaining, practicing and teaching still on the Curriculum as old as few years or even more than a decade. Not going through the reasons for this inertia, the University Grants Commission, realising the need in this context and in relevance to its mandate of coordinating and maintaining standard of higher education, decided to adopt a pro-active role to facilitate this change and to ensure that the university Curriculum are soon updated to provide a standard education all over the country.

Curriculum Development Committee for each subject was constituted with the respective Convenor as its nodal person. The Committee besides having five subject experts drawn from the university system, was given a wider representation of various sub subject experts attending meetings of the Committee as the esteemed co-opted members which kept on changing from time to time as the need arose. The Committees, therefore, had representations from a large number of experts and had many meetings before final updated Model Curricula were presented to UGC.

The University Grants Commission and I as its Chairman are grateful to the nodal persons, a large number of permanent and co-opted members in different subjects and their sub disciplines for having worked seriously with committed devotion to have produced a UGC Model Curriculum in 32 subjects within a record period of 18 months.

The exercise would not have been possible without the support of our entire academic community. We can only hope that the results will fulfil their expectations and also those of university community and Indian society.

The UGC Model Curriculum has been produced to take care of the lacuna, defects/ shortcomings in the existing Curricula in certain universities, to develop a new Model Curriculum aiming to produce the one which is compatible in tune with recent development in the subject, to introduce innovative concepts, to provide a multi disciplinary profile and to allow a flexible cafeteria like approach including initiating new papers to cater to frontier development in the concerned subject.

The recommendations have been compiled by panels of experts drawn from across the country. They have attempted to combine the practical requirements of teaching in the Indian academic context with the need to observe high standards to provide knowledge in the frontier areas of their disciplines. It has also been aimed to combine the goals and parameters of global knowledge with pride in the Indian heritage and Indian contribution in this context.

Today all knowledge is interdisciplinary. This has been duly considered. Flexible and interactive models have been presented for the universities to extend them further as they would like. Each institution may have to work out certain uniform structures for courses at the same level, so that effective interaction between subjects and faculties is possible. The tendency across the country is now to move from the annual to the semester system, and from award of marks to award of credits. There is perceptible growing interest in modular framing as well.

The recommendations while taking all these features into account, have also made provisions for institutions who may not be in a position to undertake radical structural reform immediately. In any country, especially one as large and varied as India, academic institutions must be allowed enough autonomy and freedom of action to frame courses according to specific needs. The recommendations of the Curriculum Development Committees are meant to reinforce this. The purpose of our exercise has been to provide a broad common framework for exchange, mobility and free dialogue across the entire Indian academic community. These recommendations are made in a spirit of openness and continuous improvement.

To meet the need and requirement of the society and in order to enhance the quality and standards of education, updating and restructuring of the curriculum must continue as a perpetual process. Accordingly, the University Grants Commission constituted the Curriculum Development Committees. If you need to seek any clarification, you may contact Dr. (Mrs.) Renu Batra, UGC Deputy Secretary and Coordinator of CDC who shall accordingly respond to you after due consultation with the respective nodal person of the concerned subject.

The University Grants Commission feels immense pleasure in forwarding this Model Curriculum to the Hon'ble Registrars of all Universities with a request to get its copies made to be forwarded also to the concerned Deans and Heads of Departments requesting them to initiate an early action to get their Curriculum updated. The University Grants Commission Model Curricula is being presented to the Registrar of the university with **options** either to adopt it in toto or adopt it after making necessary amendments or to adopt it after necessary deletion/addition or to adopt it after making any change whatsoever which the university may consider right. This UGC Model Curriculum has been provided to the universities only to serve as a base and to facilitate the whole exercise of updating the Curriculum soon.

May I request Hon'ble Vice Chancellor and the Hon'ble Registrar including the esteemed Deans, Heads of Departments, Members of the Faculty, Board of Studies and Academic Council of the Universities to kindly update their Curriculum in each of the 32 subjects in consultation with Model Curriculum provided here. This has to be done and must be done soon. May I request the Academic administration of the universities to kindly process it immediately so that an updated Curriculum is adopted by the university latest by July, 2002.

The University Grants Commission requests the Hon'ble Registrars to confirm that this time bound exercise has been done and send a copy of the university's updated Curriculum in each subject to UGC by July 31, 2002. It is a must. It has to be done timely, failing which, the UGC may be forced to take an appropriate unpleasant action against the concerned university.

The UGC looks forward for your active participation in this joint venture to improve the standards to achieve excellence in higher education.



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December 2001

## CONTENTS

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<b>PREFACE</b>	(i)
<b>UNDERGRADUATE PROGRAMME</b>	1
<b>B.Sc. &amp; B.Sc. (Hons.) BIOCHEMISTRY</b>	5
<b>Ist Year</b>	
PAPER I (BCH 101): Biomolecules	6
PAPER II (BCH 102): Biophysical and Biochemical Techniques	8
Laboratory I (BCH 105): (Practicals) for Ist Year	10
<b>IInd Year</b>	
PAPER III (BCH 201): Enzymology	11
PAPER IV (BCH 202): Intermediary Metabolism	13
LABORATORY II (BCH 205): (Practicals) for IInd Year	14
<b>IIIrd Year</b>	
PAPER V (BCH 301): Molecular Biology	15
PAPER VI (BCH 302): Nutritional, Clinical & Environmental Biochemistry	17
LABORATORY III (BCH 305): (Practicals) for IIIrd Year	19
<b>SPECIAL PAPER for B.Sc. (Hons.)</b>	
PAPER VII (BCH 311): Immunology	20
PAPER VIII (BCH 312): Microbiology and Virology	21
PAPER IX (BCH 313): Cell Biology and Membrane Biochemistry	22
PAPER X (BCH 314): Human Physiology	23
<b>M.Sc. BIOCHEMISTRY</b>	24
<b>SEMESTER-I</b>	
PAPER 1 (BCH 501): Organic and Biophysical Chemistry	27
PAPER 2 (BCH 502): Cell Biology and Physiology	29
PAPER 3 (BCH 503): Bioenergetics and Intermediary Metabolism	30
PAPER 4 (BCH 504): Plant Biochemistry	32
PAPER 5 (BCH 505): Laboratory Course-I	33
<b>SEMESTER-II</b>	
PAPER I (BCH 506): Advanced Enzymology	34
PAPER 2 (BCH 507): Advanced Molecular Biology	35
PAPER 3 (BCH 508): Technical Writing, Computers and Bioinformatics	36
PAPER 4 (BCH 509): Immunology	40
PAPER 5 (BCH 510): Laboratory Course-II	42

(ii)

UGC Model Curriculum

## SEMESTER-III

PAPER 1 (BCH 511): Methods in Molecular Biology	43
PAPER 2 (BCH 512): Nutritional Biochemistry	44
PAPER 3 (BCH 513): Research Methodology and Biostatistics	45
PAPER 4 (BCH 515): Laboratory Course–III	45
PAPER 5 (BCH 514): Thesis/Project Work (Seminar)	45

## SEMESTER-IV

**Options (Any Two Courses)**

Biochemical & Environmental Toxicology (BCH 516)	46
Muscle Biochemistry and Biomembranes (BCH 517)	47
Microbial Biochemistry (BCH 518)	48
Clinical Biochemistry (BCH 519)	49
Neurobiochemistry (BCH 520)	51
Genetics for Biologists (BCH 521)	54

## PREFACE

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The syllabi of Biochemistry followed in different universities have wide variations. Although some of the universities have revised their syllabi keeping in view the future needs whereas the syllabus of Biochemistry followed in other Universities needs revision and updating. Dr. Hari Gautam, Chairman, University Grants Commission, took a bold initiative to develop the course curriculum in all the subjects so that there could be both horizontal and vertical mobility amongst the students to meet the future challenges in the era of fast growing Science and Technology. The CDC in Biochemistry was given the mandate to formulate the syllabus both at undergraduate and postgraduate level in view of the significant progress made in molecular biology during the last three decades. Hence, there is a need to make drastic changes in the teaching programme at the undergraduate and postgraduate level. Since new tools and techniques have come up which can be effectively be used to strengthen both the teaching and practical programmes, it has become imperative that the training imparted to the students should be in line with the changing scenario.

In early fifties, Biochemistry gave birth to the molecular structure of nuclear acid and for these efforts James Watts and Francis Crick won the noble prize. The DNA sequences have revolutionized the information about the living systems. Now techniques are available for polymerase chain reaction, DNA sequencing and gene cloning. In addition to the molecular biology techniques, spread of the information technology has revolutionized the quantum of information available. Its exploitation/use for teaching and research in the universities is very crucial. Keeping in view the wide diversity of colleges and universities in the country, having wide range of infrastructure and facilities, it becomes essential that good quality basic biochemistry education be given to all the students so that they can find employment after their basic degrees. In addition, there should be scope for vertical and horizontal mobility in the education system so that the students can enter different modules to update their knowledge depending upon the employment opportunities in each area.

University Grants Commission has taken up the task of updating/framing the curriculum in different subjects by constituting the respective Curriculum Development Committees.

Keeping in view the mandate given, the committee of the following experts was constituted to formulate the syllabus of B.Sc, B.Sc. (Hons.) and M.Sc. in Biochemistry:

1. Prof. A.P.S. Mann, Head, Deptt. of Biochemistry, PAU, Ludhiana (Nodal person).
2. Prof. G.K. Khullar, Head, Deptt. of Biochemistry, Postgraduate Institute of Medical Research, Chandigarh.



(iv)

UGC Model Curriculum

3. Prof. R.K. Jethi, Prof. of Biochemistry, Panjab University, Chandigarh.
4. Prof. N.B. Patil, Head, Deptt. of Biochemistry, Shivaji University, Kohlapur.
5. Prof. R. Salvam, Head, Deptt. of Biochemistry, Dr. A.L.M. PG Institute of Basic Medical Sciences, University of Madras, Taramani, Chennai.
6. Prof. A.K. Tyagi, Delhi University, Delhi.
7. Dr. Debi. P. Sarkar, Delhi University, Delhi.
8. Dr. (Mrs) Renu Batra, Deputy Secretary, UGC, New Delhi

(Prof. A.K. Tyagi and Dr. Debi. P. Sarkar were members of the Committee but, could not attend the meeting)

The committee held a series of meetings from time to time to formulate the course curriculum in Biochemistry both at the Undergraduate and Postgraduate levels. The Committee also recommends that:

1. The course content of three years B.Sc. programme should have Biochemistry as one of the subject. In addition to this, the students can take the following: Chemistry, Botany, Zoology, Mathematics, Applied Physics and Computer Science. Two special papers can be taken by the students out of the various options for the Honours degree in Biochemistry, keeping in view the local needs and employment opportunities.
2. The M.Sc. programme of two years should be divided into four semesters with the project report or dissertation in the second year. This will help the students to undergo practical training and develop reasoning to critically evaluate the results obtained from the projects. The optional courses can be decided by the universities or institutions depending upon the facilities available in the area and expertise of the faculty. The committee further suggested that each University may be allowed to change 20% of the syllabus at the B.Sc. & M.Sc. levels keeping in view of the local requirements and funds available.
3. However, the colleges and universities who want to start B.Sc and M.Sc. programme should have minimum infrastructure as per UGC norms so that teaching & practical programme is conducted according to the general guidelines. This will help to maintain the standard of education in Biochemistry in the country as well as allow mobility of the students to the other part of the country.

The committee is highly thankful to Dr. (Mrs.) Renu Batra, Deputy Secretary, UGC, who helped in coordinating the meeting and also interacting actively during the deliberations with constructive suggestions.

APS MANN

## UNDERGRADUATE PROGRAMME

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As all the biological sciences converge to molecular aspects of living organism, hence basic knowledge of Biochemistry is absolutely essential for students of life sciences like Botany, Zoology, Genetics and Biotechnology both at Undergraduate and Postgraduate levels. It is thus imperative that Biochemistry subject should be taught as a subject at under-graduate level both in Colleges and in Universities.

The students joining the Biochemistry stream should also be acquainted with Biology, Chemistry, Physics and Fundamental Mathematics. By the time, they have finished their **undergraduate courses in Biochemistry**, they should have the following:

1. Knowledge and understanding of the fundamentals of Chemistry and Biology.
2. Understanding of the key principles of Biochemistry and Molecular Biology.
3. Ability to critically evaluate a problem.
4. Awareness of the major issues at the forefront in Biochemistry discipline.
5. Good quantitative skills, for example, the ability to prepare standard reagents and have reproducibility in the experiments.
6. Ability to work safely and effectively in laboratory.
7. Awareness of the resources and how to effectively use them.
8. Ability to think in an integrate manner and look at problems from different perspectives so as to develop need based inter-disciplinary approach.

## MASTER'S PROGRAMME

The students joining the Master's Programme should have studied the following subjects at undergraduate level:

1. Biochemistry;
2. Chemistry;
3. Botany/Zoology;
4. Genetics

The students should also have the basic knowledge of Physics and applied Mathematics. The students coming from other streams should take up the deficiency courses in Basic Biochemistry, Chemistry and Genetics in order to develop a sound base for take off in the field of Biochemistry and Molecular Biology at the postgraduate level. The course contents of Master's programme should be such as to enable the students to have the understanding of the following:

1. Fundamentals of molecular structures and functions.
2. Intermolecular interactions – approaches to study them.

3. Concept of Biocatalysis.
4. Enzymes – structure, functions, mechanisms of action & regulation.
5. Basic Bio-regulatory mechanisms.
6. Basic mechanisms of cell division and macro molecular diversity and organization.
7. Cell types, their structure and functions.
8. Basics of tissue development, differentiation and genetic diseases.
9. Molecular evolution, fundamentals of cellular and molecular immunology.
10. Biochemical and Biophysical Techniques employed in isolation purification and characterization of biomolecules.
11. Ability to design experiments and to understand the limitations of a given experimental approach and research methodology.
12. Ability to assess the primary research paper critically.
13. Biostatistics and fundamentals of molecular modelling with computer.
14. Techniques for cloning and polymerase chain reaction.

