University of Mumbai

No. UG/ 70 of 2019-20

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, Directors of the recognized Institutions in Science & Technology Faculty is invited to the syllabus uploaded by Academic Authority Unit which was accepted by the Academic Council at its meeting held on 27th February, 2013 **vide** item No. 4.47 relating to the revised syllabus as per (CBSGS) for B.Sc. in Biochemistry (3Units) (Inter-disciplinary subject) Sem. V & VI w. e. f. the academic year 2013-14.

They are hereby informed that the recommendations made by the Board of Studies in Biochemistry at its meeting held on 17th May, 2019 have been accepted by the Academic Council at its meeting held on 26th July, 2019 **vide** item No. 4.2 and that in accordance therewith, the revised syllabus as per the (CBCS) for the T.Y.B.Sc. - Biochemistry 3 Units (US3BCH) (Inter-disciplinary subject) has been brought into force with effect from the academic year 2019-20, accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
14th August, 2019

(Dr. Ajay Deshmukh)
REGISTRAR

To

The Principals of the affiliated Colleges, and Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.2/26/07/2019

****

No. UG/ 70 -A of 2019-20 MUMBAI-400 032 14th August, 2019

Copy forwarded with Compliments for information to:-

1) The I/c Dean, Faculty of Science & Technology,
2) The Chairman, Board of Studies in Bio-chemistry,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Co-ordinator, University Computerization Centre,

(Dr. Ajay Deshmukh)
REGISTRAR

Cover Page

AC 26/7/19
Item No. 4.2

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	BIOCHEMISTRY- 3 UNITS
2	Eligibility for Admission	SECOND YEAR B.Sc
3	Passing Marks	40/ 100
4	Ordinances / Regulations (if any)	O.2145
5	No. of Years / Semesters	TWO SEMESTERS
6	Level	U.G.
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic Year	From Academic Year : 2019-20

Date: May 2016 Signature :

Name of BOS Chairperson / Dean : Dr. Nupur Mehrotra

Recd
Dr R G Deshmukh

UNIVERSITY OF MUMBAI

Syllabus for the T. Y. B.Sc.
Program: B.Sc.
Course: Biochemistry - 3 units, US3BCH
(Inter-disciplinary subject)

(Choice Based Credit System with effect from the academic year 2019–2020)

Course overview

The subject of Biochemistry is offered at third year level as a double major. Two papers are offered spread over two semesters V and VI. Paper I titled Bioorganic and Biophysical Chemistry introduces the students to all the biomolecules which constitute life. The biophysical parameters involved, and the various techniques and instrumentation utilized to study these molecules are also included. Paper II titled Metabolism, Nutrition and Advanced Biochemical Concepts gives the students an overview of all that encompasses Biochemistry i.e. nutrition the feeder branch, metabolism of various biomolecules for maintenance of life, genetics for perpetuation of life, immunology dealing with defense mechanisms, endocrinology the regulatory process branch , biotechnology the industrial application branch and biostatistics, bioinformatics the data analysis branch.

At the end of the course the Biochemistry double majors will be able to demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules, metabolic pathways, and the regulation of biological/biochemical processes.

The course will enable them to learn and integrate fundamentals in Chemistry, Biology and Biochemistry and will prepare them for careers and postgraduate education.

T.Y.B.Sc.
Biochemistry (3 units)

Choice Based Credit System

To be implemented from the academic year 2019-2020

Semester V

Course Code	Unit	Topics	Credits	L/week
US3BCH501	**Bio-organic and biophysical chemistry - I**		**2.5**	
	I	Proteins and amino acids		1
	II	Enzymes and Nucleic acids		1
	III	Carbohydrates		1
	IV	pH and Radioactivity		1
US3BCH502	**Metabolism, nutrition and advanced biochemical concepts - I**		**2.5**	
	I	Nutrition and Biostatistics		1
	II	Carbohydrate metabolism		1
	III	Amino acid and protein metabolism and Immunology		1
	IV	Genetics and Industrial Biotechnology		1
US3BCHP05		Practical of course US3BCH 501 & course US3BCH 502	**3**	8

Semester VI

Course Code	Unit	Topics	Credits	L/week
US3BCH601	**Bio-organic and biophysical chemistry - II**		**2.5**	
	I	Lipids		1
	II	Chromatography		1
	III	Electrophoresis		1
	IV	Centrifugation and Spectrophotometry		1
US3BCH602	**Metabolism, nutrition and advanced biochemical concepts - II**		**2.5**	
	I	Lipid Metabolism		1
	II	Bioenergetics and photosynthesis		1
	III	Endocrinology		1
	IV	Recombinant DNA Technology and Bioinformatics		1
US3BCHP06		Practical of course US3BCH 601 & course US3BCH602	**3**	8

