Enclosure –II B

Shree Manibhai Virani and Smt. Navalben Virani Science College, Rajkot (Autonomous)
Affiliated to Saurashtra University, Rajkot

Department of Biotechnology

M. Sc. BIOTECHNOLOGY

OBJECTIVES OF THE PROGRAMME:

The curriculum is framed to accomplish the following program objectives which students shall accomplish by the end of their post graduation study.

1. To inculcate in-depth knowledge, scientific thinking and practical skills in biotechnology and allied fields so that students can pursue career in industry, academia or research at different capacities and address their contemporary problems.
2. To produce postgraduates with ability to design, plan and implement research projects and apply them to solve problems related to areas of biotechnology.
3. To develop ability to work safely, autonomously and effectively in biotechnology lab and undertake a suite of molecular biology methods and prepare scientific reports.
4. To instill a crucial awareness of advances at the forefront of biotechnology.

SCHEME OF INSTRUCTION AND EXAMINATIONS
For Students Admitted from A.Y. 2016-2017 & Onwards

Semester- I							
Course Code	**Course**	**Hrs of Instruction / week**	**Exam Duration (Hrs)**	**Max Marks**			**Credit**
				CIE	**SEE**	**Total**	
Part-I							
16PBTCC01	**Core 1:** Molecular Cell Biology	4	3	30	70	100	4
16PBTCC02	**Core 2:**Basic Biochemistry	4	3	30	70	100	4
16PBTCC03	**Core 3:** Microbiology	4	3	30	70	100	4
16PBTDC01/ 16PBTDC02	**Discipline Specific Elective- I:** Research Methodology and Experimental Design/ Good Laboratory Practices	4	3	30	70	100	4
16PBTCC04	**Combined Practical (Core)- I** : Biochemical and Microbial Techniques	10	9*	100	150	250	5
Part-II							
16PBTCE01	Research Paper Presentation	1	-	50	-	50	1
16PBTCE02	**Technical Skill-I** Mathematical Calculations in Biology	2	-	100	-	100	1
		29				**800**	**23**
Part-III							
16PVE01	Value Education	1	-	Remarks			1
Total		**30**					**24**
Career Skill Enhancement Training one hrs/week in Semester I & II compulsory to be taken by all students which will be evaluated at the end of second semester. It is Compulsory to complete the course for all the M.Sc. Biotechnology students to get the degree.							

Semester-II							
Course Code	**Course**	**Hrs of Instruction / week**	**Exam Duration (Hrs)**	**Max Marks**			**Credit**
				CIE	**SEE**	**Total**	
Part-I							
16PBTCC05	**Core 4:** Molecular Biology and Genetics	4	3	30	70	100	4
16PBTCC06	**Core 5**:Bioprocess Technology	4	3	30	70	100	4
16PBTCC07	**Core 6**: Bioenergetics and Cellular Metabolism	4	3	30	70	100	4
16PBTDC03/ 16PBTDC04/ 16PBTDC05	**Discipline Specific Elective- II:** Soil and Agriculture Microbiology / Food and Dairy Technology/ Cell Culture Technology	4	3	30	70	100	4
16PBTCC08	**Combined Practical (Core Papers) II:** Molecular Techniques & Fermentation technology	8	6*	80	120	200	4
16PBTDC06/ 16PBTDC07/ 16PBTDC08	**Discipline Specific Elective Practical-II :** Soil and Agriculture Microbiology / Food and Dairy Technology/ Cell Culture Technology	2	3	20	30	50	1
Part-II							
16PBTCE03	**Research Proposal Writing**	1	-	50	-	50	1
16PBTCE04	**Technical Skill- II:** Career Competency Skill Development –I	2	-	100	-	100	2
Total		**29**				**800**	**24**
Career Skill Enhancement Training one hrs/week in Semester I & II compulsory to be taken by all students which will be evaluated at the end of second semester. It is Compulsory to complete the course for all the M. Sc. Biotechnology students to get the degree.							

Semester-III							
Course Code	**Course**	**Hrs of Instruction / week**	**Exam Duration (Hrs)**	**Max Marks**			**Credit**
				CIE	**SEE**	**Total**	
Part-I							
16PBTCC09	**Core 7:** Genetic Engineering	4	3	30	70	100	4
16PBTCC10	**Core 8**: Immunology	4	3	30	70	100	4
16PBTCC11	**Core 9**: Analytical Techniques	4	3	30	70	100	4
16PBTCC12	**Core 10:** Computer Based Test	-	-	100	-	100	1
16PBTDC09/ 16PBTDC10/ 16PBTDC11	**Discipline Specific Elective- III:** Advanced Molecular Techniques/ Pharmaceutical Technology / Nanobiotechnology	4	3	30	70	100	4
16PBTCC13	**Combined Practical (Core) – IV:** Genetic Engineering, Immunological & Analytical Technique	6	9*	60	90	150	3
16PBTDC12/ 16PBTDC13/ 16PBTDC14	**Discipline Specific Elective- III: Practical** Advanced Molecular Techniques/Pharmaceutical Technology / Nanobiotechnology	2	2	20	30	50	1
	Project	4	-	-	-	-	-
Part-II							
16PBTCE05	**Summer Training**	-	-	20	30	50	1
16PBTCE06	**Technical Skill- III:** Career Competency Skill Development –II	2	-	100	-	100	2
Total		**30**				**850**	**24**

* 3hrs each on Day1 and Day 2.

Semester- IV							
Course Code	**Course**	**Hrs of Instruction / week**	**Exam Duration (Hrs)**	**Max Marks**			**Credit**
				CIE	**SEE**	**Total**	
Part-I							
16PBTCC14	**Core11:** Bioinformatics	4	3	30	70	100	4
16PBTDC15/ 16PBTDC16/ 16PBTDC17	**Discipline Specific Elective IV:** Bio entrepreneurship / Bioethics and IPR/ Environmental Biotechnology	5	3	30	70	100	5
16PBTCC15	**Practical (Core) – V:** Bioinformatics Practical	3	3	40	60	100	2
16PBTCC16	**Project / Internship/ Training**	18	3	120	80	200	12
Part-II							
16PBTCE07	**Educational Tour**	-	-	50	-	50	1
Total		**30**				**550**	**24**
TOTAL OF ALL SEMESTERS						**3000**	**96**

TOTAL MARKS AND CREDIT DISTRIBUTION

S.NO	PART	Total Marks	Total Credits
1.	**PART I:** Core, Discipline Specific Elective Courses	2500	86
2.	**PART II :** Competency Enhancement Courses	500	9
3.	**PART III:** Value Education	Remarks	1
	TOTAL	**3000**	**96**
It is Compulsory to complete the Career Skill Enhancement Training course in Semester I & II for all the M. Sc. Biotechnology students to get the degree.			

