MAHARSHI DAYANAND SARASWATI UNIVERSITY, AJMER

पाठ्यक्रम

SYLLABUS

SCHEME OF EXAMINATION AND COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. BIOTECHNOLOGY

M.Sc. Previous Examination

M.Sc. Final Examination

२००९–१० से प्रभावी**(w.e.f.)**

सत्र २०१३–१४

महर्षि दयानन्द सरस्वती विश्वविद्यालय, अजमेर

NOTICE

1. Change in Statutes/Ordinances/Rules/Regulations/ Syllabus and Books may, from time to time, be made by amendment or remaking, and a candidate shall, except in so far as the University determines otherwise comply with any change that applies to years he has not completed at the time of change.**The decision taken by the Academic Council shall be final.**

सूचना

1. समय-समय पर संशोधन या पुनः निर्माण कर परिनियमों /अध्यादेशों / नियमों / विनियमों / पाठ्यक्रमों व पुस्तकों में परिवर्तन किया जा सकता है, तथा किसी भी परिवर्तन को छात्र को मानना होगा बशर्ते कि विश्वविद्यालय ने अन्यथा प्रकार से उनको छूट न दी हो और छात्र ने उस परिवर्तन के पूर्व वर्ष पाठ्यक्रम को पूरा न किया हो। **विद्या परिषद द्वारा लिये गये निर्णय अन्तिम होंगे।**

M.Sc. (Biotechnology)
Scheme of Examination

Theory papers

1. A total of sixteen theory papers (8 each for Previous and Final) (3 hrs. duration and maximum 50 marks each) and two combined practical examinations are prescribed.
2. Each theory paper is divided into three units. The papers are as below.

M. Sc. (Biotechnology) Previous

S.No.	Theory/ Practical	Subject of the Paper	Marks for sub heads if any	Maximum Marks
BTT	Theory			
	BTT 1	Biomolecules & Bioenergetics		50
	BTT 2	Microbial diversity & Physiology		50
	BTT 3	Molecular Biology		50
	BTT 4	Biotechniques		50
	BTT 5	Biostatistics and Computational Biology		50
	BTT 6	Immunology		50
	BTT 7	Enzymology		50
	BTT 8	Food Microbiology		50
BTCP	Combined Practical			200
		Experimental work on the basis of following	100	
	BTCP 1	General & Food Microbiology		
	BTCP 2	Analytical Biochemistry & Physiology		
	BTCP 3	Molecular Biology and Immunology		
	BTCP 4	Enzymology & Computational Biology		
		Record	15	
		Viva voce	20	
		Seminar	15	
		Project work	50	
	Sub total (M.Sc. Previous)			600

M. Sc. (Biotechnology) Final

S.No.	Theory/ Practical	Subject of the Paper	Marks for sub heads if any	Maximum Marks
	BTT 9	Genetic Engineering		50
	BTT 10	Bioinformatics & Information Biology		50
	BTT 11	Plant Biotechnology & Tissue Culture		50
	BTT 12	Animal Biotechnology		50
	BTT 13	Bioprocess Engineering & Technology		50
	BTT 14	Microbial Technology		50
	BTT 15	Environmental Biotechnology		50
	BTT 16	Food Processing & Technology		50
BTCP	Combined Practical			200
		Experimental work on the basis of following	100	
	BTCP 5	Genetic Engineering & Bioinformatics		
	BTCP 6	Plant & Animal Biotechnology		
	BTCP 7	Applied Microbiology & Fermentation Technology		
	BTCP 8	Environmental Biotechnology & Food Processing & Technology		
		Record	15	
		Viva voce	20	
		Seminar	15	
		Project work	50	
	Sub total (M.Sc. Final)			600
	GRAND TOTAL (M.Sc.)			1200

Theory question Papers

3. Question paper for each theory paper will have three sections: Part A, B and C.

4. Part A (Maximum 10 marks) will have 10 questions of 1 mark each, all of which must be attempted by the candidate. This question will have at least three questions set from each unit of the course contents of the paper. Word limit for the answers is 20 only.

5. Part B (Maximum 10 marks) of the question paper will have 5 compulsory questions. A minimum of 1 question will be asked from each unit of the course content of the paper. Each question will carry 2 marks. Word limit for the answer is 50 only.

6. Part C (Maximum 30 marks) will have total 3 questions, one from each unit of the course content of the paper. Each question will carry 10 marks and

will have one choice from the same unit. Word limit for the answer to each question is 400 only.

Practical examination

7. A combined practical examination (Maximum 200 marks with break up as below) shall be conducted at the end of each year.

a. Experimental work (Max. marks 100, 10 hrs. duration, to be completed in two days) shall be performed by each candidate as per the question paper set on the basis of 4 courses* of practical each year as mentioned in the syllabus (*concerned department depending upon the facilities available with them can modify syllabus up to a maximum of 30%).

b. Date wise, signed record (maximum 15 marks) of the experiments conducted by each student throughout the academic session shall be placed by him/her before the examining panel on the day of practical examination.

c. Seminar/Poster paper presentation (Maximum marks 15, 30 min. duration): Two seminars will have to be presented orally by each candidate in each academic session in the presence of Head of the Department and/or faculty member(s) appointed by him. A printed write up for each seminar shall be submitted by the student on A-4 size paper. The seminar evaluation record as well as the write up shall be placed before the panel of practical examiners by the Head of the Department for final valuation.

Introductory Seminar : In M.Sc. Previous, students will be provided with information and training on seminar presentation styles, abstract and precis preparation, and computer generation of both slides and posters. Each student must present one seminar and one poster paper on a topic of their choice, as well as must participate in the presentations of colleagues and selected faculty.

Advanced Seminar : In M.Sc. Final, each student will prepare either an oral or a poster presentation on his/her dissertation work. They will also be responsible for participating in the organization of a departmental student symposium during which they will make presentations that will be evaluated. Students must also attend weekly departmental seminars and prepare 5 precis for evaluation.

d. Project work/Review essay (Max marks 50): In M.Sc. Previous, the students shall submit a review essay. The essay assignment is intended to assist in achieving a better understanding of some aspects of the subject through critical reading and analysis of current research literature on a specific subject.

Essay Format and Requirements: Topics for essays shall be decided by the departmental committee and displayed o the notice board. Students shall give prioritized choices of three topics. Based on this the departmental committee shall assign the topic as well as supervisor to each student. All essays shall reach the supervisor by 12:00 noon on **Feb 28th every year.** An up-to-date and in-depth review of the **current** state of knowledge in some aspects of the

subject matter should be written according to the style of an article in Indian Journal of Microbiology. One must consult the "Instruction to Authors" for this journal for preparation of essay. One *may find it useful to first prepare an outline (such as a Table of Contents indicating the major subheadings) of the essay and discuss it with the supervisor before proceeding with essay writing.* The essay should be a review of recent scientific research literature, consisting of at least 20 original research articles. Textbooks can be quoted, but not counted as one of the 20 articles. The review article, including tables, figures, and references must not exceed 20 pages (A 4 size) of double-spaced typing. Photocopies of figures and tables shall not be accepted. One should prepare his/her own tables and figures for illustration. Working in groups of 2 shall be encouraged, although this is not an absolute requirement. Whether working alone or as a pair, the requirements for the essay are the same, and the same marks will be awarded to each member of the group. It is, therefore, useful and highly recommended to engage in constructive criticism and discussion of partner's portion of the essay. Submitted essays will not be returned. One may, of course, review the essays after they have been marked.

In M.Sc. Final, students will be given project work. Project work is intended to make the students learn scientific and methodical planning and conduction of experiments and preparation of reports.

Project Work: The report of project work shall be submitted by each student on the basis of experimental work performed by him/her on a defined problem assigned by the supervising faculty member in consultation with the Head of the Department. This shall be submitted in typed (on A-4 size paper) and bound form before the panel of examiners on the day of practical examination.

