



# University of Rajasthan Jaipur

## SYLLABUS

### M.Sc. (Biotechnology)

#### (Semester Scheme)

I & II Semester Examination      2020-21

III & IV Semester Examination      2021-22

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## 1. Scheme of Examination:

1. Each theory paper EoSE shall carry 100 marks. The EoSE will be of 3 hours duration. Part A of theory paper shall contain 10 Short Answer Questions of 20 marks based on knowledge, understanding and applications of the topics/ texts covered in the syllabus. Each question will carry two marks for correct answer.
2. Part "B" of paper will consist of four questions with internal choice (except in case where a different scheme is specified in the syllabus) of 20 marks each.
3. Each Laboratory EoSE will be of six hour duration and involve laboratory experiments/exercises, and viva-voce examination with weightage in ratio of 75:25.

## 2. Course Structure:

The details of the courses with code, title and the credits assigned are as given below.  
Abbreviations Used

### Course Category

CCC: Compulsory Core Course

ECC: Elective Core Course

OEC: Open Elective Course

SC: Supportive Course

SSC: Self Study Course

SEM: Seminar

PRJ: Project Work

Contact Hours


L: Lecture

T: Tutorial

P: Practical

S: Self Study

The medium of instruction and examination shall be English only.

  
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## M.Sc. BIOTECHNOLOGY

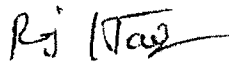
### FIRST- SEMESTER

S. No.	SUBJECT ODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1	BTH 701	Cell Biology	CCC	4	4	0	0	3	0
2	BTH 702	Genetics	CCC	4	4	0	0	3	0
3	BTH 703	Microbiology	CCC	4	4	0	0	3	0
4		Theory Elective-1	ECC	4	4	0	0	3	0
5		Theory Elective-2	ECC	4	4	0	0	3	0
6		Theory Elective-3	ECC	4	4	0	0	3	0
7	BTH 711	General Practical Lab. (Based on BTH 701, BTH 702 & BTH 703)	CCC	6	0	0	9	0	6
8		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10		Elective Practical Lab-3	ECC	2	0	0	3	0	4

  
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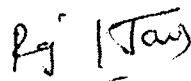
**SECOND SEMESTER**

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1	BTH 801	Molecular Biology	CCC	4	4	0	0	3	0
2	BTH 802	Virology & Immunology	CCC	4	4	0	0	3	0
3	BTH 804	Biological Macromolecules & Enzymology	CCC	4	4	0	0	3	0
4		Theory Elective-1	ECC	4	4	0	0	3	0
5		Theory Elective-2	ECC	4	4	0	0	3	0
6		Theory Elective-3	ECC	4	4	0	0	3	0
7	BTH 811	General Practical Lab. (Based on BTH 801, BTH 802 & BTH 803)	CCC	6	0	0	9	0	6
8		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10		Elective Practical Lab-3	ECC	2	0	0	3	0	4

  
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## THIRD SEMESTER

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1	BTH 901	Genetic Engineering	CCC	4	4	0	0	3	0
2	BTH 902	Animal Biotechnology	CCC	4	4	0	0	3	0
3	BTH 903	Seminar, Scientific Writing & Presentation	CCC	4	4	0	0	3	0
4		Theory Elective-1	ECC	4	4	0	0	3	0
5		Theory Elective-2	ECC	4	4	0	0	3	0
6		Theory Elective-3	ECC	4	4	0	0	3	0
7	BTH 911	General Practical Lab. (Based on BTH 901, BTH 902 & BTH 903)	CCC	6	0	0	9	0	6
8		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10		Elective Practical Lab-3	ECC	2	0	0	3	0	4

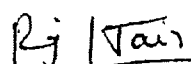
  
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**FOURTH SEMESTER**

S. No.	SUBJECT CODE	Course Title	Course Category	Credit	Contact hours per week			EoSE duration (Hrs.)	
					L	T	P	Theory	P
1	BTH X01	Plant Biotechnology	CCC	4	4	0	0	3	0
2	BTH X02	IPR & Biosafety	CCC	4	4	0	0	3	0
3	BTH X03	Dissertation & Industrial Training	CCC	4	4	0	0	3	0
4		Theory Elective-1	ECC	4	4	0	0	3	0
5		Theory Elective-2	ECC	4	4	0	0	3	0
6		Theory Elective-3	ECC	4	4	0	0	3	0
7	BTH X11	General Practical Lab. (Based on BTH X01 & BTH X02)	CCC	6	0	0	9	0	6
8		Elective Practical Lab-1	ECC	2	0	0	3	0	4
9		Elective Practical Lab-2	ECC	2	0	0	3	0	4
10		Elective Practical Lab-3	ECC	2	0	0	3	0	4

**Note:-**

1. Elective core courses lab. can be opted only if the respective Elective theory has been opted by the student. ECC lab. Examination will be based on ECC lab. work of above papers wherever applicable.
2. Department will offer minimum three and maximum six theory elective courses for the semester based on options submitted by the students and availability of Faculty to teach the course.

  
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**Theory Elective Courses****Specialization Clusters:-**

A.GEN-General


B.IB- Industrial Biotechnology

C.EB- Environmental Biotechnology

D.PE- Protein Engineering

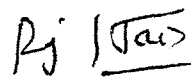
**Theory Elective Courses**

Elective Course Code	Specialization	Course Title	Prerequisite	Semester In which course will be available
BTH A01	GEN	Analytical Techniques		I
BTH A02	GEN	Bioinformatics & Biostatistics		II
BTH A03	GEN	Entrepreneurship & Ethics		III
BTH A04	GEN	Virology		IV
BTH B01	IB	Enzyme Technology		I
BTH B02	IB	Bioprocess Engineering		I
BTH B03	IB	Industrial Biotechnology & Biosafety		II
BTH B04	IB	Nanobiotechnology		IV
BTH C01	EB	Biodiversity, Ecology and Evolution		II
BTH C02	EB	Applied Environmental Biotechnology		IV
BTH D01	PE	Protein Engineering		III
BTH D02	PE	Proteomics & Genomics		III

  
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## Laboratory Elective Courses

Elective Course Code	Specialization	Course Title	Prerequisite	Semester In which course will be available
BTH A11	GEN	Analytical Techniques		I
BTH A12	GEN	Bioinformatics & Biostatistics		II
BTH A13	GEN	Entrepreneurship & Ethics		III
BTH A14	GEN	Virology		IV
BTH B11	IB	Enzyme Technology		I
BTH B12	IB	Bioprocess Engineering		I
BTH B13	IB	Industrial Biotechnology & Biosafety		II
BTH B14	IB	Nanobiotechnology		IV
BTH C11	EB	Biodiversity, Ecology and Evolution		II
BTH C12	EB	Applied Environmental Biotechnology		IV
BTH D11	PE	Protein Engineering		III
BTH D12	PE	Proteomics & Genomics		III

  
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**BTH 701– Cell Biology**

**The Dynamics of cell, shape and motility:** Structural organization of the plant, animal & microbial cells, Cytoskeleton, microtubules and microfilaments, motor and flagellar movements. 3

**Cell wall, plasma membrane and plasmodesmata:** Structure and functions, biogenesis, growth models and functions, ion carriers, channels and pumps, receptors. Role in movement of molecules and macromolecules across membranes, comparison with gap junctions. 4

**Other Cellular organelles:** Structure and functions of micro-bodies, Golgi apparatus, ribosomes, lysosome, endoplasmic reticulum.

**Plant vacuole:** Structure and function 5


**Chloroplast and mitochondria:** Fine Structure and function of the organelles, their electron transport systems, import of nuclear encoded proteins, ATP synthases, structure, organization and function of mitochondrial and chloroplast genomes, mechanism of organelle gene expression, diversity and evolution of organelle genomes. 6

**Nucleus:** Structure, nuclear envelope (karyotheca), nuclear pores, nuclear lamina, nucleolous and nuclear matrix. 2

**Chromatin organization :**Chromosome structure and packaging of DNA, nucleosome organization, molecular organization of centromere and telomere, nucleolus and ribosomal RNA genes, euchromatin and heterochromatin, specialized types of chromosomes, polytene, lampbrush, B-chromosomes , supernumerary chromosomes, molecular basis of chromosome pairing. 6

**Cell Cycle and Mechanics of cell division:** Cell cycle control mechanisms -Negative and Positive intra & extra cellular controls, Role of cyclins&cyclindependent kinases (CDKs). Cytokinesis and cell plate formation. The events of m phase, CDK & cyclin B leading to Metaphase. The spindle assembly check points leading to Anaphase. DNA damage check point controlled by P 53 protein. Map & *mitogen-activated protein kinase (MAPK) : Erk1 & Erk2, Ras* (mitogen activated protein kinases). 8

**Mechanism at different stages of mitosis:** Cohesins and condensins in chromosome segregation, Microtubules in spindle assembly, Structure of kinetochore, centrosome and its functions, Sister Chromatid separation. Cytokinesis actin & myosin in the generation of contractile ring, somatic metaphase. 5

  
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**Meiosis**– Significance, Chiasma formation- Synaptonemal complex, Recombination during meiosis- Recombination nodules. 2

**Apoptosis(Programmed cell death):** Mechanism of apoptosis, Apoptosis triggered by internal & external signals, Apoptosis inducing factors, cancer, oncogenesis& its mutations. 4

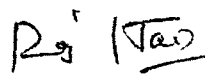
**Cell communication and Signal transduction:** Overview of extra cellular signaling signal molecules- hormones, neurotransmitter proteins, environmental factors  
Second messengers and their role in signal transduction - lipid and phosphatidyl inositol derived second messengers & Role of calcium as second messenger 6

**Cell surface receptors in signal transduction:** G-protein coupled receptor – structure and function, Ion channel receptors, Tyrosine kinase linked receptors, Receptors with intrinsic enzyme activity (RTK). 5

**Interaction and regulation of cell signaling pathways** - bacterial and plant two component signaling system, bacterial chemotaxis and quorum sensing. 4

### ***Suggested Laboratory Exercises***

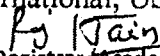
1. EM study of cell organelles
2. Fluorescence staining with FDA for cell viability.
3. Cell wall staining with calcofluor
4. Study of stages in cell cycle
5. Mitosis and Meiosis
6. Histochemical localization of protein, carbohydrate, fats, starch, lignin, nucleic acids
7. Isolation of mitochondria and the activity of its marker enzyme, succinate dehydrogenase (SDH).
8. Demonstration of SEM and TEM.
9. Karyotype analysis, banding patterns.
10. Polytene, lampbrush, B-chromosomes and sex chromosomes,
11. Preparation of Polytene chromosome from *Chironomus* larva/*Drosophila* larva
12. Silver banding for staining nucleolus-organizing region, where 18S and 28S rDNA are transcribed.

  
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13. Orcein and Feulgen staining of the salivary gland chromosomes of *Chironomas* and *Drosophila*.
14. Characteristics and behavior of B chromosomes using maize or any other appropriate material.
15. Any other practical based on theory syllabus.

### ***Suggested Readings:***

1. Krishnamurthy, K.V. (2000). *Methods in Cell Wall Cytochemistry*. CRC Press, Boca Raton, Florida.
2. Reeve, ECR. (2001). *Encyclopedia of Genetics*, F. D. Publication, Chicago, USA
3. De, DN. (2000). *Plant Cell Vacuoles: An Introduction*. CSIRO Publication, Collingwood, Australia.
4. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). *Cell and Molecular Biology*. (VIII Edition). Lippincott Williams and Wilkins, Philadelphia.
5. Cooper, G.M. and Hausman, R.E. (2009). *The Cell: A Molecular Approach*. ( V Edition). ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). *The World of the Cell*. (VII Edition). Pearson Benjamin Cummings Publishing, San Francisco.
7. Kleinsmith, L.J. and Kish, V.M. (1995). *Principles of Cell and Molecular Biology* (2nd Edition). Harper Collins College Publishers, New York, USA.
8. Harris, N. and Oparka, K.J. (1994). *Plant Cell Biology: A Practical Approach*. IRL Press, at Oxford University Press, Oxford, U.K.
9. Gunning, B.E.S. and Steer, M.W. (1996). *Plant Cell Biology: Structure and Function*. Jones and Bartlett Publishers. Boston, Massachusetts.
10. Karp, G. (2010). *Cell and Molecular Biology: Concepts and Experiments*. VI Edition. John Wiley & Sons.Inc.
11. Griffiths. A.J.F. et. al.(2000). *An introduction to genetic analysis*, W. H. Freeman and Company, New York, USA.
12. Rana, S.V.S., (2012). *Biotechniques, theory and practices* (Third edition), Rastogi publications, Meerut.
13. Hall, J.L. and Moore, A.L. (1983). *Isolation of Membranes and Organelles from Plant Cells*. Academic Press, London, UK.
14. Roy, S.C. and De, KK. (1999). *Cell Biology*. New Central Book Agency (P) Ltd., Calcutta.
15. Hartl, D. L. (1994). *Genetics*. Jones and Bartlett Publishers International, USA.

