Department of Biochemistry
Mahatma Phule Krishi Vidyapeeth
Rahuri-413 722, Dist. Ahmednagar (MS)

Master's Programme in Biochemistry

Course Layout

Minimum Credit Requirements

Sr. No.	Subject	Minimum credit(s)
1.	Major	21
2.	Minor	09
3.	Supporting	05
4.	Seminar	01
5.	Research	20
	Total Credits	56
	Compulsory Non Credit Courses	06

Sr. No.	Course Number	Course Title	Credits
A) Major Subjects (Min. 21 credits)			
1	BIOCHEM 501	BASIC BIOCHEMISTRY	2+1=3
2	BIOCHEM 502	INTERMEDIARY METABOLISM	3+0=3
3	BIOCHEM 503	ENZYMOLOGY	2+1=3
4	BIOCHEM 504	MOLECULAR BIOLOGY	2+1=3
5	BIOCHEM-505	TECHNIQUES IN BIOCHEMISTRY	1+2=3
6	BIOCHEM 507	PLANT BIOCHEMISTRY	3+0=3
7	BIOCHEM 510	CARBON AND NITROGEN METABOLISM	2+1=3
		Total	**15+6=21**
B) Minor Subjects (Min. 9 credits)			
1	MICRO 501	MICROBIAL GENETICS	2+1=3
2	FST 523	NEUTRACEUTICALS AND HEALTH FOODS	2+1=3
3	PP 503	PHYSIOLOGICAL AND MOLECULAR RESPONSES	2+1=3

		OF PLANTS TO ABIOTIC STRESSES	
		Total	6+3=9
C) Supporting Subjects (Min. 5 credits)			
1	STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	2+1=3
2	MBB 508	GENOMICS AND PROTEOMICS	2+0=2
		Total	**4+1=5**
D) Seminar (01 credit)			
1	BIOCHEM 591	MASTER'S SEMINAR	1+0=1
		Total	**1+0=1**
E) Master's Research (20 credits)			
1	BIOCHEM 599	MASTER'S RESEARCH	0+20=20
F) Non Credit Compulsory Courses			
1	PGS 501	LIBRARY AND INFORMATION SERVICES	0+1=1
2	PGS 502	TECHNICAL WRITING AND COMMUNICATION SKILLS	0+1=1
3	PGS 503	INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE	1+0=1
4	PGS 504	BASIC CONCEPTS IN LABORATORY TECHNIQUES	0+1=1
5	PGS 505	AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES	1+0=1
6	PGS 506	DISASTER MANAGEMENT	1+0=1
		Total	**3+3=6**

Course Contents

BIOCHEM 501 BASIC BIOCHEMISTRY 2+1

Theory:

UNIT I

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.

UNIT II

Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids.

UNIT III

Structure and biological functions of vitamins, enzymes classification and mechanism of action; regulation, factors affecting enzyme action. Hormones- animal plants and insects, Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

UNIT IV

Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology

Practical:

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by phenylamine and orcinol methods. Estimation of ascorbic acid, separation of biomolecules by TLC and paper chromatography.

Suggested Readings:

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry.* John Wiley.

Metzler DE. 2006. *Biochemistry.* Vols. I, II. Wiley International.

Nelson DL & Cox MM. 2004. *Lehninger Principles of Biochemistry*. 4th Ed. MacMillan.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry.* JohnWiley.

BIOCHEM 501 BASIC BIOCHEMISTRY 2+1

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No of Lecture	Weightage (%)
1	Scope and importance of biochemistry in agriculture	1	3
2	Fundamental principles governing life	1	3
3	Structure of water, acid-base concept	1	3
4	Buffer and pH, hydrogen bonding, hydrophobic, electrostatic and van der Waals forces	1	4
5	Fundamentals of thermodynamic principles applicable to biological processes, bioenergetics	2	5
6	Classification, structure and functions of carbohydrates	1	5
7	Metabolism of carbohydrates	2	6
8	Electron transport chain and oxidative phosphorylation	1	6
9	Photosynthesis	2	6
10	Classification, structure and functions of lipids Metabolism of lipids	2	4
11	Classification, structure and functions of amino acids and proteins. Metabolism of proteins	2	6
12	Structure, biological functions and classification of vitamins	1	4
13	Enzyme classification, factors affecting on enzyme action	1	4
14	Mechanism of enzyme action	2	4
15	Regulation of enzyme activity	1	4
16	Hormones: animals, plants and insects	2	4
17	Structure and functions of nucleic acids	1	5
18	Metabolism of nucleic acids	2	5
19	DNA replication	1	5
20	DNA transcription	2	4
21	Translation	2	5
22	Recombinant DNA technology	1	5
	Total	**32**	**100**

BIOCHEM 501 BASIC BIOCHEMISTRY 2+1

Lesson Plan (Theory)