The report of project work and review essays shall be submitted to the panel of examiners (the same that has been appointed for the practical examination). The assessment of the report of the project work however shall be done after the completion of the practical examination the second day, where in the candidate will have to answer questions on the out come of the work performed by him. (The examiners shall be paid remuneration separately for practical examination and evaluation of project work as per the rates prescribed by the university for the M.Sc. Practical and dissertation respectively).

8. The number of papers and the maximum marks for each paper/practical are shown in the scheme. It will be necessary for a candidate to pass in the theory as well as in the practical part of a paper/subject separately.

A candidate for a pass at each of the Previous and the Final Examinations shall be required to obtain (i) at least 36% marks in the aggregate of all the papers prescribed for the examination* and (ii) at least 36% marks in Combined practical examination each year,

*provided that if a candidate fails to secure at least 25% marks in each

individual paper at the examination and also in the Project work/Seminar, wherever prescribed, he/she shall be deemed to have failed at the examination not withstanding his/her having obtained the minimum percentage of marks required in the aggregate for the examination.

9. No division shall be awarded at the end of M.Sc. Previous examination. Division shall be awarded at the end of the Final examination on the combined marks obtained at the Previous and the Final Examinations taken together, as noted below:

First division: on >60% marks and

Second division: on >48% marks.

10. If a candidate clears any paper(s) prescribed at the Previous and/or Final examination after a continuous period of three years, then for the purpose of working out his/her division the minimum passing marks only viz. 25% (36% in case of practical) shall be taken into account in respect of such paper(s)/ practical(s) cleared after expiry of the aforesaid period of three years; provided that in case where a candidate requires more than 25% marks in order to reach the minimum aggregate as many marks out of those actually secured by him/ her will be taken into account as would enable him/her to make up the deficiency in the requisite minimum aggregate.

Course Content

M.Sc. (Biotechnology) Previous

Theory

BTT 1. Biomolecules & Bioenergetics

Section A

Composition of living matter. Biomolecules: Structure, function, diversity and distribution. Cellular environment. Water, its structure and properties. Physiological buffers. pH. pH indicators. PH as the master variable. Acids & Bases. Redox potential and redox indicators. Molecular, Atomic and subatomic forces of interaction. Classification of organic compounds and functional groups. Bioenergetics and stoichiometry: Thermodynamics-Principles. Entropy, enthalpy, bonding energy. Phosphorylation. Flow of energy through biosphere. Strategy of energy production in the cell, oxidation - reduction reactions, coupled reactions and group transfer. ATP production. Transport, free energy and spontaneity of reaction. G, G^0, G' and equilibrium.

Section B

Structural features, constituting units, nomenclature, classification and chemistry of macromolecules: Nucleic acids, Proteins, peptidoglycan, chitin, glyco- and lipoproteins.

Structural features, constituting units, nomenclature, classification and chemistry of macromolecules: Carbohydrates, specific reference to cellulose, agar agar, alginic acid, agarose, carragenan, pectins, sialic acid, blood group polysaccharides, bacterial cell wall polysaccharides. Lipids, pigments, vitamins and hormones antibiotics and other secondary metabolites.

Section C

Conformational properties of polynucleotides and polysaccharides - secondary and tertiary structural features and their analysis.Macromolecular and supra molecular assemblies. Protein folding. Organization of macromolecule complexes: Chromatin, ribosomes, membrane, extracellular matrix..

Text Books:

1. Stryer L. 2001. Biochemistry 5/e, W.H. Freeman. New York.
2. Zubey G.L., Parson W.W. and Vance D.E. 1994. Principles of Biochemistry. Wm. C. Brown, Oxford.
3. Lehninger 2000. Principles of Biochemistry. 3/e. Nelson and Cox (Worth) Pub.
4. Harper's Biochemistry 1999. Mc Graw Hill.
5. Friefilder, D. Essentials of Molecular Biology. Jones & Barlett Pub.
6. Creighton TE. Proteins- Structure & Molecular properties. WH Freeman & Company.

7. Lewin B. Genes VVII. Oxford Univ. Press.
8. Branden C and Tooze J. Introduction to Protein Structure. Garland Pub., New York.
9. Kendrew J. Encyclopedia of Microbiology. Blackwell Sci., Oxford.
10. Tanford C. Physical chemistry of macromolecules. John Wiley & Sons.
11. Martin RB. Introduction to Biophysical Chemistry. McGraw Hill, New York.
12. Cantor. Biophysical Chemistry. WH Freeman.
13. Perutz Max. Protein Structure.

BTT 2 Microbial Diversity & Physiology

Section A

History and scope of Microbiology. Introduction to microbial diversity. Unculturable and culturable bacteria. Classification of microorganisms. Haeckel's three kingdom concept. Whittaker's five kingdom concept. Three domain concept of Carl Woese. Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Morphology, ultrastructure, components, appendages, shapes and arrangement of bacterial cell. Cell wall and cell membrane in archaebacteria, Gram positive and Gram negative eubacteria and eukaryotes. Morphology, physiology and diversity of bacterial spores. Cell division. Reserve food material. Acellular living entities: Viruses, Viroids, Virusoids and Prions. Nature, diversity, morphology, ultrastructure and mode of replication. Capsids and their arrangements. Types of envelopes and their composition.

Section B

General features and importance of algae, fungi and protozoa. Morphological diversity of cells, cell structures and thallus. Types of life cycle. Structure of cells and growth. Dormancy (spore diversity) and reproduction. Parasexuality; Nuclear cycle. Heterokaryosis, sexual compatibility.

Metabolism and fueling reactions. Catabolic principles and breakdown of carbohydrates, lipids, proteins and nucleic acids. Biosynthesis and degradation of amino acids, fatty acids and nucleotide bases. Transport in cells.

Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, Xanthophylls, phycobilliproteins. Carbohydrates-anabolism, autotrophy, oxygenic and anoxygenic photosynthesis. Calvin cycle. C3, C4 pathway. Chemolithotrophy-Sulfur, iron, hydrogen, nitrogen oxidations. Methanogenesis, Acetogenesis, Bioluminiscence.

Section C

Oxidative and substrate level phosphorylation. Fermentation of carbohydrates. Homo- and heterolactic fermentations. Respiratory metabolism-

Embden Mayer Hoff pathway, Entner Doudoroff pathway. Glyoxylate pathway. Kreb's cycle. Reverse TCA cycle. Gluconeogenesis. Pasteur effect. ETC-Electron carriers. Artificial electron donors. Inhibitors, Uncouplers.

Nirogen fixation. Genes involved in nitrogen fixation and their regulation. Assimilation of nitrogen, dinitrogen, nitrate nitrogen, ammonia, synthesis of major amino acids. Polyamines. Synthesis of polysaccharides. Cell wall and membrane chemistry in bacteria, algae and fungi. Peptidoglycan. Cell division. Synthesis of cell wall and its regulation in bacteria.

Text Books:

1. Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.
2. Moat AG & Foster JW 1999. Microbial Physiology. Wiley
3. Stanier RY, Ingraham JL and Wheelis, ML and Painter PR 1986. General Microbiology. Mac Millan Education Ltd., London
4. Brun Y V, and Shimkets LJ 2000. Prokaryotic development. ASM Press.

BTT 3 Molecular Biology

Section A

Nucleic acids as genetic information carriers: experimental evidence. DNA structure and topology. Melting of DNA. Basic features of the genetic code. Breaking the code. Evolution of genetic code, Juke's doublet codon theory. Mitochondrial code.

DNA replication: general principles, various modes of replication, Construction of replication fork in test tube, isolation and properties of DNA prokaryotic and eukaryotic polymerases, Superhelicity in DNA, linking number, topological properties, mechanism of action of topoisomerases. Retroviruses and their unique mode of DNA synthesis. Relationship between replication and cell cycle. Inhibitors of DNA replication (blocking precursor synthesis, nucleotide polymerization, altering DNA structure).