  
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16. Becker, W.M., Kleinsmith, L.J., Hardin, J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco. USA

### BTH 702– Genetics

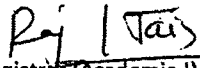
**Gene Structure and expression:** Genetic fine structure, Operon concept, Introns and Exons, cis-trans test, fine structure analysis of eukaryotes, introns and their significance, Gene family. 5

**Inheritance and allelism:** Mendelian and non-Mendelian inheritance, Gene interaction: Complementary genes (9:7 ratio); Supplementary genes (9:3:4 & 9:6:1 ratios), Epistasis (12:3:1, 13:3 ratios), Duplicate genes (15:1) co-dominance, Lethal Genes, Polygenic inheritance. Extra nuclear inheritance: Cytoplasmic male sterility, inheritance of mitochondrial and chromosomal plant genes, Hardy-Weinberg Law. Gene frequency and genotype frequency. Sex determination, sex linked inheritance, sex limited characters and sex reversal, multiple alleles and blood groups in man. 9

**Genetic recombination:** Homologous and non-homologous recombinations; independent assortment and crossing over; molecular mechanism of recombination, Holiday junction, site-specific recombination, FLP/ FRT and cre / lox recombination, role of Rec A and Rec BCD enzymes and other recombinations. 5

**Mutation and types of DNA damage:** Mutagens and their effects – Physical (Radiations) and Chemical (Base analogues, Intercalating agents, Alkylating agents and others), Types of mutation- Spontaneous and induced mutations, lethal, conditional, biochemical, loss and gain of function, base substitution, frame-shift mutation, germinal versus somatic mutation, Mutations induced by transposons. 2

**Repair mechanisms of mutational DNA damages-** Direct reversal of damages (Photoreactivation and Dealkylation), Excision Repair mechanisms (NER and BER),

  
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Post-replication repair mechanisms (Mismatch repair and Recombination repair), SOS repair. Inherited diseases and defects in DNA repair. 5

**Mutagenesis:** Insertional mutagenesis, site-directed mutagenesis, *in vitro* mutagenesis and deletion techniques, Ames test for mutagenesis. Ploidy and their genetic implications. 5

**Chromosome mapping:** Linkage map, mapping with genetic markers including RAPD, QTL, construction of molecular maps, restriction mapping- concept and technique, correlation of genetic and physical maps, mapping by using somatic cell hybrids. 6

**Structural and numerical alterations in chromosomes :** Origin, meiosis and breeding behaviour of duplication, deficiency, inversion and translocation heterozygotes. Origin, occurrence, production and meiosis of haploids, aneuploids and euploids; origin and production of autopolyploids; chromosome and chromatid segregation, allopolyploids types; genome constitution and analysis. Evolution of major crop plants. induction and characterization of trisomics and monosomics. 8

**Molecular cytogenetics :** Nuclear DNA content, C-value paradox, cot curve and its significance, multigene families and their evolution, *in situ* hybridization - concept and techniques, computer assisted chromosome analysis, chromosome microdissection and microcloning, flow cytometry and confocal microscopy in karyotype analysis. 7

**Cancer:** Proto- oncogenes, oncogenes and tumor suppressor genes. 3

**Human genetics:** Pedigree analyses, lod score for linkage testing, karyotypes and genetic disorders. Population genetics; General account of inherited human diseases 5

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### Suggested Laboratory Exercises-

1. Study of Hardy-Weinberg Law using simulations (seeds).
2. Linear differentiation of chromosomes through banding techniques, such as G-banding, C-banding and Q-banding.
3. Working out the effect of mono- and trisomy on plant phenotype.
4. Induction of polyploidy using colchicine.
5. Different applications of Colchicine.
6. Study of variations in plants due to numerical alterations in chromosomes.
7. Isolation of chlorophyll mutants following irradiation and treatment with chemical mutagens.
8. Numericals based on inheritance and gene interactions.
9. Flow cytometry and confocal microscopy.
10. Any other practical based on theory syllabus.

### Suggested Readings:

1. Atherly, AG., Girton, JR. and McDonald, JF. (1999). The Science of Genetics. Saunders College Publishing, Fort Worth, USA.
2. Burnham, CR. (1962). Discussions in Cytogenetics. Burgess Publishing Co. Minnesota.
3. Busch, H. and Rothblum, L. (1982). Volume X. The Cell Nucleus rDNA Part A. Academic Press.
4. Hartl, DL. and Jones, EW. (1998). Genetics: Principles and Analysis (4th edition). Jones & Bartlett Publishers, Massachusetts, USA.
5. Khush, GS. (1973). Cytogenetics of Aneuploids. Academic Press, New York, London.
6. Lewis, R. (1997). Human Genetics: Concepts and Applications (2nd editions). WCB McGraw Hill, USA.
7. Russel, P.J. (1998). Genetics (5th edition). The Benjamin/Cummings Publishing Company Ind., USA.
8. Fukui, K. and Nakayama, S. (1996). Plant Chromosomes: laboratory Methods. CRC Press, Boca raton, Florida.
9. Sharma, AK. and Sharma, A. (1999). Plant Chromosome Analysis, Manipulation and Engineering. Hoarwood Academic Publisher, Australia.
10. Gardner, EJ., Simmons, MJ., Snustad, DP. (2008). Principles of Genetics (VIII ed). John Wiley & Sons.

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11. Snustad, D.P. and Simmons, M.J. (2009). Principles of Genetics (V Edition). John Wiley and Sons Inc. USA.
12. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics (XI Edition). Benjamin Cummings Publishing Company INd., USA.
13. Russell, P. J. (2009). Genetics - A Molecular Approach.( III Edition). Benjamin Cummings Publishing Company INd., USA.
14. Pevsner, J. (2009). Bioinformatics and Functional Genomics (II Edition). John Wiley & Sons.
15. Griffiths, A.J.F. Wessler, SR., Lewontin, RC. and Carroll, SB. (2008). Introduction to Genetic Analysis ( IX Edition). W. H. Freeman & Co.
16. Arora, MP. Gurdarshan and Sandhu, S. (2004). Genetics.Himalaya Pub. House, New Delhi.

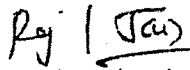
### **BTH 703– Microbiology**

**History and Development:** Microbial evolution, systematic and taxonomy; primitive organisms and their metabolic strategies and molecular coding; New approaches to bacterial taxonomy classification including ribotyping, Ribosomal RNA sequencing. 7

**Prokaryotic and eukaryotic diversity:** Nomenclature and Bergey's Manual; Prokaryotic Cells: Structure and Function-Cell wall composition of Gram+ve& -ve bacteria; Cell wall and cell membrane synthesis; Flagella and motility; cell inclusions like endospores, gas vesicles. Bacteria: Purple and green bacteria, budding bacteria, Spirochaetes; Sheathed bacteria, Endospore forming rods and cocci; Mycobacteria; Mycoplasma, Archaea: Archaea as earliest life forms; Halophiles, Methanogens; Hyperthermophilicarchaea and Thermoplasma.

**Eukarya:** Algae, Fungi, Slime molds and Protozoa- General characteristics and types 15

**Pathogenic bacteria of medical importance:** Nomenclature and Classification; Gram Positive cocci of Medical Importance - Pneumococcus, Staphylococcus, Micrococcus, Streptococcus; Gram negative cocci - Neisseria, Branhamella; Gram positive bacilli - Coryneform organisms, Actinomyces, Clostridium; Gram negative bacilli- Vibrios, Aeromonas, Haemophilus, Bordetella, Enterobacteriaceae, mycobacteria, spirochetes, Chlamydiae, Rickettsiae. Establishment, spread, tissue damage and anti- phagocytic factors. 10

  
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**Microbial Growth:** Pure culture technique; Microbial Growth- definition, mathematical expression of growth, growth curve, measurement of growth and growth yields, Synchronous growth, Continuous, Batch and Fed Batch Culture; Factors affecting growth: temperature, acidity, alkalinity, water availability and oxygen; Culture collection maintenance and preservation. 6

**Bacterial genetic system:** Recombination - transformation, conjugation, transduction; Bacterial genetic map with reference to *E. coli*.

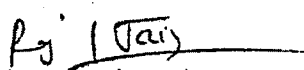
Genetic system of yeast and *Neurospora* 5

**Physiology and Metabolic Diversity among Microorganisms:** Nutritional classification of microorganisms- chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms. Photosynthesis in microorganisms; Chemolithotrophy; Hydrogen, Iron, Nitrate and oxidizing bacteria; Nitrate and sulfate reduction; Nitrogen metabolism; Nitrogen fixation. 12

**Chemotherapy and Antimicrobial agents:** Sulfa drugs; Antibiotics; Penicillin and Cephalosporin; Antibiotics from prokaryotes and eukaryotes; Mode of action; Resistance to antibiotics. 5

### Suggested Laboratory Exercises:-


1. Preparation of liquid and solid media for growth of microorganisms.
2. Isolation and maintenance of organisms by plating, streaking and serial dilution methods, slants and stab cultures, storage of microorganisms.
3. Isolation of pure cultures of bacteria from soil and water.
4. Growth; Growth curve, Measurement of bacterial population by turbidometry and serial dilution methods.
5. Effect of temperature, pH and carbon and nitrogen source on growth.
6. Microscopic examination of bacteria, yeast and molds.
7. Staining techniques to observe bacterial structure: Simple staining, Gram staining, Negative staining, Endospore staining, Capsule staining
8. Study of mutations by Ames test.
9. Biochemical characterization of selected bacterial strains.
10. Isolation and identification of pathogenic fungi from plants.
11. Isolation and identification of nonpathogenic fungi from soil.
12. Raising fungal pure cultures by hyphal tip culture & single spore culture.
13. Microbiological examination of milk: By Methylene-blue dye reduction test
14. Other practical based on theory syllabus.

  
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**Suggested Readings:**

1. Pelczar, M.J.Jr., Chan, E.C.S. and Kreig, N.R. (2004). *Microbiology* (5<sup>th</sup> Ed). Tata McGraw Hill.
2. Maloy, S.R., Cronan, J.E.Jr. and Freifelder, D. Jones, *Microbial Genetics* Bartlett Publishers.
3. Benson, H.J. *Microbiological Applications, (A Laboratory Manual in General Microbiology)*. WCG; WmC. Brown Publishers.
4. Purohit, S.S. *Microbiology: Fundamentals and Applications* Published by Agrobios, India.
5. Sallé, A.J. (1999). *Fundamental Principles of Bacteriology*, (7th ed.) Tata- McGraw Hill
6. Prescott, L.M., (2005). *Microbiology*, (6th ed.) McGraw-Hill.
7. Kathleen Park Talaro & Arthur Talaro (2002) *Foundations in Microbiology* International edition. McGraw Hill.
8. Alexopoulos CJ, Mims C'W, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
9. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. W.M.T. Brown Publishers.
10. Cappuccino J and Sherman N. (2010). *Microbiology. A Laboratory Manual*. 9th edition. Pearson Education limited.
11. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/Benjamin Cummings.
12. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). *General Microbiology*. 5th edition. McMillan.
13. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition. Pearson Education.
14. Vashishta BR and Sinha AK. (2008). *Fungi*. S. Chand and Company Ltd.
15. Black JG. (2008). *Microbiology: Principles and Explorations*. 7th edition. Prentice Hall
16. Srivastava S and Srivastava PS. (2003). *Understanding Bacteria*. Kluwer Academic publishers, Dordrecht
17. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition Pearson Education.
18. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*.