Lecture No	Name of the topics
1	Scope and importance of biochemistry in agriculture-Origin of biochemistry, details of the contributions of various biochemists
2	Fundamental principles governing life-Cellular foundation, chemical foundation, physical foundation ,genetic, evolutionary
3	Structure of water-Physical and chemical properties of water, suitability of

	water as a solvent for a living cell ,acid-base concept
4	Buffers and pH, bonds and various forces-Definition of buffer, suitability of buffer for various bimolecular extractions, strength and molarity of buffer, definition of pH, Handerson-Hasselbalch equation, hydrogen bonding, hydrophobic bond, electrostatic bond, van der Waals forces,
5	Fundamentals of thermodynamic principles applicable to biological processes, bioenergetics, entropy, enthalphy, Gibbs equation
6	Classification, structure and functions of carbohydrates
7	Metabolism of carbohydrates- glycolysis, TCA cycle, pentose phosphate pathway, glyoxylate cycle, sucrose synthesis, glucose and fructose synthesis
8	Electron transport chain and oxidative phosphorylation
9	Photosynthesis-structure of chloroplasts, photosystem I and photosystem II
10	Classification, structure and functions of lipids
11	Metabolism of lipids- β-oxidation of fatty acids, synthesis of fatty acids by acyl carrier protein
12	Classification, structure and functions of amino acids and proteins
13	Metabolism of proteins: protein degradation and protein synthesis
14	Structure, biological functions and classification of vitamins
15	Enzyme Classification, factors affecting enzyme activity: substrate concentration, enzyme concentration, temperature and pH
16	Mechanism of enzyme action : Ribonuclase A, chymotrypsin, lysozyme
17	Regulation of enzyme activity- Allosteric enzyme, covalent modification, kinetic properties of enzymes, proteolytic cleavage of enzymes
18	Hormones: animals, plants and insects-Diverse structure & functions, action through specific high affinity cellular receptors, insulin, glucagon, epinephrine.
19	Structure and functions of nucleic acids-double helix structure of DNA, nitrogenous bases, DNA as the genetic material.
20	Metabolism of nucleic acids-nucleotide synthesis
21	DNA replication
22	DNA transcription
23	Translation of genetic information
24	Recombinant DNA technology-Total RNA isolation, cDNA synthesis, cloning of cDNA in a vector

BIOCHEM 501 BASIC BIOCHEMISTRY 2+1

Lesson Plan (Practical)

Sr. No.	Name of the practical	No. of practical classes	Weightage (%)
1.	Preparation of standard and buffer solutions	2	10
2.	Estimation of reducing sugars by Nelson-Somogyi method	1	12

3.	Estimation of free amino acids by ninhydrin method	1	12
4.	Estimation of protein by Lowry method	2	15
5.	Isolation of DNA and its quantification	3	15
6.	Estimation of ascorbic acid	1	12
7.	Isolation of RNA and its quantification	2	12
8.	Separation of amino acid by TLC	2	8
9.	Separation of amino acids by paper chromatography	2	4
	Total	**16**	**100**

BIOCHEM 502 INTERMEDIARY METABOLISM 3+0

Theory:

UNIT I

The living cell a unique chemical system, Introduction to metabolism, methods of studying metabolism, transport mechanism, bioenergetics, biological oxidation, signal transduction.

UNIT II

Catabolic and anabolic pathways of carbohydrates, lipids, regulation and their metabolic disorders. Energy transduction and oxidative phosphorylation.

UNIT III

General reactions of amino acid metabolism, Degradative and biosynthetic pathways of amino acids and their metabolic disorders. Sulphur metabolism, Metabolic engineering concepts.

UNIT IV

Compartmentation of metabolic pathways, metabolic profiles of major organs and regulation of metabolic pathways.

Suggested Readings:

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry.* 5th Ed. WH Freeman

Metzler DE. 2006. *Biochemistry.* Vols. I, II. John Wiley.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry.* John Wiley.

Zubey GL. 1998. Biochemistry. 4th Ed. WCB London.

BIOCHEM 502 Intermediary Metabolism 3+0

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No of Lectures	Weightage (%)
1	The living cell, unique chemical system, introduction to metabolism, methods of studying metabolism.	02	7
2	Transport mechanism	02	5
3	Bioenergetics, biological oxidation	05	10
4	Signal transduction	02	6
5	Catabolic and anabolic pathways of carbohydrates, regulation and their metabolic disorders.	08	15
6	Catabolic and anabolic pathways of lipid, regulation and their metabolic disorders	07	12
7	Energy transduction and oxidative phosphorylation	05	10
8	General reactions of amino acid metabolism	02	5
9	Degradative and biosynthetic pathways of amino acid their metabolic disorders.	05	10
10	Sulphur metabolism	02	5
11	Metabolic engineering concepts	02	5
12	Compartmentation of metabolic pathways	02	5
13	Metabolic profiles of major organs and regulation of metabolic pathways.	04	5
	Total	**48**	**100**

BIOCHEM 502 Intermediary Metabolism 3+0

Lesson Plan (Theory)