The ultimate aim of comprehensive syllabi, is to enable the students to develop an integrated approach for understanding the various life sciences problems at the molecular level. The subjects such as Immunology, Biophysics & Biotechnology all fall under the interdisciplinary umbrella. Hence the postgraduate students should be well prepared to take on the future challenges of research by adopting need based interdisciplinary approach. Breakthroughs of the 21<sup>st</sup> century will undoubtedly come from understanding the molecular basis of various life processes.

The students need to see and appreciate the significance of having an integrative approach right from the very beginning. They should be constantly reminded of fundamentals of physical sciences and their applications to Life Sciences. In future, the students need to have the fundamentals constantly reinforced. To this end, the revolution in Informational Technology will greatly help the students.

## **PRACTICAL CLASSES**

Various practical courses have been so designed to not only enable the students to appreciate scientific basis of various life processes but also to train them for self-employment. Specifically students would be required to know the following:

- To develop a logic based analytical approach.
- Use of various Biochemical & Biophysical techniques.
- Quantitative & Qualitative analysis of various biomolecules and physiological significance of the results obtained.
- Functional tests of vital body organs & their physiological significance.
- Use of various techniques employed in the diagnosis of diseases.
- Ability to interpret the data.

## **ACADEMIC PROGRAMME TO BE FOLLOWED AT B.Sc. UNDERGRADUATE AND HONS. DEGREE LEVEL**

- It is proposed that B.Sc. degree should be for 3 years and each lecture at the undergraduate level should be of 60 minutes duration.

The details of the course to be taught for B.Sc. are as under:-

- It is proposed that there should be a common teaching program in the first 2 years of the B.Sc. degree. In the III year, there will be 2 additional papers for the students who want to obtain their degree in biochemistry with honors.
- The syllabus for the chemistry should be as per the syllabus proposed by CDC for chemistry.
- Special need has been felt that the students of biology must have basic understanding of mathematics, physics and computer science. Therefore, these 3 subjects have been proposed to be taught during I and II year of the degree programme.
- The syllabus of applied mathematics (Statistics) and computer science is being enclosed. However, Universities/Departments may consult the CDC Reports of Physics, Statistics & Mathematics.
- The University can have 20% variation in course contents by adding/deleting or substituting various topics depending upon the local requirements.

## STRUCTURE OF B.Sc. PROGRAMME WITH SPECIALIZATION IN BIOCHEMISTRY

### Study Classes Per Week

(One practical class will be equivalent to two lecture periods)

B.Sc. I	Language	3 (theory)
	Mathematics	3 (theory)
	Chemistry	6 (theory)
		6 (practical)
	Biochemistry	6 (theory)
		6 (practical)
B.Sc. II	Botany/Zoology	6 (theory)
		6 (practical)
	Physics for Biologists	3 (theory)
	Computer Science	3 (theory & practical)
	Chemistry	6 (theory)
		6 (practical)
B.Sc. III	Biochemistry	6 (theory)
		6 (practical)
	Applied Genetics	3 (theory)
	Environmental Sciences	3 (theory)
	Chemistry	6 (theory)
		6 (practical)
B.Sc. III	Biochemistry	6 (theory)
		6 (practical)
	Botany/Zoology	6 (theory)
		6 (practical)
	Applied Genetics	3 (theory)
	Environmental Sciences	3 (theory)
Chemistry	6 (theory)	
	6 (practical)	
Biochemistry	6 (theory)	
	6 (practical)	
Botany/Zoology	6 (theory)	
	6 (practical)	

## **B.Sc. & B.Sc. (Hons.) BIOCHEMISTRY**

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### **SYLLABUS**

#### **Structure of B.Sc. Programme with Specialisation in Biochemistry**

##### **Ist Year**

BCH 101	Biomolecules
BCH 102	Biophysical & Biochemical Techniques
BCH 105	Laboratory I

##### **IInd Year**

BCH 201	Enzymology
BCH 202	Intermediary Metabolism
BCH-205	Laboratory II

##### **IIIrd Year**

BCH 301	Molecular Biology
BCH 302	Nutritional, Clinical & Environmental Biochemistry
BCH 305	Laboratory III

##### **Honours in Biochemistry (any two of the following)**

BCH 311	Environmental Biochemistry & Immunology
BCH 312	Microbiology & Virology
BCH 313	Cell Biology & Membrane Biochemistry
BCH 314	Human Physiology

**PROPOSED SYLLABUS FOR B.Sc. IN BIOCHEMISTRY  
AT COLLEGE LEVEL: PAPER-I TO PAPER-VI  
SPECIAL PAPER VII-X (SELECT ANY TWO FOR HONOURS)**

**PAPER-I (BCH 101)  
BIOMOLECULES**

**Introduction**

Introduction to Biochemistry, water as a biological solvent, weak acids and bases, pH, buffers, Henderson-Hasselbalch equation, physiological buffers, fitness of the aqueous environment for living organisms.

**i) Carbohydrates**

Structure of monosaccharides. Stereoisomerism and optical isomerism of sugars. Reactions of aldehyde and ketone groups. Ring structure and anomeric forms, mutarotation. Reactions of sugar due to hydroxyl groups. Important derivatives of monosaccharides, disaccharides and trisaccharides (structure, occurrence and functions of important ones). Structure, occurrence and biological importance of monosaccharides, oligosaccharides and polysaccharides e.g. Cellulose, chitin, agar, algenic acids, pectins, proteoglycans, sialic acids, blood group polysaccharides, glycogen and starch. Bacterial cell wall polysaccharides etc. Glycoproteins.

**ii) Lipids**

Definition and classification. Fatty acids: introduction, classification, nomenclature, structure and properties of saturated and unsaturated fatty acids. Essential fatty acids, prostaglandins. Triacylglycerols: nomenclature, physical properties, chemical properties and characterization of fats - hydrolysis, saponification value, rancidity of fats, Reichert-Meissel number and reaction of glycerol. Biological significance of fats. Glycerophospholipids (lecithins, lysolecithins, cephalins, phosphatidyl serine, phosphatidyl inositol, plasmalogens), sphingomyelins, glycolipids – cerebrosides, gangliosides. Properties and functions of phospholipids, isoprenoids and sterols.

**iii) Proteins**

Introduction, classification based on solubility, shape, composition and functions. Amino acids: common structural features, stereo-isomerism and RS system of designating optical isomers, classification and structures of standard amino acids as zwitterion in aqueous solutions, physical and chemical properties, titration of amino acids, separation of amino acids. Essential amino acids.

Peptides: structure of peptide bond, chemical synthesis of polypeptides - protection and deprotection of N-terminal, and C-terminal ends and functional groups in the side-chains, formation of peptide bonds, condensing agents, strategy of chemical synthesis, Merrifield solid-phase peptide synthesis. Determination of the amino acid sequence of a polypeptide chain, specific chemical and enzymatic cleavage of a polypeptide chains and separation of peptides. Protein structure: levels of structure in protein architecture, primary structure of proteins, secondary structure of proteins – helix and pleated sheets, tertiary structure of proteins, forces stabilizing the tertiary structure and quaternary structure of proteins. Denaturation and renaturation of proteins. Behaviour of proteins in solutions, salting in and salting out of proteins. Structure and biological functions of fibrous proteins (keratins, collagen and elastin), globular proteins (hemoglobin, myoglobin), lipoproteins, metalloproteins, glycoproteins and nucleoproteins

#### ***iv) Nucleic acids***

Nature of genetic material; evidence that DNA is the genetic material, Composition of RNA and DNA, generalized structural plan of nucleic acids, nomenclature used in writing structure of nucleic acids, features of DNA double helix. Denaturation and annealing of DNA, structure and roles of different types of RNA. Size of DNA in procaryotic and eucaryotic cells, central dogma of molecular biology, Gene, genome, chromosome.

#### ***v) Porphyrins***

Porphyryns: Porphyryn nucleus and classification of porphyryns. Important Metalloporphyryns occurring in nature. Detection of porphyryns spectrophotometrically and by fluorescence. Bile pigments – chemical nature and their physiological significance.



PAPER-II (BCH 102)  
**BIOPHYSICAL AND BIOCHEMICAL TECHNIQUES**

**i) Concepts of Bioenergetics**

Principles of thermodynamics and their applications in biochemistry – introduction, thermodynamic system, thermodynamic state functions, first and second laws of thermodynamics, concept of free energy, standard free energy, determination of  $\Delta G$  for a reaction, relation between equilibrium constant and standard free energy change, biological standard state and standard free energy change in coupled reactions. Biological oxidation-reduction reactions – introduction, redox potentials, relation between standard reduction potentials and free energy change (derivations and numericals included). High-energy phosphate compounds – introduction, phosphate group transfers-free energy of hydrolysis of ATP and sugar phosphates along with reasons for high  $\Delta G$ .

**ii) Hydrodynamic Methods**

Sedimentation – sedimentation velocity, preparative and analytical ultracentrifugation techniques, determination of molecular weight by hydrodynamic methods (derivations excluded and numericals included).

**iii) Measurement of pH**

Principles of glass and reference electrodes, types of electrodes, complications of pH measurement (dependence of pH on ionic strength, electrode contamination and sodium error) and use of pH paper.

**iv) Radioisotopic Techniques**

Types of radioisotopes used in Biochemistry, units of radioactivity measurements, techniques used to measure radioactivity (gas ionization and liquid scintillation counting), nuclear emulsions used in biological studies (pre-mounted, liquid and stripping), isotopes commonly used in biochemical studies –  $^{32}\text{P}$ ,  $^{35}\text{S}$ ,  $^{14}\text{C}$  and  $^3\text{H}$ , Autoradiography. Biological hazards of radiation and safety measures in handling radioisotopes. Biological applications.

**v) Chromatography**

General principles and applications of:

1. Adsorption chromatography
2. Ion-exchange chromatography
3. Thin-layer chromatography
4. Molecular-sieve chromatography
5. Hydrophobic chromatography

6. Gas-liquid chromatography
7. HPLC
8. Affinity chromatography
9. Paper chromatography

#### **vi) Electrophoresis**

Basic principles of agarose electrophoresis, PAGE and SDS-PAGE, Two-dimensional electrophoresis, its importance. Isoelectrofocussing.

#### **vii) Spectroscopic Techniques**

Beer-Lambert law, light absorption and its transmittance, determination and application of extinction coefficient, application of visible and UV spectroscopic techniques (structure elucidation and numericals excluded). Principle and application of NMR, ESR, Mass spectroscopy. Fluorescent and emission spectroscopy.

#### **viii) Immunological Techniques**

Immunodiffusion, immunoelectrophoresis, radioimmunoassay, ELISA, immunofluorescence.

**PRACTICAL FOR 1st YEAR**  
**LABORATORY-I (BCH 105)**

1. Preparation of standard buffers and determination of pH of a solution.
2. Qualitative tests for :
  - a. Carbohydrates
  - b. Proteins and amino acids
  - c. Lipids
3. Determination of saponification value and iodine number of fats.
4. Estimation of ascorbic acid.
5. Titration curve for amino acids and determination of pK value.
6. Verification of Beer-Lambert's law.
7. Estimation of
  - i) Carbohydrate by anthrone method.
  - ii) Blood glucose by the methods (a) Folin-Wu, (b) Nelson-Somogyi
8. Estimation of amino acids by ninhydrin method.
9. Isolation and assay of glycogen from rat liver.
10.
  - i) Extraction of total lipids by Folch method
  - ii) Estimation of food adulterant.
11. Estimation of DNA and RNA.
12. Separation of sugars using paper chromatography.

**IInd YEAR**  
**PAPER-III (BCH 201)**  
**ENZYMOLOGY**

**i) Introduction**

History, general characteristics, nomenclature, IUB enzyme classification (rationale, overview and specific examples), significance of numbering system. Definitions with examples of holoenzyme, apoenzyme, coenzymes, cofactors, activators, inhibitors, active site (identification of groups excluded), metallo-enzymes, units of enzyme activity, specific enzymes, isoenzymes, monomeric enzymes, oligomeric enzymes and multi-enzyme complexes. Enzyme specificity.

Historical perspective, nature of non-enzymatic and enzymatic catalysis. Measurement and expression of enzyme activity-enzyme assays. Definition of IU, Katal, enzyme turn over number and specific activity. Role of non-protein organic molecules and inorganic ions-coenzyme, prosthetic groups. Role of vitamins as coenzymes precursors (general treatment).

**ii) Enzyme catalysis**

Role of cofactors in enzyme catalysis: NAD/NADP<sup>+</sup>, FMN/FAD, coenzyme A, biocytin, cobamide, lipoamide, TPP, pyridoxal phosphate, tetrahydrofolate and metal ions with special emphasis on coenzyme functions. Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase, ribonuclease and lysozyme.

**iii) Enzyme Purification**

Methods for isolation, purification and characterization of enzymes.

**iv) Enzyme Kinetics**

Factors affecting enzyme activity: enzyme concentration, substrate concentration, pH and temperature. Derivation of Michaelis-Menten equation for uni-substrate reactions.  $K_m$  and its significance. Line Weaver-Burk plot and its limitations. Importance of  $k_{cat}/K_m$ . Bi-substrate reactions-brief introduction to sequential and ping-pong mechanisms 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 uncompetitive inhibitions, determination of  $K_m$  &  $V_{max}$  in presence and absence of inhibitor. Allosteric enzymes.