- **Part- I: CORE, DSE CORE**

CORE COURSES (Theory)

S.No	Semester	Course Code	Course
1.	I	16PBTCC01	Molecular Cell Biology
2.		16PBTCC02	Basic Biochemistry
3.		16PBTCC03	Microbiology
4.	II	16PBTCC05	Molecular Biology and Genetics
5.		16PBTCC06	Bioprocess Technology
6.		16PBTCC07	Bioenergetics and Cellular Metabolism
7.	III	16PBTCC09	Genetic Engineering
8.		16PBTCC10	Immunology
9.		16PBTCC11	Analytical Techniques
10.		16PBTCC12	Computer Based Test (MCQs on Fundamentals and Principles of Core up to 3rd Semester)
11.	IV	16PBTCC14	Bioinformatics

CORE COURSES (Practical)

S.No	Semester	Course Code	Course
1.	I	16PBTCC04	Biochemical and Microbial Techniques Practical
2.	II	16PBTCC08	Molecular techniques and Fermentation Technology
3.	III	16PBTCC13	Genetic Engineering, Immunological and Analytical Techniques
4.	IV	16PBTCC15	Bioinformatics Practical

OTHER CORE COURSES

S.No.	Semester	Course Code	Course
1.	IV	16PBTCC16	Project / Internship / Training

DSE CORE COURSE (Theory & Practical)

Students are required to opt for any one of the courses offered in each semester respectively

S. No	Semester	Theory		Practical	
		Course Code	Course	Course Code	Course
1.	I	16PBTDC01	Research Methodology and Experimental Design	-	-
		16PBTDC02	Good Laboratory Practices	-	-
2.	II	16PBTDC03	Soil and Agriculture Microbiology	16PBTDC06	Soil and Agriculture Microbiology Practical
		16PBTDC04	Food and Dairy Technology	16PBSDC07	Food and Dairy Technology Practical
		16PBTDC05	Cell Culture Technology	16PBSDC08	Cell Culture Technology Practical
3	III	16PBTDC09	Advanced Molecular Techniques	16PBTDC12	Advanced Molecular Techniques Practical
		16PBTDC10	Pharmaceutical Technology	16PBSDC13	Pharmaceutical Technology Practical
		16PBTDC11	Nanobiotechnology	16PBSDC14	Nanobiotechnology Practical
4.	IV	16PBTDC15	Bio-Entrepreneurship	-	-
		16PBTDC16	Bioethics and IPR	-	-
		16PBTDC17	Environmental Biotechnology		

Part- II COMPETENCY ENHANCEMENT COURSES

S.No	Semester	Course Code	Course
1.	I	16PBTCE01	Research Paper Presentation
2.		16PBTCE02	Mathematical Calculations in Biology
3.	II	16PBTCE03	Research Proposal Writing
4.		16PBTCE04	Career Competency Skill Development -I
5.	III	16PBTCE05	Summer Training
6.		16PBTCE06	Career Competency Skill Development -II
7.	IV	16PBTCE07	Educational Tour

- **Part III** VALUE EDUCATION

S.No	Semester	Course Code	Course
1.	I	16PVE01	Value Education

M.Sc. BIOTECHNOLOGY

SEMESTER I

16PBTCC01	Core 1: Molecular Cell Biology	4hrs/week	4 Credits

Objectives:

Upon completion of the course students will be able to

1. Understand basic principles of signal transduction mechanisms, recurrent themes of post-translational modifications and cell cycle regulation.
2. Compare and contrast Apoptosis pathway, cellular organization and cytoskeleton.
3. Illustrate diagnosis, treatment and genetic basis of cancer, developmental aspects of human and *in vitro* fertilization methods

Unit 1: Cell Signaling & Intracellular Protein Traffic (10 hrs)

- Molecular basis of signal transduction
- Signaling through G-Proteins & Enzyme linked cell surface receptors
- Second messenger system
- Protein synthesis on free and bound polysomes, uptake into ER, membrane proteins
- Golgi sorting, post- translational modifications

Unit 2: Cell Cycle & Apoptosis (10 hrs)

- Molecular aspects of Cell division & Cell Cycle
- Regulation of Cell Cycle events & Check Points
- Role of Protein Kinase in Cell Cycle
- Phenomena of Apoptosis
- Factors regulating apoptotic death in normal cells and tumorous cells

Unit 3: Endo-membrane System and Cytoskeleton (10 hrs)

- Structure and function of Microbodies, Golgi, Lysosomes & Endoplasmic Reticulum
- Organization and Role of Microtubules
- Microfilaments and cell motility
- Actin & Myosin, Functional role of Actins filaments and Motor Proteins, Muscle Contraction
- Intermediate filaments

Unit 4: Molecular Biology of Cancer (9 hrs)

- Characteristics of Cancer cells
- The genetic basis of Cancer, Tumor Suppressor Genes (P53) and their functions
- Proto-Oncogenes Viral Oncogenes & Cancer
- Early detection & Molecular diagnosis of Cancer

- Cancer treatment present & future

Unit 5: Developmental Biology (9 hrs)

- Differentiation of Specialized Cells
- Morphogenesis and Gametogenesis
- Events during fertilization
- Post fertilization event, Cleavage and Early Embryonic Development
- *In vitro* Fertilization

Reference Books:

1. Berk, A., Zipursky, S., & Lodish, H. (2000). *Molecular Cell Biology*. 4th edn. New York: W.H. Freeman.
2. Cooper, G. M., & Hausman, R. E. (2000). *The cell*. Sunderland: Sinauer Associates.
3. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., &Losick, R. (2008). *Molecular biology of the gene*. 6th edn. New York: Pearson Education.
4. Lewin, B. (2008). *genes IX*. Mc Graw-Hill Interamericana.
5. Karp, G. (2004). *Cell and Molecular Biology: Concepts and Experiments 4th Edition with Study*. John Wiley & Sons.