No. of Lecture	Name of the topics
1	The living cell, unique chemical system
2	Introduction to metabolism: catabolism and anabolism, methods of studying metabolism-types, regulation
3	Transport mechanism: Introduction to membrane, membrane permeability, passive transport.
4	Active transport: ATP-driven active transport, action of Na^+/K^+-ATPase, ion driven transport, glucose transport into intestinal epithelial cells, glucose rehydration therapy, exocytosis, endocytosis, picocytosis, receptor mediated- endocytosis.
5	Bioenergetics: General concepts of thermodynamics, free energy, enthalpy

	and entropy
6	Exergonic and endergonic reaction, their coupling.
7	Equilibrium constant
8	ΔG, ΔG^0
9	High-energy compounds
10	Signal transduction: cell signaling hormones
11	Cell- surface receptors, secondary messengers
12	Carbohydrate metabolism: Glycolysis, fates of pyruvate, inhibitors of glycolysis and regulation of glycolysis
13	TCA cycle and its regulation
14	Gluconeogenesis, glyoxylate cycle,
15	Glycogen metabolism, glycogenesis, glucogenolysis
16-17	Starch synthesis, sucrose synthesis, interconversion of starch and sucrose and its regulation
18	HMP shunt, Entner-Doudoroff pathway
19	Regulation of carbohydrate metabolism
20	Lipid metabolism: Fatty acid oxidation: β-oxidation in mitochondria, oxidation of palmitate, oxidation of odd chain of fatty acids
21	Oxidation of unsaturated fatty acids (one double bond and two double bond)
22	β-oxidation of fatty acids in peroxisomes, regulation of fatty acid oxidation
23	α-and ω-oxidation of fatty acids, formation of ketone bodies
24	Biosynthesis of fatty acids and regulation
25	Elongation of saturated fatty acids, desaturation of fatty acid chain
26	Biosynthesis of triacylglycerol, metabolism of phospholipids, synthesis of spingolipids, degradation of spingomyelin
27	Energy transduction and oxidative phosphorylation: Redox potential, electron transport from NADH
28	Formation of an H^+ gradient, electron transport from $FADH_2$, electron transport inhibitors
29	Oxidative phosphorylation, ATP synthesis as a rotatory engine
30	Coupling and respiratory control,
31	Uncouplers, reoxidation of cytosolic NADH
32	Overview of catabolism of amino acids, urea cycle, metabolic fates of amino groups
33	General aspects of amino acid metabolism (transamination and deamination)
34-35	Pathways for amino acid degradation: ten amino acids degraded to acyl CoA five amino acids are converted to α-ketoglutarate, four amino acids are converted to succinyl CoA, two amino acids are degraded to oxaloacetate
36	Biosynthesis of amino acids: α-ketoglutarate to glutamine, glutamate, proline and arginine, 3-phosphoglycarate to glycine, serine and cysteine
37	Three non-essential and six essential amino acids are synthesized from oxaloacetate and pyruvate.
38	Three amino acids synthesis from PEP and erythrose 4-phosphate, histidine biosynthesis, regulation of amino acids synthesis
39-40	Sulphur metabolism: sulphur assimilation, transport and reduction, sulphur cycle

41	Modulation of specific metabolic pathways,
42	Gene silencing by antisense RNA technology
43	Gene activation for enhanced expression coding for important regulatory enzymes
44	Compartmentation of metabolic pathways: Metabolic pathways in peroxisomes and glyoxysomes, metabolic pathways operating in mitochondria
45	Compartmentation of glycolytic and glycolgenolytic metabolism.
46-47	Metabolic profiles of major organs and regulation of metabolic pathways: Organ specialization and metabolic integration (liver, adipose tissue, skeletal muscles, brain, blood)
48	Regulation of metabolism

BIOCHEM 503 ENZYMOLOGY 2+1

Theory:

UNIT I

Introduction and historic perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, isolation and purification of enzymes, measurement of enzyme activity. ribozymes, isozymes, abzymes,

UNIT II

Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. cofactors, coenzymes- their structure and role.

UNIT III

Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes, allosteric enzymes and their kinetics, regulation of enzyme activity.

UNIT IV

Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Practical:

Enzyme assay by taking any model enzyme like alpha-amylase or acid phosphatase, isolation and purification of any model enzyme like alpha amylase or acid phosphatase, study of the effect of enzyme and substrate concentrations and determination of Km and Vmax, determination of pH 32 and temperature optima and effect of various inhibitors, determination of the pH and temperature stability of enzyme.

Suggested Readings:

Bergmeyer HU. 1983. *Methods of Enzymatic Analysis*. Vol. II. Verlag Chemie, Academic Press.

Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. *Enzyme*s. 3rd Ed. Longman.

Maragoni AG. 2003. *Enzyme Kinetics - A Modern Approach*. John Wiley.

Palmer T. 2001. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. 5th Ed. Horwood Publ.

Price NC & Stevens L. 2003. *Fundamentals of Enzymology*. Oxford Univ. Press.

Wilson K & Walker J. (Eds.). 2000. *Principles and Techniques of Practical Biochemistry*. 5th Ed. Cambridge Univ. Press.