**v) Industrial and Clinical Application of Enzymes**

Immobilization of enzymes and their industrial 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; medical application of enzymes; use of glucose oxidase in enzyme electrodes.

PAPER-IV (BCH 202)  
INTERMEDIARY METABOLISM

**i) Introduction to Metabolism**

General features of metabolism, experimental approaches to study metabolism: use of intact organism, bacterial mutants, tissue slices, stable and radioactive isotopes.

**ii) Carbohydrate Metabolism**

Reactions and energetics of glycolysis. Alcoholic and lactic acid fermentations. Entry of fructose, galactose, mannose etc. Reactions and energetics of TCA cycle. Gluconeogenesis, glycogenesis and glycogenolysis. Reactions and physiological significance of pentose phosphate pathway. Regulation of glycolysis and TCA cycle. Photosynthesis, a brief review.

**iii) Electron Transport Chain and Oxidative Phosphorylation**

Structure of mitochondria, sequence of electron carriers, sites of ATP production, inhibitors of electron transport chain. Hypothesis of mitochondrial oxidative phosphorylation (basic concepts). Inhibitors and uncouplers of oxidative phosphorylation. Transport of reducing potentials into mitochondria.

**iv) Lipid Metabolism**

Introduction, hydrolysis of triacylglycerols, transport of fatty acids into mitochondria,  $\beta$ -oxidation of saturated fatty acids, ATP yield from fatty acid oxidation. Biosynthesis of saturated and unsaturated fatty acids. Metabolism of ketone bodies, oxidation of unsaturated and odd chain fatty acids. Biosynthesis of triglycerides and important phospholipids, glycolipids, sphingolipids and cholesterol. Regulation of cholesterol metabolism.

**v) Amino acid Metabolism**

General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Urea cycle. Degradation and biosynthesis of amino acids. Glycogenic and ketogenic amino acids.

**vi) Nucleotide Metabolism**

Sources of the atoms in the purine and pyrimidine molecules. Biosynthesis and degradation of purines and pyrimidines. Regulation of purine and pyrimidine biosynthesis.

**vii) Porphyrin Metabolism**

Biosynthesis and degradation of porphyrins. Production of bile pigments.

**PRACTICAL for IIInd YEAR**  
**LABORATORY-II (BCH 205)**

1. Separation of Blood Plasma and Serum
  - a. Estimation of proteins from serum by biuret and Lowry methods.
  - b. Determination of albumin and A/G ratio in serum.
2. Estimation of bilirubin (conjugated and unconjugated) in serum.
3.
  - i) Estimation of total lipids in serum by vanillin method.
  - ii) Estimation of cholesterol in serum.
4. Estimation of lipoproteins in plasma.
5. Estimation of lactic acid in blood before and after exercise.
6. Estimation of blood urea nitrogen from plasma.
7. Separation and identification of amino acids by (a) paper chromatography and (b) thin-layer chromatography.
8. Separation of polar and non-polar lipids by thin-layer chromatography.
9. Estimation of SGPT and SGOT in serum.
10.
  - a. Assay of serum alkaline phosphatase activity.
  - b. Inhibition of alkaline phosphatase activity by EDTA.
  - c. Effect of substrate concentration on alkaline phosphatase activity and determination of its  $K_m$  value.
11.
  - a. Effect of temperature on enzyme activity and determination of activation energy.
  - b. Effect of pH on enzyme activity and determination of optimum pH.
  - c. Effect of enzyme concentration on enzyme activity.
12.
  - a. Preparation of starch from potato and its hydrolysis by salivary amylase.
  - b. Determination of achromatic point in salivary amylase.
  - c. Effect of sodium chloride on amylases.

**IIIrd YEAR**  
**PAPER-V (BCH 301)**  
**MOLECULAR BIOLOGY**

**i) Basic Concepts of Genetic Information**

- a. Nucleic acids as genetic information carriers, experimental evidence e.g. bacterial genetic transformation, Hershey-Chase Experiment, TMV reconstitution experiment.
- b. Central dogma of molecular genetics – current version, reverse transcription and retroviruses.
- c. Primary structure of nucleic acids and their properties, salient features of eukaryotic, prokaryotic and viral genomes; highly repetitive, moderately repetitive and unique DNA sequences.
- d. Basic concepts about the secondary structures of nucleic acids, 5' → 3' direction antiparallel strands, base composition, base equivalence, base pairing and base-stacking in DNA molecule.  $T_m$  and buoyant density and their relationship with G-C content in DNA.

**ii) Structural Levels of Nucleic Acids and Sequencing**

- a. Secondary and Tertiary structure of DNA: Watson and Crick model, A, B and Z types of DNA, major and minor grooves, chirality of DNA, tertiary structure of DNA.
- b. Structures and properties of RNA: Classes of RNA, secondary and tertiary structures.
- c. Nucleic acid hybridization : *Cot* value and satellite DNA.
- d. Sequencing : Restriction and modification system; sequencing of DNA and RNA.

**iii) DNA Replication**

DNA replication in prokaryotes-conservative, semiconservative and dispersive types, experimental evidence for semiconservative replication. DNA polymerases, other enzymes and protein factors involved in replication. Mechanism of replication. Inhibitors of DNA replication.

**iv) Transcription**

Transcription in prokaryotes. RNA polymerase, promoters, initiation, elongation and termination of RNA synthesis, inhibitors of transcription. Reverse transcriptase, post-transcriptional processing of RNA in eukaryotes.

**v) Translation and Regulation of Gene Expression**

- a. Genetic code: Basic features of genetic code, biological significance of degeneracy. Wobble hypothesis, gene within genes and overlapping genes.



- b. Mechanisms of translation: Ribosome structure, A and P sites, charged tRNA, f-met-tRNA, initiator codon, Shine-Dalgarno consensus sequence (AGGA), formation of 70S initiation complex, role of EF-Tu, EF-Ts, EF-G and GTP, non-sense codons and release factors, RF1 and RF2.
- c. Regulation of Gene Expression in prokaryotes: Enzyme induction and repression, operon concept, Lac operon, Trp operon.

#### **vi) Mutation and Repair**

- a. Mutation: Molecular basis of mutation, types of mutation, e.g. transition, transversion, frame shift, insertion, deletion, suppresser sensitive, germinal and somatic, backward and forward mutations, true reversion and suppression, dominant and recessive mutations, spontaneous and induced mutations – Lederberg's replica plating experiment.
- b. Mutagenicity testing: Correlation of mutagenicity and carcinogenicity: Ames testing, Random and site-directed mutagenesis.
- c. DNA Repair: UV repair systems in *E. coli*, significance of thymine in DNA.

#### **vii) Recombinant DNA Technology**

Restriction endonucleases, brief discussion of steps in DNA cloning. Applications of recombinant DNA technology.

## PAPER-VI (BCH 302)

**NUTRITIONAL, CLINICAL & ENVIRONMENTAL BIOCHEMISTRY****A. Nutritional Biochemistry**i) ***Nutrition and dietary habits***

- a. Introduction and definition of foods and nutrition. Factors determining food acceptance, physiological, energy, body building (growth and development). Regulation of body temperature. Physiology and nutrition of carbohydrates, fats, proteins and water. Vitamins A, D, E, K, Vit. B-complex and Vit. C and minerals like Ca, Fe and Iodine and their biological functions. Basic food groups: energy giving foods, body building foods and protective foods.
- b. Composition of balanced diet, recommended dietary allowances (RDA) for average Indian, Locally available foods, inexpensive quality foods and food stuffs rich in more than one nutrients. Balanced vegetarian and non-vegetarian diets, emphasis on nutritional adequacy.

ii) ***Nutritive and calorific value of foods***

- a. Basic concepts of energy expenditure, units of energy, measurement of energy expenditure by direct or indirect calorimetry, calculation of non-protein RQ with respect to carbohydrate and lipids. Determination of heat production of the diet. The basal metabolism and methods of measuring basal metabolic rate (BMR); energy requirements during growth, pregnancy, lactation and various physical activities. Calculation of energy expenditure of average man and woman.
- b. Specific dynamic action (SDA) of foods, nutritive value of various kinds of foods generally used by Indian population. Planning of dietary regimes for infants, during pregnancy and old age. Malnutrition, its implications and relationship with dietary habits and prevention of malnutrition specially protein – calorie malnutrition (Kwashiorkor and Marasmus) by improvement of diets. Human milk and its virtues, breast vs formulated milk feeding. Food preservation standards, food adulterations and precautions, government regulations on preservation and quality of food.

**B. Clinical Biochemistry**i) ***Basic concepts of clinical biochemistry***

- a. Definition and scope of clinical biochemistry in diagnosis, a brief review of units and abbreviations used in expressing concentrations and standard solutions. Quality control. Manual vs automation in clinical laboratory.
- b. Collection and preservation of biological fluids (blood, serum, plasma, urine and CSF). Chemical analysis of blood, urine and CSF. Normal values for important constituents (in SI units) in blood (plasma/serum), CSF and urine, clearance test for urea.

ii) **Clinical enzymology**

- a. Definition of functional and non-functional plasma enzymes. Isozymes and diagnostic tests. Enzyme pattern in health and diseases with special mention of plasma lipase, amylase, cholinesterase, alkaline and acid phosphatase, SGOT, SGPT, LDH and CPK.
- b. Functional tests of kidney, liver and gastric fluids.

iii) **Disease related to metabolism**

Hypo- and hyper-glycemia, glycogen storage diseases; lipid mal-absorption and steatorrhea, sphingolipidosis; role of lipoproteins. Inborn errors of amino acid metabolism – alkaptonuria, phenyl-ketonuria, albinism, gout and hyper-uricemia.

**C. Environmental Biochemistry**

i) **Air pollution**

Particulate matter, compounds of carbon, sulphur, nitrogen and their interactions, methods of their estimation, their effect on atmosphere.

ii) **Water pollution**

Types of water bodies and their general characteristics, major pollutants in domestic, agricultural and industrial wastes, methods of their estimation, effects of pollutants on plants and animals, treatment of domestic and industrial wastes, solid-wastes and their treatment.

**PRACTICAL for IIIrd YEAR**  
**LABORATORY-III (BCH 305)**

1. Estimation of DNA by diphenylamine method.
2. Effect of temperature on the viscosity of DNA using Ostwald's viscometer.
3. Extraction of RNA and its estimation by Orcinol method.
4. Estimation of hemoglobin by measuring total iron in blood.
5. Estimation of calcium and phosphorus in serum & urine.
6. Estimation of creatine and creatinine in urine.
7. Estimation of immunoglobulins by precipitation with saturated ammonium sulphate.
8. Denaturation of enzyme, studies on DNA.
9.
  - a. Separation of proteins by column chromatography.
  - b. Determination of proteins by dye binding assay.
10. Separation of proteins by SDS-polyacrylamide gel electrophoresis.

**SPECIAL PAPER FOR B.SC. (HONS.)****PAPER-VII (BCH 311)****IMMUNOLOGY****A. Immunology**

1. Concept of immunity, classification
2. Humoral and cellular immunity
3. Immunoglobulins
  - a. Structure and function
  - b. Types of antibodies
4. Antigens
  - a. Nature of antigens
  - b. Immunogens
  - c. Haptens
5. Formation of antibodies in the body:
  - a. cells involved in antibody formation
  - b. Differentiation of lymphocyte
  - c. Clonal selection theory
  - d. Cooperation of T-cell with B-cell
  - e. Secretion of antibody
  - f. Genetic basis of antibody diversity
6. Antigen-antibody reactions *in vivo* and *in vitro*
7. Components of complement, complement fixation reaction
8. Immunological tolerance and immunosuppression
9. Hypersensitivity and allergy
10. Histocompatible antigens – elementary knowledge
11. Autoimmune diseases
12. Monoclonal antibody-preparation and application in biology
13. Transplantation immunology.

PAPER-VIII (BCH 312)  
**MICROBIOLOGY AND VIROLOGY**

**A. Microbiology**

i) ***Classification of microorganisms***

Types of microorganisms, general characteristics of main groups of microorganisms, criteria used in the classification of bacteria.

ii) ***Morphology, nutrition and physiology of bacteria***

a. General organization of bacterial cells – Gram-positive and Gram-negative organisms; structure and function of different polymeric components in Gram-positive and Gram-negative organisms.

b. Physiology and growth of bacterial cells and use of selective media in bacterial cultivation.

iii) ***Metabolism and genetics of Microorganisms***

a. Microbial metabolism -Special features of bacterial metabolism, Glyoxalate cycle and its role in conversion of fats into carbohydrates (compare with plants). Role of microorganisms in food spoilage, fermentation, food-borne infections and sewage (domestic and industrial) disposal.

b. Microbial genetics and differentiation – Adaptation and mutation: types of mutation and induction of mutation; transformation, conjugation, sex types, transduction, transfection, protoplast fusion, genetic recombination, plasmids and transposons.

**B. Virology**

i) ***Morphology and replication of viruses***

Definition, virus structure, viral proteins, virus classification emphasizing importance of bacteriophage and virus as tool in modern biological research. Replication of RNA viruses negative strand (VSV), positive strand (polio), retroviruses (infection cycle), replication of DNA (Adenovirus or SV40).

ii) ***Virus-host infection***

Acute virus infections – influenza, persistent virus infection, Herpes/Hepatitis A & B and AIDS; transformation and Cancer – RNA & DNA tumor viruses; Vaccine in prevention of viral infections – smallpox, polio and AIDS.