16PBTCC02	Core 2: Basic Biochemistry	4hrs/week	4 Credits

Objectives:

Upon completion of the course, student will be able to

1. Understand the role of all biomolecules in biological systems.
2. Escalate the importance of bonding and three-dimensional arrangements of molecules with reference to its relation with functioning and stability.
3. Understand the physicochemical properties of these biomolecules.

Unit 1: Molecular Properties and Acid- Base Concept (9 hrs)

- Water as solvent for molecules in cell: Bonding: Bond angles and lengths
- Conformations of molecules: Tautomerism and Resonance.
- Forces between molecules and Chemical groups
- Acids and Bases: Titration curves, pH, its measurement and significance in biological systems
- Buffers: Henderson–Hasselbach Equation; Significance of Buffer in Biological System

Unit 2: Carbohydrates (10 hrs)

- Monosaccharides and Disaccharides: Structures, Characteristics, Functions and Sources
- Polysaccharides: Homo and Hetero Polysachharides, their structure and function,
- Mucopolysaccharides, Bacterial Cell wall Polysaccharides
- Glycoconjugates: Proteoglycans, Glycoproteins and Glycolipids

- Carbohydrates as Informational Molecules: Lectin- Carbohydrate Interactions

Unit 3: Amino Acids and Proteins (10 hrs)

- Structures and classification of Amino acids, Uncommon Amino acids, Amino acids as acids and bases, titration curves, Zwitter ion form, Peptide bond and its characteristics
- Structure of Proteins: Primary, Secondary, Tertiary and Quaternary structure, Structure and Function of Fibrous proteins: Keratin, Collagen & Elastin, Globular proteins: Hemoglobins, Myoglobins, Lipoprotein, Metalloproteins & Nucleoproteins.
- Amino acid Sequencing of proteins and its significance; Protein investigation using X-ray Crystallography and Mass Spectrometry
- Protein Denaturation and Folding; Example of Ribonucleases A
- Overview of Protein- Protein Interaction & DNA- Protein Interaction

Unit 4: Lipids (9 hrs)

- Storage Lipids: Structure, Characteristics and functions of Fatty Acids, Triacylglycerols
- Structural Lipids: Glycerophospholipids, Galactolipids and Sulpholipids, Sphingolipids and Sterols
- Lipids as Signal molecules & Prostagladins
- Lipids as Cofactors, Lipids as Pigments
- Lipidomics & Lipid structure determination

Unit 5: Nucleic Acids (10 hrs)

- Structures, Characteristics and functions of Nucleotides, Unusual nucleotides
- Structure of DNA & RNA, Different Conformations of DNA, Different types of RNA
- Denaturation & Annealing of DNA
- Physical Properties of DNA such as Bending, Super Coiling and Sequence dependent changes in DNA melting
- Structure of Genomic and Organellar DNA in eukaryotes

Reference Books:

1. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger Principles of Biochemistry*. Macmillan.
2. Voet, D., & Voet, J. G. (2011). *Biochemistry.* 4th edn. NewYork: John Wiley & Sons Inc.
3. Mathews, C. K., van Holde, K. E., & Ahern, K. G. (2000). *Biochemistry*. 3rd edn. Painos.
4. Hames, B. D., & Hooper, N. M. *Instant Notes in Biochemistry*. Bios Scientific Pub.
5. Satyanarayana, U&Chakrapani, U. (2002). *Biochemistry.* 3rd edn. Kolkata, India: Books and Allied Pvt. Ltd.

16PBTCC03	Core 3: Microbiology	4hrs/week	4 Credits

Objectives:

The student will be able to

1. A detailed knowledge of structure, function and application of microorganisms with current trends in microbiology and various isolation preservation techniques
2. Understand and evaluate methods and approaches used to study relationships and evolution (phylogeny) of microbes and explore taxonomic strategies used to name and classify microbial groups
3. Describe how DNA serves as genetic information, classify mutations by type and explain the characteristics of living things and the conditions needed for life

Unit-1: Methods in Microbiology (10 hrs)

- Prokaryotic and Eukaryotic cell structures
- Pure culture techniques- isolation, cultivation, enumeration and preservation of microbes, staining techniques- simple and differential staining
- Nutritional requirements and nutritional grouping of microorganisms; Different media (simple, complex and defined)
- Growth curve, Axenic culture, Diauxic cultures, Synchronous culture, Continuous culture and Batch culture
- Microbial growth: Batch, Fed-batch, yield constants, Methods of growth estimation, Stringent response, Death of a bacterial cell
- Effects of Physical and Chemical factors on Microbial growth

Unit 2: Microbial Diversity & Systematics (10 hrs)

- Classical and Modern methods and concepts; Domain and Kingdom concepts in classification of Microorganisms
- Criteria for classification
- Classification of Bacteria according to Bergey's Manual
- Methods to assess Microbial diversity- Culture dependent and independent method
- Molecular analysis of Bacterial community: Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis (ARDRA) and Terminal Restriction Fragment Length Polymorphism (T-RFLP) in assessing microbial diversity; 16S rDNA sequencing and Ribosomal Database Project

Unit 3: Microbial Genetics (9 hrs)

- Recombination of Bacterial Genes
- Gene targeting
- Gene transfer methods- Transformation, Transduction, Conjugation
- Regulation of Gene expression: Bacteria and Phages
- Mutation: Type, causes and effect of mutation

Unit 4: Extremophiles and Virology (9 hrs)

- Distinguishing features, phylogenetic groups ecology and physiology of Archaea.
- Life at hyper extreme environments
- Genome Analysis and Biotechnological applications of Archaea in Industrial, Agricultural, Medical and Environmental field
- General characteristics and Life Cycle of Viruses (Bacteria– DNA and RNA Viruses)
- General Characteristics, Mechanism of infection of Plant and Animal Viruses

Unit 5: Microbes and Environment (10 hrs)

- Role of Microorganisms in natural system and artificial system
- Influence of Microbes on the Earth's Environment and Inhabitants
- Ecological impacts of microbes; Symbiosis (Nitrogen fixation and Ruminant Symbiosis)
- Microbes and Nutrient cycles; Microbial Communication System: Quorum sensing
- Microbial Fuel Cells; Prebiotics and Probiotics; Antimicrobial agents and Vaccines

Reference Books:

1. Prescott, L. M. H., Klein, J. P., Prescott, D. A. L. M., Harley, J. P., & Klein, D. A. (2004). *Microbiology*. McGraw-Hill.
2. Atlas Ronald, M., Bartha, and Richard (1987). *Microbial Ecology 2nd Edition*. California: Benjamin Cummings Publishing Company.
3. Pelczar, M. J., Chan, E. C. S., & Krieg, N. R. (1993). *Microbiology: concepts and applications.* New York: McGraw-Hill.
4. Maloy, S. R., Cronan, J. E., &Freifelder, D. (1994). *Microbial Genetics* 2nd edn. Massachusetts: Jones and Bartlett Publishers.
5. Martinko, J. M., & Madigan, M. T. (2005). *Brock biology of microorganisms.* Englewood Cliffs, NJ: Prentice Hall.
6. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., &Losick, R. (2008). *Molecular biology of the gene*. 6thedn. New York: Pearson Education.
7. Griffiths, A. J. F., Gilbert W. M., Lewontin, R.C.& Miller, J. H. (2002). *Modern Genetic Analysis, Integrating Genes and Genomes*. 2nded. W.H.Freeman.

16PBTDC01 / 16PMBDC01	Discipline Specific Elective- I: Research Methodology and Experimental Design	4hrs/week	4 Credits

Objectives:

Upon completion of the course the student will be able to

1. Conduct effective search for research literature, selection of the suitable journal & manage the process of publication steps.
2. Understand basic descriptive and inferential statistics including the concepts and principles of research design and statistical inference.

3. Perform and interpret descriptive and inferential statistical tools including the construction of tables and graphs, t-tests, Chi-square tests, and regression analysis using different statistical packages.

Unit 1: Introduction to Research Methods & Literature Survey (10 hrs)

- Research: Meaning, Purpose, Types (Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical) & Objective of Research
- Defining and formulating the research problem: Selecting the problem, Necessity of defining the problem
- Literature Survey: Use of Library, Books and Journals- Medline, Patent Search and reprints of articles as a source for Literature survey
- Primary and Secondary sources: Reviews, Treatise, Monographs, Patents
- Literature Search: Search engines- Google Scholar, Pubmed, INFLIBNET

. Unit 2: Kinds of Scientific Documents & Thesis Writing (10 hrs)

- Definition and kinds of Scientific documents: Research paper, Review paper, Book reviews, Thesis & Technical reports
- Standards of research journal: Impact factor, Citation index, H index, I_{10} index, Eigen factor
- Components of a research paper: Title, Authors and addresses, Abstract, Acknowledgements, Tables and illustrations, References
- Different steps in the preparation: Layout, Structure and Language of typical reports, Illustrations and tables, Bibliography, Referencing and Footnotes
- Dealing with publishers: Submission of Manuscript, Ordering reprints

Unit 3: Data Analysis Using Statistical Tools-I (10 hrs)

- Introduction and Basic concepts in Biostatistics
- Measure of Central tendency (Mean, Median and Mode)
- Measure of Dispersion (Range, Mean Deviation, Variance and Standard Deviation
- Skewness: Measure of Skewness, Karl Pearson's Coefficient of Skewness
- Kurtosis: Measure of Kurtosis

Unit 4: Data Analysis Using Statistical Tools-II (9 hrs)

- Correlation: Types & Methods of measuring Correlation
- Regression: Regression line and Equations
- Non parametric test: Chi square Test (Goodness of fit, Test of Independence)
- Parametric Test: Comparison of means of two samples: T test
- Comparisons of Means by three or more samples: F Test, ANOVA

Unit 5: Experimental Designs (9 hrs)

- Completely Randomized Design (CRD)
- Randomized Complete Block Design (RCBD)

- Latin Square Design (LSD)
- Factorial Experiments
- Split Plot and Strip Plot Design

Reference Books:

1. Khan, I. A., & Khanum, A. (2004). *Fundamentals of Biostatistics*. Ukaaz Publications.
2. Holmes, D., Moody, P., & Dine, D. (2011). *Research methods for the Biosciences*. Oxford University Press.
3. Ruxton, G., & Colegrave, N. (2010). *Experimental design for the life sciences.* Oxford University Press.
4. Glass, D. J. (2014). *Experimental Design for Biologists*. Cold Spring Harbor Laboratory Press.
5. Dutta, N. K. (2002). *Fundamentals of Biostatistics: Practical Approach*. Kanishka Publishers.
6. Gurumani, N. (2004). *An introduction to Biostatistics*. MJP publisher.
7. Rohatgi, V. K., & Saleh, A. M. E. (2015). *An Introduction to Probability and Statistics*. John Wiley & Sons

16PBTCC04	**Combined Practical (Core)- I : Biochemical and Microbial Techniques**	**10 hrs/week**	**5 Credits**

Objectives

Upon completion of the course students will be able to

1. Develop skill in microscopy for observation of stages of cell division, developmental stages of chick embryo, protein and lipid localization in plants and karyotyping.
2. Develop the hands on skills for qualitative and quantitative analysis of Biomolecules.
3. Perform routine microbiology practicals including isolation, characterization and identification of bacteria their enrichment, study their growth patterns and factors affecting their growth and perform antimicrobial testing of various antimicrobials.

LIST OF PRACTICALS

Molecular Cell Biology

1. NESTROF- Screening Test For β-Thalassemia Trait.
2. Study of various stages of Mitosis from Onion root tip cells.
3. Effect of Colchicines on the DNA content of cell.
4. Study of different stages of Meiosis in flower bud of *Tradenscantia spp.*
5. Localization of protein by Mercuric Bromophenol Blue.

6. Localization of Lipid by Sudan Black B.
7. Study of Karyotyping.
8. Staining of Mitochondria In Human Cheek Epithelial Cells.
9. Study of permanent slides of the Chick embryo.

Basic Biochemistry

1. Estimation of Protein by Folin Lowry method.
2. TLC separation of Amino acids.
3. Estimation of Reducing Sugar by Nelson- Somogyi method.
4. Estimation of Carbohydrates by Anthrone method.
5. Isolation and quantification of Starch.
6. Extraction of Lipid from various sources.
7. Determination of Iodine number.
8. Determination of saponification number.
9. Acrolein test for Glycerol.
10. Estimation of DNA by DPA method.
11. Estimation of RNA by Orcinol method.
12. Estimation of Chlorophyll.