Thimmaiah SK, 1999. *Standard Methods of Biochemical Analysis* , Kalyani Publication, New Delhi.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

BIOCHEM 503 ENZYMOLOGY 2+1

Teaching Schedule (Theory)

Sr. No.	Name of the topics	No of Lecture	Weightage (%)
1	History, importance and scope of enzymes	2	**5**
2	Enzyme nomenclature, classification and compartmentalization in cell organelles	2	**5**
3	Basic principles of enzyme isolation, purification and measurement of enzyme activities	3	**10**
4	Enzyme structure, specificity and concept of active site	2	**5**
5	Concept of free energy, transition state, activation energy in relation to enzymatic catalysis	2	**5**
6	Concept of cofactors, prosthetic group, their structures and functions	2	**10**
7	Enzyme kinetics: Michaleis- Menten Equation, Lineweaver- Burk plot, Vmax and its significance.	3	**12**
8	Enzyme inhibition: competitive non-competitive, un-competitive and irreversible inhibitions	3	**10**
9	Multienzyme systems and complexes and regulation of their activities	2	**5**
10	Allosterc enzymes, kinetics and their regulation	2	**12**
11	Regulation of enzyme activity	2	**5**
12	Meaning of isozymes, abzymes, ribozymes and their importance	2	**4**
13	Applications of enzymes in agriculture, food industry, medicine and chemical industry	2	**5**
14	Enzyme immobilization: methods, advantages and disadvantages	2	**5**
15	Biosensors and its applications	1	**2**
	Total	**32**	**100**

BIOCHEM 503 ENZYMOLOGY 2+1

Lesson Plan (Theory)

Lecture No.	Name of the topics
1	Historical development in the field of enzymology
2	Importance and scope of enzymes
3	Enzyme nomenclature and classification
4	Compartmentalization of enzymes in cell organelles
5	Principles of enzyme isolation and purification
6	Measurement of enzyme activity
7	Enzyme structure stability and specificity
8	Concept of active site of an enzyme
9	Orientation of enzyme and enzyme activity
10	Basic principles of thermodynamics and concept of free energy
10	Transition state and activation energy in relation to enzymatic catalysis
11	Enzyme co-factors: meaning, types and their functions
12	Enzyme prosthetic groups, co-enzymes: structure and functions
13	Enzyme kinetics: Michaleis- Menten Equation,
14	Enzyme kinetics: Lineweaver Burk Plot, Lineweaver Equation
15	Km, Vmax and their significance
16	Irreversible enzyme inhibition: meaning, type and example
17	Reversible enzyme inhibition: meaning, type and example
18	Multienzyme systems and complexes
19	Regulation of multienzyme activities
20	Allosteric enzymes : Meaning and their kinetics
21	Regulation of allosteric enzymes
22	Meaning and importance of isozymes, ribozymes
23	Meaning and importance of abzymes
24	Applications of enzymes in food, agriculture and medicines
25	Meaning, importance of enzyme immobilization
26	Applications of immobilized enzymes
27	Methods of enzyme immobilization, merits and demerits
28	Biosensors: meaning and its applications
29	Clinical applications of enzymes

BIOCHEM 503 ENZYMOLOGY 2+1

Practical

Practical No.	Name of the topics
1,2	Isolation and estimation of amylase activity from germinating seeds
3	Estimation of optimum temperature of amylase enzyme
4	Estimation of optimum pH of amylase enzyme
5	Estimation of V max of amylase enzyme
6	Estimation of Km value for amylase enzyme
7,8	Isolation and estimation of polyphenol oxidase activity
9,10	Isolation and estimation of peroxidase activity
11,12	Isolation and estimation of alkaline phosphatase from sugar cane juice
13.14	Isolation and estimation of acid phosphatase from sugar cane juice
15,16	Isolation and estimation of P5CS activity from stressed seedlings

BIOCHEM 504 MOLECULAR BIOLOGY 2+1

Theory:

UNIT I

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function.

UNIT II

DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing.

UNIT III

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases' inhibitors of replication, transcription and translation; translation and Post translational modification; nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation.

UNIT IV

DNA sequencing, recombinant DNA technology, vectors, isolation of genes, Recombinants vector, selection of recombinants, PCR; general features of replication, transcription, site directed mutagenesis and translation in eukaryotes.

Practical:

Isolation and purification of DNA and RNA from different sources, check of purity of isolated DNA and RNA, restriction fragmentation and separation of oligos by agarose electrophoresis, RAPD analysis of DNA, cDNA synthesis using PCR, Southern and Northern blotting experiments

Suggested Readings:

Adams RLP, Knowler JT & Leader DP. 1992. *The Biochemistry of the Nucleic Acids*. 11th Ed. Chapman & Hall.

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD 2006. *Molecular Biology of the Cell*. 6th Ed. Garland Publ.

Blackburn GM & Gait MJ. 1996. *Nucleic Acids in Chemistry and Biology*. 2nd Ed. Oxford University Press.

Freifelder D & Malacinski GM. 1996. *Essentials of Molecular Biology*. 3rd Ed. Panima.

Glick BR & Pasternak JJ. 1994. *Molecular Biology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Lewin B. 2007. *Genes* IX. Oxford University Press.

Lodish H, Berk A, Zipursky SA, Matsudaira P, Baltimore D & Darnell J. 1999. *Molecular Cell Biology*. WH Freeman.

Old RW & Primrose SB. 1989. *Principles of Gene Manipulation*: *An Introduction to Genetic Engineering*. 4th Ed. Blackwell Scientific Publ.