  
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**BTH 801- Molecular Biology**

**Genetic material:** The Structures of DNA and RNA. Genetic Material, Types of DNA, Types of genetic material, DNA topology - linking number, topoisomerases; Organization of DNA in Prokaryotes, Viruses, Eukaryotes. 6

**DNA Replication:** Genome and its organization; Prokaryotic and eukaryotic DNA replication. Unit of replicon, enzymes involved, mechanisms of DNA replication, origin and replication fork, fidelity of replication, accessory proteins involved in DNA replication. 6

**Transcription-Prokaryotic, Eukaryotic transcription.** transcriptional factors and machinery, RNA polymerases, Regulatory elements and mechanisms of transcription regulation- formation of initiation complex, transcription activators and repressors, capping, elongation and termination, RNA processing, RNA editing, structure and function of snRNA&snprotein, spliceosome, type III intron, splicing of eukaryotic RNA, polyadenylation, structure and function of mRNA; RNA transport, nuclear export of m- RNA, m-RNA stability. catabolite repression, attenuation and antitermination. 11

**Regulation at transcriptional level :** Signal transduction- Environmental signals to Cell surface, intracellular communication; Protein DNA interaction, Transcriptional complex and activation of smart gene; Activation of transcription by Gene battery; Processing regulation i.e. splicing in different manner e.g. Troponin gene; Repression of transcription- Gene silencing . 5

**Translation -Prokaryotic and eukaryotic translation,** the translation machinery. tRNA structure and function, Genetic code (nuclear and orgenell). Ribosome subunits its molecular structure and function; Formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, aminoacylation of t -RNA, aminoacyltRNAsynthetase, termination of translation, proof-reading; translational inhibitors; Co- and Post- translational modification of proteins. 12

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**Regulation at translational level :** Activation and Repression of translation through mRNA binding protein, Phosphorylation of eukaryotic initiation factors of translation; Repressor protein, Cytoplasmic control of mRNA stability. 4

**Regulation of gene expression in prokaryotes and eukaryotes -** Panoply of operon; Spatial (Tubulin gene in plants) & temporal (Globin gene in animals) regulation; Tissue specific gene regulation. 4

**Protein Localization:** Synthesis of Secretory and membrane proteins, intracellular protein traffic-import into nucleus, mitochondria, chloroplast and peroxisomes. Receptor mediated endocytosis. 6

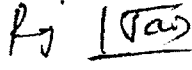
**Antisense and Ribozyme Technology:** Molecular mechanism of antisense molecules, Biochemistry of Ribozymes –Hammerhead, hairpin, RNase P and other ribozymes, applications of antisense and ribozyme technology. 6

### Suggested Laboratory Exercises:

1. Preparation of culture medium (LB) for *E.coli* (both solid and liquid) and raise culture of *E.coli*.
2. Isolation of genomic DNA. and its quantification
3. Perform DNA amplification by PCR.
4. Isolation of RNA.
5. Demonstration of antibiotic resistance
6. Metabolic labelling of proteins and immunoprecipitation.
7. Any other practical based on theory syllabus.

### Suggested Readings:

1. Voet, D. and Voet, JG. (2013). Biochemistry (4<sup>th</sup> edition), John Wiley & Sons.
2. Segel, IH. (1976). Biochemical Calculations (2<sup>nd</sup> ed.), John wiley& sons inc.
3. Voot, D. and Voet, JG. (2004). Biochemistry (4<sup>th</sup> ed.), J Wiley and Sons.
4. Berg J.M., Tymoczko J.L. and Stryer L (2002), *Biochemistry*, W.H. Freeman
5. Frefilder, D. (). Physical biochemistry, W.H. Freeman & company.
6. Work, TS. and Work, E. (1980). Laboratory Techniques in Biochemistry and Molecular Biology, online version;  
[www.sciencedirect.com/science/bookseries/00757535](http://www.sciencedirect.com/science/bookseries/00757535)
7. Rao, CNR. (1999). Understanding Chemistry, Universities press, Hydrabad.

  
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8. Wilson, K. & Goulding, KH. (1986). A Biologist's Guide to principles and Techniques of practical biochemistry, ELBS Edition.
9. Cooper, TG. (1994). Tools of Biochemistry,
10. Malacinski, GM. (2005). Essentials of Molecular Biology, Jones and Barlett publications.
11. Creighton, TE. (1993). Proteins-Structure and Molecular properties, WH freeman and company.
12. Branden, C. and Tooze, J. (1991). Introduction to protein structure, Garland publishing, New York.
13. Kendrew, J. (1994). Encyclopaedia of Molecular Biology, Blackwell scientific publications, oxford.
14. Taft, C. (). Physical chemistry of Macromolecules, John Wiley and Sons.
15. Cantor, CR. and Schimmel, PR. (1980). Biophysical chemistry, WH Freeman.
16. Marie-Claire Bellissent-Funel (ed.) (1992). Protein Structure by Max Perutz Perutz. In: Hydration Processes in Biology: Theoretical and Experimental Approaches.
17. Gelvin. S.B. and Schilperoort, R.A. (eds.) (1994). Plant Molecular Biology Manual. 2nd edition, Kluwer Academic Publishers, Dordrecht. The Netherlands.
18. Glick B.R. and Thompson, J.E. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
19. Glover, D.M. and Hames, B.D. (Eds.) (1995). DNA Cloning 1 : A Practical Approach, Core Techniques, 2nd edition. IRL Press at Oxford University Press, Oxford.
20. Shaw, C.H. (Ed.) (1988). Plant Molecular Biology: A Practical Approach, IRL Press, Oxford.
21. Rana, S.V.S., 2012. Biotechniques, theory and practices (Third edition), Rastogi publications, Meerut.
22. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
23. Watson, JD., Gilman, M., Witkowski, J and Zoller, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.

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## BTH 802- Virology and Immunology

**Disease development:** Introduction and history, Host parasite relationship, Host colonization and factors predisposing to infection. Types of toxins (exotoxins, endotoxins, entrotoxins) and their structures; mode of action (biochemical, physiological); nonspecific and specific defense mechanisms. 5

**Viruses:** Nomenclature and classification; morphology and ultra-structure; Capsid and their arrangements; Genetics of viruses; distinctive properties of viruses.

10

**Animal and human viruses:** Epidemiology, life cycle, pathogenecity and diagnosis. Prevention and treatment of RNA viruses: Enteroviruses, Orthomyxoviruses, Paramyxoviruses and Rhabdoviridae. DNA viruses: Poxviridae, Herpesviridae, Adenoviridae, Hepadna virus. Viral vaccines, interferons, and antiviral drugs.

10

**Effect of viruses on plants:** Symptomatology, histopathology, physiology and pathogenicity. Common viral diseases of plants (TMV, Cauliflower mosaic virus and Potato virus X). Transmission of plant viruses through vectors (insects, nematodes, fungi) and without vectors (contact, seed, pollen transmission). Brief account of diagnostic techniques in plants; infectivity assay of plant viruses, indicator plants, histochemical tests and vector control.

15

**Immunology:** Brief history, innate responses, innate and acquired immunity, organization and structure of lymphoid organs. Nature, biology and types of antigens and super antigens. Antibody structure and types; theories of antibody production; Antigen antibody interaction.

10

**Cells of immune system:** Lymphocyte (B-cells, T-cells and natural killer cells); Antigen Presenting cells (Macrophages, B cells, dendritic cells), killer T cells, also called cytotoxic T lymphocytes (CTLs).

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Hybridoma technology & monoclonal antibodies and its applications, regulation of immune responses- Hypersensitivity, Autoimmunity. Immune response during bacterial (tuberculosis), parasitic (malaria), and viral (H.V) infections, congenital and acquired immune deficiencies, immune techniques.

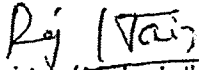
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### ***Suggested Laboratory Exercises:***

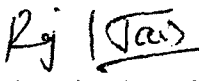
1. Study of various symptoms produced in plants due to virus infection.
2. Study of viral diseases of plants/ animals/ human (Specimen/ photographs)
3. Different type of viruses (Photographs/ sketches).
4. Raising virus free plants through apical meristem culture.
5. Blood film preparation and identification of cells.
6. Immunization, Collection of Serum.
7. Double diffusion and Immuno-electrophoresis.
8. Radial Immuno diffusion.
9. Purification of IgG from serum.
10. Separation of mononuclear cells by Ficoll-Hypaque.
11. Con-A induced proliferation of thymocytes (by MTT method).
12. ELISA.
13. Immunodiagnosics (demonstration using commercial kits).
14. Any other practical based on theory syllabus.

### ***Suggested Readings:***

1. Morag C and Timbury M.C. 1994. Medical virology-X Edition. Churchill Livingstone, London.
2. Dimmock NJ, Primrose SB. 1994. Introduction to Modern Virology, IV Edition, Blackwell Scientific Publications, Oxford.
3. Conrat HF, Kimball PC and Levy JA. 1994. Virology (III Edition), Prentice Hall, Englewood cliff, New jersey. USA.
4. Matews, RE. 1992. Functionals of plant virology, Academic press, San Diego.
5. Topley and Wilson's 1995. Text Book on principles of Bacteriology, virology and Immunology, Edward Arnold, London.
6. Lennetter, 1984. Diagnostic procedures for viral and Rickettsial diseases. American public Health association, NY.

  
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7. William Hayes, 1985. The genetics of Bacteria and their viruses. Blackwell Scientific Publishers, London.
8. Ronald M. Atlas. 1995. Principles of microbiology. Mosby Year Book Inc. Missouri 63146.
9. Kenneth M. Smith, 1996. Plant viruses. Universal Book Stall, New Delhi.
10. Walkey D.G.A. 1985. Applied Virology. International Books & Periodicals supply service. New Delhi.
11. Maramarosch Karl, 1992. Plant Diseases of viral, viroid, Mycoplasma & uncertain etiology. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi, Bombay, Calcutta.
12. Powar, C.B. and Daginawala, H.F. 2003. General Microbiology Vol. II. Himalaya Publishing House. Mumbai.
13. Biswas, A. Biswas, SK. 2006. An Introduction to Viruses. Vikas Publishing House Pvt. Ltd., New Delhi.
14. Agrios, G.N. 1997. Plant Pathology, Academic Press. NY. USA.
15. Kuby Immunology, (4<sup>th</sup> Edition) R.A. Goldsby. Thomas J. Kindr Barbara, A. Osbarne, (Freeman) & Co. New York.
16. Bloom, BR. Lambert, PH. 2000. Immunology: A short course (4<sup>th</sup> Edition), John Wiley & Sons
17. Roitt, M. 1998. Essentials of Immunology, ELBS, Blackwell Scientific publishers, London.
18. Gerhardt. P. Murray, R. Ce., Wood W.A., and Kreig N.R. (eds.) 1994. Methods for General and Molecular Bacteriology. American Society for Microbiology, Wasington D.C.
19. Pelczar MJ. Chan ECS. Krieg NR. Microbiology (5<sup>th</sup> Edition) Tata McGraw Hill, Delhi.
20. Kumar, S. 2012. Textbook of Microbiology, Jaypee Brothers Medical Publishers Pvt. Ltd., New Delhi.

  
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## BTH 804- Biological Macromolecules & Enzymology

### Amino acids and peptides:

Classification, chemical reactions and physical properties. Biosynthesis of amino acid (Reductive amination Transamination, GS-GOGAT system). Protein structure (primary, secondary, tertiary & quaternary), Protein folding, Glyco and lipoproteins - structure and function, Globular, Fibrous proteins; Hydrophobic and hydrophilic interactions, Ramachandran plot, DNA-protein interactions (Yeast hybrid system); Protein sequencing. Biological importance of proteins. 15

**Nucleotides:** Biosynthesis of purines & pyrimidines (De-novo synthesis and Salvage pathway) 5

**Carbohydrate:** Classification and reactions, structure and function of mono, disaccharides, and polysaccharides. Methods for compositional analysis of polysaccharide 5

**Lipids:** Classification, structure, biosynthesis and functions of glycerol phospholipids, sphingolipids and cholesterol. 5

**Secondary metabolites:** General introduction and significance, difference from primary metabolites, types of secondary metabolites (*alkaloids, flavonoids & steroids*). Polypeptides, Non-ribosomal peptides. 5

**Principles of thermodynamics:** First and second law, concept of free energy, isothermal process, reversible & irreversible process, high energy compounds. Maxwell equation, Joule-Thomson coefficient, Kelvin-Planck Statement, Thermodynamic properties of pure substances in solid, liquid & vapor phases. 8

**Enzymes:** classification, nomenclature, Structure: concept of holoenzymes, coenzyme, apoenzyme, isozymes and prosthetic groups, Allosteric enzymes.