Microbiology

1. Isolation, enumeration and maintenance of microbes from environmental samples – soil/ water/air. Techniques for pure culture- streaking, pour plate and spread plate and storage of microbes.
2. Stains and staining techniques, Simple staining, Negative staining & Differential staining techniques, Motility studies.
3. Bacterial growth- Growth curve, Factors affecting bacterial growth- pH, Temperature and Salinity, Growth Curve- Diauxic.
4. Biochemical characterization of selected microbes.
5. Isolation of Bacteriophages from Sewage samples.
6. Enrichment and Isolation of: Halophiles, Acidophiles, Nitrogen fixers and Antibiotic producers.
7. Random mutagenesis using UV light and isolation of Auxotrophic mutant.
8. Antibiotic sensitivity assay.
9. Isolation of Antibiotic resistant strains.
10. Determination of Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC) of given antibiotic on different organisms.

Reference Books:

1. Celis, J. E., Carter, N., Simons, K., Small, J. V., Hunter, T., & Shotton, D. (Eds.). (2005). *Cell biology, four-volume set: a Laboratory Handbook*. Academic Press
2. Celis, J. E. (1998). *Cell biology: A Laboratory Handbook,* Vol. 2. San Diego, CA: Academic Press.
3. Jayaraman, J. (1981). *Laboratory Manual in Biochemistry*. Wiley Eastern.

4. Das, S., Singh &A., Verma, A. (2014). *Laboratory Manual for Biotechnology*. S. Chand Publications.
5. Cappuccino, J. G., Sherman, N., & Microbiology, A. (1983). *A laboratory manual*. Pearson Education.
6. Brown, A. E. (2009). *Benson's microbiological applications: laboratory manual in general microbiology, Short Version*. McGraw Hill.
7. Benson, H. J. (2001). *Microbiological applications: a laboratory manual in general microbiology*. McGraw-Hill.

16PBTCE02	Technical Skill: I Mathematical Calculations in Biology	2 hr/week	1 Credit

Objectives:

After the completion of the course the student will be able to

1. Perform various calculation related to solutions, Concentrations, pH, Dilutions and will be able to represent them in appropriate metric systems.
2. Create and analyze a standard curve with Lab samples, Represent data graphically and perform basic statistical analyses on Laboratory data
3. Use and interpret data derived from Spectrophotometry and calculate amount of analytes including Nucleic acids and Proteins present in solution.

Course Contents:

1. Metric system conversions: Temperature conversions (Celsius to Kelvin to Fahrenheit), Weight conversions (Kg to Pounds), Volume conversions (ml to cm^3), Pressure conversions (Atm to Pascals to inches of mercury to Bar to Torrs to psi to N/m^2), Length conversions (Miles to Km/m/cm/micrometer to inches), Angle conversions (degree to radians)
2. Calculations with exponents and Scientific notation: Expressing numbers in Scientific notion, Converting numbers from Scientific notion to Decimal notion, Subtracting numbers written in Scientific notion
3. Significant figures: Introduction, Rounding off significant digits in Calculations
4. Concentration problems: Calculations based on mole concept, Molarity, Normality Calculating moles of compound present in given solution, Gram molecular weight, Preparation of Molar, Molal and Normal solutions, Converting Molarity to percent and percent to Molarity
5. Calculations based on Molar Extinction Coefficient: Calculating concentrations form absorption data if Molar Extinction Coefficient are provided
6. Dilution series and serial dilutions: Calculating dilutions, Concentration by a factor X, Preparing percent solutions, Diluting percent solutions, Preparation of dilution series and Dilution factors
7. Calculations based on pH: Calculating pH of solutions based on H ions concentration, Calculations based on pKa and Henderson – Hasselbalch equation.
8. Standard curve (Calculation of concentration of an Unknown sample)

9. Graphical methods of describing data: Use of bar graphs, Series graph, Radial graphs, plotting standard errors and Regression values
10. Calculations pertaining to nucleic acids, proteins and enzyme activity: Quantification of nucleic acid and protein by UV absorption data, quantification of oligonucleotides, calculating Tm based on GC content, salt concentration and DNA length, calculation of enzyme activities in different units

Reference Books:

1. Stephenson, F. H. (2010). *Calculations for molecular biology and biotechnology: a guide to mathematics in the laboratory*. Academic press.
2. Segal, I. H. I. H. (1976). *Biochemical calculations: how to solve mathematical problems in general biochemistry.* New York: Wiley.

SEMESTER II

16PBTCC05	Core 4: Molecular Biology and Genetics	4hrs/week	4 Credits

Objectives:

After completion of the course student will be able to:

1. The concept and structure of Genes and DNA and its replication, expression.
2. The concept of heredity and variation and effect of factors on Gene and genetic frequency on Population.
3. Pattern of the Gene expression and its regulation at all the level.

Unit 1: Genes and Chromosomes (8 hrs)

- Fine structure of Gene, Split Genes, Overlapping Genes, Pseudogenes, Non- coding Genes and multi-gene families.
- Structure and organization of eukaryotic Chromosomes: Basic structure, Heterochromatin, Euchromatin, Histones, DNA, Nucleosome morphology and higher level organization (Super coiled loops, domains and scaffolds in eukaryotic chromosome), C-value Paradox
- Giant Chromosomes: Polytene and Lampbrush chromosomes
- Genomic organization of Prokaryotic & Eukaryotic cells
- Human chromosomal aberrations

Unit 2: Classical and Population Genetics (8 hrs)

- Mendelian inheritance: Inheritance patterns & Laws of Heredity
- Gene Interaction: Allelic Interaction (Dominance, Incomplete Dominance & Co-Dominance), Non allelic Interaction (Supplementary, Complementary & Duplicative genes, Epistasis)
- Linkage & Linkage Maps
- Sex Determination and Extra Chromosomal Inheritance
- Genetic polymorphism, Genetic Drift & Hardy Weinberg Law of equilibrium

Unit 3: DNA: Structure, Replication and Repair (10 hrs)

- DNA as genetic material: Experimental evidences (Direct & Indirect Evidences), Watson & Crick Model, Alternative forms of DNA
- Enzymes & accessory proteins involved in DNA Replication
- Models of Replication in Prokaryotes
- Mechanism of Replication process in Prokaryotic & Eukaryotic DNA, Fidelity of Replication, Telomere synthesis-Role of Telomerase, Inhibitors of Replication
- DNA Repair: Types of DNA Repair, Mechanism of DNA Repair