Sambrook J & Russel DW. 2001. *Molecular Cloning: A Laboratory Manual*. Vols. I-III. Cold Spring Harbor.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

BIOCHEM 503 MOLECULAR BIOLOGY 2+1

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No of Lecture	Weightage (%)
1	Historical development of molecular biology-nucleic acids as genetic material	2	**5**
2	Chemistry and structure of DNA and RNA	3	**10**
3	Genome organization in prokaryotes and eukaryotes, chromatin structure and function	3	**10**
4	DNA replication, DNA polymerase, topoisomerase, DNA ligase, reverse transcriptase, repetitive and non-repetitive DNA, satellite DNA	3	**15**
5	Transcription , RNA editing and RNA processing	2	**10**
6	Ribosome- structure, function and organization	1	**5**
7	Genetic code , mechanism of protein biosynthesis in prokaryotes and eukaryotes and post translational modifications in eukaryotes	3	**10**
8	Inhibitors of replication, transcription and translation	2	**5**
9	Gene expression in prokaryotes and eukaryotes,	3	**10**

10	Restriction enzymes and vectors	2	**5**
11	Recombinant DNA technology, recombinant vectors and selection of recombinants	3	**5**
12	PCR	1	**2**
13	Molecular mechanism of mutation and site directed mutagenesis	2	**3**
14	DNA sequencing	2	**5**
	Total	**32**	**100**

BIOCHEM 504 MOLECULAR BIOLOGY 2+1

Lesson Plan (Theory)

Lecture No.	Name of the topics
1	Historical development of molecular biology
2	Nucleic acids as genetic material
3	Structures of nitrogen bases, nucleoside, nucleotides-chemistry of nucleic acids and hydrogen bonding
4	Structure of DNA, Watson –Crick model
5	Types of RNA- differences between prokaryotes and eukaryotes, function of RNA
6	Genome organization in prokaryotes
7	Chromatin structure
8	Genome organization in eukaryotes
9	DNA replication, semi conservative mechanism
10	Enzymatic mechanisms of DNA replication, role of various enzymes during DNA replication
11	Repetitive and non-repetitive DNA
12	Transcription , RNA polymerase structure, functions and steps
13	Regulation of transcription, RNA editing and processing
14	Ribosome- types, structure, function and organization of ribosomal proteins
15	Genetic code- properties and codon assignment, amino acyl- tRNA synthetase (Wobble hypothesis)
16	Protein biosynthesis in prokaryotes
17	Protein biosynthesis in eukaryotes
18	Post translational modifications
19	Inhibitors of DNA replication and transcription
20	Inhibitors of translation in prokaryotes and eukaryotes
21	Operon- system of positive and negative control, indication and repression
22	Lactose, arabinose and galactose operon
23	Tryptophan operon and attenuation control of gene regulation in eukaryotes,
24	Restriction enzymes, types, specificity, enzyme units, restriction modification system
25	Vectors- plasmids, cosmids and bacteriophages

26	Basic steps in recombinant DNA technology
27	Isolation of genes and cloning strategies
28	Recombinant plasmids and methods for selection of recombinants
29	Polymerase chain reaction
30	Mutation- types, transition, transversion, point mutation, chromosomal abberation
31	Site directed mulagenesis
32	DNA sequencing methods

BIOCHEM 504 MOLECULAR BIOLOGY 2+1

Practical

Practical No.	Name of the topic
1,2	Isolation and purification of plant genomic DNA
3-5	Isolation and purification of RNA from plant tissues and other sources
6-7	Quantification of plant genomic DNA, testing purity of isolated plant genomic DNA by agarose gel electrophoresis
8-11	Purification and restriction enzyme analysis of DNA, agarose electrophoresis and staining of gel, visualization of gel under UV transilluminator, Southern blotting
12,13	RAPD analysis of DNA by random dacamer primers
14,15	Isolation of mRNA, cDNA synthesis using PCR
16	Northern blotting of RNA and Western blotting of proteins

BIOCHEM 505 TECHNIQUES IN BIOCHEMISTRY 1+2

Theory

UNIT I

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid, Liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel electrophoresis PAGE) like native and SDS-PAGE, 2D-PAGE, capillary electrophoresis.

UNIT II

Spectrophotometry: Principles and applications UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy.

UNIT III

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation- their principles, variants and applications.

UNIT IV

Tracer techniques in biology: Concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of α, β and γ emitters, scintillation counters, γ-ray spectrometers, autoradiography, applications of radioactive tracers in biology, principles and applications of phosphor imager.

Practical:

Determination of absorption maxima of some important chemicals from their absorption spectra, estimation of biomolecule using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer and column chromatography, Separation of proteins by ion exchange and gel filtration chromatography, Electrophoretic techniques to separate proteins and nucleic acids ,Centrifugation- Cell fractionation, Application of GLC, 34 HPLC, FPLC in separation of biomolecules, Use of radioisotopes in metabolic studies.

Suggested Readings:

Clark JM. 1977. *Experimental Biochemistry.* 2nd Ed. WH Freeman.

Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa.

Willard M, Merritt LL & Dean JA.1981. *Instrumental Methods of Analysis.* 4th Ed. Van Nostrand.

William BL & Wilson K. 1975. *Principles and Techniques of Practical Biochemistry*. Edward Arnold.