PAPER-IX (BCH 313)  
CELL BIOLOGY AND MEMBRANE BIOCHEMISTRY

**A. Cell Biology**

i) ***Morphology of cell***

Cell size, shape, comparison of prokaryotic and eukaryotic cell structure, cell types including cellular specialization and differentiation, differences in plant and animal cells, Photosynthesis and Nitrogen metabolism.

ii) ***Structure and function of cell organelles***

Detailed description of eukaryotic cell structure, endoplasmic reticulum, nucleus, mitochondria, lysosomes, peroxisomes, Golgi apparatus, ribosomes and polysomes, cytoskeletal elements.

iii) ***Cell biology techniques***

Use of light microscopy, phase contrast microscopy, transmission and scanning electron microscopy, electron tunneling microscopy and freeze fracture technique in the study of cells and cell organelles.

iv) ***Cell division***

Cell cycle and Cell growth, Cell and tissue culture techniques, properties of cell in culture.

**B. Membrane Biochemistry**

i) ***Biological membranes***

Types and sub cellular location. Chemical composition of biomembranes, Gap and tight junctions. Model lipid membranes – preparation and properties. Similarities and differences between biomembranes and artificial phospholipid membranes. Physical and biochemical methods to study membrane structure and properties. Different models of cell membrane – a historical perspective. Functions of biomembranes with examples-energy transduction, signal recognition. Specialized forms of membranes-brush border, flagella and pancreatic activity.

ii) ***Membrane transport***

Nutrient transport across biomembranes. Simple diffusion and Fick's law. Porins facilitated diffusion. Porter molecules, Kinetics of facilitated transport. Symport, antiport and uniport. Red cell membrane-proteins. Anion porter and glucose porter. Active transport, Proton and Na<sup>+</sup>-K<sup>+</sup> pumps – examples and metabolic significance.

iii) ***Membrane receptors***

Structure and functions. Methods to study membrane receptors. Purification and characterization of adrenergic and cholinergic receptors.

iv) ***Bacterial and plant cell walls***

Structure, composition and biosynthesis. Inhibitors of cell wall synthesis.

## PAPER-X (BCH 314)

## HUMAN PHYSIOLOGY

**i) Cardiovascular and Lymphatic System**

Blood components and their functions, genesis of erythrocytes and leukocytes, granular and agranular leukocytes. Resistance of the body to infection: the macrophage system and inflammation, phagocytosis by neutrophils and macrophages. T and B lymphocytes: blood groups: the ABO system, the rhesus system, blood clotting factors, intrinsic and extrinsic pathways for blood clotting; composition and functions of lymph and lymphatic system; overall design of circulatory system; pulmonary and systemic circulation.

**ii) Respiratory System**

Components of respiratory system (nasal cavity, trachea, pharynx, larynx, lungs, bronchi, bronchioles and alveoli) and their functions; Diffusion of oxygen and CO<sub>2</sub>; transport of oxygen; role of hemoglobin, dissociation curve of oxyhemoglobin and its significance, Bohr's effect; transport of CO<sub>2</sub> and 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.

**iii) Excretory System**

Kidney: Structure and its organisation. Functions of glomerular membrane and glomerular filtration rate (GFR). Structural and functional characteristics of tubules, selective reabsorption and secretion, active and passive transport of various substances (sugars, amino acids, urea and creatinine); antiport capabilities and capacities of various tubule segments, role of aldosterone and antidiuretic hormones and mechanism of urine formation.

**iv) Digestive and Endocrine System**

- a. **Digestive system:** Structure and functions of different components, digestion and absorption of carbohydrates, lipid and proteins, role of various enzymes and hormones involved in these processes, mechanism of HCl formation in stomach, role of bile salts in lipid digestion and absorption. Role of  $\gamma$ -glutamyl cycle in amino acid absorption.
- b. **Endocrine system:** A brief outline of various endocrine glands and their physiological roles; storage and secretion of hormones; feed-back regulation of hormone secretion, hormone receptors and their activation, mechanism of extracellular and intracellular hormone action.

**v) Nervous System**

- a. **Nervous system:** Organization of the system, nerve cells, nerve fibers, nerve impulses and neurotransmission, synapses: chemical and electrical synapses, functional properties of nerve fiber, action potential, the reflex action and reflex arc.
- b. **Biochemistry of vision:** Basic structure of cones and rods, rhodopsin cycle and role of vitamin A.



## **M.Sc. BIOCHEMISTRY**

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### **SYLLABUS**

#### **Structure of M.sc. Degree Course for Biochemistry**

A two years M.Sc. programme is formulated for developing competent biochemists, who are confident enough to take up various jobs. The course is based on interdisciplinary nature of Biochemistry, Chemistry, Quantitative Biology, Genetics, Microbiology and Biophysics. The programme obliges students to read original publications and envisages significant inputs in laboratory work, communication skill, creativity, planning, execution and critical evaluation of the scientific data. The specializations introduced in the two years course of Biochemistry are; Enzymology, Molecular Biology, Immunochemistry, Neurochemistry, Biotechnology, Clinical Biochemistry, Nutritional Biochemistry, Environmental Biochemistry and Toxicology.

#### **Semester I**

- BCH 501 : Organic and Biophysical Chemistry
- BCH 502 : Cell Biology and Physiology
- BCH 503 : Bioenergetics and Intermediary Metabolism
- BCH 504 : Plant Biochemistry
- BCH 505 : Laboratory Course I

500 marks (100 marks for each paper)

#### **Semester II**

- BCH 506 : Advanced Enzymology
- BCH 507 : Advanced Molecular Biology
- BCH 508 : Technical Writing and Bioinformatics
- BCH 509 : Immunology
- BCH 510 : Laboratory Course II

500 marks (100 marks for each paper)

#### **Semester III**

- BCH 511 : Methods in Molecular Biology
- BCH 512 : Nutritional Biochemistry
- BCH 513 : Research Methodology & Statistics
- BCH-514 : Seminars
- BCH-515 : Laboratory Course III
- BCH 600 : Project work–dissertation (examination to be conducted at the end of IV semester)

450 (100 marks for each paper and 50 marks for seminar)

**Semester IV**

BCH 516 : Any two courses from the following (200 marks)

BCH	:	516	517	518
		519	520	521
		522	523	524

Project Work/Dissertation (continued from III Semester) (350 marks)

550 marks

GRANT TOTAL

2000 marks

4 periods of 60 minutes per paper x 4 papers = 16 hours/week

Laboratory Practicals = 15 hours/week

Seminars = 2 hours/week

Project work/Dissertation = 2 hours/week

TOTAL = 34 hours/week

It is also suggested that every student undertake two hours library work under the supervision of faculty members. It is envisaged that the research projects (dissertation) and specialization will inculcate aptitude for research and practical applications. The students will also have basic inputs on communications skills and computers knowledge (information technology) and learn the basics of scientific writing and presentation.

**Eligibility for Admission:** Graduates in Biochemistry, Chemistry, Microbiology and Life Sciences as principal subject or Biochemistry as subsidiary subject are eligible for admission to the Course.

Number of seats : 20-25 candidates be selected on merit cum Entrance examination basis.

Note : Each theory paper will be covered in 64 contact hour.

Course : A course means a semester course.

Credit : One clock hour theory lecture per week per semester is equivalent to one credit. A two hour practical/seminar/oral/tutorial per week is equivalent to one credit.

Semester : Each semester consists of 20 weeks of study;  
(16 weeks actual contact hours and 4 weeks examinations).

Semester I and Semester II – 15<sup>th</sup> June to 15<sup>th</sup> November

Semester II and Semester IV – 15<sup>th</sup> December to 15<sup>th</sup> May

Mid Semester Vacation – 16<sup>th</sup> November to 14<sup>th</sup> December

Summer Vacation – 16<sup>th</sup> May to 14<sup>th</sup> June

(A faculty member can avail of 2 weeks vacation during mid semester and 4 weeks vacation during summer vacation)

## PER WEEK WORK LOAD

Semester	Theory	Lab.	Library and Tutorial Work	Seminar	Dissertation Project Work	Total Workload per Week
I	4x4=16	15	3	–	–	= 34
II	4x4=16	15	3	–	–	= 34
III	3x4=12	15	5	2	–	= 34
IV	2x4=8	–	6	–	20	= 34

**SEMESTER I**  
**PAPER-1 (BCH 501)**  
**ORGANIC AND BIOPHYSICAL CHEMISTRY**

### **Organic Chemistry**

Electronic theory of valency, dipole moments. Electronic displacements in a molecule: Inductive effect, electronic effect, resonance. The hydrogen bond, hydrophobic interactions. Atomic and molecular orbitals. Shapes of biomolecules, hybridization and tetravalency of carbon.

**Isomerism:** Structural isomerism, Stereoisomerism, geometrical isomerism (E & Z nomenclature)

**Types of organic reactions:** Substitution, addition, elimination, rearrangement, condensation and polymerization.

**Free radicals in biological systems:** Oxygen as a free radical in the autooxidation of fats. Antioxidants (Free radical inhibitors in the cell such as vitamin A, vitamin E, vitamin C, Se etc.)

**Mechanism of substitution in the benzene ring:** o-, p- and m-directing groups. The concept of resonance with reference to benzene derivatives. Direct influence of substituents-electronic interpretation.

**Stereochemistry:** Optical isomerism, optical activity, meso-compounds, specific rotation, chirality, chiral center, enantiomers, diastereoisomers, D L, R S, threo erythro notations, conformation and configuration, dihedral angles, conformational analysis of ethane, n-butane, cyclohexane, mono- and di-substituted cyclohexane, monosaccharides, boat and chair forms, eclipsed, gauche and staggered conformations, axial and equatorial bonds. Anomers and mutarotation, glycoside, epimers, glucopyranose, fructopyranose, periodic acid oxidation of sugars.

**Heterocyclic systems occurring in living systems:** Numbering of the ring and properties of pyran, furan, thiazole, indole, pyridine, pyrimidine, quinone, purine and pteridine.

### **Biophysical Chemistry**

**Thermodynamics studies in chemistry and biochemistry:** Open, closed and isolated system; first law of thermodynamics, heat of formation and heat of reaction; second law of thermodynamics, molecular basis of entropy, Helmholtz and Gibbs free energy; third law of thermodynamics and calculation of entropy; application of the first and second law of thermodynamics in understanding energies in living cells, chemical potential, equilibrium constant.

Types of electrodes, standard electrode potential and its determination, its relationship with emf, electron transfer measures.

Phosphate group transfer potentials, coupled reactions.

**Water:** Physical properties and structure of water, hydrogen bonding, ionization of water, pH scale, acids-bases, Handerson-Hasselbalch equation, buffers, ionization behaviour of amino acids and proteins, titration curve, buffer solutions and their action.

**Radioisotope techniques:** Nature of radioactivity, properties of  $\alpha$ ,  $\beta$  and  $\gamma$ -rays, measurement of radioactivity, use of radioisotopes in research. *In vivo* and *in vitro* labelling techniques, double labelling, quenching, internal standard, channel ratio, external standard ratio, emulsion counting, radioactive decay, autoradiography.

**Viscosity:** Its measurement, viscosity of macromolecules, molecular weights of biomolecules. Sedimentation of macromolecules, centrifugation techniques and their applications, differential centrifugation, density gradient and ultracentrifugation techniques. Subcellular fractionation.

**Electrophoretic techniques:** Moving boundary and zonal electrophoresis, paper and gel electrophoresis, isoelectric focusing.

**Chromatography:** Paper, TLC, Adsorption, partition, ion-exchange, reverse phase, gel filtration, affinity, gas chromatography, HPLC (High Pressure Liquid Chromatography).

**Spectroscopy:** Basic concepts and applications of X-ray diffraction, NMR, ESR, UV, IR, fluorescence, Raman, mass spectroscopy in structure determination of organic and biomolecules, CD and ORD.

**Microscopy:** Light, electron (scanning and transmission), phase contrast, fluorescence microscopy, freeze-fracture techniques, specific staining of organelles or marker enzymes.

PAPER-2 (BCH 502)  
CELL BIOLOGY AND PHYSIOLOGY

### Cell Biology

**Cell classification:** Cell variability (size, shape, complexity, functions).

Structural organisation of prokaryotic and eukaryotic cells. The ultra structure of nucleus, mitochondria, endoplasmic reticulum, rough and smooth, Golgi apparatus, lysosomes and peroxisomes and their functions.

The cytoskeleton – microtubules and microfilaments.

Types of tissues, epithelium – types, epithelial apices – glycocalyx, microvilli. The basement membrane – structural features and characteristics. The extracellular matrix-collagen, elastin, fibrillin, fibronectin, laminin and proteoglycans.

Plant and animal cells: variation in structure and function.

**Viruses:** Structure and classification. Life cycle. Culture techniques to study cell division – cell division by mitosis and meiosis. Cell cycle.

Cell differentiation – organogenesis, morphological, functional and biochemical maturation of tissues.

Biochemistry of cancer – carcinogenesis, characteristics of cancer cell, agents promoting carcinogenesis.

### Physiology

**Blood:** Composition and functions of plasma, erythrocytes including Hb, leukocytes and thrombocytes plasma proteins in health and diseases.

Blood coagulation – mechanism and regulation. Fibrinolysis, transfers of blood gases – oxygen and carbon dioxide. Role of 2,3 DPG, Bohr effect and chloride shift.

Hydrogen ion homeostasis- Factors regulating blood pH – buffers, respiratory and renal regulation. Acid-base balance – metabolic and respiratory acidosis and alkalosis.

**Digestive system:** Composition, functions and regulation of saliva, Gastric, pancreatic, intestinal and bile secretions – digestion and absorption of carbohydrates, lipids, proteins, nucleic acids, minerals and vitamins.

**Excretory system:** Structure of nephron, formation of urine, glomerular filtration, tubular re-absorption of glucose, water and electrolytes – tubular secretion.

Regulation of water and electrolyte balance, role of kidneys and hormones in their maintenance.

**The endocrine glands:** secretion and function – reproduction, pregnancy and lactation.

Biochemistry of vision.