Unit 4: Transcription and Translation (14 hrs)

- Prokaryotic Transcription; Transcription unit, Promoters- Constitutive and Inducible, Regulatory elements, Bacterial RNA polymerases, Mechanism of transcription in Prokaryotes
- Eukaryotic Transcription; Eukaryotic Promoters and Enhancers, RNA Polymerase I, II, III structure and assembly, Transcription factors, Activators and repressors, Mechanism of transcription in Eukaryotes
- Post Transcriptional Modifications; 5'-Cap formation, 3'-end Polyadenylation, Splicing, RNA editing, Nuclear export of mRNA, RNA stability, Processing of tRNA and rRNA, Inhibitors of transcription. Ribozyme technology: mechanism of action and applications.
- Ribosomes, Genetic code, mechanism of activation of amino acids, Role of t RNA, Mechanism of translation in prokaryotes and eukaryotes, Co- and Post-translational modifications
- Inhibitors of Protein synthesis, Protein localization and Targeting, Protein stability, Protein turnover and degradation

Unit 5: Regulation of Gene expression in Prokaryotes & Eukaryotes (8 hrs)

- Operon concept- Inducible and repressible systems (Lac Operon, trp Operon, His Operon and Arabinose Operon) Attenuation & Termination
- Chromatin modification & Gene expression - Histone acetylation & Deacetylation
- Environmental regulation of Gene expression
- Gene silencing- DNA Methylation, RNAi pathway (si RNA and mi RNA)

Reference Books:

1. Watson, J. D., Baker, T. A., Bell, S. B., Gann, A., Levine, M., & Losick, R. (2008). *Molecular biology of the gene.* 6th edn. New York: Pearson Education.
2. Lewin, B. (2008). *genes IX*. Mc Graw-Hill Interamericana
3. Griffiths, A. J. F., Gilbert W. M., Lewontin, R.C.& Miller, J. H. (2002). *Modern Genetic Analysis, Integrating Genes and Genomes*. 2nded, W.H.Freeman
4. Brown, T. A. (2006). *Genomes*. Garland science
5. Weaver, W. (1970). *Molecular biology: Origin of the Term.* Science.
6. Winnacker, E. L. (1987). *From genes to clones: introduction to gene technology.* VCH Verlagsgesellschaft.
7. Brooker, R. J. (1999). *Genetics: Analysis and Principles*. Addison-Wesley.
8. Friefelder, D. (1985). *Essentials of Molecular Biology*. Jones and Bartlett.
9. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., Watson, J. D., & Grimstone, A.V. (1995). *Molecular Biology of the Cell.* 3rd edn. Trends in Biochemical Sciences, 20(5), 210-210.

16PBTCC06	Core 5: Bioprocess Technology	4hrs/week	4 Credits

Objectives:

Upon completion of the course students will be able to

1. Learn and reinforce fundamental Bioprocess principles, Strain improvement, Preservation, Media optimization, Growth kinetics and Design bioreactor.
2. Analyze the performance of Mass transfer process, Scale up, Control system, Downstream process and its application for various biological products.

Unit 1: Basic Principle of Biochemical engineering (9 hrs)

- Isolation and screening of Industrially useful Microorganisms
- Strain Improvement
- Preservation of Microorganisms
- Starter culture, its importance and preparation
- Substrates for Fermentation processes

Unit 2: Design of Fermentor and Growth rate parameter (9 hrs)

- Medium Optimization
- Sterilization of media and air
- Various Design and types of Fermentors & Bioreactor
- Batch, Fed-batch and Continuous culture operations
- Microbial growth and Death kinetics

Unit 3: Concepts of basic mode of fermentation processes (10 hrs)

- Aeration and agitation, Oxygen transfer rate
- Heat control, Mass transfer bioprocess
- Methods of scale up and their analysis
- Measurement and control of Bioprocess parameters
- Controller and application of Computer in Control system

Unit 4: Downstream Processing (10 hrs)

- Bioseparation- Filtration, Centrifugation, Sedimentation, Flocculation
- Cell disruption; Liquid-liquid extraction
- Purification by Chromatographic techniques; Reverse Osmosis and Ultra filtration
- Drying; Crystallization, Storage and Packaging
- Fermentation economics

Unit 5: Industrial production of chemicals (10 hrs)

- Alcohol fermentation, Vitamins (Vit. B12)
- Organic acids (Gluconic acid & Citric acid), Amino acids (Lysine & Glutamic acid)

- Antibiotics (Penicillin & streptomycin)
- Single cell protein
- Enzyme (Amylase, Protease & lipase)

Reference Books:

1. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2013). *Principles of fermentation technology*. Elsevier.
2. Crueger, W., & Crueger, A. (2006). *Biotechnology: a textbook of industrial microbiology*. Panima Publications.
3. MacNeil, B., & Harvey, L. M. (Eds.). (1990). *Fermentation: a practical approach*. IRL press.
4. Shuler, M. L., & Kargi, F. (2002). *Bioprocess engineering*. New York: Prentice Hall.
5. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical. Engineering Fundamentals*. New York: McGraw-Hill.
6. Doran, P. M. (1995). *Bioprocess engineering principles*. Academic press.

16PBTCC07	Core 6: Bioenergetics and Cellular Metabolism	4hrs/week	4 Credits

Objectives:

Upon completion of the course, student will be able to

1. Discuss cellular metabolic processes and how they relate to Biotechnology.
2. Understand the function of specific Anabolic and Catabolic pathways and how these pathways are controlled and interrelated.
3. Appreciate the diversity of Metabolic regulation, and how this is specifically achieved in different cells.