Wilson K, Walker J & Walker JM. 2005. *Principles and Techniques of Practical Biochemistry.* Cambridge Univ. Press.

Thimmaiah SK, 1999. *Standard Methods of Biochemical Analysis* , Kalyani Publication, New Delhi.

BIOCHEM: 505 TECHNIQUES IN BIOCHEMISTRY 1+2

Teaching Schedule (Theory)

Sr. No.	Name of the topic	No of Lecture	Weightage (%)
1	Spectrophotometer-laws, principles and applications of UV-Visible spectrophotometer	1	**10**
2	Florescence, IR and FTIR	1	**6**
3	Raman, NMR and FINMR	1	**6**
4	ESR and X-ray spectroscopy	1	**6**
5	Hydrodynamic method of separation of biomolecules such as viscosity, sedimentation-their principles, variants and applications	1	**8**
6	Chromatographic techniques, classification, principles and application of paper and thin layer	1	**8**
7	GLC	1	**6**
8	HPLC and FPLC	2	**8**

9	Paper and gel electrophoresis, PAGE	1	**9**
10	SDS-PAGE,2D-PAGE and capillary electrophoresis	1	**9**
11	Tracer techniques in biology-Concepts of radioactivity, radio activity counting, methods with principles of different types of counters	2	**6**
12	Concept of α β & γ emitters ,scintillation counters and gamma ray spectrophotometers	1	**6**
13	Auto radiography, applications of radioactive tracers in biology	1	**6**
14	Principles and applications of phosphor imager	1	**6**
	Total	16	**100**

BIOCHEM 505 TECHNIQUES IN BIOCHEMISTRY 1+2

Lesson Plan (Theory)

Lecture No.	Name of the topic
1	Laws of spectrophotometry, Beer- Lamberts law, UV spectrophotometry, principles of instrumentation and applications
2	Spectrophotometry : principles and instrumentation, infrared spectrophotometer: principles of instrumentation, FTIR
3	Raman effect: NMR, FINMR
4	ESR (Electro spin resonance) spectrophotometry, applications, X-ray spectroscopy
5	Hydrodynamic methods of separation of biomolecules : viscosity, principles and application, sedimentation, centrifugation, principles and types of centrifugations
6-7	Chromatography: principles and classification, paper chromatography: principle and application, thin layer chromatograph and HPTLC: principles and applications
8	Ion exchange chromatography: principle, instrumentation and application. Gel filtration chromatography: principle, instrumentation and applications. Affinity chromatography: principle, instrumentation and applications.
9	GLC: principle, instrumentation and applications
10	HPLC and FPLC : principle, instrumentation and applications
11	Paper and gel electrophoresis, PAGE: principle, instrumentation and applications
12	SDS-PAGE: principle, instrumentation and applications, 2D-PAGE :principle, instrumentation and application and capillary electrophoresis: principle, instrumentation and application
13-14	Tracer techniques in biology-Concept of radioactivity- atomic stability and radiation. Types of radioactive decay, rate of radio -active decay, units of radioactivity, radio activity counting methods: absolute and relative counting, methods based on gas ionization, excitation, exposure of photographic emulsions, principles of different types of counters
15	Autoradiography: gel exposed to x- ray film, x- ray film development, applications of radioactive tracers in biology
16	Principles and applications of phosphor imager

BIOCHEM 505 TECHNIQUES IN BIOCHEMISTRY 1+2

Practical

Sr. No	Name of the practical	No. of practical classes	Weightage (%)
1	Centrifugation- cell fragmentation	2	8
2	Determination of absorption maxima of some important chemicals	3	12
3	Estimation of biomolecules using spectrophotometer	2	8
4	Separation of amino acids by paper chromatography	2	6
5	Separation of amino acids by TLC	2	6
6	Protein extraction: ammonium sulphate precipitation and separation of proteins by ion exchange and gel filtration chromatography	6	14
7	Separation of proteins by PAGE	4	12
8	Isolation and separation of nucleic acids on agarose gel	4	12
9	Fatty acids separation by GLC	3	12
10	Plant metabolite separation and estimation by HPLC	4	10
	Total	**32**	**100**

BIOCHEM 507 PLANT BIOCHEMISTRY 3+0

Theory:

UNIT I

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function of cell organelle. Photosynthetic pigments in relation to their functions, photosynthesis, C3, C4 and CAM pathways, photorespiration.

UNIT II

Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur in to amino acids.

UNIT III

Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction.

UNIT IV

Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

Suggested Readings:

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry and Molecular Biology of Plants.* 2nd Ed. John Wiley.

Dey PM & Harborne JB. 1997. *Plant Biochemistry*. Academic Press.

Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*. Pergamon Press.

Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ. Press.