Transcription: general principles, basic apparatus, Structural features of RNA (rRNA, tRNA and mRNA) and relation to function. Types of RNA polymerases. Steps: Initiation, elongation and termination, inhibitors of RNA synthesis. Polycistronic and monocistronic RNAs. Control of transcription by interaction between RNA polymerases and promoter regions, use of alternate sigma factors. Controlled termination, attenuation and antitermination. Transcriptional and post transcriptional gene silencing. Enhancer and uppressor gene.

Maturation and processing of RNA: Methylation, cutting and trimming of rRNA, capping, polyadenylation and splicing of mRNA, Nuclear export of mRNA. mRNA stability. Cutting and modification of tRNA degradation system. Catalytic RNA, Group I and group II intron splicing. Rnase P.

Section B

Translation and its regulation. Protein synthesis: steps, details of initiation, elongation and termination. Role of various factors in the above steps. Inhibitors of protein synthesis. Synthesis of exported proteins on membrane –bound ribosomes, signal hypothesis. *In vitro* transcription and translation systems. Co- and post translational modification of proteins.

Regulation of gene expression: Operon concept, catabolite repression, instability of bacterial RNA, positive and negative regulation, *lac* operon, *ara* operon, *his* and *trp* Global regulatory responses: heat shock response, stringent response and regulation by small molecules such as ppGpp and cAMP, regulation of rRNA and tRNA synthesis.

Section C

Recombination: Homologous and illegitimate, Holliday model, gene targeting, gene disruption, FLP/FRT and Cre/Lox recombination, RecA and other recombinases. Gene mapping. Heterozygote analysis. Complementation. Transposons, retroposons, transposition in prokaryotes and eukaryotes.

DNA damage and repair: types of DNA damage (deamination, oxidative damage, alkylation, pyrimidine dimers). Repair pathways-methyl-directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination repair, SOS system.

Gene transfer mechanisms - transformation, transduction, conjugation, transfection, sexual reproduction, Genetic analysis of microorganisms. Genetic systems of yeast and *Neurospora*. Extrachromosomal inheritance. Mutation. Types of mutations, molecular nature of mutations. Mutagenesis. Ame's test for mutagenesis.

Text Books:

1. Lewin 2000. Genes VII. Oxford University Press.
2. *E. coli* and *Salmonella*: Cellular and molecular biology. 2/ed.
3. Neidhardt *et al*. 1996. (ASM Press).
4. Lodish, Berk, Zippursky. Molecular Cell Biology. W.H. Freeman.
5. Matsudaira, Baltimore, Darnell 2000. 4/e.
6. Watson JD, Baker, TA, Bell SP, Gann A, Levine M, Losick R 2004. Molecular biology of the gene. 5/e. Pearson Education Inc., Delhi.

BTT 4. Biotechniques

Section A

Sub cellular fractionation and criteria of functional integrity. Separation techniques for different biomolecules (Filtration, Centrifugation, Density gradient centrifugation, Chromatography: CC, PC, TLC, GC, HPLC).

Small and macromolecule quantification (Colorimetry, Photometry,

Nephelometry, Flame photometry, Vis, UV,and Atomic Absorption Spectroscopy).

Section B

Physical techniques in protein, nucleic acids and polysaccharide structure analysis. (UV, IR, NMR, LASER, Raman, Mass, Fluorescence and Mossebäuer spectroscopy, Differential calorimetry, X-Ray crystallography, STEM, Electron, Cryo and Atomic Force Microscopy). Molecular approaches in taxonomy and ecology: Ribotyping, Ribososmal RNA sequencing. Characteristics of primary domains.

Section C

Fractional precipitation. Gel filtration. Gel electrophoresis, Northern, Western, Southern blotting, Colony hybridization. Sequencing proteins and Nucleic acids.

Diffusion, osmosis. osmometry. Viscometry. Surface tension determination. Conductimetry. Dielectrometry. Polarography. Microcalorimetry. ESR. Optical rotational dispersion. Circular dichroism. Immunological techniques Tests : Agglutination, Complement fixation, Ouchterloney, Rocket electrophoresis, ELISA.

Text Books:

1. Branden & Tooze 1991.Introduction to Protein Structure. Garland Pub. Comp.
2. Adams *et al.* 1992. Biochemistry of Nucleic Acids. Chapman & Hall.
3. Rhodes, G 1993. Crystallography made crystal clear. Academic Press.
4. Van Holde *et al.* 1998. Principles of Physical Biochemistry. Prentice Hall.

BTT 5. Biostatistics and Computational Biology

Section A

Introduction: Meaning and scope of statistics. Population and universe. The sample and population. Parameter and statistics. Descriptive statistics-Classification and tabulation of data. Proportion data: (Examples: MPN, sterility testing of medicines, animal toxicity, therapeutic trial of drugs and vaccines, infection and immunization studies). Count data: (Examples: bacterial count, radioactivity count, colony count and plaque titres). Graphic representation and frequency distribution. Statistical inference. Measures of Central Tendency-Mean, mode median. Measures of dispersion- Mean deviation standard deviation, variance and coefficient of variance. Uncertainties in the estimation of a mean. Comparison of means and variances. Probability, Normal distribution, Poisson distribution.

Section B

Hypothesis testing: Statement of hypothesis, Null hypothesis, Alternate

hypothesis. Confidence limits, Types of error, Standard Error. Parametric and Non parametric tests of significance: goodness of fit, Student's t- , F -, chi square-, Kruskaal Wallis' H-, Wilcoxon's T-,and Mann Whitney's U- test.

Correlation and regression. Line fitting through graph points. Standard curves. Correlation, testing significance of correlation coefficient, Detecting association between a pair of species. Cole's measure of association and point correlation coefficient. Linear regression (fitting the best straight line through a series of points). Standard curves and interpolation of unknown Y values. Multiple Linear Regression, Coefficient of determination. Analysis of variance: Analysis of covariance. One way and two way classification. Utility and characteristics of ANOVA. Multicollinearity. Multiple comparisons.

Section C

Experimental designs. Statistical basis of biological assays: Response-dose metameter. Statistical modeling. Ordination techniques and their use. Resource utilization models.

Computers, their organization: Hardware, software. Operating system (command line and WIMP), Elementary idea of language hierarchy. Data processing and presentation (Spreadsheet and statistical analysis). LIMS, CAL, Computers in taxonomy, clinical microbiology, fermentation technology, simulation and modeling. Computers as audio visual aid and as word processor. Use of internet.

Text Books:

1. Bliss C.I.K. 1967. Statistics in Biology. Vol. I. Mc Graw Hill, New York.
2. Campbell R.C. 1974. Statistics for Biologists. Cambridge University Press, Cambridge.
3. Hewitt W. 1977. Microbiological assay. Academic press, New York.
4. Lutz W. 1967. Statistical methods as applied to immunological data. Pp. 1163-1206. In: D.M. Weir (ed). Handbook of Experimental Immunology. Blackwell Pub., Oxford.
5. Hardlaw A.C. 1982. (i) Four point parallel line assay of penicillin pp. 370-379. (ii) Microbiological assay of a vitamin-nicotinic acid. Pp. 214-233. In: S.B. Primrose and A.C. Waardlaw (eds) Sourcebook of experiments for the teaching of microbiology. Academic Press, London.
6. Wardlaw A.C. 1985. Practical statistics for experimental biologists. John Wiley and sons, New York.
7. Ron White. 2000. How computers work. Techmedia.
8. Preston Gralla 2000. How the internet work. Techmedia

BTT 6. Immunology

Section A

Natural or innate immunity. Determinants of innate immunity. Immune system: Organs and cells involved in immune system and immune response.

Acquired immunity: Humoral and cellular immunity. Phagocytosis. Lymphocytes, their subpopulation, their properties and functions, Membrane bound receptors of lymph cells. B cells, T cells: their types and role in immune response. Antigens, structure, properties and types of antigens, antigen specificity. Adjuvants-antigen specificity, form, dose and route of entry of antigen.

Acute phase proteins. Complements- Structure, properties and functions. Complement pathways and biological consequence of complement activation.