### PAPER-3 (BCH 503)

## BIOENERGETICS AND INTERMEDIARY METABOLISM

**Bioenergetics:** Energy transformation, Laws of thermodynamics, Biological oxidations, oxygenases, hydroxylases, dehydrogenases and energy transducing membranes. Gibbs energy, free energy changes and redox potentials, phosphate potential, ion electrochemical potentials, proton electrochemical potential, membrane potentials, photons energy interconversions. Chemotaxis and chemoreceptors chemo-osmotic theory, ion transport across energy transducing membranes. Influx and efflux mechanisms. Proton circuit and electrochemical gradient, the transport and distribution of actions, anions and ionophores. Uniport, antiport and symport mechanisms, shuttle systems.

The mitochondrial respiratory chain, order and organization of carriers, proton gradient, iron sulphur proteins, cytochromes and their characterization. The Q cycle and the stoichiometry of proton extrusion and uptake; P/O and H/P ratios. Reversed electron transfer, respiratory controls and oxidative phosphorylation, uncouplers and inhibitors of energy transfer. Fractionation and reconstitution of respiratory chain complexes.

ATP – synthetase complex. Microsomal electron transport, partial reduction of oxygen, superoxides.

**Intermediary metabolism:** Approaches for studying metabolism.

### **Carbohydrates:**

Glycolysis, citric acid cycle its function in energy generation and biosynthesis of energy rich bonds, pentose phosphate pathway and its regulation. Alternate pathways of carbohydrate metabolism.

Gluconeogenesis, interconversions of sugars.

Biosynthesis of glycogen, starch and oligosaccharides.

Regulation of blood glucose homeostasis.

Hormonal regulation of carbohydrate metabolism.

### **Lipids**

**Fatty acid biosynthesis:** Acetyl CoA carboxylase, Fatty acid synthase, desaturase and elongase. Fatty acid oxidation:  $\alpha$ ,  $\beta$ ,  $\omega$  oxidation and lipoxidation. Lipid Biosynthesis: Biosynthesis of triacylglycerols, phosphoglycerides and sphingolipids, Biosynthetic pathways for terpenes, steroids and prostaglandins. Ketone bodies: Formation and utilisation. Metabolism of Circulating lipids: chylomicrons, LDL, HDL and VLDL. Free fatty acids. Lipid levels in pathological conditions.

**Amino Acids**

Biosynthesis and degradation of amino acids and their regulation.

Specific aspects of amino acid metabolism.

Urea cycle and its regulation,

In-born errors of amino acid metabolism.

**Nucleic Acids**

Biosynthesis of purines and pyrimidines

Degradation of purines and pyrimidines

Regulation of purine and pyrimidine biosynthesis

Structure and regulation of ribonucleotide reductase

Biosynthesis of ribonucleotides, deoxyribonucleotides and polynucleotides

Inhibitors of nucleic acid biosynthesis



**PAPER-4 (BCH 504)**  
**PLANT BIOCHEMISTRY**

Structure and functions of plant cell (including cell wall, plasmodesmata, meristematic cells, vacuoles, secretory systems and root quiescent zone), Isolation of cell organelles, absorption, adsorption and transport of water and ions in plants. Evapotranspiration.

Photosynthesis – structure of organelles involved in photosynthesis in plants and bacteria. Proton gradients and electron transfer in chloroplasts of plants and in purple bacteria – differences from mitochondria. Light receptors – chlorophyll, light harvesting complexes, bacteriorhodopsin, rhodopsin as ion pump.

Photosystems I and II, their location, mechanism of quantum capture and energy transfer between photosystems – ferridoxin, plastocyanin, plastoquinone, carotenoids.

The Hill reaction, photophosphorylation and reduction of CO<sub>2</sub>.

C<sub>3</sub>, C<sub>4</sub> and CAM metabolism, light and dark reactions. Light activation of enzymes, regulation of photosynthesis. Photorespiration.

Biological nitrogen fixation and ammonia assimilation.

Nitrate and sulphate reduction and their incorporation into amino acids.

Translocation of inorganic and organic substances.

Special features of secondary plant metabolism, formation of phenolic acids, tannins, lignins, lignans, pigments, terpenes, terpenoids, plant phenolics, alkaloids and surface waxes - their biosynthesis and functions, cell wall components.

Plant hormones - Growth regulating substances and their mode of action. Molecular effects of auxin in regulation of cell extension and of gibberellic, abscisic acids and cytokinins in the regulation of seed dormancy, germination, growth and development, and embryogenesis.

Biochemistry of seed development and fruit ripening.

Defence system in plants.

Tissue culture and transgeneic plants.

**PAPER-5 (BCH 505)**  
**LABORATORY COURSE – I**

Chemical tests for bioconstituents.

Assay of enzymes like salivary amylases and alkaline phosphatases.

Biochemical estimation like cholesterol, sugars, free fatty acids, iodine value and saponification value in oils, Vitamin C in fruit juices, preparation of casein from milk and tests for proteins and amino acids.

Microscopic examination and chemical analyses of blood.

Electrophoretic separation of serum proteins.

Disc gel electrophoretic separation of isoenzymes.

Microscopic examination and chemical analyses of urine and stools.

Histobiology of blood, urine and stools.

Radio-immunoassay of hormones.

Bacterial and chemical analysis of domestic and industrial effluents.

**SEMESTER II**  
**PAPER-1 (BCH 506)**  
**ADVANCED ENZYMOLOGY**

- Review of unisubstrate enzyme kinetics and factors affecting the rates of enzyme catalyzed reactions. Michaelis pH functions and their significance.
- Classification of multisubstrate reactions with examples of each class. Kinetics of multisubstrate reactions. Derivation of the rate of expression for Ping Pong and ordered Bi Bi reaction mechanism. Use of initial velocity, inhibition and exchange studies to differentiate between multisubstrate reaction mechanisms.
- Concept of Convergent and Divergent evolution of enzymes.
- Methods of examining enzyme-substrate complexes.
- Flexibility and conformational mobility of enzymes.
- Methods for measuring kinetic and rate constants of enzymic reactions and their magnitudes.
- Enzymes Turnover and methods employed to measure Turnover of enzymes. Significance of enzymes Turnover.
- Protein – Ligand binding, including measurement, analysis of binding isotherms. Co-operativity phenomenon. Hill and Scatchard Plots.
- Allosteric enzymes, Sigmoidal kinetics and their physiological significance. Symmetric and sequential modes for action of allosteric enzymes and their significance.
- Immobilized enzymes and their industrial applications. Effect of partition on kinetics and performance with particular emphasis on changes in pH and hydrophobicity.
- Multienzyme system : Occurrence, isolation and their properties. Polygenic nature of multienzyme systems. Mechanism of action and regulation of pyruvate dehydrogenase and fatty acid synthetase complexes. Immobilized Multienzyme Systems and their applications.
- **Co-enzymes and cofactors:** Water soluble vitamins and their coenzymes. Metallo enzymes.
- Detailed Mechanisms of Catalysis of serine proteases. Ribonuclease, and Triose phosphate isomerases.
- **Enzyme regulation:** General mechanisms of enzyme regulation: Feed Back Inhibition and Feed forward stimulation; Enzyme repression, induction and degradation, control of enzymic activity by products and substrates; Reversible and irreversible covalent modifications of enzymes; Mono-cyclic and multi-cyclic cascade systems with specific examples.

**PAPER-2 (BCH 507)**  
**ADVANCED MOLECULAR BIOLOGY**

**Recombinant DNA Technology**

Methods of creating recombinant DNA molecule, splicing, properties of restriction endonucleases and their mode of action, selection/screening, construction of DNA library, genomic Vs cDNA library, chemical synthesis of gene, cloning vectors ( $\lambda$ -phage, plasmid, M-13 phage, cosmid) shuttle vectors, yeast and viral vectors, expression vectors, uses of cloned gene, subcloning, sequencing by Sanger's method, proteins production in bacteria, site directed mutagenesis, RFLP, PCR, DNA finger printing, antisense-RNA technology, chromosomal walking.

**Hybridoma Technology**

Monoclonal antibodies, mycelium cell fusion, selection of hybrids, hybridomas, protoplast fusion and HAT-medium, screening assays, purification and application of monoclonal antibodies.

**Plant and Animal Cell Culture**

Micropropagation, somatic cell culture, somaclonal variations, somatic cell hybridization, protoplast isolation, protoplast fusion, protoplast culture, genetic transformation, various methods of gene transfer (all vector and vectorless methods), production of transgenic plants and animals, production of secondary metabolites, primary and transferred cell culture, differentiated cells in culture, applications.

**Fermentation Technology**

Primary and secondary metabolites in biotechnology, continuous and batch type culture techniques, principle types of fermentors, general design of fermentor, fermentation processes- brewing, manufacture of penicillin, production of single cell proteins, production strategies for other antibiotics and other organic compounds.

PAPER-3 (BCH 508)  
**TECHNICAL WRITING, COMPUTERS AND BIOINFORMATICS**

**Technical Writing**

Preparation of scientific report. Thinking and planning, information, ideas, order of paragraph writing, proper use of nouns, pronouns and articles, tenses, spellings etc.

Presentation of a review. Objective, design of the experiment, parameters used, data obtained, interpretation, summary.

**Bioinformatics*****Computer basics***

- Course Introduction, MS windows basics, UNIX basics.
- PC X *Windows* (NCD PCXWARE).
- File management.
- E-Mail (PINE, EUDORA, NETSCAPE MAIL).
- File transfer (ftp, WSftp).

***Review of key molecular genetic internet sites & searching for similar sequences & multiple sequence alignment***

- Internet World Wide Web resources (a list and description is provided in SOME USEFUL SITES ON THE INTERNET).
- Similarity searching *BLAST/FASTA*.
- Retrieving and installing a program (*Tree Tool*).
- Multiple sequence alignment (*CLUSTAL W* and *bee*).

**The Virtual Library**

- Searching *MEDLINE* on the *PubMed* system from the National Center for Biotechnology Information.
- Searching the *Science Citation Index* and *Current Contents Connect* from the Institute for Scientific Information.
- Using bibliographic databases and tables of content services to stay current of the biomedical literature.
- Accessing full-text journals on the Internet and printing articles.
- Finding grant and funding resources on the Internet.

### ***Higher-order sequence analysis searching for simple repeat sequences restriction site analysis***

- *MAR inder*
- Identifying Repetitive Elements
- Identifying Transfactor Binding site candidates

### ***GCG sequence analysis or other comparable suite***

- Introduction to GCG: sequence analysis
- GCG Manual: <http://cmmg.biosci.wayne.edu/gcg/gcgmanual.html>
- *SeqLab*: the X Interface to GCG
- *SeqWeb*: the Web interface to GCG
- Basic sequence analyses
- Multiple Sequence analysis

### **Some Useful Sites on the Internet**

#### ***Databases and search tools***

NCBI

\*<http://www.ncbi.nlm.nih.gov/>

EMBL SERVER

\*<http://www2.ebi.ac.uk/services.html>

Genome Navigator: *Saccharomyces cerevisiae* Genome Index

<http://www.mpimg-berlin-dahlem.mpg.de/~andy/GN/S.cerevisiae/>

#### **Sequence Allignment**

GENEBEE MULTIPLE SEQUENCE ALIGNMENT

\*<http://www.genebee.msu.su/>

TREEVIEW

\*<http://taxonomy.zoology.gla.ac.uk/rod/treeview.html>

CLUSTAL W

\*<http://www2.ebi.ac.uk/clustalw/>

GENEDOC: Multiple Sequence Alignment Editor, Analyser and Shading Utility for Windows.

<http://www.cris.com/~ketchup/genedoc.shtml>

## Sequence Analysis

Restriction Enzyme Site Digestion

Webcutter 2.0: Analyze your sequence also a direct reference to REBASE.

\*<http://www.firstmarket.com/cutter/cut2.html>

Search for potential transcription factor binding sites with MatInspector V2.2

\*<http://transfac.gbf-braunschweig.de/>

MAR-Finder: Deduce the presence of matrix association regions, or MARs, in DNA Sequences.

\*<http://www.ncgr.org/MarFinder/>

Computational Genomics Group of the Sanger Centre Informatics Division

<http://genomic.sanger.ac.uk>

BCM Search Launcher

<http://kiwi.bcm.tmc.edu:8088/search-launcher/launcher.html>

## Repetitive Elements

RepeatMasker2 Web Server

\*<http://ccr-081.mit.edu/Repeats.html>

CENSOR Web Server

\*<http://charon.girinst.org/~server/censor.html>

## Image Analysis, Experimental Protocols, and Computer Courses

ANALYSIS-NIH IMAGE PROGRAM MAC & PC (FREE)

<http://www.scioncorp.com/>

PCR and multiplex PCR: guide and troubleshooting guide

<http://info.med.yale.edu/genetics/ward/tavi/PCR.html>

Welcome to the VSNS BioComputing Division

<http://www.techfak.uni-bielefeld.de/bcd/welcome.html>

## Other Useful Sites

The Really Quite Useful MolBioPage

<http://www.lars.bbsrc.ac.uk/plantsci/molbiol/molbiol.html>

Alex's Cyber-Science Jumpstation

<http://www.flnet.nl/~bossers/>

On line analysis tools

<http://www-biol.univ-mrs.fr/english/logligne.html>

Welcome to the Globin Gene Server

<http://globin.cse.psu.edu/>

ExpPASy Molecular Biology Server: Swiss Institute of Bioinformatics (SIB) 2-D PAGE.

<http://expasy.hcuge.ch/>

**Computer peripherals and hardware description:** Computer system design. Recognition and structure of different components of a computer system and their respective usage, I/O and storage devices with data communication with introduction of internet.