Physiochemical and biological properties, role of enzymes as catalysts; substrate specificity, Mechanism of enzyme action (active site, chemical modification) and regulation (Zymogens, Isozymes) 7

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**Enzyme kinetics and regulation:** Michaelis-Menten equation,  $K_m$  value, Kinetics of bi substrate reaction. Enzyme inhibition- irreversible, reversible, competitive, non-competitive and uncompetitive inhibition. Regulation of enzyme activity- feedback inhibition.

Enzyme catalysis-effect of organic solvents on enzyme catalysis, Immobilization of enzymes and its application. Determination of active sites. Functional proteins- structure and drug target (enzyme and receptors). Effects of substrate, temperature, pH and inhibitors on enzyme activity and stability, Enzyme engineering. Importance and applications of enzymes. Industrial aspects of enzymology

10

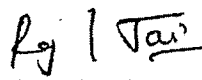
### ***Suggested Laboratory Exercises:***

Separation and Characterization of macromolecules molecular shape and size; molecular weight; by liquid chromatography, electrophoresis and spectroscopy

1. Reactions of amino acids, sugars and lipids.
2. Isolation, purity determination and quantitation of cholesterol.
3. Electrophoresis of proteins.
4. Quantification of proteins and sugars.
5. Analysis of oils-iodine number, saponification value, acid number.
6. UV- Visible and IR Spectroscopy- absorption spectra.
7. Separation techniques- Centrifugation, Chromatography (Ion exchange-TLC etc.)
8. Electrophoresis of DNA-linear, circular
9. Demonstration of HPLC.
10. Enzyme: Purification and Kinetic analysis.
11. Hybridoma technology
12. Any other practical based on theory syllabus

### **Text Book:**

1. Murray. R.K. Granner.D.K, Mayes. P. A, Rodwell. V. W. Harper's Biochemistry. 27th ed. McGraw Hill, 2006.
2. Berg.J.M, Tymoczko.J.L, Stryer, L. Biochemistry. 6 th ed. Freeman, 2006.
3. Nelson.D.L, Cox. M. M. Lehninger's Principle of Biochemistry. 4th ed. Freeman, 2004
4. Biochemistry, Voet and Voet, 2<sup>nd</sup> edition, 2004

  
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**Suggested Reading:**

1. Principles of Biochemistry, Voet, Voet, and Pratt, Fourth addition, 2012.
2. FUNDAMENTALS OF BIOCHEMISTRY: LIFE AT THE MOLECULAR LEVEL, VOET, VOET, AND PRATT, 2008
3. PRINCIPLES AND TECHNIQUES OF BIOCHEMISTRY AND MOLECULAR BIOLOGY, WILSON AND WALKER, 2010.
4. Adams. R.L, Knowler.J.Leader.D.P. Biochemistry of Nucleic Acids.Cambridge Univ. Press, 1998.
5. Dixon & Webb. Enzymes.3rd ed. Longmans, 1979.

**BTH 901- Genetic Engineering**

**Genetic engineering tools and their applications:** Restriction-modification system & enzymes, modification enzymes (methylases and other enzymes needed in genetic engineering), DNA and RNA markers. Gene Cloning Vectors- Plasmids, bacteriophages, phagemids, cosmids. Artificial chromosome vectors (YAC, BAC, MAC), CHEF analysis, virus derived vectors-SV40, M13, retroviral vectors, and general applications.

8

**Nucleic Acid Sequencing and Amplification:** Sequencing methods and their Applications- Maxim & Gilbert's and Sanger's methods; Pyrosequencing, Thermal PCR, Shot gun sequencing and Automated method. Nucleic Acid purification and Yield Analysis; PCR – Types and applications.

6

**Gene manipulation:** cDNA Synthesis and its Cloning; mRNA enrichment, DNA primers, linkers and adaptors, Library (cDNA and Genomic) construction and screening. Alternative Strategies of Gene Cloning- Two and three hybrid systems, cloning of genes in expression vectors and regulation, DNA microarrays.

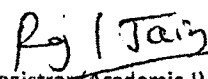
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**Study Gene Regulation and analysis of gene Expression:** DNA transfection methods, Northern blot, Primer extension, SI mapping, RNase protection assays, Reporter assays.

6

Southern and Western blotting, DNA fingerprinting, Chromosome walking, Southern and Fluorescence *in situ* hybridization;

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**Mutagenesis, Protein Engineering & Processing of Recombinant proteins** - Directed Mutagenesis- Oligonucleotide with M13 DNA, PCR amplified oligonucleotide and Random mutagenesis. Protein Engineering: adding disulfide bonds, reducing number of free sulphydryl residues, changing aminoacids, increasing and modifying enzymatic activity. Processing of Recombinant proteins: Purification and refolding, characterization of recombinant proteins, stabilization of proteins.

6

**T-DNA and Transposon Tagging:** Role of gene tagging in gene analysis, T-DNA and Transposon tagging, Identification and isolation of genes through T-DNA or transposon. Transgenic and Gene Knockout Technologies. Targeted gene replacement, Chromosome engineering.

6

**Expression Strategies for Heterologous Proteins:** Vector engineering, host engineering, in vitro transcription and translation, expression in bacteria, yeast, insects and insect cells, expression in mammalian cells and plants.

8

**Gene Therapy-Vector engineering.** Strategies of gene delivery, gene replacement/ augmentation, gene correction, gene editing gene regulation and silencing.

6

**Application of genetic engineering:** Uses of Transgenic plants and animals; production of recombinant pharmaceuticals, disease diagnoses and nanotechnology.

1

### ***Suggested Laboratory Exercises:-***

1. Growth characteristics of *E. coli* using plating and turbidometric methods.  
Growth Cover
2. Bacterial culture and antibiotic selection on media.
3. Isolation of plasmid from *E. coli* by alkaline lysis method and its quantification by spectrophotometer.
4. Amplification of DNA by PCR .
5. Restriction enzyme digestion of genomic DNA and plasmid DNA from *E. coli* and estimation of size of DNA fragments after electrophoresis using DNA markers.
6. RFLP analysis
7. RAPD analysis
8. Demonstration of DNA fingerprinting. Humane Forensic

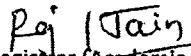
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9. Restriction digestion of the plasmid and estimation of the size of various DNA fragments & Construction of Restriction digestion map.
10. Cloning of DNA fragment in a plasmid vector.
11. Transformation of the given bacterial population and selection of recombinants.
12. Co-cultivation of the plant material ( e.g. leaf discs) with *Agrobacterium* and study GUS activity histochemically.
13. Any other practical based on theory syllabus.

### **Suggested Reading:-**

1. Sambrook, J., Fritsch, EF. and Maniatis, T. (2000). Molecular Cloning: A Laboratory Manual Cold Spring Harbor Laboratory Press, New York.
2. Glover, DM. and Hames, BD. (1995). DNA Cloning: a practical Approach IRL Press Oxford.
3. Kaufman, PB., Wu, W., Kim, D. and Cseke, LJ. (1995). Molecular and cellular Methods in Biology and Medicine CRC Press, Florida.
4. Berger, SL. and Kimmel, AR. (1998). Guide to Molecular Cloning Techniques, Academic press Inc. San Diego.
5. Goodol, DV. (1990). Gene Expression Technology Academic Press Inc., San Diego, 1990.
6. Mickloss, DA. and Greyer, GA. (1990). DNA Science A First Course in Recombinant Technology, Cold Spring Harbor Laboratory Press, New York.
7. Primorso, SB. (1994). Molecular Biotechnology (2nd Edn.), Blackwell Scientific Publishers, Oxford.
8. Davies, JA. and Roznikolf, WS. (1992). Milestones in Biotechnology. Classic papers on genetic Engineering Butterworth-Heinemann, Boston.
9. Walker, MR. and Repley, R. (1997). Route Maps in Gene Technology. Blackwell Science Ltd, Oxford.
10. Kingsman, SM. and Kingsman, AJ. (1998). Genetic Engineering: An Introduction to gene analysis and exploitation in eukaryotes. Blackwell Scientific publications, Oxford, 1998.
11. Glick BR. and Thompson, JE. (1993). Methods in Plant Molecular Biology and Biotechnology. CRC Press, Boca Raton, Florida.
12. Glover, D.M. and Hames, B.D. (Eds.) (1995). DNA Cloning 1 : A Practical Approach, Core Techniques, 2nd edition. PAS, IRL Press at Oxford University Press, Oxford.
13. Hackett, PB., Fuchs, JA. and Meesing, JW. (1988). An Introduction to Recombinant DNA Techniques : Basic Experiments in Gene Manipulation. Benjamin/Cummings Publishing Co., Inc. Menlo Park, California.

  
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14. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
15. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.

### **BTH 902- Animal Biotechnology**

**Tools and Culture Media:** Equipments and materials for animal cell culture technology. Introduction to the balance salt solutions and simple growth medium. Brief account on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements, Serum & protein free defined media and their application. **5**

**Basic understanding for cell culture:** Structure and organization of animal cell, Cell physiology. Primary and established cell line cultures. Biology and characterization of the cultured cells and measuring their growth. **5**

**Techniques of cell culture:** Basic techniques of mammalian cell culture *in vitro*; disaggregation of tissue and primary culture; maintenance of cell culture; cell separation. Scaling-up of animal cell culture, measurement of viability and cytotoxicity. Cellsynchronization. Cell cloning, micromanipulation and types of cloning. Stem cell culture, embryonic stem cells and their applications. Measurement of cell death. Apoptosis. Three dimensional culture and tissue engineering. **15**

**Mammalian Cell transformation :** Establishment of Immortal cell lines, transfection, selection by selectable markers, gene amplification for high level protein expression. Specialized methods to transfer difficult cell types; Uses of viral vectors, Vaccinia and Baculovirus and Retrovirus in gene transfer; and use of antisense RNA and DNA in controlling gene function. Mice as the experimental material for gene introduction. **10**

**Impact of Recombinant DNA on human Genetics:** Mapping and cloning human disease genes- Positional cloning, subchromosomal mapping and markers, in situ hybridization to chromosomes and RFLP. **8**

**Applications of Animal cell and Recombinant DNA technology:** Cell culture based vaccines. Somatic cell genetics. Organ and histotypic cultures. Development of Transgenic animals (Mice, Cattle, Sheep, Goat, Pigs, Birds and Fish) and their uses.

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DNA- based diagnosis of genetic diseases; Human somatic cell gene therapy for single-gene disorders.