Section B

Immunoglobulins, Structure, heterogeneity, types and subtypes, properties. Diversity of antibodies and its generation. Theories of antigen recognition. Cellular interaction in the induction of antibody formation. Cellular interactions in the induction of immune T cells. Lymphoid cell interactions. *In vivo*-immune memory.

Hypersensitivity reactions: Types of hypersensitive reactions, their principles, respective diseases and their diagnosis. Lymphokines and cytokines-their assay methods. Immune tolerance and autoimmunity. Autoimmune diseases.

Antigen-antibody reactions: *In vitro* methods-agglutination, precipitation, complement fixation, immunofluorescence, ELISA, Radioimmunoassays. *In vivo* methods- Skin tests and immune complex tissue demonstrations. Applications of these methods in diagnosis of microbial diseases.

Hybridoma technology and monoclonal antibody production.

Section C

Major Histocompatibility Complex and Tumor Immunology: Structure and functions of MHC and HL-A system. HL-A and tissue transplantation. Tissue typing methods for organ and tissue transplantation in humans. Graft versus host reaction and rejection. Oncogenes (Viral and cellular) and tumor suppressor genes in man. Tumor specific antigens. Immune response. Immunodiagnosis and detection of tumor markers. Carcinoembryonic antigen. Alphafoetal proteins.

Infectious diseases in man: TB, leprosy, AIDS, Rabies, Plague, Rickettsia, Malaria, Kala Azar, Filaria, Typhoid, Cholera, hepatitis. Normal flora of skin, GI, respiratory and urogenital tract. Pathogen entry and colonization. Factors predisposing to infections. Toxins, their structure and mode of action. Virulence and pathogenesis. Immunity to Microbial infections.

Therapy: Chemotherapy. Antibiotics, their classification, mode of action and target organisms. Resistance against antibiotics. Disease prevention: Vaccines.

Text Books:

1. Henderson *et al.* 1999. Cellular Microbiology. Wiley.
2. de Bruijn *et al.* 1998. Bacterial genomics. Chapman & Hall.
3. Dorman C.J. 1994. Genetics of bacterial virulence. Blackwell.
4. Barrett J.T. 1983. Textbook of immunology: An introduction to immunochemistry and immunology. Mosby, Missouri.
5. Boyd R.F. 1984. General Microbiology. Times Mirror/Mosby (College Pub, St. Louis).
6. Davis, Dulbecco. Microbiology.
7. Broude A.I. 1981. Medical Microbiology and infectious diseases. W.B. Saunders & Co., Philadelphia.
8. Chapel and Haeney 1984. Essential of Clinical Immunology. Blackwell Sci.

References;

1. Clark W.R. 1991. The experimental foundations of modern immunology. John Wiley
2. Mackie & McCartney. Medical Microbiology. 14/e.
3. Bailey & Scott's Diagnostic Microbiology.
4. Franklin TJ, Snow GA. 1981.Biochemistry of antimicrobial action. Chapman & Hall, New York.
5. Roitt IM. 1995. Essential Immunology. Blackwell Sci. Oxford.
6. Roth J.A. 1985. Virulence mechanisms of bacterial pathogens. American Society for Microbiology. Washington D.C.
7. Smith CGC. 1976. Epidemiology and infections. Medowfief Press Ltd. Shildon, England.
8. Stiem F. 1980. Immunological disorders in infants and children. W.B. Saunders & Co. Philadelphia.
9. Todd IR. 1990. Lecture notes in immunology. Blackwell Sci. Pub. Oxford.
10. Roitt IM, Brostoff and Male 1995. Immunology 4/e Gower Medical Pub Co..
11. Kuby J 1994. Immunology. 2/e. W.H. Freeman and Co., New York.

BTT 7 Enzymology

Section A

Enzymes: Introduction, enzymes as biocatalysts, isolation and purification.Structure of enzymes. Enzyme classification.

Mechanism of enzyme action. Enzyme kinetics in free and immobilized enzymes: Michaelis-Menten kinetics, kinetics for reversible reactions. Effect of various types of inhibition, Evaluation of kinetic parameters. Multistep reactions and rate limiting steps.

Section B

Micro environmental effects on enzyme kinetics, Enzyme deactivation.

Enzyme regulation. Control of single enzyme activity. Control of metabolic pathways with examples. Organised enzyme systems.

Enzymes in cell. Enzyme turn over. Enzyme reactions in organic media. Free and immobilized enzymes: Methods of immobilisation. Applications in Industrial, Medical, Analytical, Chemical, Pharmaceutical and Food sec tors.

Section C

Design and Analysis of enzyme reactors: Ideal reactors, Reactor dynamics, Reactors with non-ideal mixing. Internal and external mass transfer effects in immobilized-enzyme reactors. Intra-particle diffusion and reaction, operational stability and optimization, general design considerations.

Text Books:

1. Lee James M. 1992. Biochemical Engineering, Prentice Hall.
2. Lehninger A. 1987. Principles of Biochemistry
3. W.R. Vieth *et al.* Design and Analysis of immobilized Enzyme Flow Reactors.
4. Price NC & Stevens L. 1984. Fundamentals of Enzymology. Oxford Univ Press.

BTT 8 Food Microbiology

Section A

Food as substrate for microorganisms: Microorganisms important in food microbiology-Molds, Yeasts and bacteria. General characteristics, classification and importance. Food chemistry with reference to their shelf life. Factors influencing microbial growth in food. Extrinsic and intrinsic factors.

Contamination and spoilage: Cereals, Sugar products, vegetables, fruits, meat and meat products. Milk and milk products, Fish and sea foods, poultry, spoilage of canned foods. Detection of spoilage and characterization. Food sanitation in manufacture and retail trade.

Section B

Food-borne infections and intoxications: Bacterial and non bacterial with examples of infective and toxic types- *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia.* Nematodes, protozoa, algae, fungi and viruses. Foodborne outbreaks. Laboratory testing procedures. Prevention measures.

Principles of food preservation. Asepsis-Removal of microorganisms (anaerobic conditions, high temperatures, low temperature, drying). Chemical preservatives and food additives. Food fermentation: Bread, Cheese, Vinegar, Fermented vegetables. Fermented dairy products. Experimental and industrial production methods. Spoilage and defects of fermented dairy products. Oriental fermented foods, their quality, standards and control. Indian fermented foods.

Section C

Microbial cell as food (SCP), SCO. Cultivable mushrooms and their production technology. Production of yeast (Baker's yeast as food and fodder). Food control agencies and its regulations. Plant sanitation. Employees' health standards. Waste treatment. Disposal. Quality control. Genetically modified foods. Biosafety.

Text Books:

1. Adams MR and Moss MO 1995. Food Microbiology. Royal Society of Chemistry Pub., Cambridge.
2. Frazier WC and Westhoff DC 1988. Food Microbiology. Tata Mc Graw Hill Pub Comp. New Delhi.
3. Stanbury PF, Whittaker A and Hall SJ 1995. Principles of fermentation technology. 2/e Pergamon Press.
4. Banwart GJ 1989. Basic Food Microbiology. CBS Pub and distributors, Delhi.
5. Hobbs BC and Roberts D 1993. Food Poisoning nad Food Hygiene. Edward Arnold (A division of Hodder and Stoughton) London.
6. Robinson RK. 1990. Dairy Microbiology. Elsevier Applied Sciences, London.

Combined Practical

BTCP 1. General & Food Microbiology

Microscopy. Microscope and its operations. Components, Adjustments, Light sources, Microscopic measurements (Micrometry). Calibration. Types of microscopes, Theory. Observation of various types of microbes under phase contrast, dark field and fluorescence.

Preparation of glassware. Washing and sterilization techniques. Wet heat, dry heat, filter types, Laminar flow chamber types. CDC safety levels. Asepsis concepts and practice. Efficacy of HEPA filter, UV, disinfectants, dry heat. Survival curves for UV and dry heat.