T.Y.B. Sc. - BIOCHEMISTRY
3 – UNITS INTERDISCIPLINARY SUBJECT
Semester V

COURSE TITLE**: BIO-ORGANIC AND BIOPHYSICAL CHEMISTRY - I**

COURSE CODE**: US3BCH501**

CREDITS: 2.5

Learning Objectives:

- This paper is focused to acquaint the learner with the chemistry and reactions of important biomolecules which constitute life i.e. carbohydrates, amino acids, proteins, nucleic acid and enzymes.
- The learner should also comprehend the principle, working and applications of analytical techniques that serve as important tools in separation and in deciphering the structure and function of biomolecules.
- This paper will acquaint the student to concepts of pH, acids- bases and the important phenomenon of radioactivity and its significance in biochemistry.

Learning Outcome:

At the end of the course the learner should

- be familiar with the chemistry of biomolecules and should be able to appreciate and correlate how structure determines the function of these biomolecules.
- be well versed with properties of acids, bases and buffers and should be able to solve numerical problems based on the concept of pH and buffers.
- have learnt the applications of radioactivity and radioisotopes in biology.

Unit No.	Topic No.	Topic	No. of L
I	**1.0**	**Amino acids and Proteins**	**15**
	1.1	**Amino acids**	
	1.1.1	Classification of amino acids based on the polarity of R-groups (structure of 20 amino acids)	
	1.1.2	Chemical reactions of amino acids with following reagents – Ninhydrin, Sanger's, Edman's, Dansyl chloride. Cleavage of polypeptide- Trypsin, Chymotrypsin, Pepsin, Aminopeptidase, Carboxypeptidase, S-S bond- Mercaptoethanol.	

	1.2	**Proteins**	
	1.2.1	Proteins: ASBC-APS classification on the basis of shape and function. Formation and characteristic of peptide bond.	
	1.2.2	Primary structure, Secondary structure-alpha helix and beta sheet. Tertiary structure - myoglobin, Quaternary structure - hemoglobin.	
	1.2.3	Forces stabilizing protein structure	
	1.2.4	Protein denaturation	
II	**2.0**	**Enzymes and Nucleic acids**	**15**
	2.1	**Enzymes**	
	2.1.1	Basic concepts- enzyme, apoenzyme, holoenzyme, prosthetic group, active site, enzyme specificity, turnover number, specific activity, Katal, IU, coenzyme, cofactor, allosteric enzymes. Isozymes	
	2.1.2	IUB/EC Classification (up to one digit)	
	2.1.3	Factors affecting enzyme reaction – pH, temperature, substrate concentration, enzyme concentration, product concentration, inhibitors, activators	
	2.1.4	Enzyme kinetics-Derivation of Michaelis-Menten equation and Lineweaver-Burk plot for mono-substrate reaction and numerical problems based on them.	
	2.1.5	Enzyme inhibition - Competitive and Non-competitive	
	2.1.6	Enzymes of clinical significance – ALT, AST, ALP, LDH, amylase, lipase	
	2.2	**Nucleic acids**	
	2.2.1	Structure of purine and pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides. c AMP and formation of polynucleotide strand with its shorthand representation.	
	2.2.2	RNAs- (various types in pro and eukaryotes) rRNA, t-RNA (Clover –leaf model), m-RNA and action of alkali on RNA	
	2.2.3	DNA-X-ray diffraction pattern (Physical evidence), Chargaff's rules (Chemical evidence), Watson –Crick model of DNA and its characteristic features, A, B, Z forms of DNA	
	2.2.4	Physical properties of DNA - Ionization, Viscosity, Buoyant density, UV absorption and Hypochromism, Hyperchromism, Denaturation of DNA, Tm.	
III	**3.0**	**Carbohydrates**	**15**
	3.1	Monosaccharides –Definition and classification of carbohydrates (mono, oligo & poly), classification of monosaccharides in terms of – A) aldoses and ketoses. B) Number of carbon atoms. Reactions of monosaccharides – 1) Oxidation to produce aldonic,	

		aldaric and Uronic acid (only w.r.t glucose), 2) Osazone (only w.r.t glucose and fructose), 3) Reducing action of sugar in boiling alkaline medium (enediol formation) - only w.r.t glucose and fructose, 4) Orcinol (for ribose)	
	3.2	Disaccharides - Occurrence and structure of maltose, lactose, sucrose	
	3.3	Polysaccharides- Classification based on function (storage & structural), composition (homo & hetero) giving examples. Storage polysaccharrides (Starch and Glycogen), action of amylase on starch.	
	3.4	Structural polysaccharides - Cellulose, Chitin and Peptidoglycan frame work. (With structures of NAG & NAMA)	
	3.5	Extracellular matrix proteoglycan - Hyaluronate, Chondroitin sulphate and Heparin (function and structure).	