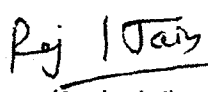
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***Suggested Laboratory Exercises:-***

1. Preparation of tissue culture medium and membrane filtration.
2. Preparation of single cell suspension from spleen and thymus.
3. Cell counting and cell viability.
4. Macrophage monolayer from PEC, and measurement of pathogenicity activity.
5. Trypsinization of monolayer and subculturing.
6. Cryopreservation and thawing.
7. Measurement of doubling time.
8. Role of serum in cell culture.
9. Preparation metaphase chromosome from cultured cells.
10. Isolation of and demonstration of apoptosis of DNA laddering.
11. MTT assay for cell viability and growth.
12. Cell fusion with PEG.
13. Any other practical based on theory syllabus

***Suggested Readings:-***

1. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
2. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
3. Froshney, RI. Culture of Animal Cells, (3rd Edition), Wiley-Liss.
4. Mesters, JRW. (Ed) Animal Cell Culture-Practical Approach, Oxford.
5. Basega, R. (Ed), Cell Growth and Division: A Practical Approach, IRL Press.
6. Butler, M. & Dawson, M. (Eds) Cell Culture Lab Fax. Eds., Bios Scientific Publications Ltd. Oxford.
7. Martin Clynes. M. (Ed). Animal Cell Culture Techniques. Springer.
8. Jenni, Mathur P. and Barnes, D (Eds). Methods in Cell Biology, Vol.57, Animal Cell Culture Methods. Academic Press.
9. Glick, BR. And Pasternak, JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
10. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
11. Kumar, HD. (1998). Modern Concept of Biotechnology, Vikas Publishing House, New Delhi

  
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**BTH 903- Seminar, Scientific Writing & Presentation****Practical's through Assignments:**

100

1. Writing Review of Literature: Review of the Literature/Annotated Bibliography Locate, analyze, summarize, and evaluate at least 3 scholarly and 3 popular sources in an area of interest and produce an Annotated Bibliography/Review of the Literature using appropriate citation style, to support the Long Article (4-6 pages).
2. Data analysis and presentation: How to present data? Which diagrams to use? What programs and data formats to use for data visualization?
3. Types of graphs (Microsoft graphics 3D): Different graphs for different purposes (poster, talk, manuscript). Students will be able to correctly identify and describe four kinds of graphs commonly used in science: pie charts, line graphs, scatter plots, and bar graphs.
4. How to give a Seminar: introduction and background information on topic. What relevant research has been performed previously? State the problem(s) that remain unanswered. State objectives and specific hypotheses you wish to test. Describe the methodology used to test your hypotheses. Present Data, Results, Discussion and Interpretations (fact vs. fiction) and explain the significance of your findings.
5. Scientific presentations/Poster/Power Point (short and long): Document Analysis Presentation (Information Literacy) Through multimedia presentation (PowerPoint or Poster Session) by analyzing selected articles and scholarly and popular science writing and journals. Use visuals. What does a good poster need? Structure of a good poster.

**Suggested Reading:-**

1. Scientific Writing and Communication: Papers, Proposals, and Presentations, 1st Edition, by Angelika Hoffman, ©2010 Oxford University Press, ISBN 978-0-19-539005-6
2. The Craft of Scientific Presentations: Critical Steps to Success and Critical Errors to Avoid by Michael Alley, ©2013 Springer, ISBN 978-1441982780
3. Bennett, B. 2001. The three P's of scientific talks: Preparation, practice, and presentation. Society for Economic Botany Newsletter. 15: 6-9. can be found on-line at: [http://www.econbot.org/webmaster/pubs\\_p&p/issues/2001\\_spring.pdf](http://www.econbot.org/webmaster/pubs_p&p/issues/2001_spring.pdf)



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<b>Examination Scheme:-</b>	<b>MM:-100</b>
Presentation	50
Poster Presentation (on Computer)	25
Practical Record	15
Viva-Voce	10

### **BTH X01- Plant Biotechnology**

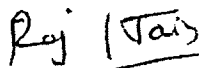
**Plant tissue culture:** Principles, Concept, History of development of plant tissue culture. Concept of totipotency, PTC laboratory facilities, operation and management, General methodology. Different PTC media and their nutritional components, media preparation and sterilisation techniques. aseptic techniques and preparation of explants, histological techniques for plant tissue culture. Cryopreservation and slow growth for germplasm preservation. 5

**Plant tissue culture technology:** Shoot morphogenesis and organogenesis, rooting, hardening and field transfer; Micropropagation, production of virus free plants, callus and suspension cultures, single cell culture. Ovary, anther and microspore culture for production of haploid plants. Somatic embryogenesis, synthetic seeds and its cryopreservation. Plant tissue culture as a technique to produce novel plants, somaclonal variations. Overview of Plant Tissue Culture Applications. 7

**Protoplast technology:** Protoplast isolation, purification, viability tests, plating efficiency, culture, Somatic cell hybridization, selection of hybrid, cybrids and their regeneration. 6

**Plant transformation (Recombinant DNA) technology:** Tools and techniques, Vectors for plant transformation (Viral and Bacterial), Basic molecular characteristics of *Agrobacterium*, Basis of tumor and hairy-root formation, Characteristic features of vectors (Co-integrative and binary vectors, Ti, Ri plasmids, 35S and other promoters and terminators, selectable markers, reporter genes, origin of replication etc.). 7

***Agrobacterium*-mediated plant transformation:** Cloning of selected gene, its integration into *Agrobacterium*. *Agrobacterium*-mediated gene transfer - mechanism of T-DNA transfer and its integration into plant genome. role of virulence gene, selection of transformed cells/ tissues, expression of the integrated gene in plants. Multiple gene transfer. Practical applications of *Agrobacterium*-mediated gene transfer. 6

  
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**Direct gene transfer methods :** Particle bombardment, electroporation and micro injection. Transgenic gene incorporation, stability and expression; gene silencing. Cryopreservation and Genebanks. 6

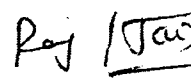
**Plant Breeding:** Brief idea about conventional Plant Breeding Methods- Character identification, incorporation (hybridization), selection and release of variety; Role of **Molecular markers:** RFLP, RAPD, STS, SCAR, SSCP, AFLP in plant breeding applications. Green house and green-home technology. 7

**Transgenic approaches to crop improvement:** Resistant against biotic (virus, fungi, bacteria, nematode, insect, weed) and abiotic stress (salinity, drought, herbicide, cold, metals), longer shelf life. Improvement of crop yield and quality - golden rice and other developments. Extension of flower life, pigmentation and fragrance. 8

**Manufacture of valuable products:** Industrial applications of plant cell culture; Plant cell culture and biosynthesis of secondary products; Manufacture of - antigens, antibodies, edible vaccines, enzymes, proteins. 8

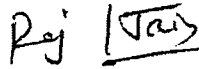
### ***Suggested Laboratory Exercises:***

1. Preparation of Stock solutions for MS medium.
2. Preparation of medium.
3. Micro propagation technique
4. Surface sterilization and Organ culture.
5. Callus induction, propagation, and differentiation
6. Organogenesis- Shoot and root formation and their organic connection.
7. Hardening and transfer of plants to soil.
8. Study of somatic embryogenesis.
9. Anther culture, production of Haploids.
10. Ovary culture
11. Somatic embryogenesis using appropriate explants and Preparation of synthetic seeds
12. Protoplast isolation and culture.
13. Demonstration of protoplast fusion employing PEG.
14. Cytological examination of regenerated plants.
15. Isolation & Identification of Sec. metabolite from Plant Cell Cultures.
16. Agrobacterium culture, selection of transformants, reporter gene(GUS)assays.
17. Any other practical based on theory syllabus

  
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**Suggested Readings:-**

1. Bhojwani, S.S. and Razdan, M.K. (1996). Plant Tissue Culture : Theory and Practice (a revised edition). Elsevier Science Publishers, New York. USA.
2. Slater A, Scott N, Fowler M (2010). Plant biotechnology: the genetic manipulation of plants. Oxford: Oxford University Press.
3. Hammond, J. McGarvey P. and Yusibov V.(Eds.) (2000). Plant Biotechnology. Springer Verlag, Germany.
4. Fu,T -J., Singh, G. and Curtis, WR. (Eds) (1999). Plant Cell and Tissue Culture for the Production of Food ingredients. Kluwer Academic/Plenum Press.
5. Chawla, HS. (1998). Biotechnology in Crop improvement. International Book Distributing Company.
6. Henry, RJ. (1997). Practical Application of plant Molecular Biology. Chapman and hall.
7. Butenko, RG. (2000). Plant Cell Culture, University Press of Pacific.
8. Collin, H.A. and Edwards, S. (1998). Plant Cell Culture. Bios Scientific Publishers, Oxford, UK.
9. Dixon, RA. (Ed.) (1987). Plant Cell Culture :Practical Approach. IRL Press, Oxford.
- 10: George, EF. (1993). Plant Propagation by Tissue Culture. Part 1. The Technology, 2nd edition. Exegetics Ltd., Edington, UK.
11. Hall, RD. (Ed.) (1999). Plant Cell Culture Protocols. Humana Press, Inc., New Jersey, USA.
12. Shaw, CH. (Ed.) (1988). Plant Molecular Biology: A Practical Approach, IRL Press, Oxford.
13. Smith, RH. (2000). Plant Tissue Culture: Techniques and Experiments. academic press, New York.
14. Kumar, A. and Roy, S. (2006). Plant Biotechnology & is applications in Tissue Culture. I.K. International Pvt. Ltd.
15. Kumar, A. and Roy, S. (2011). Plant Tissue Culture and Applied Biotechnology, Aavishkar Publishers, Jaipur.
16. Mascarenhas, AF. (1991). Handbook of Plant Tissue Culture, ICAR, New Delhi.
17. Ramawat, KG. (2000). Plant Biotechnology, S. Chand & Co. Ltd. New Delhi.
18. Rajdan, MK. (1993). An Introduction to Plant Cell Culture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.
19. Narayanaswamy, S. (1994). Plant Cell and Tissue Culture. Tata McGraw-Hill Pub. Com. Ltd. New Delhi.

  
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20. Ammirato, PV, Evans, DA, Sharp, WR. And Yamada, Y. (1984). Hand Book of Plant Cell Culture, Vol. 1-3, Macmillan Pub. Co. NY & Collier Macmillan Pub. London.
21. Gupta, PK. (2010). Plant biotechnology, Rastogi Pub. Meerut.
22. Natesh, S, Chopra, VL. And Ramachandran, S. (1987). Biotechniques in Agriculture. Oxford & IBH Publishing Co. Pvt. Ltd. New Delhi.

## **BTH X02- IPR & Biosafety**

**Introduction to Intellectual Property:** Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, International framework for the protection of IPIP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS 15

### **Concept of 'prior art'**

Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation

### **Basics of Patents:-**

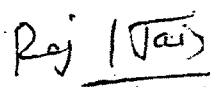
Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application 15

### **Patent filing and Infringement**

Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement- meaning, scope, litigation, case studies and examples 15

### **Biosafety**

Introduction: Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety Protection of New GMOs; guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM,

  
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GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartagena Protocol. 15

### Suggested Exercises:-

1. List of Patent offices in India
2. Preparation of Patent document
3. Case studies of Biotechnology patents
4. List of cotemporary GMOs and their challenges
5. Exercises as per syllabus

### Important Links

<http://www.w3.org/IPR/>  
<http://www.wipo.int/portal/index.html.ens>  
[http://www.ipr.co.uk/IP\\_conventions/patent\\_cooperation\\_treaty.html](http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html)  
[www.patentoffice.nic.in](http://www.patentoffice.nic.in)  
[www.iprlawindia.org/](http://www.iprlawindia.org/) - 31k - Cached - Similar page  
<http://www.cbd.int/biosafety/background.shtml>  
<http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm>  
<http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html>

### BTH X03-Dissertation & Industrial Training

The project work will involve in depth practical work on a problem suggested by the supervisor of the candidate. The evaluation of the dissertation will be done by the external examiner. The dissertation submitted by the candidate shall be evaluated by one external expert, Head of the department and supervisor of the candidate. The seminars, in-plant training and industrial visit reports will also be submitted by the candidate to the Head of the Department who will submit these to the external examiner. The examination shall be held in the department and the dissertation etc. will NOT be required to be mailed to the external examiner. The distribution of the marks will be as under:

	<b>M.M. 100</b>
<b>Dissertation Report</b>	<b>50</b>
<b>Evaluation</b>	<b>50</b>
<b>(PPT &amp; Viva-voce)</b>	

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**Theory Elective Course**  
**Cluster: GEN- GENERAL**  
**BTH A01:GEN: Analytical Techniques**

**Basic Techniques**

Buffers; Methods of cell disintegration; Enzyme assays and controls; Detergents and membrane proteins; Dialysis 4

**Spectroscopy Techniques**

UV, Visible and Raman Spectroscopy; Theory and application of Circular Dichroism; Fluorescence; MS, NMR, PMR, ESR and Plasma Emission spectroscopy 6

**Chromatography Techniques**

TLC and Paper chromatography; Chromatographic methods for macromolecule separation - Gel permeation, Ion exchange, Hydrophobic, Reverse-phase and Affinity chromatography; HPLC and FPLC; Criteria of protein purity 8