Preparation of culture media. Nutritional needs of microbes. Dehydrated, Selective, Differential. Autotrophic, heterotrophic. Culture techniques (Spreading, streaking, pour plating, pouring a plate, plugging glassware, transferring and inoculating microorganisms) Adjustment of pH, buffers, pure culture techniques. Preparation of slants. Subculturing and techniques to preserve and maintain pure cultures.

Microbial growth measurements. Cell count. Turbidity measurement. Percentage transmission. Optical density. Serial dilution and numerical exercises. Standard Plate count.

Morphological, nutritional and cultural characteristics of bacteria and

identification of microbes. Types of dyes. Preparation. Staining techniques. Simple, Gram's, Capsule, Negative, Flagella, spore and nuclear. Determining motility in organisms.

Production of sauerkraut and yoghurt.

References:

1. Coss R.C. Experimental Microbiology, Laboratory Guide. Kalyani Pub., Ludhiana.
2. Cappuccino JG, Sherman, N 1996. Microbiology- A Laboratory Manual. Benjamin/Cummings.
3. Atlas. Hand Book of Microbiological Media.

BTCP 2. Analytical Biochemistry & Physiology

Laboratory rules and safety regulations. First Aid.

Measurement: Criteria of reliability. Precision, Accuracy, Sensitivity, Specificity and numerical exercises.

Preparation of solutions: Normal, Molar, Molal, Percent, ppm, ppb and numericals.

Principles of colorimetry: Verification of Beer's law. Estimation of a selected protein, Finding out I_{max}. Relation between O.D. and percentage transmission. Isolation and quantification of DNA chlorophyll, phycobillins, carotenoids, carbohydrates, proteins, RNA, glycerol and mannitol.

pH, pK, Henderson-Hasselbalch equation. Preparation of buffers.

Separation of amino acids by paper chromatography.

Separation of sugars by TLC.

FAME profiling using GC.

Separation of haemoglobin and blue dextran by gel filtration.

Biochemical characterization of microorganisms: Oxygen requirement, TSI test, H_2S production, MRVP test, Indole test, Tolerance to salt and temperature. Utilization of sugars by oxidation and fermentation techniques.

References:

1. Alcamo I.E. 2001. Laboratory fundamentals of Microbiology. Jones and Bartlett.

BTCP 3. Molecular Biology and Immunology

Separation of serum proteins by electrophoresis.

Single colony isolation and checking genetic markers.

Demonstration of Diauxie.

Demonstration of photoreactivation of DNA damage.

One step growth curve of bacteriophage T4. Spontaneous and induced mutations. Isolation of antibiotic resistant and auxotrophic mutants.

Selective enrichment of auxotrophic and antibiotic (tet^r) mutants.

Genetic mapping by conjugation and P 1 transduction.

Transposon mutagenesis.

Gene fusion using bacteriophage Mu.

Isolation of chromosomal DNA from *E.coli*. Estimation of DNA by spectrophotometry. Plasmid DNA isolation and restriction digestion. Agarose gel electrophoresis.

Preparing antibiogram for given microorganisms.

Determining blood group ABO and Rh factor.

Dermatophyte slides.

RBC, WBC, TLC, DLC.

Preparation of culture media. Simple tissue culture methods for growing different pathogenic microorganisms.

Diagnostic immunological principles and methods

Precipitation, agglutination, immunodiffusion, immunoelectrophoresis, Widal test, Haemagglutination and ELISA.

Separation and characterization of lymphocytes from blood.

Demonstration of lymphocyte subpopulations.

References:

1. Miller JH 1992. Short course in bacterial genetics. CSH Laboratories.
2. Murray et al. 1994. Methods for General and Molecular Bacteriology. ASM Press.
3. Silhavy T. 1994. Experiments with gene fusions. Cold Spring Harbour Lab Press.
4. Hudson & Hay. Practical immunology

BTCP 4. Enzymology & Computational Biology

Qualitative determination of enzyme reactions: Oxidase, catalase, Amylase, Caseinase and Gelatinase.

To study constitutive and adaptive enzymes in *E.coli*.

Factors affecting enzyme activity: Temperature, substrate concentration and pH using any stable enzyme and kinetics of enzyme activity.

Study of isoenzymes of lactate dehydrogenase by PAGE.

Statistical exercises and computer acquaintance.

M.Sc. (Biotechnology) Final

BTT 9. Genetic Engineering

Section A

Core techniques and essential enzymes used in rDNA technology: Restriction digestion, ligation and transformation. Nucleic acid amplification, purification and yield analysis. Plasmids (F,Ti, Col), charactersitics of plasmids and replication. Bacteriophages, Lytic phages- T7 and T4. Lysogenic phages I and P1. M13 and fx 174 and their life cycles.

Cloning strategies. Cloning in *Escherichia coli*. Vectors: Plasmids, phages, phasmids and cosmids. Expression vectors, Promoter probe vectors, vectors (Artificial chromosomes- YAC, BAC) for library construction. cDNA and genomic libraries.

Section B

Expression in bacteria, yeast, insect cells, mammalian cells and plants. Expression strategies for heterologous genes , codon optimization.

Site directed muatgenesis and protein engineering. Processing recombinant proteins: Purification and refolding, Characterization of recombinant proteins, stabilization of proteins.

Whole Genome analysis: Genome sizes, organelle genomes. Genetic and physical maps. Molecular markers in genome analysis. Restriction mapping. Chromosome microdissection and microcloning. RFLP, RAPD and AFLP analysis and their applications. Shotgun libraries and sequencing. Physical mapping and map based cloning. Choice of mapping population. Application of sequence information for identification of defective genes. Cloning interacting genes- Two- and three hybrid systems, cloning differentially expressed genes.

Section C

Genetic disorders in man and future of control and cure. Strategies of gene delivery. Gene replacement/augmentation, Gene correction and editing, regulation and silencing.

Antisense and ribozyme technology: Molecular mechanism of antisense molecules, inhibition of splicing, polyadenylation and translation, disruption of RNA structure and capping. Biochemistry of ribozyme, hammerhead, hairpin and other ribozymes. Strategies for designing ribozymes. Applications of antisense and ribozyme technologies.

Vaccines, their production. Genetic engineering of vaccines.

Text Books:

1. Maloy *et al*. 1994. Microbial Genetics. Jones & Bartlett Pub.
2. Dale J.W. 1994. Molecular Genetics of Bacteria. John Wiley & sons

3. Streips & Yasbin. 1991. Modern Microbial Genetics. Niley Ltd.
4. Old & Primrose. 1994. Principles of Gene Manipulation. Blackwell Scientific Pub.
5. Sambrose & Russell. 2000. Molecular cloning. 3 volumes. CSH Press
6. 2000. Genome Analysis. 4 volumes. CSH Press

BTT 10. Bioinformatics & Information Biology

Section A

Introduction to bioinformatics. Objectives. Bioinformatics and data analysis. Beyond data analysis. Database: concept. Elementary knowledge of structured query language. Biological databases: Microbiological databases, Virology Information database, Cell-gene banks related sites. Biodiversity information databases. Parasite bioinformatics, Metabolomes and metabolic pathway engineering.

Microbial and eukaryotic genomes. Genome analysis. DNA sequencing. Genome sequencing. Finding and retrieving sequences. Sequence database. Submission of sequences to databases. Sequence formats. Conversion of one sequence format to another multiple sequence format. Protein and nucleic acid sequence database. Structural database. Identifying protein sequence from DNA sequence.

Section B

Searching database for similar new sequences. Computer tools for sequence analysis. Finding and retrieving sequences. Introduction to sequence alignment. Alignment of pairs of sequences. Multiple sequence alignments. Homology algorithms (BLAST, FASTA) for proteins and nucleic acids. Optimal alignment methods. Substitution scores and gap penalties. Annotations of genes. Identifying protein sequence from DNA sequence.