IV	**4.0**	**Ionic Equilibria and Acids, Bases, Buffers & Radioactivity**	**15**
	4.1	**Ionic Equilibria and Acids, Bases, Buffers** :	
	4.1.1	Importance of water as solvent: Kw Concept of acids, bases: pH, pK	
	4.1.2	Concept of buffer and buffering capacity, Derivation of Hendersen –Hasselbalch equation	
	4.1.3	Amino acids as buffers: Titration and ionization of Gly, Lys and Asp and relation between IEpH, pHm and pKa values of these amino acids, Sorensen's reaction and formol titration of amino acids (Ala).	
	4.1.4	Physiological Buffers - Hb – Carbonate buffer, phosphate buffer and protein buffer.	
	4.1.5	pH meter, glass electrode.	
	4.1.6	Numerical problems based on above concepts.	
	4.2	**Radioactivity**	
	4.2.1	Definition – Radioactivity, types of emissions, decay constant, half-life period, applications of radioisotopes in biological studies: – Metabolic pathway (glycolysis, TCA, Urea) w.r.t ^{14}C, ^{15}N, Molecular biology studies w.r.t ^{32}P, Clinical studies (w.r.t.^{131}I in hypo/hyperthyroidism detection)	
	4.2.2	Radioisotopes in distribution studies and therapeutics	

Semester V

COURSE TITLE: **METABOLISM, NUTRITION AND ADVANCED BIOCHEMICAL CONCEPTS - I**

COURSE CODE: **US3BCH502**

CREDITS: 2.5

Learning Objectives:

- The objective of this paper is to familiarize the learner with the concepts of nutrition.
- This paper also aims to acquaint the learner with the life processes like digestion and absorption of biomolecules like carbohydrates and proteins and the reactions/pathways involved in their oxidation and biosynthesis.
- The learners will also be exposed to an introduction to the branch dealing with the protective mechanisms/defense processes, immunology; branch dealing with the blue print of our cells and perpetuation of life, genetics; and application based industrial biotechnology.
- As statistics is an indispensable tool for a biochemist, the paper aims to lay a foundation for learning statistics during higher studies.

Learning Outcome:

At the end of the course the learner should

- be able to familiarize with the important components of food and learn the techniques and tools employed for nutritional assessment.
- understand basic concepts related to metabolism, be familiar with the various metabolic pathways and should be able to appreciate the importance of enzymes and coenzymes in pathophysiology of diseases.
- be acquainted with basics of immunology and application based industrial Biochemistry.
- be able to appreciate the experiments carried out by various scientists to prove DNA as the genetic material and understand the mechanisms of DNA replication, transcription and translation in prokaryotes.
- be able to perform statistical analysis of experimental results.

Unit No.	Topic No.	Topic	No. of L
I	**1.0**	**Nutrition and Biostatistics**	**15**
	1.1	**Nutrition**	
	1.1.1	Definition-Calorie and Joule	
	1.1.2	Food calorimetry-calorific value by Bomb calorimeter, calorific values of proximate principles, concept of BMI, BV and PER.	