Lea PJ & Leegood R C. 1993. *Plant Biochemistry and Molecular Biology.* 2nd Ed. John Wiley

BIOCHEM 507 PLANT BIOCHEMISTRY 3+0

Teaching Schedule

Sr. No.	Name of the topic	No of Lectures	Weightage (%)
1	Scope and importance of biochemistry in agriculture	2	**3**
2	Plant cell organelles : separation, structure & functions	2	4
3	Photosynthetic pigments in relation to their functions	2	**4**
4	Photosynthesis : Light reaction, Z- scheme water splitting complex, photosystems,	3	**7**
5	Carbon reduction and assimilation : Kinetics of Rubisco	3	**7**
6	C_3, C_4 and CAM metabolism	3	**10**
7	Photorespiration: Reactions & significance	1	**3**
8	Sucrose-starch interconversion	2	**5**
9	Biosynthesis of structural carbohydrates	2	**5**
10	Biosynthesis of storage proteins & lipids	2	**3**
11	Biochemistry of nitrogen fixation	4	**7**
12	Biochemistry of nitrate assimilation	3	**5**
13	Sulphate reduction and assimilation	3	**5**
14	Biochemistry of seed germination and development	2	**5**
15	Biochemistry of fruit ripening	2	**5**
16	Phytohormones and their mode of action	4	**7**
17	Signal transduction	3	**5**
18	Biochemistry and significance of secondary metabolites	3	**5**
19.	Plant defense system	2	**5**
	Total	**48**	**100**

BIOCHEM 507 PLANT BIOCHEMISTRY 3+0

Lesson Plan

Lecture No.	Name of the topic
1	Historical developments in the field of plant biochemistry
2	Scope and importance of biochemistry in agriculture
3	Structure and functions of plant cell organelles
4	Methods of cell organelles separation
5	Photosynthetic absorption spectra, mechanism of light absorption
6	Various photosynthetic pigments : absorption maxima, LHCs and photosystems
7	Light reactions of photosynthesis in photosynthetic bacteria, algae and higher plants
8	Z- scheme of photosynthesis, coordination of PSI and PSII
9	Water splitting complex and mechanism of ATP synthesis
10	Photosynthetic carbon reduction cycle, stages of CO_2 assimilation
11	Kinetic mechanism of CO_2 fixation with Rubisco
12	Reduction phase in photosynthesis and regeneration of acceptor molecule
13	C_3 and C_4 metabolism : significance and detail enzymatic mechanism
14	CAM metabolism and physiological significance
15	Photorespiration : enzymatic reactions and metabolic significance
16	Biosynthesis of sucrose and starch in plants
17	Regulation of sucrose-starch interconversion
18	Biosynthesis of storage polysaccharides
19.	Biosynthesis of structural polysaccharides
20.	Biosynthesis of storage proteins
21.	Biosynthesis of storage lipids
22.	Overview of nitrogen cycle
23.	Free living nitrogen fixers and enzymes involved in N_2 fixation
24.	Structure of nitrogenase complex and coordination between components, H_2 evolution during dinitrogen fixation
25.	Symbiotic nitrogen fixation
26.	Mechanism of nitrate uptake and reduction and regulation of nitrate reduction in higher plants
27.	Reactions of ammonia assimilation
28.	Mechanism of sulphate reduction and enzymatic mechanism of sulphate assimilation
29.	Incorporation of reduced sulphur in plants and regulation of sulphur assimilation
30.	Biochemical changes during seed germination
31.	Biochemical changes during plant development
32.	Biochemical mechanism of fruit ripening
33.	Role of ethylene and other enzymes during ripening
34.	Phytohormones: classification and physiological functions

35.	Auxins, Cytokinins
36.	Gibberelins
37.	ABA, ethylene and other plant growth regulators
38.	Introduction to signal transduction and perception in plant development
39.	Mechanisms of signal transduction in plants
40.	Introductions and significance of secondary plant metabolites
41.	Structure and classification of secondary plant products
42.	Secondary metabolites of major importance
43.	Plant defense systems
44.	Biochemical and molecular regulation of plant defense system

BIOCHEM 510 CARBONS AND NITROGEN METABOLISM 2+1

Theory:

UNIT I

Carbon metabolism: Synthesis of sucrose, Regulation of sucrose phosphate synthesis, Transport of sucrose, phloem loading and unloading, synthesis of starch in leaves and seeds, concept of transitory starch.

UNIT II

Synthesis of fructose, galactomannans, raffinose series oligosaccharides and trehalose.

UNIT III

Nitrogen cycle- Biochemistry of nitrate assimilation and its regulation, GS/GOGAT and GDH pathway, ureides and amides as nitrogen transport compounds, chemoautotrophy in denitrifying bacteria.

UNIT IV

Biological nitrogen fixation; structure function and regulation of nitrogenase; nif genes and their regulation; biochemical basis of legume- Rhizobium symbiosis, genes involved in synthesis.

Practical:

Estimation of nitrite content, Estimation of protein by Lowry's method, Estimation of starch, Estimation of nitrate content by hydrazine sulphate reduction method, i*n vivo* assay of nitrate reductase activity, *in vitro* assay of nitrate reductase activity, *in vitro* assay of nitrite reductase activity, *in vitro* assay of glutamine synthetase activity, *in vitro* assay of glutamate synthase and glutamate dehydrogenase activity, Estimation of ureides and amides, Assay of nitrogenase activity by acetylene reduction method, Estimation of hydrogen evolution by legume nodules.

Suggested Readings:

Beevers L. 1979. *Nitrogen Metabolism in Plants.* Gulab Vazirani for Arnold-Heinermann.