Section C

Phylogenetic analysis. Phylogenetic predictions. Predictive methods using protein and nucleic acid sequences. Submitting DNA sequence to databases. Structure function relationships. Scoring matrices for similarity searches. DNA microarray. Analysis of single nucleotide polymorphisms using DNA chips. Protcome analysis: Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Protein microarray. Gene prediction.

Information. Information molecules. Biochips and biocomputers. Information theory and molecular biology. Complexity, stability and information. Information content or complexity of protein families: Homologous protein family and cytochrome C family, their information content, complexity and

mutual entropy. Predicting functionally equivalent amino acids at a given site. Intracellular and extracellular signaling. Prokaryotic and eukaryotic Signaling mechanisms and pathways. Prokaryotic signaling: Quorum sensing and bacterial pheromones. Chemotaxy. Semiochemicals (Pheromones, Kairomones, Alarmones etc).

Text Books:

1. Baxevanis 1998. Bioinformatics
2. Higgins & Taylor 2000. Bioinformatics. OUP
3. Nucleic Acid Research January 2004 Genome database issue
4. Yoki. Information theory and molecular biology.

BTT 11. Plant Biotechnology & Tissue Culture

Section A

Introduction to cell and tissue culture. Tissue culture as a technique to produce novel plants and hybrids. Tissue culture media (composition and preparation). Ini on and maintenance of callus and suspension culture, single cell clones. Organogenesis. Somatic embryogenesis. Acclimatization/hardening of tissue culture raised plants. Shoot tip culture and production of virus-free plants. Clonal propagation. Embryo culture and embryo rescue. Protoplast isolation, culture and fusion, selection of hybrid cells and regeneration of hybrid plants, symmetric and asymmetric hybrids, cybrids. Anther, pollen and ovary culture for production of haploid plants and homozygous lines. Cryopreservation, DNA banking for germplasm conservation.

Section B

Plant transformation technology. Features of Ti and Ri plasmids and their use as vectors, mechanisms of DNA transfer, role of virulence genes, Binary vectors, Use of 35S and other promoters, genetic markers, use of reporter genes, reporter genes with introns, use of scaffold attachment regions, methods of nuclear transformation, viral vectors and their applications, multiple gene transfers, Vector mediated or direct DNA transfer, particle gun technology, electroporation, microinjection. Transgene stability and gene silencing.

Application of plant transformation for productivity and performance. Herbicide resistance, phospoinothricin, glyphosate, sulfonyl urea, atrazine, insect resistance, Bt genes, Non Bt like protease inhibitors, alpha amylase inhibitor, virus resistance, coat protein mediated, nucleocapsid gene, disease resistance, chitinase, 1-3, beta glucaase, RIP, antifungal proteins, thionins, PR proteins, nematode resistance, abiotic stress, post harvest loss, long shelf life of fruits and flowers, use of ACC synthase, polygalacturanase, ACC oxdiase, male sterile lines, bar and barnase systems, carbohydrate composition and

storage, ADP glucose pyrophosphatase.

Section C

Chloroplast transformation: Advantages, Vectors, success with tobacco and potato.

Metabolic engineering and industrial products: Plant secondary metabolites, control mechanisms and manipulation of phenyl propanoid pathway, shikimate pathway, alkaloids, industrial enzymes, biodegradable plastics, PHB, therapeutic proteins, lysosomal enzymes, antibodies, edible vaccines, purification strategies, oleosin partitionng technology.

Conventional Plant Breeding. Molecular-marker aided breeding: RFLP maps, linkage analysis, RAPD markers, STS, microsatellites, SCAR (sequence characterised mplified regions), SSCP (single strand conformational polymorphism) AFLP, QTL, map based cloning, molecular marker assisted selection. Operation, management and commissioning of green house. Biotechnology for arid regions.

Books:

1. Hammond J, McGarvey P and Yusibov V (eds). Plant Biotechnology. Springer Verlag.
2. Fu TJ, Singh G and Curtis WR (eds). 1999. Plant cell and tissue culture for the production of food ingradients. Kluwer Academic/Plenum Press.
3. Chawla HS. 1998. Biotechnology in crop improvement. International Book Distributing Comp.
4. Henry RJ 1997. Practical apllication of plant molecular biology. Chapman and Hall.
5. Gupta PK. 1996. Elements of biotehnology. Rastogi & Co., Meerut.

BTT 12. Animal Biotechnology

Section A

Diversity of cell types, size and shape. Cell Organisation and Biotechnological considerations. Cell cycle-molecular events and model systems. Cell organelles and their organization. Prokaryotic and eukaryotic organization. Thermodynamics and cell life. Concets of free energy and high energy intermediates. Oxidation-reduction reaction. Oxidative and non oxidative phosphorylation. Surface architecture-extracellular environment. Cell wall. Cell surface. Cell recognition. Cell agregation. Surface projections. Membrane transport. Cell signaling. Antigen mediated response.

Germ cell migration, gametogenesis and fertilization, gastrulation in invertebrate and vertebrate, cell lineage. Axis specification in vertebrates, Fate of ectoderm, mesoderm and endoderm. Cell fate and commitment, its mechanism.

mosaic and regulative development, maintenance of differentiation, pattern formation and compartments, morphogenesis. Model organism, Developmental mutants. Transgenic organism in development, cellular and microsurgical techniques. Micromanipulation techniques. Nuclear transplantation experiments. Gene transfer by microinjection.

Section B

Genes and their role in development, signal transduction in development, Differentiation and development in *Drosophila* and *Arabidopsis*. Spatial and temporal regulation of gene expression. Spatial and temporal regulation of gene expression. Cell differentaition mechanism and factors affecting it. Developmental gradients in *Hydra*. Axial gradients in *Drosophila* development. Organogenesis in invertebrates and vertebrates. Programmed cell death, aging and senescence. Retinoids in pattern formation during development. Homeotic transdifferentiation. Molecular biology of cancer. Oncogenes. Chemical carcinogenesis.

Unit 4. Cell, tissue, organ and embryo culture. Equipment and material for animal cell culture technology. Design and lay out of tissue-culture lab and equipments required. Primary and established cell line cultures. Cell and tissue culture. Difference between *in vivo* and *in vitro* system.

Biology of cultured cells. Culture environment -Substitute, gas phase and temperature. Media and supplements. Balanced salt solutions and simple growth and culture medium. Preparation and sterilization methods. Disaggregation of the tissue and primary culture. Maintenance of culture cell lines. Cloning and selection of specific cell types. Physical method of cell separation. Maintenance of cell culture. Characterization of culture. Measurement of viability and cytotoxicity.

Section C

Biology and characterization of mammalian cell culture *in vitro*. Cell synchronization. Cell cloning and micromanipulation. Cell transformation. Scaling up of animal cell culture. Stem cell cultures, embryonic stem cells and their applications. Cell culture based vaccines. Somatic cell genetics. Organ and histotypic cultures. Measurement of cell death. Apoptosis. Cryopreservation techniques. Embryo biotechnology. Development and cryopreservation of tissues and organs. Tissue transplantation technology. Preparation of host and graft. Transplantation and development of graft. Limb regeneration. Wound healing. Dedifferentiation. Redifferentiation. Pattern formation in vertebrates. Programmed cell death during development. Tissue engineering. Repair of damaged organs and tissues. Tissue and organ bank.

Books:

1. R. Ian Freshney. Culture of animal cells (3/e). Wiley-Liss.
2. Masters John RW. Animal cell culture-Practical approach. Oxford.
3. Basega R (ed) Cell grwoth and division. IRL press.
4. Butler M & Dawson M Cell culture lab. Bios scientific Pub, Oxford.
5. Clynes Martin (ed) Animal cell culture techniques. Springer.
6. Mather JP & Barnes D. Methods in cell biology. Vol. 57. Animal cell culture methods. Academic Press.
7. Twyman RM 2001. Developmental biology. Viva Books Pvt Ltd., New Delhi.
8. Gilbert S. 1997. Developmental Biology (5/e). Sineaur Ass. Inc.
9. Slack JMV 1991. From egg to embryo. (2/e). Cambridge Univ Press
10. Wolpert L 1997. Principles of development. Oxford Univ Press.