	1.1.3	BMR- definition, factors affecting BMR, significance of BMR in clinical diagnosis.	
	1.1.4	SDA - General concept and significance, energy requirement of individuals for various activities-sedentary, moderate and heavy.	
	1.1.5	Nutritional significance of carbohydrates, protein, lipids, vitamins, minerals and water.	
	1.1.6	Numerical problems based on above concepts	
	1.2	**Biostatistics**	
	1.2.1	Data-collection and presentation.	
	1.2.2	Frequency distribution, normal distribution	
	1.2.3	Measures of central tendency – Mean (Arithmetic), Median and Mode.	
	1.2.4	Measures of variation - Range, Variance and Standard deviation.	
	1.2.5	Numerical problems based on above concepts to the biological data.	
II	**2.0**	**Carbohydrate metabolism**	**15**
	2.1	Digestion and absorption of carbohydrates	
	2.2	An introduction to carbohydrate metabolism: -Glycolysis - Cellular location, sequence of reactions, labeling of C-atoms and energetics of glycolysis (aerobic and anaerobic) Krebs cycle: Cellular location, sequence of reactions, and energetics	
	2.3 2.3.1 2.3.2 2.3.3 2.3.4	Other pathways of glucose metabolism HMP Shunt (Synthesis of pentose phosphates)-Cellular location, sequence of reactions, oxidative and non-oxidative phases of pathway and multifunctional nature. Glycogenesis and glycogenolysis Gluconeogenesis Glyoxylate pathway.	
	2.4	Anaplerotic reactions –Pyruvate carboxylase, PEP carboxykinase, Malic enzyme, role of Kreb's cycle in anabolism	
III	**3.0**	**Amino acids and Protein Metabolism and Immunology**	**15**
	3.1	**Amino acids and Protein Metabolism**	
	3.1.1	Digestion and absorption of proteins	
	3.1.2	Reactions of amino acids –Transamination (GOT/GPT and mechanism of transamination), Decarboxylation (His, Trp, Glu and mechanism of decarboxylation). Deamination: Oxidative – Glu, Tyr; Nonoxidative – Asp, Cys, Ser.	
	3.1.3	Formation and transport of ammonia and ammonia toxicity Urea Cycle - Cellular location, sequence of reactions, labeling of N-atom	

	3.2	**Immunology**	
	3.2.1	Immunity, types of immunity, An introduction to antigen, hapten and antibody.	
	3.2.2	Cells and organs of immune system.	
	3.2.3	Immunoglobulins basic structure, classes and sub-classes-their structure and functions.	
	3.2.4	Antigen– antibody reactions - Precipitation, agglutination.	
IV	**4.0**	**Genetics and Industrial Biotechnology**	**15**
	4.1	**Genetics**	
	4.1.1	Replication of DNA - mechanism of replication, modes of DNA replication, semi-conservative replication, discontinuous DNA synthesis, termination of replication.	
	4.1.2	Transcription of DNA - in prokaryotes, prokaryotic RNA polymerases, synthesis of RNA species and their processing, concept of split genes, reverse transcription.	
	4.1.3	Translation (protein biosynthesis) in prokaryotes - activation of amino acids, chain initiation, chain elongation, chain termination, post translational modifications of proteins.	
	4.2	**Industrial Biotechnology**	
	4.2.1	Concept of fermentation, general process overview, steps involved in setting up an industrial fermentation process basic component of a typical fermenter, fermentation process for alcohol / wine/beer production**.**	
	4.2.2	An introduction to Plant tissue culture - definition of totipotency, callus regeneration, protoplast fusion and techniques and application of plant tissue culture in brief.	

PRACTICALS based on US3BCH501 & US3BCH502
US3BCHP05

Sr No.	Experiments
I	**Isolation:**
	1.Casein from milk 2. Starch from potato.
	Colorimetric estimations:
	1.Proteins by Biuret method 2.RNA by Orcinol method 3.Glucose by Folin –Wu method/ by GOD- POD method
III	**Volumetric estimations:**
	1.Lactose by Cole's method 2.Vitamin C by iodimetric method 3.Glucose by Benedict's method
IV	**Qualitative Analysis:**
	1.Carbohydrates - Glucose, Fructose, Maltose, Lactose, Sucrose, Starch, Dextrin. 2.Proteins - Albumin, Casein, Gelatin, Peptone.
V	**Viva-Voce:**
	Based on fundamental concepts covered in practicals.
VI	**Journal:**
	Duly signed by the Teacher –in –charge and certified by the - Head of the department.
VII	**Demonstration Experiment**
	(To be entered in the Journal but not to be asked in the university Practical Examination) 1. TLC of oils and plant pigments 2. Preparation of buffers and use of pH meter

Semester VI

COURSE TITLE: **BIO-ORGANIC AND BIOPHYSICAL CHEMISTRY II**

COURSE CODE:**US3BCH601**

CREDITS: 2.5

Learning objectives:

- This paper aims that the learner learns the types, chemistry and reactions of lipids.
- The learner should be familiarized with various separation and analytical techniques used to study the biomolecules i.e. the principle and biochemical applications of i.e. Chromatography, Spectrophotometry, Centrifugation and Electrophoresis.

Learning outcome:

At the end of the course the learner should

- be well versed with the classes of lipids, their structure and biochemical functions.
- have learnt the principle, working and applications of various analytical techniques.
- be able to appreciate the contribution of these techniques (chromatography, colorimeter/spectrophotometer, centrifuges and electrophoresis) as tools in understanding the structure and function of biomolecules.