**Electrophoretic techniques**

Theory and application of Polyacrylamide and Agarose gel electrophoresis; Capillary electrophoresis; 2D Electrophoresis; Disc gel electrophoresis; Gradient electrophoresis; Pulsed field gel electrophoresis 5

**Centrifugation**

Basic principles; Mathematics & theory (RCF, Sedimentation coefficient etc); Types of centrifuge -

Microcentrifuge, High speed & Ultracentrifuges; Preparative centrifugation; Differential & density gradient centrifugation; Applications (Isolation of cell components); Analytical centrifugation; Determination of molecular weight by sedimentation velocity & sedimentation equilibrium methods 15

**Radioactivity**

Radioactive & stable isotopes; Pattern and rate of radioactive decay; Units of radioactivity; Measurement of radioactivity; Geiger-Muller counter; Solid & Liquid scintillation counters (Basic principle, instrumentation & technique); Brief idea of radiation dosimetry; Cerenkov radiation; Autoradiography; Measurement of stable isotopes; Falling drop method; Applications of isotopes in biochemistry; Radiotracer techniques; Distribution studies; Isotope dilution technique; Metabolic studies; Clinical application; Radioimmunoassay 15

  
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**Advanced Techniques**

Protein crystallization; Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis, Ultrafiltration and other membrane techniques 7

**Elective Practical Lab BTH A11: Analytical Techniques****Suggested Laboratory Exercises:-**

1. Preparation of buffers
2. Study of enzyme kinetics for effect of time/ enzyme concentration/ pH
3. Extraction of proteins from plant tissue and their quantitative (Bradford's) and qualitative (SDS, PAGE gel) analysis.
4. Isolation of DNA/RNA from plant tissue and agarose gel electrophoresis.
5. Quantification of nucleic acids by spectrophotometer
6. Qualitative and quantitative analysis of photosynthetic pigments and anthocyanins by spectrophotometric and chromatographic techniques.
7. Isolation of bioactive compounds from medicinal plants using column chromatography and TLC.
8. Isolation and purification of nuclei, mitochondria or chloroplasts or other cell components
9. Analysis of crude extracts from medicinal plants using HPLC.
10. 2D electrophoresis
11. Any lab exercise based on analytical techniques

**Texts/References**

1. Freifelder D., Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd Edition, W.H. Freeman & Company, San Francisco, 1982.
2. Keith Wilson and John Walker, Principles and Techniques of Practical Biochemistry, 5th Edition, Cambridge University Press, 2000.
3. D. Holme & H. Peck, Analytical Biochemistry, 3rd Edition, Longman, 1998.
4. R. Scopes, Protein Purification - Principles & Practices, 3rd Edition, Springer Verlag, 1994.
5. Selected readings from Methods in Enzymology

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## BTH A02:GEN: Bioinformatics & Biostatistics

**Concepts of Bioinformatics:** Introduction and future prospects; Applications in genomics and proteomics; Public databases; Gene bank; Database searches: sequence retrieval systems; Similarity searching: BLAST, FASTA; Multiple sequence alignment: CLUSTALW; Detecting functional sites in DNA; Motif and domain prediction and analysis; Identification of open reading frames (ORF); Gene annotation technology.

11

**Databases and online tools:** Biological Databases:- Types and applications; Sequence databases:- GenBank, EMBL, DDBJ, PIR-PSD, SWISS-PROT; Structure Databases:- PDB, SCOP, NDB; Derived Databases:- PROSITE, PRINTS, TIGR, Online tools:- Genetool; STRING; I-TASSER; Bioedit; BioGRID; MEGA; Sequin, Bankit

09

**Applications of Bioinformatics:** Computational methods for sequence analysis: Dot blot and dynamic programming methods; Phylogenetic analysis; Virtual and electronic cell; Internet tools for DNA sequence translation; Restriction enzyme mapping; Prediction of secondary structure of proteins; Application tools- primer designing, molecular mapping and concept and tools of computer aided drug designing

10

**Fundamentals of statistics:** Arithmetic mean, median, mode: theory and simple numerical problem; Measures of variation: standard deviation, variance, coefficient of variation; Correlation, types and methods: simple, multiple, linear and nonlinear correlation, spearman's correlation, rank correlation; Regression: linear and curvilinear regression (for two variable X and Y only), Regression lines by least square method; regression equations of X on Y and Y on X only; Sample size; Power of study.

13

**Tests of significance:** Null hypothesis; Standard error; Level of significance; Degrees of freedom; Significance of mean for large samples; Significance in means for small samples (students t-test); Significance in ratio of two samples: F test (for difference between variance of two samples); Chi square test; Analysis of variance test (ANOVA) for one and two way classification; Calculation of an unknown variable using regression equation.

13

Laws of probability, theorem of total probability

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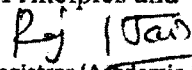
## Elective Practical Lab BTH A12: Bioinformatics & Biostatistics

### Suggested Lab Exercises:-

1. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB etc.
2. Sequence retrieval using BLAST
3. Sequence alignment
4. Phylogenetic analysis using clustalW
5. Protein structure prediction
6. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction).
7. Prediction of different features of a functional gene
8. Determination of Statistical averages/ central tendencies
  - a) Arithmetic mean b) Median c) Mode
9. Determination of measures of Dispersion a) Mean deviation b) Standard deviation and coefficient of variation c) Quartile deviation
10. Tests of Significance-Application of following a) Chi- Square test b) t- test c) Standard error
11. To learn graphical representations of statistical data with the help of computers (e.g. MS Excel).

### Suggested Reading

1. Introduction to Bioinformatics, Arthur M. Lesk, Oxford University Press.
2. Introduction to Bioinformatics, Attwood, Pearson Education.
3. A Textbook of Systems Biology, E. Klipp, W. Liebermeister, C. Wierling, Axel Kowald, H. Lehrach, R. Herwig (2009), Wiley-VCH Verlag GmbH & Co.
4. Bioinformatics: Sequence and Genome Analysis, David W. Mount (2001), Cold Spring Harbor (CSH) Laboratory Press.
5. Plant System Biology, Coruzzi, G.M. (2009), Wiley Publishing House.
6. Bioinformatics - A Practical Guide to the Analysis of Genes and Proteins. 2nd Edition by Baxevanis.
7. Bioinformatics: Sequence, structure and Data Bank: A Practical Approach by Higgs.
8. Bioinformatics - from Genomes to drug. 2 volumes by Lenganer.
9. Bioinformatic Methods and Protocols - Misener
10. Bioinformatics: Sequence and Genome analysis
11. Introduction to Bioinformatics by Altwood.
12. Proteome Research: New Frontiers in Functional Genomics: Principles and Practices.

  
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13. Genomics: The Science and Technology behind the human project.
14. Protein Biotechnology. Edited by Felix Franks. Humana Press, Totowa, New Jersey.
15. Practical Statistics for experimental biologist by Wardlaw, A.C. (1985).
16. Statistical Methods in Biology - 2000 by Bailey, N.T. J. English Univ. Press.
17. Biostatistics - 7th Edition by Daniel 8. Fundamental of Biostatistics by Khan
18. Statistics for Biologist by Campbell R.C. (1974) Cambridge University Press
19. Introduction to Biostatistics, Le and Chap (2009), Wilay and Sons.
20. Fundamentals of Biostatistics, B. Rosner (2005), Duxbury Press.
21. Medical Statistics from Scratch, Bowers (2008), Wiley and Sons.

### **BTH A03:GEN: Entrepreneurship & Ethics**

**Entrepreneurship:** concept, definition, structure and theories of entrepreneurship. Types of start-ups. Types of entrepreneurship, environment, process of entrepreneurial development. Entrepreneurial culture, entrepreneurial leadership, product planning and development. Project management. Search for business idea. Concept of projects. Project identification, formulation, design and network analysis. Project report and project appraisal. 15

#### **Entrepreneurship in Biotechnology:**

Integration of Science, technology and business, Basic principles and practices of management, Definition, concepts and application; Organization types, coordination, control and decision making in management; Conceptual framework and characteristics for being an entrepreneur in biotechnology. Case studies of successful and unsuccessful bio-entrepreneurs. 8

**Biotechnology:** emerging industries with examples from: Transgenics, Environmental biotechnology, New drug development, DNA chip technology, Stem cell research, Tissue engineering. Contract Research Organization, marketing consultancy, bio-learning module. 10

**Business development in biotechnology:** Factors affecting biotech business: (finance, infrastructure, equipment, manpower, resources, project location, end product, quality issues etc).

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Core concept of Market: Identification and evaluation of market potential of various bio-entrepreneur sectors. Marketing , marketing research-concept and techniques.. Role of government and schemes, financial institutions in fostering bio-entrepreneurship. 15

**Skills in bio-entrepreneurship:**

Personality and attitude, Organizational behavior, Leadership, Principles of effective communication- Body language, public speaking, presentation, business proposal writing. Communication aid and application of technology. 6

**Ethical issues:** Introduction- causes of unethical acts, ignorance of laws, codes, policies and procedures, recognition, friendship, personal gains. Professional ethics- professional conduct. Ethical decision making, ethical dilemmas. Teaching ethical values to scientists, good laboratory practices, manufacturing practices, laboratory accreditation, IPR, Forms of IPR 6

**Elective Practical Lab BTH A13: Entrepreneurship & Ethics**

**Suggested Laboratory Exercises:-**

1. Innovation and Entrepreneurship
2. Development of Networking
3. Business Communication
4. Forms of IPR
5. Industrial visit (Report)
6. Success stories of Entrepreneurs
7. Support & Start up schemes.
8. Business modeling

**Suggested Readings:**

1. Álvaro Cuervo, Domingo Ribeiro and Salvador Roig, 2007, Entrepreneurship Concepts, Theory and Perspective. Part II, 155-170
2. Hannafey, FT. (2004). Entrepreneurship and Ethics: A Literature Review. J. of Bussiness Ethics, Volume 46, Number 2, 99-110

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3. Hassan, E., Yaqub, O., Diepeveen, D. (2010). Intellectual Property and Developing Countries: A review of the literature, the RAND Corporation, 1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
4. Krattiger et al (2007) "Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices", Managing Innovation for a Better World
5. Hahn, R.W. (2005). *Intellectual Property Rights in Frontier Industries: Software and Biotechnology*, AEI Press.
6. Miller, Raphael, A. and Michael HD. (2000) *Intellectual Property: Patents, Trademarks, and Copyright*. 3rd ed. New York: West/Wadsworth.
7. Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, California: Sage Publications.
8. Creswell, J. (2003). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. Thousand Oaks, California: Sage Publications.
9. John W. Creswell, 2009, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, Third Edition, [www.sagepub.com](http://www.sagepub.com), ISBN: 978-1-4129-6557-6
10. Dahlia K. Remler, Gregg G., Van Ryzin, R. (2011). *Research Methods in Practice, Strategies for Description and Causation*. , [www.sagepub.com](http://www.sagepub.com), ISBN: 978-1-4129-6467-
11. Glenn, MacDonald, L. (2011). *Ethical Issues in Genetic Engineering and Transgenics*
12. McGee, G. "Primer on Ethics and Human Cloning" <http://www.actionbioscience.org/biotech/mcgee.html>
13. "Primer on Ethics and Crossing Species Boundaries" [http://www.actionbioscience.org/biotech/baylis\\_robert.html](http://www.actionbioscience.org/biotech/baylis_robert.html)
14. Grey, ST. "Genetic Engineering and Xenotransplantation" <http://www.actionbioscience.org/biotech/grey.html>
15. Kolehmainen, S.M. "The Dangerous Promise of Gene Therapy" <http://www.actionbioscience.org/biotech/kolehmainen.html>
16. Sherlock, R. and Morrey, JD. (2002). *Ethical issues in biotechnology*, Rowman & Littlefield Publishers, Inc., Maryland.
17. Paul B. Thompson (2007). *Food biotechnology in ethical perspective*, The Springer, 2<sup>nd</sup> Ed., The Netherlands.
18. Krishna R. Dronamraju, (2008). *Emerging consequences of biotechnology: biodiversity loss and IPR issues*. World Sc. Publ. Co. Pvt. Ltd., Singapore.