BTT 13. Bioprocess Engineering & Technology

Section A

Bioreactors: Design and components. Inoculation and sampling devices, valves etc. Types of bioreactors: Shake flask, Stirred tank, Air lift fermenter, Fed Batch, Continuous and immobilized cell reactor. Analysis of ideal bioreactors: The Ideal Batch reactor, Continuous Stirred Tank Reactor (CSTR), series of CSTRs and Plug flow Reactors. Sterilization. Kinetics of thermal death of microorganisms. Batch and continuous sterilization. Scale up, Instrumentation control. Physical and chemical environment sensors. Foam and antifoam agents. Types of fermentation. Continuous culture system, productivity and product formation. Aeration and agitation. Power requirement. Oxygen transfer kinetics.

Section B

Fluids vs solids, Fluid statics and applications including manometer; Mass and energy balances in fluid flow, Bernoulli's equation, its corrections and applications including pump work. Newton's law of viscosity, Measurement of viscosity of fermentation broths, flow curves for Non Newtonian fluids, and examples from bioprocess fluids. Pressure drop due to skin friction by Rayleigh's method of Dimensional Analysis. Significance of friction factor and Reynold's number. Boundary layer theory and form friction, Pressure drop due to form friction. Flow past immersed bodies and drag coefficients. Pressure drop in flow through packed beds. Fluidization and Pressure drop across fluidized beds. Flow machinery and control: overview of valves and pumps. Concept of Newtonian and non Newtonian fluids. Plastic fluids. Apparent viscosity.

Fick's law of diffusion, analogy with momentum and energy transport, diffusivities of gases and liquids; Fundamentals of mass transfer: Theories of mass transfer, concept of mass transfer coefficient, Dimensional analysis of

some mass transfer operations, dimensionless numbers and significance, correlation for mass transfer coefficients; Overview of separation operations.

Section C

Thermodynamics, mass and energy balances in microbial metabolism, cell growth and product formation; metabolic heat generation. Kinetics of microbial growth, substrate utilization and product formation: Growth phases of a batch culture, Monod's model including the effects of inhibition, determination of kinetic parameters by batch, fed batch and continuous culture and analysis of chemostat performance. Primary metabolites & Secondary metabolites. Structured models: Compartmental & metabolic models; Product formation kinetics: Gaden's and Deindoerfer's classifications, chemically & genetically structured models; Kinetics of growth & product formation by filamentous organisms. Role of maintenance and endogenous metabolism in substrate utilization & growth.

Mass and energy balance in metabolism. Models of heat transfer and examples. Metabolic heat generation. Fourier's law of heat conduction and analogy with momentum transfer, heat transfer through a cylindrical pipe wall. Convection and concept of heat transfer coefficient, application of dimensional analysis to heat transfer from pipe to a flowing fluid. Thermal boundary layer and Prandtl number. Overall heat transfer coefficient. Correlations for heat transfer coefficients in natural and forced convection, significance of dimensionless numbers. Overview of heat exchangers and concept of LMTD.

Text Books:

1. Stanbury PFA, Whittaker & Hall 1995. Principles of fermentation technology. Pergamon Press.
2. Fermentation: A practical approach. IRL Press.
3. "Biochemical Engineering fundamentals" 2nd ed. by J E Bailey and D F Ollis, McGraw-Hill (1986)
4. "Comprehensive Biotechnology" Vol.2 Ed.: M. Moo-Young (1985)
5. BIOTOL series. Principles of Cell Energetics, Butterworth - Heinemann.
6. Atkinson B. and Mavituna F. 1991.Biochemical Engineering and Biotechnology Handbook, 2/e. Stockton Press.
7. Moser A. 1981.Bioprocess Technology - Kinetics & Reactors. Springer-Verlag
8. Schugerl K. 1991. Biotechnology" Vol.4 Meaning, Modeling and Control. VCH
9. Cussler E L 1984. Diffusion. Cambridge University Press.

BTT 14. Microbial Technology

Section A

Fermentation media. Principles of microbial nutrition, formulation of culture media, selective media, factors influencing the choice of various carbon and nitrogen sources, vitamins, minerals, precursors & antifoam agents. Importance of pH. Measurement of growth (Cell number, direct and indirect methods).

Yield. P/O quotients. Efficiency of growth and product formation, growth stoichiometry. Strategies of yield improvement in industrial strains. Metabolic pathways and metabolic control mechanism. Primary and secondary metabolites. Metabolite overproduction and growth efficiency. Strategies for selection, improvement and maintenance. Maintenance energy requirement and maximum biomass. Input economy and cost-benefit analysis. Process optimization.

Section B

Engineering recombinants for insulin, somatostatin, HGH, interferons, cell growth factors and tissue plasminogen activator. Large scale production using recombinant microorganisms.

Alcoholic brews and ethanol production. Fermented beverages-Wine, Beer, Whisky. Production of glutamate, lysine, penicillin and vitamin B_{12}.Cell immmobilisation.

Industrial production of lactic acid, citric acid, enzymes viz. Proteases, amylases, cellulases. Acetic acid. Production and diversification of antibodies. Steroid conversions and their industrial applications. Biogums, Bioplastics, Biochips, Biosensors. Nanotechnology.

Biofertilizers: Production technology and storage methods for *Rhizobium, Azotobacter, Azospirillum*, Cyanobacteria, *Azolla*, PSM, Cellulolytes, VAM and PGPR. Biopesticides: Organisms, their targets, ideal candidates, biology of commercialized biopesticides. Chemistry of biocidal component, effect on target pests. Production technology and storage methods for *Bacillus thuringiensis* and Baculovirus.

Section C

Down stream processing: Principles, operation, design and scale-up. Mechanical methods: Cell disintegration, separation of particulate by filtration, centrifugation, settling, sedimentation, decanting and microfiltration. Primary isolation methods including solvent extraction, sorption, precipitation, ultrafiltration and Reverse osmosis. Two phase aqueous extraction. Purification methods: Fractional precipitation electrophoresis and various kinds of chromatography and adsorption. Drying devices. Crystallization. Whole broth

processing. Product recovery trains - a few examples. New and Emerging techniques: Pervaporation, Supercritical fluid extraction. Foam based separation.

Text Books:

1. BIOTOL. Biotechnological innovations in chemical synthesis. Butterworth-Heinemann.
2. Reed G (ED). Industrial Microbiology. CBS Pub (AVI Pub. Comp.)
3. Demain A.L. Biology of industrial microorganisms.
4. Hershnergev CL, Queener SW and Hegeman Q. 1998. Genetics and biotechnology of industrial microorganisms. American Soc. Microbiol.
5. Ewesis *et al.* 1998. Bioremediation principles. Mc Graw Hill.
6. McCabe W L, Smith J C and Harriot P. 1993. Unit operations of Chemical Engineering. 5/e. Mc Graw-Hill.
7. Doran Pauline M. Bioprocess Engineering Principles. Academic Press.

BTT 15. Environmental Biotechnology

Section A

Ecological principles, Basic concepts and issues of environment (Ozon depletion, UV-B, Green house effect/Global warming, Acid rain). Pollution and its indicators. Eutrophication. Methods to measure pollution. Ecological indicators and biomarkers.

Biogeochemical cycles : Biochemical, Chemical and microbiological aspects of Carbon, Nitrogen, Phosphorus, Sulfur Cycles. Geomicrobiology of Iron, Magnesium, Manganese, Calcium etc. Bioleaching of metals. Biomining.

Section B

Biodegradation and Biodeterioration : Paper, wood, paint, textile and metal corrosion, Biological deterioration and preservation of Archaeological monuments, Biodegradation of Xenobiotics (Plastics, pesticides, dyes, surfactants, hydrocarbons, oils and others). Bioremediation and Bioaugmentation - Solid Waste Management: Biodegradable solid waste: Composting - substrate, process operation and control process economics. Biogas production, Ensilage. Non biodegradable Solid waste and its management. Phytoremediation.