Unit No.	Topic No.	Topic	No. of L
I	**1.0**	**Lipids**	**15**
	1.1	Definition and Bloor's Classification of lipids.	
	1.2	Fatty acids & Tri acyl glycerols: Saturated fatty acids – definition, classification of C2 and C20 (only even C chain fatty acids) Unsaturated fatty acids – MUFA, PUFA (2,3,4 db), Omega 3, Omega 6 and Omega 9 fatty acids. Triacylglycerol - Simple and mixed	
	1.3	Chemical reactions - Saponification, Iodination, Ozonolysis, Auto-oxidation, Phospholipases, action of heat on glycerol and choline, Rancidity of fats. Definition and significance - Acid Number, Saponification Number, Iodine Number and Reichert-Meissel Number.	
	1.4	Compound lipids – Structure and function of Glycerophospholipids (Cephalin, Lecithin and Phosphotidyl inositol), Phosphosphingolipids (ceramide, Sphingomyeline), Glycolipids or Cerebrocides (Galacto and Glucocerebrocides).	

	1.5	Steroids and Lipoproteins Steroids - Cholesterol structure and biochemical significance Lipoproteins –Types (Chylomicron, VLDL, LDL, HDL) and biochemical significance - Schematic depiction of interrelationship.	
II	**2.0**	**Chromatography**	
	2.1	**Chromatography:** Principle, instrumentation and working of- Partition chromatography (Paper), Adsorption chromatography (TLC and Column), Ion exchange chromatography (Column) and Gel filtration.	
	2.2	Introduction to GLC, HPLC and Affinity chromatography - Principles only	
	2.3	Applications of partition, adsorption, ion exchange and gel filtration chromatography techniques	
	2.4	Numerical problems based on above concepts	
III	**3.0**	**Electrophoresis**	**15**
	3.1	Principles of electrophoresis, Factors affecting the rate of migration of sample in electric field	
	3.2	Moving boundary and Zone electrophoresis; Components of electrophoresis unit/apparatus	
	3.3	Support media - paper, cellulose acetate, agar, agarose and polyacrylamide	
	3.4	Technique of electrophoresis with staining/visualization method • agarose electrophoresis for separation of DNA • Native PAGE for separation of proteins • SDS PAGE for molecular weight determination; • Discontinuous electrophoresis • Other applications of electrophoresis: blotting techniques- Southern, Northern, and Western.	
	3.5	Isoelectric focusing of proteins	
IV	**4.0**	**Centrifugation and Spectrophotometry**	**15**
	4.1	**Centrifugation**	
	4.1.1	Basic concept and principle of RCF and RPM, derivation of equation relating RCF and RPM, Nomogram	
	4.1.2	Types of centrifuges - Clinical, High Speed, Ultra –preparative and Analytical	
	4.1.3	Components and working of Analytical Ultracentrifuge (with diagram).	
	4.1.4	Applications of centrifugation – Use of preparative centrifuge in the separation of cell organelles by differential centrifugation, proteins by rate zonal centrifugation and nucleic acids by isodensity centrifugation.	

	4.1.5	Use of Analytical Ultracentrifugation in the determination of molecular weights (sedimentation velocity method), conformational studies and purity of a sample.	
	4.1.6	Numerical problems based on above concepts	
	4.2	**Spectrophotometry**	
	4.2.1	Principle and concept of lambda max, derivation and limitations of Beer-Lambert Law, molar extinction coefficient and its significance	
	4.2.2	Construction and working of simple colorimeter (single beam) and a UV/Vis spectrophotometer (double beam)	
	4.2.3	Application of Beer Lambert Law & Numerical problems based on above concepts.	

Semester VI

COURSE TITLE: **METABOLISM, NUTRITION AND ADVANCED BIOCHEMICAL CONCEPTS-II**

COURSE CODE: **US3BCH602**

CREDITS: 2.5

Learning Objectives

- This paper aims to acquaint the learner with the life processes like digestion and absorption of lipids and the reactions/pathways involved in their oxidation and biosynthesis.
- This paper also aims to acquaint the learner with oxidative phosphorylation, photophosphorylation and fixation of carbon dioxide.
- The learner will be introduced to an overview of the chemistry, action and physiological role of important hormones.
- The learner will also be introduced to application based Recombinant DNA Technology.
- The last unit of this paper introduces "Bioinformatics" and lays the foundation to comprehend Bioinformatics during higher studies.