**Operating systems:** System and application software, evolution of operating systems, layered structure of operating system, CUI and GUIs, DOS internet & external commands, Batch files; WIN 95/98: Anatomy of windows and features, multitasking.

**Office applications:** MS-office 95/97/2000 including MS-Word, MS-Excel, and MS-Powerpoint.

**Logic development:** Generations of programming languages, emulation of common DOS commands using C and C++, data structures in C, objects and classes, pointers, arrays (One & two dimensional) normal string and file handling in C++.



## PAPER-4 (BCH 509)

### IMMUNOLOGY

#### **Introduction to Immune System**

- Memory, specificity, diversity, innate and acquired immunity, self vs non-self discrimination.
- Structure and functions of primary and secondary lymphoid organs.

#### **Cells Involved in Immune Responses**

- Phagocytic cells and their killing mechanisms
- T and B lymphocytes
- Differentiation of stem cells and idiotypic variations.

#### **Nature of Antigen and Antibody**

- Antigen vs Immunogen, Haptens
- Structure and functions of immunoglobulins
- Isotypic, allotypic and idiotypic variations.

#### **Generation of Diversity in Immune System**

- Clonal selection theory – concept of antigen specific receptor.
- Organization and expression of immunoglobulin genes: generation of antibody diversity.
- T cell receptor diversity.

#### **Humoral and Cell Mediated Immune Responses**

- Kinetics of primary and secondary immune responses
- Complement activation and its biological consequences
- Antigen processing and presentation
- Cytokines and costimulatory molecules: Role in immune responses.
- T and B cell interactions.

#### **Major Histocompatibility Complex (MHC) Genes and Products**

- Polymorphism of MHC genes
- Role of MHC antigens in immune responses
- MHC antigens in transplantation.

## **Development, Regulation and Evolution of the Immune System**

### **Measurement of Antigen – Antibody Interaction**

- Production of polyclonal and monoclonal antibodies: Principles, techniques and applications.
- Agglutination and precipitation techniques
- Radio immunoassay
- ELISA
- Immunofluorescence assays: Fluorescence activated cell sorter (FACS) technique.

### **Measurement of T Cell Activation**

- Fraction of leukocytes on density gradient
- Delayed type hypersensitivity technique
- Leukocyte migration inhibition technique
- Cytotoxicity assay
- Cytokines assay: ELISA and ELISPOT.

### **Tolerance vs Activation of Immune System**

- Immune –tolerance
- Immunosuppression
- Hypersensitivity (Types I, II, III and IV).

### **Immune Responses in Diseases**

- Immune responses to infectious diseases: viral, bacterial and protozoal
- Cancer and immune system
- Immunodeficiency disorders
- Autoimmunity.

### **Immunization**

- Active immunization (immunoprophylaxis)
- Passive immunization (Immunotherapy)
- Role of vaccines in the prevention of diseases.

**PAPER-5 (BCH 510)**  
**LABORATORY COURSE-II**

Subcellular fractionation of organelles from liver cells and identification by the use of marker enzymes.

Purification of an enzyme using ion-exchange columns, gel filtration, affinity chromatography.

Molecular weight determination and kinetic studies on purified enzymes.

Writing a BASIC computer program to plot graphs of enzyme kinetic data by a variety of linear transforms and the Michaelis-Menten hyperbolic plot.

Protein synthesis in a cell free protein synthesizing system from rat liver or wheat germ.

Extraction of lipids from tissues, separation and estimation using thin layer chromatography.

Separation of phospholipid species in HPLC and estimation of their fatty acid composition by GLC.

**SEMESTER-III**  
**PAPER-1 (BCH 511)**  
**METHODS IN MOLECULAR BIOLOGY**

Rapid DNA sequencing techniques and strategies details of a range of methodologies, e.g. plus and minus, dideoxynucleotide, partial ribosubstitution, Maxam and Gilbert. Use of thin gels, resolution etc. Interpretation of DNA sequences.

Role of counterions, deep and narrow grooves, single stranded DNA, A, B and Z DNA etc. Chirality of the helix, syn/antiparallel complementary strands.

**Physical properties of RNA:** Classes of RNA, rRNA, tRNA, mRNA, HnRNA etc. Structure and methods of isolation and fractionation, gel electrophoresis and Dnases, Rnases, Phosphodiesterases.

**Rapid RNA sequencing techniques:** plus and minus, dideoxy-nucleotide, Zimmern and Kaesberg, Peattie, Simoncsits *et al.*, method etc. Interpretation of RNA sequence.

**Classes of DNA sequences:** Zero-order bending, highly repetitive, unique. Methods of distinguishing double and single stranded DNA.

**Re-association kinetics:** Cot values, experimental procedure, qualitative significance, use of Ag<sup>+</sup> cesium sulphate.

**Satellite DNA:** C-value paradox, possible functions of satellite DNA, Mechanical strength, gene library, suppressor mutation, centromeric DNA, split genes.

**Chromatin:** Histone and non-histone proteins, general properties of histones, packing density. Nucleosomes, size variable linker, role of H1. Solenoid structure. Transcriptionally active chromatin.

**Movable genes:** transposons and associated inverted repeats. The cassette model. Transforming DNA and plant genes. Retrovirus life cycle.

Strategies for cloning in plasmid vectors, features of commonly used vectors, their purification and characterization. Identification of bacterial colonies that contain recombinant plasmids. Bacteriophage  $\lambda$  vectors, growth, purification. Cloning in Bacteriophage  $\lambda$  vectors.

Cloning in cosmid vectors. Construction of Genomic DNA libraries in cosmid vectors. Enzymes used in molecular cloning, restriction enzymes, DNA-Polymerases, ligases, kinases, phosphatases, and nucleases. DNA binding proteins.

Agarose gel and polyacrylamide gel electrophoresis, detection and extraction of DNA from gels. Construction and analysis of c-DNA; protocols and strategies for c-DNA cloning. Analysis of Genomic DNA by Southern Hybridization. Amplification of DNA by the polymerase chain reaction. Preparation of radiolabeled DNA and RNA probes. Synthetic oligonucleotides probes. Expression of cloned Genes in cultured cells. Screening expression with antibodies and oligonucleotides.

**PAPER-2 (BCH 512)**  
**NUTRITIONAL BIOCHEMISTRY**

- **Basic Concepts:** Composition of human body. Energy content of foods. Measurement of energy expenditure: Direct & indirect calorimetry. Definition of BMR and SDA and factors affecting these. Thermogenic effects of foods. Energy requirements of man and woman and factors affecting energy requirements.
- **Carbohydrates:** Dietary requirements and sources of available and unavailable carbohydrates. Physico-chemical properties and physiological actions of un-available carbohydrates (dietary fibre).
- **Proteins:** Protein reserves of human body. Nitrogen balance studies and factors influencing nitrogen balance. Essential amino acids for man and concept of protein quality. Cereal proteins and their limiting amino acids. Protein requirement at different stages of development.
- **Lipids:** Major classes of dietary lipids. Properties and composition of plasma lipo- proteins. Dietary needs of lipids. Essential fatty acids and their physiological functions.
- **Electrolytes and water balance:** Electrolyte concentrations of body fluids. Acid base regulation by the human body. Concept of metabolic and respiratory acidosis and alkalosis.
- **Minerals:** Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.
- **Vitamins:** Dietary sources, biochemical functions and specific deficiency diseases associated with fat and water-soluble vitamins. Hypervitaminosis symptoms of fat- soluble vitamins. Nutritional requirements during pregnancy, lactation and of infants and children.
- Food processing and loss of nutrients during processing and cooking
- **Anti-nutrients: Naturally occurring food born toxicants: Protease inhibitors, Hemagglutins, Hepatotoxins, Allergens, Oxalates, Toxins from Mushrooms, Animal food stuffs and sea foods.**
- **Protein energy malnutrition (PEM):** Aetiology, clinical features, metabolic disorders and management of Marasmus and Kwashiorkor diseases.
- **Starvation:** Techniques for the study of starvation. Protein metabolism in prolonged fasting. Protein sparing treatments during fasting. Basic concept of High protein, low caloric weight reduction diets.
- **Obesity:** Definition and classification. Genetic and environmental factors leading to obesity. Obesity related diseases and management of obesity. Role of leptin in regulation of body mass.
- **Clinical nutrition:** Role of diet & nutrition in the prevention and treatment of diseases: Dental caries, Fluorosis, Renal failure, Hyperlipidemia, Atherosclerosis & Rheumatic disorders, Inherited metabolic disorders: Phenyl ketonuria, Maple syrup disease. Hemocystinuria, Galactosemia, Gout, Diabetes Insipidus and Diabetes Mellitus.
- **Food allergy:** Definition, Role of antigen, host and environment. Types of Hypersensitivities. Diagnosis and management of allergy.

**PAPER-3 (BCH 513)**  
**RESEARCH METHODOLOGY AND BIOSTATISTICS**

- Methodology of scientific research
- The nature of scientific methods
- Design of experiments in biochemistry
- Significance of statistical methods of biological investigations
- Sampling techniques
- Statistical evaluation of results, probability theory, random variables and distribution functions.
- Point and interval estimation, multiple linear regression
- Correlation and analysis of variance and covariance
- Distribution of student t, chi-square ( $X^2$ ), F test, correlation coefficient (r).
- Non-parametric statistics
- Use of packaged statistical computer programmes for statistical analysis

**PAPER-4 (BCH 515)**  
**LABORATORY COURSE-III**

- End groups analysis of proteins
- Peptide mapping
- Preparation of plasmid DNA, digestion by endonucleases and separation of DNA restriction fragment on agarose gel electrophoresis.
- Restriction mapping of DNA
- DNA and RNA techniques using nitrocellulose – Southern & Northern Blotting.
- Electroblothing of DNA restriction fragments.
- Sequencing of DNA and RNA on polyacrylamide gels.
- Production of antisera – immunodiffusion and immuno-electrophoresis, complement fixation.

**PAPER-5 (BCH 514)**  
**THESIS/PROJECT WORK-STARTS**  
**SEMINAR**

## SEMESTER-IV

### Any Two Courses from the Following Options

#### BIOCHEMICAL & ENVIRONMENTAL TOXIOLOGY (BCH 516)

- **Definition and scope of toxicology:** Eco-toxicology and its environmental significance. Toxic effects: Basis for general classification & nature. Dose – Response relationship: Synergism and Antagonism, Determination of  $ED_{50}$  &  $LD_{50}$ . Acute and Chronic exposures. Factors influencing Toxicity. Pharmacodynamics & Chemodynamics.
- **Principles & procedures of testing for acute toxic effects:** Regulatory guidelines, Mammalian systems affected & the clinical signs of Systemic Toxicity. Factors affecting acute Toxicity studies.
- **Xenobiotic metabolism:** Absorption & distribution. Phase I reactions. Oxidation, Reduction, Hydrolysis and Hydration. Phase II reactions/Conjugation: Methylation, Glutathione and amino acid conjugations. Detoxification.
- **Biochemical basis of toxicity:** Mechanisms of Toxicity : Disturbance of Excitable membrane function. Altered calcium Homeostasis. Covalent binding to cellular macromolecules & Genotoxicity. Tissue specificity of Toxicity.
- **Toxicity testing:** Test Protocol, Genetic toxicity testing & Mutagenesis assays: *In vitro* Test systems – Bacterial Mutation Tests: Reversion Test, Ames Test, Fluctuation Tests and Eukaryotic Mutation Tests. *In vivo* Mammalian Mutation tests – Host mediated assay & Dominant Lethal Test. Use of *Drosophila* in Toxicity testing. DNA repair assays. Chromosome damage test. Toxicological evaluation of Recombinant DNA – derived proteins.
- **Pesticide toxicity:** Insecticides: Organochlorines, Anti-cholinesterases – Organophosphates and Carbamates. Fungicides. Herbicides. Environmental consequences of pesticide toxicity. Biopesticides.
- **Food toxicology:** Role of diet in cardio-vascular diseases and cancer. Toxicology of food additives.
- **Metal toxicity:** Toxicology of Arsenic, mercury, lead and cadmium. Environmental factors affecting metal toxicity – effect of light, temperature & pH.
- **Diagnosis of toxic changes in liver and kidneys:** Metabolism of Haloalkanes, Haloalkenes & Paracetamol with their toxic effects on tissues.
- **Air pollution:** Common air Pollutants & their sources. Air pollution & ozone. Air pollution due to chlorofluorocarbons (CFCS) and asbestos.
- **Occupational toxicology & assessment of occupational hazards:** Industrial effluent toxicology & Environmental health.
- **An overview of regulatory agencies:** Responsibilities of regulatory agencies. Management of Toxicological risk. Regulatory approaches. Regulatory systems & organizations.

## MUSCLE BIOCHEMISTRY AND BIOMEMBRANES (BCH 517)

### Muscle Biochemistry

#### Skeletal muscle structure

Biochemical characterization of the extracellular matrix, plasmalemma, transverse tubular system, Sarcoplasmic reticulum and myofibrils.

Actin, myosin, tropomyosin, troponin, Z disc and H line components. The sliding filament mechanism and subcellular ion movements during the contraction cycle in skeletal muscle, length tensions relationship.

Metabolic and functional classification of skeletal muscle fibers (types 1, 2A, 2B). Twitch speeds and myosin ATPase activities. Oxidative and anaerobic metabolism.

Enzyme, histochemical and immunofluorescence characterization of muscle fibers

The motor unit and redifferentiation following cross insertion

Effect of aging and thyroid states. Skeletal muscles diseases

Specialized metabolism in cardiac and smooth muscle

All or none versus graded responses. Thick filament regulation.

Cyclic AMP and hormonal sensitivity.