  
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**BTH A04:GEN: VIROLOGY****Innate Immunity**

Activation of the Innate Immunity through TLR mediated signaling; Adaptive Immunity; T and B cells in adaptive immunity; Immune response in infection; Protective immune response in bacterial; Viral and parasitic infections; Correlates of protection 15

**Vaccination and immune response**

Appropriate and inappropriate immune response during infection: CD4+ and CD8+ memory T cells; Memory B cells; Generation and Maintenance of memory T and B cells; Dendritic cells in immune response 12

**Adjuvants in Vaccination**

Induction of Th1 and Th2 responses by using appropriate adjuvants; Microbial, Liposomal and Microparticles as adjuvant; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and mucosal Immunity 13

**Conventional vaccines**

Bacterial vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine 6

**New Vaccine Technologies**

Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for specific targets; Tuberculosis Vaccine; Malaria Vaccine; HIV vaccine 14

**Elective Practical Lab BTH A14: Virology****Suggested Laboratory Exercises:-**

1. Widal Test
2. Ouchterlony double diffusion
3. Radio Immune Diffusion.
4. Precipitation reaction
5. ELISA
6. Blood Cell types
7. Identification of Mycobacterium
8. Total Leukocyte by Haemocytometer
9. Prepare a list of conventional and new vaccines.
10. Any exercise related to syllabus.

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### Texts/References

1. Edited by Stefan H.E. Kaufmann, Novel Vaccination Strategies, Wiley-VCH Verlag GmbH & Co. KGaA, 2004 or later edition.
2. Topley & Wilson's, Microbiology and Microbial Infections Immunology Edited by Stefan H.E. Kaufmann and Michael W Steward Holder Arnold, ASM Press, 2005 or later edition.
3. Edition Charles A Janeway. Jr, Paul Travers, Mark Walport and Mark J Shlomchik, Immuno Biology, The Immune system in health and Disease, 6th Edition, Garland Science, New York, 2005 or later edition.
4. Annual Review of Immunology : Relevant issues 5. Annual Review of Microbiology : Relevant issues

### Cluster: IB- Industrial Biotechnology BTH B01:IB: Enzyme Technology

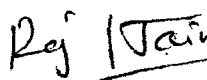
**Introduction to enzyme and enzyme technology:** History and scope of enzymes and enzyme technology, nomenclature of enzymes, enzyme activity units, enzyme business, major manufacturers of enzymes in India and World. 7

**Enzyme Kinetics** -- Activation Energy & Transition State concept. Mechanism of enzyme catalysis, simple kinetics of enzyme action. effect of pH, ionic strength, temperature and pressure on enzyme activity. reversible reaction, enzyme inhibition, determination of  $V_{max}$  and  $K_m$  values. 10

**Sources and preparation of enzymes** ---Sources of enzymes, screening strategies for novel enzymes, media for enzyme production, methods of purification and concentration of intracellular and extracellular enzymes, factors affecting enzyme stability, preparation of enzymes for sale, customer service, safety and regulatory aspects of enzyme use. 10

**Large scale use of enzymes in solution:** 8 Use of enzymes in detergents, food industry, fruit juice, wine, brewing and distilling industries, textile industries, pharmaceutical and chemical industries, application of enzymes in medicine 5

**Preparation and kinetics of immobilised enzymes:** -- Methods of immobilization of enzymes, Physical adsorption, covalent binding, entrapment and micro encapsulation, kinetics of immobilised enzymes, effect of solute partition and diffusion on the kinetics of immobilised enzymes 7

  
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**Immobilised enzymes and their use:** --Enzyme reactors, stirred tank reactors, plug flow reactors, continuous flow stirred tank fluidized bed reactor, Membrane/hollow fiber reactors, selection of reactors, productivity and performance of various types of reactors, immobilised enzyme processes - production of high fructose corn syrups, production of antibiotics, production of acrylamide and use of immobilised invertase, lactase, raffinase. 10

**Biosensors:** -Use of enzymes in analysis, biosensors- calorimetric, potentiometric, amperometric, optical piezoelectric biosensors and immunosensors. 4

**Advanced topics in enzyme technology:** -- Enzyme reactions in biphasic liquid systems; proteases, glycosidases and lipases in synthetic reactions, interesterification of lipids, artificial enzymes, un-natural substrates, enzyme engineering, extremophilic enzymes. 7

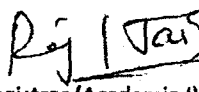
### Elective Practical Lab BTH B11: Enzyme Technology

#### Suggested Laboratory Exercise:-

1. Assay of some common enzymes (amylase, protease, pectinase, lipase etc.)
2. Microbial production of an enzyme.
3. Purification of enzyme, determination of  $V_{max}$  and  $K_m$  values.
4. Effect of temperature, pH, ionic strength and inhibitors.
5. Immobilization of enzymes/whole cells by adsorption, covalent linkage, entrapment methods.
6. Enzyme reactions in biphasic aqueous - organic solvent.
7. Application of enzymes in detergents, chemical production, juice clarification and bioprocessing.

#### List of Books :-

1. Enzyme Technology - M.F. Chaplin and D.C. Bucks
2. Industrial Enzymology - Godfrey and West
3. Enzyme - Copeland
4. Enzymes in Industry - W. Gerhartz
5. Plant enzymology and plant histoenzymology ---Mallick CP and Singh MB., Kalyani Publishers., New Delhi., (1980).

  
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**BTH B02:IB: Bioprocess Engineering**

**Introduction to Bioprocess Engineering:** Idea about Bioprocess Engineering; Measurement and control of Bioprocess parameters Classification of Bioreactor types. 8

**Types of fermentation processes:** Analysis of batch, fed batch and continuous bioreactions, biotransformation. Downstream Processing. 8

**Metabolic engineering:** control mechanisms and manipulation of shikimic acid pathway. Isolation, maintenance and preservation of industrial microorganisms, microbial growth and death kinetics. Media for industrial fermentation. Air and media sterilization. 12

**Industrial production of chemicals, utilizing wastes:** Alcohol (ethanol). Acids (citric, acetic, and gluconic), Solvents ( glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracycline), Amino acids ( lysine, glutamic acid). Single cell protein. 18

**Introduction to food technology:** principles of food processing. Elementary idea of canning and packing, sterilization and pasteurization of food products, technology of typical food products (Bread, cheese, idly); food preservation. 14

**Elective Practical Lab BTH B12: Bioprocess Engineering****Suggested Laboratory Exercises:-**

1. Isolation and preservation of industrially important microorganisms for microbial processes.
2. Determination of thermal death point (TDP) and thermal death time (TDT) of microorganism for design of a sterilizer.
3. Comparative studies of Ethanol production using different substrates.
4. Production and estimation of Alkaline Protease.
5. Use of alginate for cell immobilization.
6. Microbial production of single cell protein.
7. Any other practical based on theory syllabus

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**Suggested Readings:**

1. Aiba, S., Humphrey AE. and Millis, N.F. (1973). Biochemical Engineering(2nd Edition), Univ.of Tokyo Press, Tokyo.
2. Atkinson, B. (1974). Biochemical Reactors, Pion Ltd. London.
3. Casida Jr., L.E. (1996), Industrial Microbiology, New Age International (P) Ltd.
4. Bailey, JE. and Ollis, DF. (1986) Biochemical Engineering Fundamentals, 2nd ed., McGraw Hill Book Co., New York.
5. Enfors, S-O. and Haggström, L. (2000). Bioprocess Technology: Fundamentals and Applications, KTH, Stockholm.
6. Jackson, AT., (1991). Process Engineering in Biotechnology, Prentice Hall, Engelwood cliffs, NJ, USA.
7. Shuler, ML. and Kargi, F., (1992). Bioprocess Engineering: Basic Concepts, Prentice Hall, Engelwood Cliffs.
8. Stanbury, PF., Whitaker, A. and S. J. Hall, SJ. (1995). Principles of Fermentation Technology, Pergamon Press, Oxford.
9. Nielson, J. and Vissadsen, J., (). Bioreaction Engineering Principles, Plenum Press.
10. Doran, PM. (1995). Bioprocess Engineering Principles, Academic Press.
11. Shuler, ML.(Ed.), (1989). Chemical Engineering Problems in Biotechnology, AICHE, New York.
12. Lee, JM. (2009). Biochemical Engineering, Prentice Hall Inc.
13. Vieth, WF., (1999). Bioprocess Engineering-Kinetics, Mass Transport, Reactors and Gene Expression, John Wiley.& Sons Inc.

**BTH B03:IB: Industrial Biotechnology and Biosafety**

Selection of industrial microorganisms: industrial cultures- bacteria, algae, fungi and actinomycetes. Primary and secondary screening, Isolation and preservation of microorganisms for industrial products. Strain development- mutation, selection and recombination. Immobilisation of microbial cells and their application.

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**Microorganism as bio-resource for human needs:** Mushroom cultivation technology. Biofertilizers and their application, biopesticide in disease management; Rhizobacteria for plant growth promotion and disease management including parasitic nematodes; Bacteria and soil fungi in plant disease management; Reclamation of mining wastelands, Application of fungi for biodegradation of cellulosic waste and ethanol production. Bioplastics and biopolymers. Biosensors- application in industry.

10

**Fermentation process:** design- overview of aerobic and anaerobic fermentation process. Fermentor systems- types. *Fermentation process* and factors affecting fermentation process. Batch Fermentation, Continuous Fermentation & Semi-Continuous Fermentation. Design of fermentation media, Substrates used as carbon and nitrogen sources.

8

**Microbial fermented products:** Organic acids ( lactic acid, acetic acid & gluconic acid), Amino acid (Aspartic acids), Alcohol and beverages (acetone- butano., beer, wine). Enzymes (proteases, amylases, lipases, cellulases & pectinases). Microbial Secondary metabolites production.

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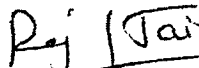
**Health care products and food additives:** Antibiotics- penicillin, streptomycin and erythromycin. Vaccines- BCG, hepatitis- B & recombinant vaccines; Vitamins- B<sub>12</sub>, D & C; dairy products- cheese, yoghurt and other products., health care and environment.

10

**Metabolic Engineering and industrial Products:** Plant secondary metabolites, control mechanisms and manipulation of phenylpropanoid pathway, alkaloids, Industrial enzymes, biodegradable plastics, polyhydroxybutyrate, therapeutic proteins.

10

**Biosafety:** Security measures, laboratory information management system (LIMS). Laboratory safety- safety policies. health hazardous compounds, chemicals (xenobiotic compounds), solvents, poisons, isotopes, radioactive materials, explosives and biological strains (bacterial, fungal etc.) and their waste management. Biosafety Cabinets, Storage of hazardous material and disposal of biological and radioisotope wastes. Biosafety regulation.

  
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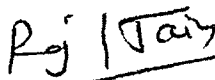
## Elective Practical Lab BTH B13: Industrial Biotechnology & Biosafety

### *Suggested Laboratory Exercises:*

1. Isolation of industrially important microorganisms for microbial processes.
2. Comparative studies of Ethanol production using different substrates.
3. Microbial production of citric acid using *Aspergillusniger*.
4. Microbial production of antibiotics (Penicillin).
5. Cultivation techniques of mushrooms.
6. Selection of efficient PGPR and mycorrhizae and their affect on growth
7. Preparation of list of the hazardous chemicals and their biosafety measures.
8. Any other practical based on theory syllabus

### *Suggested Readings:*

1. Aiba, S., Humphrey AE. and Millis, N.F. 1973. Biochemical Engineering, Univ.of Tokyo Press, Tokyo.
2. Atkinson, B. (1974). Biochemical Reactors, Pion Ltd. London.
3. Baily,J.E. and Oils,D.F., (1986). Biochemical Engineering fundamentals, McGraw Hill Book Co.,New York.
4. Enfors S.O. &Haggstrom L. 2000. Bioprocess Technology:Fundamentals and Applications, KTH,Stockholm.
5. Jackson, AT., (1991) Process Engineering in Biotechnology, Prentice Hall, Engelwood cliffs.
6. Shuler, ML. and Kargi, F., (1992). Bioprocess Engineering: Basic Concepts, Prentice Hall,Engelwood Cliffs.
7. Stanbury, PF. and Whitaker, A., (1995). Principles of Fermentation Technology, Pergamon Press, Oxford. London.
8. Nielson, J. and Vissadsen, J., Bioreaction Engineering Principles, Plenum Press.
9. Shuler, ML.(Ed.), (1989). Chemical Engineering Problems in Biotechnology, AICHE.
10. Lee, JM. (2009). Biochemical Engineering, Prentice Hall Inc.
11. Vieth, WF., (1999). Bioprocess Engeering-Kinetics, Mass Transport, Reactors and Gene Expression. John V.& Sons Inc.
12. Rai, B. and Dkhar, MS. (1998). New trends in Microbial Ecology, Deptt. Of Botany, NE Hill Univ. Shillong& ISCON, Varanasi.
13. Rai, B., Upadhyay, RS. andDubey, NK. (1998). Trends in Microbial Exploitation, ISCON, Varanasi.