Learning Outcome

At the end of the course the learner should

- be familiar with the metabolic pathways of lipids and should be able to appreciate the importance of enzymes and coenzymes in pathophysiology of diseases.
- be able to appreciate conversion of food energy and light energy to chemical energy though electron carriers and appreciate the correlation between energy molecules, reducing equivalents and pathways.
- be acquainted with the various hormones and their clinical significance.
- be familiar with the molecular biology of gene cloning, understand the basic tools & techniques and its applications for benefit of the society.
- be able to understand basics of bioinformatics.

Unit No.	Topic No.	Topic	No. of L
I	**1.0**	**Lipid Metabolism**	**15**
	1.1	Digestion and absorption of lipids	
	1.2	**Lipid Metabolism:** Catabolism - Knoop's experiment, Beta – Oxidation of even –Carbon saturated fatty acids and its energetics from C4 to C20	

	1.3	Anabolism - Fatty acid biosynthesis (only Palmitic acid) and role of fatty acyl synthetase complex. Ketone bodies formation, utilization, and physiological significance in Diabetes mellitus, starvation, alcoholism and pregnancy.	
II	**2.0**	**Bioenergetics and Photosynthesis**	**15**
	2.1	**Bioenergetics**	
	2.1.1	Definition of Free energy, respiratory electron transport chain, - basic chemistry, electron carriers, sequence - redox potentials, location of these electron carriers on mitochondrial membrane, Inhibitors of ETC –Antimycin A, Amytal, Rotenone, CN, Azide, CO.	
	2.1.2	Definition of Oxidative Phosphorylation, Structure of ATPase (F_oF_1 ATPase), Chemiosmotic hypothesis, Proton motive force.	
	2.2	**Photosynthesis**	
	2.2.1	**Photosynthesis:** Light and Dark reactions, Z-scheme and electron carriers, photophosphorylation (linear and cyclic), Calvin cycle (schematic representation only)	
III	**3.0**	**Endocrinology**	**15**
	3.1	Hormone, hormone receptor, Classification of hormones on the basis of chemistry; Hierarchical organization ; Chemistry, synthesis, secretion and metabolic effects of thyroxine, insulin; Chemistry & physiological role of oxytocin and vasopressin; Physiological role of Glucocorticoids; Mechanism of action of epinephrine (on glycogenolysis) and steroid hormone; Endocrine and other related disorders – Diabetes mellitus, Diabetes insipidus, Hypothyroidism (Cretinism & myxedema), Hyperthyroidism (Goiter – Simple & Toxic).	
IV	**4.0**	**Recombinant DNA technology and Bioinformatics**	**15**
	4.1	**Recombinant DNA technology**	
	4.1.1	Genetic engineering – Basis of DNA cloning, cloning vectors, isolation of gene from cellular chromosomes, gene library, DNA probes, DNA amplification by PCR (Cycle - with diagram , role of TAQ polymerase), techniques used (colony hybridization, blotting techniques) and applications of recombinant DNA technology in medicine (Insulin) and agriculture (Bt cotton).	
	4.2	**An introduction to Bioinformatics**	
	4.2.1	History of Bioinformatics and concept of genomics and proteomics	

	4.2.2	Databases- Definition & types – Public domain database, Sequence database, Structural database, Motif database, Genome database, Proteome database, Annotated sequence database. Full form & function in brief of – Gen Bank, EMBL, PIR, SWISS PROT, PDB, GDB.	
	4.2.4	Micro-array analysis-concept and applications.	
	4.2.5	Applications of Bioinformatics in – Sequence analysis, Molecular modeling and drug designing, Phylogeny/evolution, Ecology & population studies, Medical informatics and agriculture.	

PRACTICALS based on US3BCHP601 & US3BCHP602
US3BCHP06

I	**Chromatographic techniques:**
	Separation by Circular Paper Chromatography of: 1. Amino acids 2. Sugars
II	**Enzymes:**
	1. AMYLASE: • Activity of beta amylase • Km of amylase 2. UREASE: • Activity of urease • Km of urease
III	**Minerals Estimation:**
	1. Calcium by EDTA method 2. Magnesium by Titan Yellow method 3. Iron by Wong's method 4. Phosphorus by Fiske-Subbarow method
IV	**Viva- Voce:**
	Based on fundamental concepts covered in practicals.
V	**Journal:**
	Duly signed by the Teacher in charge and certified by the Head of the department.
VI	**Demonstration Experiments:**
	(To be entered in the Journal but not to be asked in the university Practical Examination) 1.Column chromatography - separation of chlorophylls 2.Agar/Agarose/PAGE gel electrophoresis of serum proteins