Unit 1: Bioenergetics (9 hrs)

- Laws of Thermodynamics
- Gibbs free energy, Endergonic & Exergonic reactions, Feasibility of reactions
- Standard state free energy changes
- Relationship between equilibrium constant & ΔG
- Importance of Coupled reactions & High energy compounds

Unit 2: Carbohydrate Metabolism (10 hrs)

- Glycolysis: Fate of Pyruvate under Aerobic and Anaerobic conditions, Kreb cycle & Gluconeogenesis
- Pentose Phosphate Pathway and its Significance
- Glycogen synthesis & Glycogenolysis
- Photosynthesis and Respiration, Photosynthetic Electron Transport and Respiratory Electron Transport and their coupling with energetic

- Mechanism of ATP synthesis

Unit 3: Lipid and Protein metabolism (10 hrs)

- Cholesterol biosynthesis
- Introduction, Metabolism of glycerol, Fatty acid oxidation
- Conversion of Fat into Carbohydrates
- Protein metabolism – Introduction, Conversion of amino acids, Decarboxylation, Deamination of amino acids
- Urea cycle

Unit 4: Enzymes& Hormones (10 hrs)

- Enzymes: Nomenclature and classification of Enzymes, Holoenzyme, Apoenzyme, Cofactors, Coenzyme, Prosthetic groups, Metalloenzymes, Monomeric & Oligomeric enzymes, Activation energy and Transition state, Enzyme activity, Specific activity, Common features of active sites
- Enzyme specificity: Types & theories, Mechanism of Enzyme Regulation: Covalent and Allosteric Regulation
- Role of: NAD+, NADP+, FMN/FAD, Coenzymes A, Thiamine pyrophosphate, Pyridoxal Phosphate, Lipoic-acid, Biotin vitamin B_{12}, Tetrahydrofolate and Metallic ions
- Hormones: Introduction, Definition, Classification, Structure
- Function and Application of plant hormone Auxin and Gibberellins, Animal hormones– Pituitary, Pancreas, Thyroid, Adrenal and Gonadal hormones

Unit 5: Metabolic disorders (9 hrs)

- Inborn errors related Metabolic disorders, Galactosemia, Glycogen storage diseases
- Phenylketonuria
- Type I and II Diabetes, Hypoglycemia
- Lipid malabsorption, Statorrehea, Albinism
- Nucleic acid Metabolic disorders such as Gout, Xanthinurea, Lesch-Nyhan syndrom

Reference Books:

1. Garrett, R. H., & Grisham, C. M. (2001). *Principles of biochemistry: with a human focus.* Thomson Brooks Cole.
2. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry.* Macmillan.
3. Stryer, B. (1981).*Biochemistry.* San Francisco. WH Freeman and Co.
4. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2002). *Biochemistry.* W. H. Freeman and Co.
5. Voet, D., &Voet, J. G. (2011). *Biochemistry*, 4thedn. New York: John Wiley& SonsInc.
6. Murray, R. K. (2009). *Harper's Illustrated Biochemistry*. New York: McGraw-Hill.
7. Palmer, T., & Bonner, P. L. (2007). *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry.* Elsevier.

8. Deb, A. C. (2006). *Fundamentals of Biochemistry*. New Central Book Agency (P) Limited.

16PBTDC05/ 16PMBDC05	Discipline Specific Elective II: Cell Culture Technology	4hrs/week	4 Credits

Objectives:

1. Understand the principle and application of Plant and Animal Cell culture, describe components of Plant and Animal tissue culture medium and methodology of preparation of medium.
2. Independently establish *in vitro* culture of Plant and Animal Cell lines.
3. Explain the principle of Genetic engineering and methodology of development of transgenic plants and Transfection methods in Animals.

Unit 1: Basics of Plant Tissue Culture (9 hrs)

- Plant cell culture– Basic concept, History and Scope
- Concept of Asepsis and methods of Sterilization
- Tissue culture media
- Role of Plant growth regulators in tissue culture
- Pathways and different stages of Clonal Micropropagation

Unit 2: Protoplast isolation and culture (9 hrs)

- Protoplast - Isolation, Culture, Regeneration and fusion
- Selection of hybrid and Regeneration of hybrid
- Symmetric and Asymmetric hybrid
- Cybrid
- Embryo culture and Embryo rescue

Unit 3: Variation in Tissue Culture (10 hrs)

- Variation in Plant tissue culture: Origin and causes
- Cryopreservation and Germplasm storage
- Methods of Gene transfer in Plants and Animals
- Transgenic Plant with special reference to Biotic and Abiotic stress
- Transgenic animal: Transfection methods and application

Unit 4: Basics of Animal Cell Culture I (10 hrs)

- Animal cell culture – Introduction, History and Scope
- Brief discussion on Chemical, Physical and Metabolic functions of different constitution of Animal cell culture media
- Balanced salt solutions and Simple growth medium
- Different growth factors promoting proliferation of Animal cells in culture

- Serum and Protein-free defined media and their applications

Unit 5: Animal Cell Line **(10 hrs)**

- Primary culture and Animal Cell lines
- Characterization and biology of cultured cells
- Measuring parameter of Growth and Test of viability
- Transformed Animal Cells– Established/continuous Cell lines
- Commonly used Animal Cell lines– Their origin and characteristics

References Books:

1. Bhojwani, S. S., &Razdan, M. K. (1986). *Plant tissue culture: Theory and practice.* Vol. 5. Elsevier.
2. Chawla, H.S. (2002). *Introduction to Plant Biotechnology*. Oxford & IBH Publishers.
3. Freshney, I. (2010). *Culture of Animal Cell (6th edition)*. John Wiley.
4. Gamborg, O. L., & Phillips, G. (Eds.). (2013). *Plant cell, tissue and organ culture: fundamental methods.* Springer Science & Business Media.
5. Masters, J. (2005). *Animal Cell Culture (3rd edition)*. Panima Publishing Corporation.
6. Narayanaswamy, S. (1994). *Plant cell and tissue culture*. Tata McGraw-Hill Education.
7. Smith, R. (2012). *Plant tissue culture: Techniques and Experiments*. Elsevier Science.
8. George, E. F., Hall, M. A., & De Klerk, G. J. (Eds.). (2007). *Plant propagation by tissue culture: volume 1. The background* (Vol. 1). Springer Science & Business Media.

16PBTCC08	Combined Practical (Core) II: Molecular Techniques & Fermentation Technology	8hrs/week	4 Credits

Objectives:

Upon completion of the course students will be able to

1. Perform basic molecular biology technique involving isolation and estimation of DNA and plasmid form bacterial and plant cells.
2. Study effect of various factors on Enzymatic reactions.
3. Acquire the hands on training for biochemical analysis of various metabolites and its relevance to metabolic disorders.

Molecular Biology and Genetics

1. Isolation of Genomic DNA from bacterial cell / plant cell.
2. Plasmid DNA isolation from bacterial cell.
3. Spectrophotometric estimation of nucleic acids.
4. Problems Solving : Population Genetics and Mendel Genetics.