Role of calmodulin, phospholamban, cardiac troponin I, slow  $\text{Ca}^{++}$  channel phosphorylation. Depolarization induced and calcium induced release from S.R.I. calcium export from muscle cells. Role of sodium, effects of ouabain, stimulation frequency and verapanil.

Structure of eukaryotic and prokaryotic cell covering including cell membrane and walls of bacteria, fungi and plant cell.

### Bio-membranes

#### Biological membranes and transport.

Physicochemical properties of cell membranes, molecular constituents of membranes-supra molecular architecture of membranes – asymmetrical organisation of lipids and proteins.

Solute transport across membranes : Fick's law, Types of transport – simple diffusion, passive – facilitated diffusion.

Active transport – primary & secondary group translocation.

Transport ATPases

Molecular models of transport mechanism:

Mobile carrier and pores mechanisms.

Transport by vesicle formation:

Endocytosis, exocytosis

Intracellular communication through junctions gap junction, tight junction, desmosomes. Membrane biogenesis and regulation of cell membrane components; cell-cell interaction Artificial membranes – transport studies.



## **MICROBIAL BIOCHEMISTRY (BCH 518)**

Types of microorganisms, general characteristics of main groups of microorganisms. Criteria used in the classification of microorganisms – cytology, genetics, host specialization, serology, different phases of growth.

Nutrition, physiology and growth of microbial cells.

Gram positive and gram-negative organisms. Structure and functions of peptidoglycan in gram-positive and gram-negative organisms. Functions of polymeric components in outer membrane and acidic polymers in gram-negative organisms.

Special features of bacterial metabolism.

Food spoilage, fermentation, food-borne infection.

Role of microorganisms in domestic and industrial sewage.

Microbiological standards

Virus structure, virus proteins, virus classification and methods of assay.

Replication of RNA viruses – negative strand (VSV), positive strand (polio), retroviruses (to include all events in the infectious cycle).

Replication of DNA viruses (Adenovirus or SV40).

Virus-host interaction

Vaccines and prevention – smallpox/polio/AIDS

## CLINICAL BIOCHEMISTRY (BCH 519)

- Introduction to laboratory principles and instrumentation in Clinical Biochemistry.

### Automation in the Clinical Biochemistry

- Instrumental concepts
- Chemical reaction phase
- Measurement approaches
- Selection of instruments.

### Quality Assurance

- Control of Pre-analytical variables
- Control of analytical variables
- External and internal quality control measurements.

### Disorders of Carbohydrate Metabolism

- Diabetes mellitus
- Glycohemoglobins.
- Hypoglycemia's.
- Ketone bodies
- Various types of glucose tolerance tests.
- Glycogen storage diseases
- Galactosemia

### Lipids, Lipoproteins and Apolipoproteins

- Physiology of lipids/lipoproteins, lipidosis
- Clinical inter-relationships of lipids (sphingolipidosis, multiplsclerosis), Lipoproteins and apolipoproteins.
- Diagnostic tests for apolipoproteins, HDL-cholesterol, LDL-cholesterol and triglycerides disorders.

### Disorders of Amino Acid Metabolism

- Phenylalaninemia, homocystineuria, tyrosinemia and related disorders, aminoacidurias.

### Disorders of Nucleic Acid Metabolism

- Purine metabolism
- Pyrimidine metabolism

**Inborn Errors of Metabolism****Electrolytes, Blood Gases and Acid Base Balance**

- Electrolytes, blood gases, respiration, acid-base balance and acid-base disorders, respiratory and renal mechanism of acid balance disorders.

**Evaluation of Organ Function Tests**

- Assessment and clinical manifestations of renal, hepatic, pancreatic, gastric and intestinal functions, bilirubin metabolism.
- Clinical presentation and diagnosis of various organ diseases.

**Diagnostic Enzymes**

- Principles of diagnostic enzymology
- Clinical significance of :
  - Aspartate aminotransferase
  - Alanine aminotransferase
  - Creatine kinase
  - Aldolase
  - Lactate dehydrogenase
  - Enzyme tests in determination of myocardial infarction
  - Enzymes of pancreatic origin, biliary tract.

**Hormonal Disturbances**

- Protein hormones, anterior pituitary hormones, posterior pituitary hormones, steroid hormones, adrenocortical steroids, reproductive endocrinology, thyroid function.

**Disorders of Mineral Metabolism**

- Hypercalcemia, hypocalcemia, normocalcemia, hypophosphatemia, hyperphosphatemia.

**Biochemical Aspects of Hematology**

- Disorders of erythrocyte metabolism, hemoglobinopathies, thalasseмии, and anaemias.

**Blood Clotting**

- Homeostasis and thrombosis, extrinsic and intrinsic pathways of blood clotting, laboratory test to measure coagulation and thrombolysis.

**Detoxification Mechanism in the Body**

- Enzymes of detoxification – polymorphism in drug metabolizing enzymes.
- Detection of toxic substances by specific procedures.

**Disorders of Vitamins and Trace Elements**

## NEUROBIOCHEMISTRY (BCH 520)

**Neuromorphology and Neurocellular Anatomy:** Central Nervous system – General features of Neurons. Cellular organisation of neurons, Dendrites and Axons, neurotubules, neurofilaments, synapse neuralgia, astrocytes, oligodendrocyte, ependymal cells, schwa cells.

**Peripheral Nervous System (PNS):** Muscle, nerve endings, sensory receptors and effector endings; peripheral nerves, spinal and cranial nerves; plexuses ganglia, afferent pathways and sense organs.

**Spinal Cord:** Topographical anatomy, spinal nerves, spinal meninges, joint reflexes, gray and white matter of spinal cord.

**Role of the Nervous System in Homeostasis:** Cellular organization of specific regions such as cerebellum, cerebral cortex, hippocampus, retina, evolution of the nervous system – a comparative aspect.

**Neurophysiology:** Neuronal membrane, excitability, ion channels and transport of ions.

**Nerve and Synapse Structures:** Structure function correlation at the synapse. Transmission across the synapse: membrane potential in the steady state, action potential generation and propagation.

**Presynaptic Events at the Neuromuscular Junction:** Cholinergic and non-cholinergic synapses.

**Postsynaptic Events at the Neuromuscular Junction.**

**Electrophysiology of Channels:** EEG patterns.

**Chemical Composition of Brain:** Formation, structure and biochemistry of myelin, chemistry of major brain lipids, developmental changes, lipid composition, biosynthesis and catabolism of major lipids, characteristics of brain lipids, regional variations.

**Intermediary Metabolism of Carbohydrates:** Glycogen metabolism, glycolysis, citric acid cycle, HMP shunt, metabolic compartmentation, regional differences, relationships of carbohydrates to lipid metabolism.

**Metabolism of Amino Acids:** Composition of free amino acid pools, developmental changes, transport of amino acid specific systems, regional effects of transport.

**Metabolism of Protein:** Synthesis of proteins, regulation of synthesis and degradation of specific proteins, structural modifications, techniques for studying protein metabolism in the nervous system, structural modification of proteins at nerve endings, special nervous system proteins.

**Neurotransmitter:** Chemistry, synthesis, storage and release of nervous neurotransmitters, transmitter action, synaptic modulation and mechanism of neuronal integration.

**Energy Metabolism:** Normal oxygen consumption by the brain, energy demanding functions, role of cerebral circulation, local cerebral blood flow and metabolism, effects of glucose deprivation,

influence of age and development on cerebral energy metabolism, cerebral energy metabolism in pathological status, convulsive disorders, coma.

**Blood Brain CSF Barriers:** Special transport systems, characteristics of BBB – morphology, diffusion, mediated transport, enzymatic barriers in capillary endothelium. Characteristics of blood CSF barrier, composition of CSF, formation of CSF, active transport from CSF to brain. CSF brain interface, similarities of BBB to blood CSF barrier.

**Ion Transport:** Isolation and identification of transport systems, transport proteins, macrocyclic carriers, and active transport.

**Synaptic Transmission:** Structure of the synapse, correlation of structure and function at the synapse, transmission across the synapse, pre and post synaptic events, membrane potential in the steady state action, action potential and propagation of nerve impulse. cAMP in hormone action. Cyclic nucleotide and synaptic transmission – cAMP and neuronal function, neurotransmitter sensitive adenylate cyclases and their role in neuronal function, mechanism of action of cAMP in synaptic transmission, cAMP and cell growth with differentiation, cAMP and microtubule function.

**Neuropeptides** – Classes of neuropeptides, mode of action, role of neuropeptides in obesity and pain. Neuropeptide receptors, coexistence of neuropeptides with other neurotransmitters in “Dorsomedial Hypothalamic Nucleus”.

**Importance of Cell Culture in Studying the Metabolism of Nerve Cells** - Use of cell culture to study steroid and membrane receptors. Generation of cell specific RNA, generation of cell specific markers.

**Secondary Messengers:** Importance of cyclic nucleotides and protein phosphorylations in nervous system. Involvement of protein kinases and calcium in neuronal metabolism.

**Endocrine Effects on the Brain and their Relationship to Behaviour:** Behavioral control of hormone secretion, biochemical aspects of activational hormones effects, steroid receptor sites in brain, integration of behavioral and neuroendocrine effects, organizational effects of hormones on developing brain, thyroid hormone and brain development.

**Developmental Neurobiology:** Organogenesis and neuronal multiplication, axonal and dendritic growth, glial multiplication and myelination, growth in size, regeneration and repair mechanisms, plasticity.

**Disorders of Metabolism of Brain:** Biochemical aspects of muscle disease, muscular dystrophies, myotonic dystrophy, periodic paralysis, glycogen storage diseases affecting muscle functions.

#### **Disorders of Amino Acid Metabolism and Carbohydrate Metabolism**

**Sphingolipidosis and other Lipid Disorders:** Diseases involving myelin classification, and biochemistry of demyelinating diseases.

**Biochemical Pathology of Vitamin and Nutritional Deficiencies:** Neurotoxic agents and diseases related to them.

***Psychopharmacology and Biochemical theories of Mental Disorders:*** Chemistry of neuroleptics and anxiolytics, antidepressants, hallucinogenic agents, biochemical theories of mental disorders.

***Learning and Memory:*** Correlation of behavioural and biochemical events, measurement of learning and memory, agents affecting learning and memory, genetic manipulations, enhancing agents, biochemical correlates of excitation, learning and behaviour.

***Neurodegenerative Disorders:*** Parkinson's, Alzheimer's disease, amyotrophic lateral sclerosis, senile dementia.

***Ageing:*** Basic, immunological, viral and clinical aspects of ageing. Social behavioural and psychological factors, pharmacological control of ageing.

***Neurological Behaviour:*** Mechanism of sleep, wakefulness, self stimulation.

***Natural, Genetic and Environmental Factors Affecting the Development of CNS.***

## GENETICS FOR BIOLOGISTS (BCH 521)

Totipotency; Requirements for cell and Tissue cultures; Explant culture; callus formation, shoot culture and Micropropagation; cell culture; Protoplast fusion and somatic hybridization; Anther and Pollen culture; Somaclonal variation.

### **Genetic Counseling**

Possible approaches for tackling genetic disorders; Diagnosis of genetic defects; Positive eugenics; Negative eugenics; genetic counseling (antenatal diagnosis, fetus sexing).

### **General Principles and Techniques of Plant Breeding**

Principles of plant/animal breeding; Techniques of plant/plant breeding; Goal and Objects of plant/plant breeding; Methods of crop and livestock improvement.

### **Restriction Maps and Molecular Genetic Maps**

Restriction Mapping. Restriction fragment length polymorphisms (RFLPs); Linkage and recombination between molecular and phenotypic markers; Random amplified polymorphic DNA (RAPDs) using PCR. Chromosome walking; reverse genetics and chromosome jumping

### **Applied Genetics : Scope and Importance**

What is applied genetics; Achievements of applied genetics; Need for future development.

### **Cloning and Amplification of DNA**

Restriction enzymes in cloning; Techniques used in recombinant DNA technology (Polyacrylamide gel electrophoresis, Southern, Northern and Western blotting); Cloning vectors for recombinant DNA; cloning in bacteria, Molecular probes, Construction and screening of genomic and cDNA libraries; PCR and its applications.

### **Isolation, Sequencing and Synthesis of Genes**

Isolation of genes (genes with Tissue specific expression; mutant complementation, transposon tagging); Sequencing of genes (Maxam-Gilbert's method); Synthesis of genes (organochemical synthesis of tRNA gene and interferon gene).

### **Gene Transfer Methods and Transgenic Organisms**

Gene transfers methods for animals and plants; Agro-bacterium mediated gene transfer, electroporation and particle gun. Transgenic animals (mouse and rabbit); Transgenic plants (Herbicide insect and virus resistance).

**SUGGESTED READINGS: B.Sc. AND B.Sc. (HONS.) – BIOCHEMISTRY****PAPER-I (BCH-101): BIOMOLECULES**

- i) Lehninger's Principles of Biochemistry (2000) by Nelson, David L and Cox, M M, Macmillan/Worth, NY.
- ii) Fundamentals of Biochemistry (1999) by Donald Voet, Judith G Voet and Charlotte W Pratt, John Wiley & Sons, NY.
- iii) Biochemistry III ed (1994) by Lubert Stryer, WH Freeman and Co., San Francisco.
- iv) Outlines of Biochemistry (1987) by Eric E Conn, P K Stumpf, G Bruening and Ray H Doi, John Wiley & Sons, NY.