SCHEME OF EXAMINATION

Biochemistry, as an interdisciplinary subject, consists of 03 (Three) Units of T.Y.B.Sc. carrying 600 marks as follows:

COURSE CODE	Title of Paper	Semester end Examination marks	Total Marks
US3BCH501	Bio-organic and Biophysical Chemistry I	100	100
US3BCH502	Metabolism, Nutrition and Advanced Biochemical concepts I	100	100
	TOTAL		**200**
US3BCH601	Bio-organic and Biophysical Chemistry II	100	100
US3BCH602	Metabolism, Nutrition and Advance Biochemical concepts II	100	100
	TOTAL		**200**

PRACTICALS:		
COURSE CODE	**Marks per course**	**Total per semester**
US3BCHP05	100 for US3BCH501& US3BCH502	**100**
US3BCHP06	100 for US3BCH601 & US3BCH602	**100**
TOTAL		**200**

SCHEME OF PRACTICAL EXAMINATION
SEMESTER V

Course US3BCHP05	**Experiments**	**Marks**
	a. Isolation	20
	b. Colorimetric estimation	20
	c. Volumetric estimation	20
	d. Qualitative Analysis	20
	e. Certified Journal*	10
	f. *Viva voce*	10
	TOTAL	**100**

* Candidate without duly certified Journals **shall not** be allowed to appear for the University Practical Examination.

1. The Semester V practical examination shall be conducted by respective colleges on behalf of the University
2. There shall be 02 (Two) examiners to conduct the practical examination –one Internal examiner and other external examiner
3. The external examiner shall be on the panel of examiner approved by the University of Mumbai.
4. The college shall invite one such examiner from approved panel as an external examiner
5. Duration for the Practical examination for Semester V
   a) One days of 2 sessions of 3½ hours each.
   b) Morning session: 09.00 am to 12.30 pm.
   Afternoon session: 01.00 pm to 04.30 pm.

SCHEME OF PRACTICAL EXAMINATION

SEMESTER VI

Course US3BCHP06	Experiments	Marks
	a. Chromatographic separation	20
	b. Mineral Estimation	20
	c. Enzymology	20
	d. Interpretation and analysis of data provided	10
	e. Summary report of educational tour/Industrial visit/ Assignment	10
	f. Certified Journal*	10
	g. Viva voce	10
	TOTAL	**100**

* Candidate without duly certified Journals **shall not** be allowed to appear for the University Practical Examination.

1. The Semester VI practical examination shall be conducted by the University of Mumbai
2. There shall be 02 (Two) external examiners appointed by the University from the panel of approved examiners
3. Duration for the Practical examination for Semester VI
   a) One days of 2 sessions of 3½ hours each.
   b) Morning session: 09.00 am to 12.30 pm.
      Afternoon session: 01.00 pm to 04.30 pm.

Scheme of Examination for Third year Science Undergraduate students

Scheme of Theory examination at T.Y.B.Sc. (Semester V and Semester VI)

1) Each theory paper will be of **100** marks

2) Each theory paper will be of **3** hours duration

3) Each theory paper will contain **05** questions of **20** marks each as follows:

T.Y.B.Sc. theory question paper pattern with marks distribution

Q. No.	Unit /s	Sub Q.	Type and Choice	Marks	Total marks per question
1.	I	A	Four objective questions – fill in the blanks, match the columns etc.	04	20
		B	Short answers – any one out of two	04	
		C	Long answers – • Any two, out of three of 06 marks each • Any one out of two for 12/6+6/8+4 marks	12	
2.	II	A	Four objective questions – fill in the blanks, match the columns etc.	04	20
		B	Short answers – any one, out of two	04	
		C	Long answers – • Any two out of three of 06 marks each • Any one out of two for 12/6+6 /8+4 marks	12	
3.	III	A	Four objective questions – fill in the blanks, match the columns etc.	04	20
		B	Short answers – any one out of two	04	
		C	Long answers – • Any two out of three of 06 marks each • Any one out of two for 12/6+6/8+4 marks	12	
4.	IV	A	Four objective questions – fill in the blanks, match the columns etc.	04	20
		B	Short answers – any one out of two	04	
		C	Long answers – • Any two out of three of 06 marks each • Any one out of two for 12/6+6/8+4	12	

			marks		
5.	I - IV	A	Any four definitions etc. of 2 marks each; a or b from unit I, c or d from unit II, e or f from unit III, g or h from unit IV	08	20
		B	Any six true or false with justification of 02 marks each from units I to IV	12	

External Examination for practical

Sr. No.	**Particulars for External Practical Examination**		**Marks**
	Particulars for External Practical Examination Semester End Practical Examination		100 Marks
1	Laboratory Work	80 Marks	
2	Journal	10 Marks	
3	Viva	10 Marks	

Educational Tour/Industrial Visit

It is COMPULSORY that TYBSc students of Biochemistry MUST go for Educational Tour/ Industrial Visit in Mumbai/Maharashtra/other States in India to visit various Universities/ Research Centres/Industries (pharma, food, chemicals, biochemicals, beverages, oils etc.) to give the firsthand knowledge of current trends in research and the exposure to the working of industry, academia and research centres.