Bioprocess Technology

1. Primary Screening of Amylolytic, Proteolytic, and Lipolytic Microorganisms.
2. Alcohol Tolerance of Yeast.

3. Sugar Tolerance of Yeast.
4. Alcohol Fermentation using Yeast.
5. Alcohol Estimation.
6. Bioassay of Antibiotic.
7. Fermentation of Ca-Gluconate.
8. Preparation of Standard Curve of Ca-Gluconate.
9. Microbial Production of Citric acid Using *Aspergillus Niger.*

Bioenergetics and Cellular Metabolism

1. Partial purification of Amylase from sprouted Mung beans and its Enzyme activity.
2. Determination of Km value from partially purified Amylase.
3. Determination of Vmax value from partially purified Amylase.
4. To study the effect of pH on the activity of partially purified Amylase.
5. To study the effect of temperature on the activity of partially purified Amylase.
6. Effect of Enzyme Inhibitors on Enzyme activity.
7. Estimation of blood glucose by GOD- POD/ Hexokinase method.
8. Determination of protein profile & Albumin ratio.
   i. Total protein estimation by Biuret method.
   ii. Albumin estimation by Bromo Cresol Blue method.
9. Study of blood plasma protein by Electrophoresis.
10. Estimation of total Cholesterol from blood.
11. Determination of Renal function by Creatinine and Urea.
12. Liver function test (SGPT, SGOT, Alkaline phosphatase, Serum Bilirubin).

Reference Books:

1. MacNeil, B., & Harvey, L. M. (Eds.). (1990). *Fermentation: a practical approach*. IRL press.
2. Baltz, R. H., Demain, A. L., & Davies, J. E. (Eds.). (2010). *Manual of industrial microbiology and biotechnology*. American Society for Microbiology Press.
3. Wilson, K., & Walker, J. (2000). *Principles and techniques of practical biochemistry*. Cambridge University Press.
4. Mu, P., & Plummer, D. T. (1988). *Introduction to practical biochemistry*. Tata McGraw-Hill Education.
5. Varley, H., Gowenlock, A. H., & Bell, M. (1980). *Practical clinical biochemistry*, vol. 1. William and Helnemann Med. Books Ltd.

16PBTDC08/ 16PMBDC08	Discipline Specific Elective Practical- II : Cell Culture Technology Practical	2hrs/week	1 Credit

Objective:

After completion of the course students will be able to prepare Plant Tissue Culture medium, independently establish Plant cell cultures and prepare Synthetic seeds.

List of Experiments

1. Introduction to plant tissue culture laboratory, instruments, growth room and aseptic technique.
2. Preparation of Plant tissue culture medium.
3. Explant preparation and Sterilization.
4. Aseptic inoculation of explant for establishment of nodal culture/Callus culture from study of pathways of Micropropagation.
5. Anther culture for production of Haploids.
6. Establishment of Cell suspension culture.
7. Study of Callus characteristics.
8. Preparation of Synthetic seeds.
9. Isolation of plant protoplast from Leaf.
10. Preparation of Animal tissue culture medium and Balanced salt solution.

Reference Books:

1. Chawla, H.S. (2002). *Introduction to Plant Biotechnology*. Oxford & IBH Publishers.
2. Purohit, S.D. & Joshi, N. (2007). *Plant Biotechnology: Practical Manual.* Apex Publication.
3. Giri, C. & Giri, A. (2007). *Plant Biotechnology: A practical Manual.* I.K. Publication.
4. Helgason, C. D. & Miller, C.L. *Basic cell culture protocols. Vol 290.* Humana press

16PBTCE04/ 16PMBCE04	Technical Skill- II: Career Competency Skill Development –I	2hrs/week	2 Credits

Objectives:

Upon completion of the course the student will be able to:

1. Understand the central ecological process and able to describe interaction among and between biotic and abiotic component of ecosystem.

2. Understand the concept behind evolution, changes during era and periods and able to explain about role of light in plant development and stress physiology.

3. Understand the logical and technical concept based on mathematical formula.

Course contents:

1. Habitat and niche concepts (1 hr)
   Concept of Habitat and niche, Niche width and overlap, Fundamental and realized niche, Resource partitioning, Character displacement.
2. Population Ecology (1 hr)

Characteristics of a Population, Population growth curves, Population regulation, life history strategies (R and K- selection), Concept of Metapopulation– demes and dispersal, Interdemic extinctions, Age structured populations

3. Species interactions (1 hr)
   Types of interactions, Interspecific competition, Herbivory, Carnivory, Pollination, Symbiosis
4. Community ecology & successions (2 hr)
   Nature of communities, Community structure and attributes, Levels of species diversity and its measurement, Edges and Ecotones, Succession: Types, mechanisms, changes involved in succession, Concept of climax
5. Ecosystem & Biomes (2 hr)
   Structure and function, energy flow and mineral cycling (CNP), primary production and decomposition, structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine), type of Biomes
6. Biodiversity (2 hr)
   Level, Scope and loss of Biodiversity, Diversity index, effort for Biodiversity conservation, IUCN category of species of animal and plant
7. Sensory photobiology (2 hr)
   Structure, function and mechanisms of action of Phytochromes, Cryptochromes and Phototropins; Stomatal movement; Photoperiodism and biological clocks
8. Stress physiology (1 hr)
   Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses, Mechanisms of resistance to biotic stress and tolerance to abiotic stress
9. Evolution (2 hr)
   Periods & Era, Concepts of neutral evolution, Molecular divergence and Molecular clocks, Molecular tools in phylogeny, Classification and identification, Protein and nucleotide sequence analysis, Origin of new Genes and Proteins, Gene duplication and divergence.
10. Secondary metabolites (2 hr)
    Biosynthesis of terpenes, Phenols and Nitrogenous compounds and their roles
11. Mensuration (2 hr)
    Area, Volume, Perimeter, Sphere, Circle, Rectangle, Square
12. Number system (2 hr)
13. Geometry (2 hr)
14. Problem based on number sequence (2 hr)

Reference Books:

1. Agarwal,R.S.(2013). *Quantitative Aptitude for Competitive Examinations*, 20th edition, S Chand Publications.
2. Odum, E.P. (2004). *Fundamentals of Ecology*. 5th edn, Brooks Cole
3. Salisbury, F. B., & Ross, C. W. (1992). *Plant Physiology*. 4th. *edn.* Belmont, CA. Wadsworth.