Bioremediation and Bioaugmentation- Liquid Waste Management: Waste treatment strategies. Waste exploitation for higher value products e.g. SCP and alcohol, xanthan. Water (Making water potable) and waste water treatment plants (Oxidation ditch, Oxidation Ponds, Trickling Filter, Activated Sludge Plant, High Rate Algal Bacterial Ponds, Rotary Contactors, Fluidized Bed Reactor, Mechanical aeration systems, Sanitary systems and their design, Anaerobic digestion reactors). Oil spills and their cleaning. Treatment schemes

for wastewater of dairy, tannery, distillery, sugar and antibiotic industry. Removal of heavy metals-biosorption technology. Flue Gas Management: Treatment strategies and microbiological options. Coal desulfurization.

Section C

Genetic manipulation of organisms to reduce pollutants with longer residual time. Oil bug and other specific cases. GMOs, risks and benefits and techniques for their ecological monitoring. Chemical Technology v/s Microbial Technologies: Surfactants v/s biosurfactants, Plastics v/s bioplastics, Colours v/s biocolours, Fertilizers v/s biofertilizers, Pesticides v/s biopesticides. Biohazards. Biological warfare.

Text Books:

1. Alexander M 1971. Microbial Ecology. John Wiley & Sons Inc., New York.
2. Alexander M. 1977. Introduction to Soil Microbiology. John Wiley & Sons New York.
3. Eldowney Ec S., Hardman DJ. and Waite S 1993. Pollution: Ecology and biotretament. Longman Scientific Technical.
4. Baker KH and Herson DS 1994. Bioremediation. Mc Graw Hill Inc., New York.
5. Erneasst WC 1982. The environment of the deep sea. Vol.II J.G. Morin Rubey.
6. Marshall KC 1985. Advances in Microbial Ecology. Vol.8 Plenum Press.
7. Burns RG and Slater JH 1982. Experimental Microbial Ecology. Blackwell Scientific Pub, Oxford.
8. Norris JR and Pettipher GL 1987. Essays in agricultural and food microbiology. John Wiley & Sons, Singapore.
9. Burges A and Raw F 1967. Soil Biology. Academic Press, London.
10. Vanghan D and Malcolm RE. 1985. Soil Organic Matter and Biological Activity. Martinus Nighoff W. Junk Pub.
11. Buckman H. and Brady N.C. The nature and properties of soil. Eurasis Pub. House (P.) Ltd. New Delhi.
12. Brock TD and Madigan. Biology of Microorganisms. Prentice Hall Int. Inc.
13. Michel R. 1999. Introduction to environmental microbiology.
14. Ehrlich. Geomicrobiology.

BTT 16. Food Processing & Technology

Section A

Physical principles in food processing operations. Thermal processing. Refrigeration. Freezing. Dehydration. Ionizing radiations. Flux, dose, duration,

applicability and safety requirements of techniques. Chemical principles in food processing. Preservation by sugar, salt, curing, smoke, acid and chemicals. Dose, duration, applicability and safety requirements. Chemical and biochemical reactions affecting food quality.

Processing technology of foods and nutritional implications with reference to cereal, pulses, oilseeds, fruits and vegetables: Wheat: grain characteristics, products, milling process, durum or semolina, macaroni or pasta, noodles, Baked products (Biscuits, bread and cakes). Fractionation of starch and gluten. Corn: Wet milling, Zein separation and starch products. Barley: malting, dry milling, wet fractionation and pearling. Rice: processing, fractionation, quick-cooking rice, parboiled rice and instant foods. Pulses: removal of toxic factors, quick cooking dals, fermentation and germination. Oilseeds: Pressing, solvent extraction, purification, hydrogenation, plasticizing and tempering, Products: Butter, margarine, shortening, mayonnaise and salt dressing. MCT production.

Section B

Fruits and Vegetables: Harvesting and pre processing considerations for fruits and vegetables. Perishability, its reasons and changes in quality. Post harvest processing:Canning, freezing, dehydration, pickeling and chutneys. Potato: Production of Chips, French fries and dehydrated granules, boiled/ canned potatoes. Fruit juices (Citrus, grapes, apple), Fruit slices, dehydrated fruit products, raisins. Canning fruit beverages and concentrates. Squashes, jams, jellies, ketchups, sauces, high sugar, high acid products.

Milk and milk products: Milk processing. Classification, separation, standardization, pasteurisation, off-flavour removal, homogenization, packaging, UH sterile milk. Milk Products: Fortified, skimmed and concentrate milk, cream, butter, cultured milk products, dehydrated milk products, ice creams. Indigenous products: Khoa, Chhena, Paneer, Curd, Ghee, Kulfi.

Section C

Additives & Preservatives: Definition of additives, acids, bases, buffer systems, salts, chelating agnets, antimicrobials, sweeteners, thickeners, fat replacers, firming texturisers. Appearance control and clarifying agents. Flavour enhancers, aroma substances, sugar substitutes, sweeteners, antioxidants. Anticaking agents, bleaching agnets, protective gases. Spices: Processing and extraction of essential oils and colours, stability, storgae and preservation.

Books:

1. Gould GW 1995. New methods of food preservation. Blackie Academic & Professional, London.
2. Connor JM & Schick WA. 1997. Food processing: An industrail power house in transition. John Wiley, NY.

3. Arthey D & Ashurst PR. 1986. Fruit processing. Blackie Academic & Professional, London.
4. Inglett GC & Munet L 1980. Cereals for food & beverages. Academic Press, NY.
5. Hirasa K & Takemasa M 1998. Spice Science and technology. Lion Corp., Tokyo.
6. Von Loesecke HW 1998. Food Technology Series: Drying and dehydration of foods. Allied Scientific Pub.
7. Matz SA 1996. Bakery technology & engineering. (3/e). CBS Pub. New Delhi.
8. Fellows PJ 2000. Food processing technology: Principles and practice. (2/e). CRC Woodhead Pub Ltd., Cambridge.
9. Hoseney RC 1996. Principles of cereal science and technology. 2/e. American Asso. Cereal Chemiss, St. Paul, Minnesota.
10. Salunkhe DK & Kadam SS 1995. Handbook of fruit science and technology: Production, composition, storage and processing. Marcel Dekker Inc, NY.

BTCP. Combined Practical

BTCP 5. Genetic Engineering & Bioinformatics

DNA cloning using plasmid vectors and in *E. coli* expression vectors.

Analysis of recombinant proteins using polyacrylamide gel electrophoresis.

Southern and Northern blotting.

Restriction mapping-plasmids.

PCR analysis.

DNA sequencing. Sanger's method.

Internet surfing and use of protein and nucleic acid databases. Similarity scarch.

BTCP 6. Plant & Animal Biotechnology

Plant cell culture.

Animal cell culture.

BTCP 7. Applied Microbiology & Fermentation Technology

Demonstration of the influence of oxygen, carbon dioxide, temperature on the growth of bacteria.

Nutrition requirements of bacteria by employing appropriate culture techniques.

Production of ethanol.

Quantification of lactic acid, ascorbic acid and alcohol.

Isolation of *Rhizobium*. Use of desiccation vial and Leonard jar. Bacteroid staining.

Observing mycorrhiza.

AR assay using GC for heterocystous cyanobacteria.

Immobilization of cells.

BTCP 8. Environmental Biotechnology & Food Processing & Technology

pH, soil moisture, Eh, conductivity, Water extractable cations, organic carbon, Kjeldahl nitrogen in soil.

Estimation of BOD and DO.

Microbial flora before and after pasteurization : DMC.

Quality of milk by MBRT and resazurine test.

SPC.

Coliform test and coliform count.

References:

1. Ausbel *et al.* 2000. Current protocols in molecular biology.
2. Sambrrok & Russell 2001. Molecular cloning Vol. I-III. CSH Press.