**PAPER-II (BCH-102): BIOPHYSICAL AND BIOCHEMICAL TECHNIQUES*****Immunological techniques******Immunodiffusion, immunoelectrophoresis, radioimmunoassay, ELISA, immunofluorescence***

- i) Physical Biochemistry (II ed 1985) by vanHolde K E, Prentice Hall Inc., New Jersey.
- ii) Physical Biochemistry (II ed 1983) by D Friefelder, WH Freeman & Co., USA.
- iii) Outlines of Biochemistry by Eric E Conn. P K Stumpf, G Bruening and Roy H Doi (1987) John Wiley & Sons, NY.
- iv) Chromatography: A laboratory handbook of chromatographic and electrophoretic methods. (IIIrd 1975) by Erich Heftman, van Nostrand Reinhold, NY.

**(BCH-201): ENZYMOLOGY**

- i) Fundamentals of Enzymology (II ed) by Nicholas C Price and Lewis Stevens, Oxford Univ Press.
- ii) Principles of Enzymology for Food Science (1972) by J R Whitkar, M Dekker Publishers.
- iii) Biochemistry (3<sup>rd</sup> ed) by Lubert Stryer, WH Freeman and Co., San Francisco.
- iv) Enzymes (3<sup>rd</sup> ed. 1979) Dixon M and Webb, E C, Longmans, London.
- v) The chemical kinetics of enzyme action by K J Laidler and P S Bunting, Oxford University Press, London.
- vi) Enzyme structure and function by S Blackburn, Marcel Dekker, Inc., NY.

**PAPER IV (BCH-202): INTERMEDIARY METABOLISM**

- i) Fundamentals of Biochemistry (1999) by Donald Voet, J G Voet and C W Pratt, John Wiley & Sons., NY.
- ii) Biochemistry (IV ed 1998) by Geoffrey L Zubay, McGraw Hill.
- iii) Biochemistry (IV ed 1996) by Lubert Stryer, WH Freeman and Co., San Francisco.

**PAPER V (BCH-301): MOLECULAR BIOLOGY**

- i) Biochemistry (1989) J David Rawn, Neil Patterson Publishers, North Carolina.
- ii) Molecular Biology of the gene (IV ed 1987) J D Watson, NH Hopkins, J W Roberts, J P Stertz, A M Weiner, Freeman, San Francisco.
- iii) Fundamentals of Biochemistry (1999) by D Voet, J G Voet and C W Pratt, John Wiley & Sons., NY.
- iv) Text Book of Biochemistry (IV ed) by Thomas M Devlin, John Wiley & Sons, NY.



**BCH-302: NUTRITIONAL, CLINICAL AND ENVIRONMENTAL BIOCHEMISTRY**

1. Modern Nutrition in Health and Diseases by Whol and Goodhart.
2. Human Nutrition and Dietetics - S Davidson and J R Passmore; ELBS, Zurich.
3. Tietz Fundamentals of Clinical Chemistry by Carl A Burtis & E R Ashwood (eds.) (5<sup>th</sup> edn.) Saunders WB Co.
4. Lecture Notes on Clinical Biochemistry - L G Whitby, A F Smith, G J Beckett, S M Walker, Blackwell Sci Inc.

**PAPER VII (BCH-311): IMMUNOLOGY**

- i) Immunology (IV ed) by Ivan Roitt, J Brostoff and David Mole 1998 Mosby Times Mirror Int Pub Ltd.
- ii) Immunology (1st edn) by Janis Kuby 1992 W H Freeman and Company, USA.
- iii) Essential Immunology (9<sup>th</sup> edn.) Ivan Roitt 1997, Blackwell Science Ltd.

**BCH-312: MICROBIOLOGY AND VIROLOGY**

1. Microbiology (5<sup>th</sup> ed 2000) M J Pelczar (jr) & R D Reid, Tata-McGraw Hill.
2. Microbiology - Davis Bernard.
3. Fundamental Virology (1995) B N Fields, D M Knipe, P M Howley, R M Chanock, J L Meenick, T P Monath, S E Strans, Lippin Cott Raven.

**BCH-313: CELL BIOLOGY AND MEMBRANE BIOCHEMISTRY**

- i) Introduction to Biological membranes (2<sup>nd</sup> edn 1988) M K Jain, John Wiley & Sons, NY.
- ii) Comprehensive introduction to membrane biochemistry (1987) by D B Datta.
- iii) Biological membranes: Their structure and function (2<sup>nd</sup> edn 1980) Harrison R.

**BCH-314: HUMAN PHYSIOLOGY**

1. Text Book of Medical Physiology (10<sup>th</sup> edn. 2001) by A G Guyton and Hall J E. Harcourt, Asia.
2. Review of Medical Physiology (12<sup>th</sup> ed, 1985) Ganong W F Lange Medical Pub.

**SUGGESTED READINGS FOR M.Sc. (BIOCHEMISTRY)****BCH-501: ORGANIC AND BIOPHYSICAL CHEMISTRY**

Stereo chemistry of organic compounds (1994) by E L Eliel & SHW Awley, Inter Science Pub. 30, Wiley and Sons. Inc.

Organic Chemistry (6<sup>th</sup> ed. 2000) by R T Morrison & R N Boyd, Prentice Hall of India, New Delhi.

Organic Chemistry Vol.1 Fundamental Principles (6<sup>th</sup> Ed. 1985) by I L Finar, ELBS.

Vol.2 Stereo Chemistry and the Chemistry of Natural Products. (5<sup>th</sup> ed. 1985) by I L Finar, ELBS.

Lehninger's Principles of Biochemistry (2<sup>nd</sup> Ed 2000) D L Nelson and M M Cox, Macmillan Worth Pub. Inc NY.

Physical Biochemistry by Kansal Edward Van Holde (1971) Prentice Hall Inc. New Jersey.

Physical Biochemistry 2<sup>nd</sup> ed (1982) by David Friefelder, W H Freeman and Co. NY.

Principles and Techniques of Practical Biochemistry (4<sup>th</sup> ed 1999) by K Wilson and J Walker (eds.) Cambridge Univ. Press.

**BCH-502: CELL BIOLOGY AND PHYSIOLOGY**

Molecular Biology of the Cells (3<sup>rd</sup> edn 1994) by Alberts et al., Garland Publications Inc NY and London.

Cell Biology (1993) by E S Sedava, Jones and Barlett Publishers Boston, London.

Cell and Molecular Biology (8<sup>th</sup> ed. 2001) by E D P de Robertis & E M F de Robertis (Jr) Lippincott Williams & Wilkins, Philadelphia.

Principles of Cell Biology (1988) by Klein Smith and M.Kish, Harper-Cellins Pub. Inc. New Delhi.

Text book of Medical Physiology (10<sup>th</sup> ed. 2001) by A C Guyton & J E Hall, Harcourt Asia.

**BCH-503: BIOENERGETICS AND INTERMEDIARY METABOLISM**

Lehninger's Principles of Biochemistry (2<sup>nd</sup> edn. 2000) by D L Nelson and M M Cox, Macmillan, Worth Pub Inc., NY.

Biochemistry (4<sup>th</sup> edn. 1992) by Lubert Stryer WH Freeman & Co., NY.

Harper's Biochemistry (25<sup>th</sup> ed.) by R K Murray and others. Appleton and Lange, Stanford.

**BCH-504: PLANT BIOCHEMISTRY**

i) Handbook of photosynthesis (ed) Mohammad Pe sarakle, Marcel Dekkar, Inc. NY. Basel. Hong Kong 1997.

ii) Introduction to plant biochemistry (1983) T W Goodwin and E I Mercer. Pergaman Press, Oxford, NY, Toronto, Sydney, Paris, Frankfurt.

iii) Seed: physiology of development and germination (2<sup>nd</sup> ed. 1994) J D Bewley and M Black Plenum Press NY.

iv) Biochemistry of energy utilization in plants D T dennis Blackie, Glasgow and London 1987.

v) Plant Biochemistry by P M Dey and J B Harborne. Harcourt Asia PTE Ltd., Singapore.

**BCH-506: ADVANCED ENZYMOLOGY**

i) The chemical kinetics of enzyme action by K J Laidler and P S Bunting, Oxford University Press, London.

ii) Enzymes by M Dixon, E C Webb, CJR Thorne and K F Tipton, Longmans, London.

iii) Enzyme structure and mechanism (1977) by Alan Fersht, Reading, USA.

- iv) Enzymatic reaction mechanism (1979) by Christopher Walsh, Freeman Pub., San Francisco.
- v) Immobilized enzymes (1978) by Ichiro Chibata, Halsted Press Book.
- vi) Enzyme structure and function by S Blackburn (1976) Marcel Dekker, Inc., NY.

**BCH-507: ADVANCED MOLECULAR BIOLOGY**

- i) Biochemistry (2<sup>nd</sup> ed 1995) by Donald Voet and Judith Voet.
- ii) Molecular Biology of the gene (IV ed 1987) J Watson NH Hopkin J W Roberts J P Stertz A M Weiner, Freeman Pub., San Francisco.
- iii) Genes VII Benjamin Lewin (2000) Oxford Univ Press. London.

**BCH-509: IMMUNOLOGY**

- i) Immunology (4th edn. 1998) by Ivan Roitt, J Brostoff and David Mole (4<sup>th</sup> edn) Mosby Times Mirror Int. Pub. Ltd.
- ii) Essential Immunology (9th ed. 1997) by Ivan Roitt Blackwell Science Ltd.
- iii) Immunology (1992) by Janis Kuby W H Freeman and Co. Ltd. USA.
- iv) Immunology (2<sup>nd</sup> edn. 991) by Edwards S Golub, Sinauer Associate, Sunderland.

**BCH-511: METHODS IN MOLECULAR BIOLOGY**

- i) Molecular cloning: a laboratory manual (Vol.1, 2 & 3) (1989) by T.Maniatis, E.F.Fritsch, J.Sambrook. Cold Spring Harbor Laboratory Publications
- ii) RNA Isolation and Analysis by P.Jones, J.Qiu, D.Rickwood (1<sup>st</sup> ed. 1994) Bios Scientific Publishers.
- iii) Gene and Probes: A Practical Approach Series (1995) by B D Hames and S J Higgins. Oxford University Press.
- iv) Gel Electrophoresis of Nuclei Acids: A Practical Approach (1990) by D.Rickwood and B.D.Hames. Oxford University Press.

**BCH-512: NUTRITION BIOCHEMISTRY**

- i) Nutrition: An integrated approach (3<sup>rd</sup> edn. 1984) R L Pike and M L Brown, Wiley & Sons Inc., NY.
- ii) Text Book of Biochemistry and Human Biology G P Talwar, Prentice Hall.
- iii) Mechanism and Theory in Food Chemistry (1996) DWS Wong, CBS, New Delhi.
- iv) Text Book of Human Nutrition (1996) M S Bamji N Pralhad Rao and V Reddy, Oxford & IBH Publishers.
- v) Nutritional Biochemistry and Metabolism Linten.
- vi) Principles of Food Science -I (Food Chemistry) Fennemona D R.
- vii) Human Nutrition and Dietetics (8<sup>th</sup> Ed. 1982) by Davidson and Passmore ELBS.
- viii) Modern Nutrition in Health and Diseases (7<sup>th</sup> ed. 1988) by Maurice E Skills and V R Young K M Varghese Co. Bombay.

**BCH-513: RESEARCH METHODOLOGY AND BIostatISTICS**

1. Biostatistics: A foundation for analysis in the health. (7<sup>th</sup> ed. 1999) by W W Daniel John Wiley and Sons Inc., New York.

**BCH-516: BIOCHEMICAL AND ENVIRONMENTAL TOXICOLOGY**

General and Applied Toxicology 1995 by Marrs and Turner, Macmillan Press Ltd.

Basic Environmental Toxicology (1994) by Lorriss G. Corkerhem and Barbara S S Shane CRP Press Inc.

Introduction to Food Technology by Takayurki Shibamoto & Leonard F. Bzeldanes.

Molecular Biotechnology 2<sup>nd</sup> ed 1994 by Barnard R Glick & J J Pasternak.

**BCH-517: MUSCLE BIOCHEMISTRY**

Biochemistry by Lubert Stryer, Freeman & Co., NY.

Principles of Biochemistry -Smith, Lehman, Lefkowitz, Handler and Smith.

Lehninger's Principles of Biochemistry - D L Nelson and M M Cox, Macmillan/Worth Pub Inc., NY.

Biochemistry of Lipids, Lipoproteins and Membranes (1991) - D E Vance and J E Vance, Elsevier Sci.

**BCH-518: MICROBIAL BIOCHEMISTRY**

1. Microbial World (5<sup>th</sup> edn, 1987) R Y Stanier, Hampshire-Macmillan Press.

2. Medical Microbiology (12<sup>th</sup> edn 1973) Cruckishank R and others, ELBS Press, London.

3. Microbiology (1967) B D Davis, R Delbecco, H M Eisent H S Ginsberg, Hoeber Med Divn NY.

4. Microbiology (5<sup>th</sup> ed 2000) Michael J Pelczar (Jr) ESC Chan, N R Kreig, Tata McGraw Hill.

**BCH-519: CLINICAL BIOCHEMISTRY**

1. Tietz Fundamentals of Clinical Chemistry - (5<sup>th</sup> edn.) C A Burtis, E R Ashwood (eds.) Saunders WB Co.

2. Notes on Clinical Chemistry - Whitby L G, A F Smith, G J Beckett, S M Walker, Blackwell Sci Inc.

3. Principles of Internal Medicine (1983) Harrison T R, McGraw Hill, NY.

**BCH-520: NEURO BIOCHEMISTRY**

Basic Neurochemistry by Siegel.

Elements of Molecular Neurotoxicology by CUM Smith.

Neuru anatomy Grossman & Neavy.

**BCH-521: GENETICS FOR BIOLOGISTS**

General Genetics Sub Owen and Edger.

Genes VII (2000) Benjamin Lewin, Oxford Univ Press.

Molecular Biology of Gene (4<sup>th</sup> edn. 1987) Watson *et al.* Freeman Pub. San Francisco.