Bergersen FJ. (Ed.). 1980. *Methods for Evaluating Biological Nitrogen Fixation.* John Wiley & Sons. 38

Bray CM. 1983. *Nitrogen Metabolism in Plants*. Longman.
Buchanan BB, Gruissem W & James RL. (Eds.). 2000. *Biochemistry and Molecular Biology of Plants.* American Society of Plant Physiologists.
Mehta SL, Lodha ML & Sane PV. (Eds.). 1993. *Recent Advances in Plant Biochemistry*. ICAR.
Thimmaiah SK, 1999. *Standard Methods of Biochemical Analysis* , Kalyani Publication,
New Delhi.

BIOCHEM 510 CARBONS AND NITROGEN METABOLISM 2+1

Teaching Schedule

Sr. No.	Name of the topics	No of Lecture	Weightage (%)
1	Global climate change and its effects on plant photosynthesis	3	**5**
2	Carbon metabolism in plants : synthesis of sucrose, regulation of sucrose phosphate synthesis	3	10
3	Transport of sucrose , phloem loading and unloading	2	5
4	Synthesis of starch in leaves and regulation of sucrose-starch introversion	2	10
5	Synthesis of fructose, galactomannans, raffinose series of oligosaccharides	2	5
6	Biochemistry of nitrate assimilation and its regulation	4	15
7	Ureides and amides as nitrogen transport compounds	1	5
8	Mitochondrial metabolism in relation to carbon and nitrogen assimilation	4	15
9	Significance of alternative respiration and photorespiration in plant metabolism	2	5
10	Chemoautotrophy in denitrifying bacteria	1	5
11	Biological nitrogen fixation : structure, function and regulation of nitrogenase	3	10
12	*nif* genes and their regulation	2	5
13	Legume –Rhizobium symbiosis	3	5
	Total	**32**	**100**

BIOCHEM 510 CARBONS AND NITROGEN METABOLISM 2+1

Lesson Plan

Lecture No.	Name of the topic
1	Influence of environmental factors on crop growth and productivity
2	Present scenario of global climate change and their causes on plant metabolism
3	Influence of global climate change on photosynthesis
4	Metabolic manipulations in plants to cope up with future climate change

5	Introduction to carbon metabolism
6,7	Enzymatic mechanism of sucrose synthesis
8.	Regulation of sucrose synthesis in plants
9,10	Transport of sucrose in plants
11.	Regulation phloem loading and unloading
12	Enzymatic mechanism of starch biosynthesis in plants
13	Regulation of starch biosynthesis in higher plants
14	Sucrose – starch interconversion and regulation
15.	Mechanism of sucrose-starch interconversion during different hours of the day
16.	Synthesis of fructose and galactomannanas
17	Synthesis of raffinose family of oligosaccharides
18	Mechanism of nitrate uptake and reduction and regulation of nitrate reduction in higher plants
19.	Pathway of ammonia assimilation
20.	Transcriptional and post translational regulation of nitrate reduction and assimilation
21.	Nitrogen transport compounds
21.	Ureides and amides
22.	Free living nitrogen fixers and enzymes involved in N_2 fixation
23.	Structure of nitrogenase complex and coordination between components, H_2 evolution during dinitrogen fixation
24.	Symbiotic nitrogen fixation
25.	Mechanism of sulphate reduction and enzymatic mechanism of sulphate assimilation
26.	Incorporation of reduced sulphur in plants and regulation of sulphur assimilation
27.	Biochemical changes during seed germination, plant development and fruit ripening, enzymes involved
28.	Phytohormones: classification and physiological functions
29.	Auxins, cytokinins, gibberellins, ABA, ethylene and other plant growth regulators
30.	Introduction to signal transduction and perception in plant development mechanisms of signal transduction in plants
31.	Introductions and significance of secondary plant metabolites, structure and classification of secondary plant products, secondary metabolites of major importance
32.	Plant defense systems : Biochemical and molecular regulation

BIOCHEM 510 CARBONS AND NITROGEN METABOLISM 2+1

Practical

Practical No.	Name of the topics
1	Estimation of nitrite content by diazotization reaction from the given sample
2.	Estimation of proteins by Lowry et al. (1951) method
3	Estimation of starch by anthrone method
4	Estimation of nitrate content by hydrazine sulphate reduction method
5	*In vivo* assay of nitrate reductase from plant tissues
6,7	*In vitro* assay of nitrate reductase from plant tissues
8	*In vitro* assay of nitrite reductase from plant tissues
9	*In vitro* assay of glutamine synthetase from plant tissues
10	*In vitro* assay of glutamate synthase from plant tissues
11	*In vitro* assay of glutamate dehydrogenase from plant tissues
12,13	Estimation of allantion and allantoic acid from legumes
14	Determination of asparagine synthetase activity from plant tissues
15	Assay of nitrogenase activity by acetylene reduction method by GLC
16	Estimation of hydrogen evolution by legume nodules

Seminar (01 credit)			
1	BIOCHEM 591	MASTER'S SEMINAR	1+0=1
		Total	**1+0=1**
Master's Research (20 credits)			
1	BIOCHEM 599	MASTER'S RESEARCH	0+20=20