Summary Report of Educational Tour/Industrial Visit must be entered in the Journal as a part of Practical USBCHP602 for evaluation and such report shall carry 10 (TEN) marks separately at the University Practical Exam of P 602.

Or

Assignment

Student of TYBSc Biochemistry are required to complete an Assignment (10- 15 pages, handwritten or typed on A - 4 Size Paper and spiral- bound) on any of the Topics within the prescribed syllabus or related to the syllabus.

Such topics for the assignment may be selected by the students or assigned by the respective teachers to the students.

The Certified Assignment will have to be submitted for evaluation at the time of University Practical Exam of Semester VI as a part of USBCHP602 and shall carry 10 (TEN) marks separately in P 602.

Printed Journals

Use of Printed Journals for Semester V and Semester VI at T. Y. B. Sc. Biochemistry is permitted.

Suggested Reading

1. Biochemistry by Lehninger, Albert L.; Kalyani publishers.
2. Principles of Biochemistry by Lehninger, Albert L., Nelson David and Cox, Michael M.; CBS publishers.
3. Principles of Biochemistry by Lehninger, Albert L., Nelson David and Cox, Michael M.; CBS publishers.
4. Biochemistry by Voet, Donald and Voet, Judith G.; John Wiley & sons publishers.
5. Biochemistry by Zubay, Geoffrey L.; Wm. C. Brown publishers
6. Biochemistry by Stryer, Lubert; W.H. Freeman publishers.
7. Principles of biochemistry by White, Abraham; Handler, Philip and Smith, Emil L.; Mc Graw and Hill publishers.
8. Harpers illustrated biochemistry by Murray, Robert K. *et al*.; Mc Graw Hill.
9. Harpers illustrated biochemistry by Murray, Robert K. *et al*.; Mc Graw Hill.
10. A biologists guide to principles and techniques in practical biochemistry by William, B.L. and Wilson, K; Universities press publishers.
11. Principles and techniques of practical biochemistry by Wilson, Keith and Walker, John ; Cambridge University Press publishers
12. Tools of biochemistry by Cooper, Terence G.; Wiley & Sons publishers.
13. Outlines of Biochemistry by Conn, E.E. and Stumpf, P.K.; Wiley publications.
14. Introduction to practical biochemistry by Plummer, David T.; Tata Mc. Graw and Hill publishers.
15. Modern experimental biochemistry by Boyer, Rodney F.
16. Introductory practical biochemistry by Sawhney, S.K. and Singh, Randhir; Narosa Publishing House.
17. Biochemical calculation by Segel, Irwin H.; John Wiley & Sons publishers.
18. Text book of Medical physiology by Guyton, Arthur C. and Hall, John E.; Harcourt Brace & Company Asia Pvt Ltd.
19. Human biochemistry by Orten, J.M. and Neuhaus, O.W.; Mosby publishers.
20. Human nutrition and dietetics by Davidson, S. *et al.*; Churchill Livingstone Publishers.
21. Nutrition and dietetics by Joshi, Shubhangini A.; Tata Mc Graw and Hill publishers.
22. Nutrition Science by Srilakshmi, B.; New Age International publishers.
23. Genes VIII by Lewin, Benjamin; Pearson Prentice and Hall publishers.

24. Genetics by Russell, Peter J.; Benjamin Cummings publishers.
25. Immunology by Kuby, Janis; W.H. Freeman publishers.
26. Immunology by Roitt, Ivan M. *et al*.; Mosby publishers.
27. Fundamentals of biotechnology by Patel, A. H.
28. Industrial microbiology by Casida, L.E.; New Age International publishers.
29. Methods of biostatistics for medical students and research workers by Mahajan, B.K.; Jaypee brothers publishers.
30. Bioinformatics- Concepts, Skill and applications by Rastogi, S.C.; Mendiratta, Namita and Rastogi, Parag; C.B.S. Publishers & Distributors
31. Gene biotechnology by Jogland.
32. Essentials of biotechnology by Gupta