  
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14. Glick, BR. And Pasternak. JJ. (1994). Molecular Biotechnology Principles and Applications of Recombinant DNA. Panima Publishing Corp, New Delhi.
15. Watson, JD., Gilman, M., Witkowski, J and Zollar, M. (1992). Recombinant DNA (Sec. Ed.). Scientific American Books, New York.
16. Kumar, HD. (1998). Modern Concept of Biotechnology, Vikas Publishing House, New Delhi.

### **BTH B04:IB: Nanobiotechnology**

**Introduction: History-** The purple of Cassius, the Lycurgus cup, Michael Faraday and "divided metals", Richard Feynman, His theory and predictions, Moore's Law, Miniaturization of microprocessors. , the story of the Damascus sword. What is "nano"? Comparison with familiar objects. From nanoscience to nanotechnology: Eric Drexler. 5

**Nanoscience:** The multidisciplinary science, Bottom-up and top-down approach of research with examples, Different types of Nanomaterials, one-dimensional: CNTs, its types and characteristics; Two-dimensional: Nanofilms, nanosheets, nanowalls. 10

Properties of Nanomaterials, Different types of Nanomaterials and their Size, Quantum effects. Seeing Nanomaterials: Microscopes ( SEM, TEM, STM, AFM ) How do the different types of microscope work with Nanomaterials. Preparation of Nanomaterials: Physical Method ( hydrothermal and solvothermal) Chemical methods, Biological methods (Green synthesis using plants ,microbes & other living organisms). 15

**Nanobiotechnology:** Nanomedicine, Nanocosmetics ,Textiles, Nanosensors (Biological, chemical, Biosensors, Gas sensors, mechanical ), Drug delivery, Cancer therapy, Tissue engineering, water purification, Lab-on-a-chip (LOC), nanocomputers, DNA computer, MRI with magnetic nanoparticles. Current trends of research in Nanobiotechnology, particularly health sciences. 15

**Effect of Nanomaterials on growth and development of plants:** Biouptake, Localization, and transformation of nanoparticles within plants. Nanoagriculture for sustainable agricultural crop production, application and Perspectives, Nanoparticles for herbicide, pesticides and fertilizers delivery, Role of Nanoparticles in Photosynthesis, Mode of action of nanomaterials at gene level, Nanotoxicity and its mechanism. Safety Issues. Current trends of research in Nanotechnology pertaining to plant sciences. 15

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## Elective Practical Lab BTH B14: Nanobiotechnology

### Suggested Laboratory Exercises:-

1. Synthesis of Nanoparticles by physical method & Chemical Method.
2. Green synthesis of Nanoparticles using Plant system from Leaves, fruit, callus etc.
3. Characterization of Nanoparticles using UV Visible Spectroscopy, XRD, FTIR.
4. Visualization of Nanomaterials using SEM, TEM, AFM.
5. To check the bioactivity of Nanomaterials on various pathological Fungi and Bacteria.
6. To check the effect of Nanomaterials on Plant germination parameters.

### Suggested Readings:-

1. Manasi Karkare. Nanotechnology: Fundamentals and Applications. 2008. I.K. International
2. K. Eric Drexler, Chris Peterson and Gayle Pergamit. Unbounding the future: The Nanotechnology Revolution. 1991. William Morrow and Company, Inc., New York.
3. C N R Rao. Nanoworld: An Introduction to nanoscience and Technology. 2010. Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore.
4. Manzer H. Siddiqui, M.H. Al-Whabhi, F. Mohammad (Editors). Nanotechnology and Plant Sciences. 2015. Springer.
5. C.M. Niemeyer and C.A. Mirkin. Nanobiotechnology. 2012. Wiley-VCH
6. C.M. Niemeyer and C.A. Mirkin. Nanobiotechnology-II. 2012. Wiley-VCH

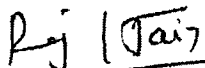
## Cluster: EB- Environmental Biotechnology

### BTH C01:EB: BIODIVERSITY, ECOLOGY AND EVOLUTION

Introduction to Biodiversity, Different types of Biodiversity and Concepts. Values and uses of Biodiversity (food, genes, biocontrol agents, natural products and medicines). Measures of biodiversity (alpha, beta- and gamma). 12

Microbial diversity & Ecology:- Prokaryotic & Eukaryotic microbes, Physiological diversity, Phylogeny of Archaea, extremophils.

Microbes in habitats like soil, oceans, human gut. Association of microbes with eukaryotes. key nutrient cycles- C, N and S. Microbial bioremediation, biodegradation, biomining 12

  
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Vegetation types of India. Hotspot biodiversity areas in India, Red Listed plants and RED Data Book, Threatened plants and animals of India. Role of biotechnology in reintroducing commercially and economically important plants to wild. 12

Conservation biodiversity, Sustainable uses of plant genetic resources and biotechnology assisted plant conservation - In situ and ex situ methods. Molecular markers and their application in plant conservation. 12

Concept and dynamics of ecosystem, Components of Ecosystem- Biotic and Abiotic, Food chain, Food web, and energy flow. Trophic levels and ecological pyramids. Biogeochemical cycles. UNIT-5 Theories of Evolution (Lamarckism, Neo-Lamarckism, Darwinism, Neo-Darwinism and De Vries theory of mutation), Molecular evolution. Theory of natural selection. Gene pool and gene frequencies. Mechanism of Isolation. Genetic basis of evolution. 12

### **Elective Practical Lab BTH C11: Biodiversity, Ecology and Evolution**

#### **Suggested Laboratory Exercises:-**

1. Vegetation Maps of India
2. Identification of locally available Medicinal Plants and their use.
3. Evaluating Diversity in fruits and vegetables and their Morphological differences
4. Study and simple tests for gums, resins, dyes, fibres from plants
5. Any other practical according to theory syllabus.

#### **REFERENCES:-**

1. An advanced Text Book of Biodiversity (2004) K.V. Krishnamoorthy, Oxford & IBH, New Delhi.
2. Biodiversity and Conservation (2004). Joshi PC and Namitha Joshi, APH Publishing Company, New Delhi.
3. Biodiversity and Conservation (2001) Melchias Oxford and IBH Publishing Company Pvt Ltd., New Delhi
4. Fundamentals of Ecology (1971) E P Odom B Saunders &co, Philadelphia, USA.
5. Evolution (1975) Savage, Amerind Publishing Company Ltd, New Delhi.

  
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6. The Theory of Evolution (1993) John Marynard Smith, Canto.
7. Evolution (2004) Mark Ridley, Wiley-Blackwell.
8. Singh, T, Purohit S.S., Parihar, P 2012, Soil Microbiology, Agrobios India.
9. Pommerville, J.C. 2010, Akario's fundamentals of Microbiology. Jones & Bart let publishers.
10. Waites, M.J., Morgan, N.L., Rockey, J.S., Highton, Gary 2001, Industrial Microbiology. An Introduction. Blackwell Science.
11. Singh, T & Purohit S.S.- Microbial Ecology 2012. Agrobios India

### **BTH C02:EB: Applied Environmental Biotechnology**

Bioremediation & Phytoremediation: Biofeasibility, applications of bioremediation, Bioreduction, Phytoremediation. 10

Bioabsorption and Bioleaching of heavy metals: Cadmium, Lead, Mercury, Metal binding targets and organisms, Bioabsorption, Metal microbial interaction, Biomethylation of elements (Methylation of mercury and arsenic), Commercial biosorbants, bioleaching, metal precipitation, advantages and disadvantages of bioleaching. 18

Waste water Treatment: Biological treatment system (Oxidative ponds, aerobic and anaerobic ponds, facultative ponds, aerated ponds), Biological waster treatment, activated sludge treatment, microbial pollution in activated sludge, percolating filters, waster water treatment by biofilms. Treatment scheme of Dairy, Distillery, Tannery, Sugar, Fertilizers, Refinery, Chemical and Antibiotic waste. 18

Solid waste pollution and its management: Current practice of solid waste management, composting systems, vermicomposting, sewage treatment. Anaerobic digestion, Land Filling. 14

### **Elective Practical Lab BTH C12: Applied Environmental Biotechnology**

#### **Suggested Laboratory Exercises:-**

Visit to

Sewage waste water treatment plants,

Farms doing floriculture, vegetable farming,

Dairy/sugar/dye industry treatment plants

Krishivaigyanikkendras for composting

Report writing of various visits.

  
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**REFERENCES---**

1. Industrial Waste Water Treatment (2008) By A D Patwardhan, Prentice Hall Of India, New Delhi.
2. Applied Bioremediation And Phytoremediation(2004) Ed By Ajay Singh And Owen P Ward, Springer
3. The Complete Book On Organic Farming And Production Of Organic Compost(2008) By Npcs Board Of Consultants And Engineers. Asia Pacific Business Press Inc.
4. The Complete Technology Book On Biofertilizer And Organic Farming (2nd Revised Edition) [Ni115] By Niir Board,
5. The Complete Technology Book On Vermiculture And Vermicompost [Ni116] By Npcs Board Of Consultants And Engineers,
6. Biopesticides Handbook [Ni210] By Npcs Board Of Consultants & Engineers,
7. Manufacture Of Biofertilizer And Organic Farming [Ni239] By H. Panda,
8. Integrated Organic Farming Handbook [Ni248] By Dr. H. Panda,

**Cluster: PE- Protein Engineering**  
**BTH D01:PE: Protein Engineering**

**Structure of Proteins and Prediction:** Overview of protein structure, PDB, structure based classification, databases, visualization tools, structure alignment, domain architecture databases, protein-ligand interactions. Primary structure and its determination, secondary structure prediction and determination of motifs, profiles, patterns, fingerprints, super secondary structures, protein folding pathways, tertiary structure, quaternary structure, methods to determine tertiary and quaternary structure, post translational modification. 12

**Introduction to Protein engineering:** definition. basic principles; Features or characteristics of protein that can be engineered (definition and methods of study). affinity and specificity: Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities etc. 8

**Method for Protein engineering:** Rational design, Directed mutagenesis, Random mutagenesis, DNA shuffling, Evolutionary methods/directed evolution, Homology modelling, De novo enzyme engineering, strategies and case studies: Addition of disulfide bonds- T4 Lysozyme, Xylanase, Human pancreatic Ribonuclease; changing asparagine to other amino acids, reducing the number of free sulphhydryl residues, increasing enzyme activity, modifying metal cofactor requirements, decreasing protease sensitivity, modifying protein specificity FokI endonuclease, Antibodies; increasing enzyme stability and specificity- altering multiple properties (Subtilisin, Peroxidase).

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**Computational approaches to protein engineering:** sequence and 3D structure analysis, bioinformatics tools for protein study, Data mining, Ramachandran map, Mechanism of stabilization of protein from psychrophiles and thermophiles vis-a-vis those from mesophiles; Protein design.

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**Application of Protein engineering:** Food and detergent industry applications, Environmental challenges and protein engineering, therapeutic protein production, antibody modelling, biopolymer production, applications in Nanobiotechnology, Applications with redox proteins and enzymes, industrially important enzymes, role in gene regulation, Other new applications

15


### **Elective Practical Lab BTH D11: Protein Engineering**

#### **Suggested Laboratory Exercises:-**

1. Isolation and purification of protein
2. SDS - PAGE
3. Demonstration of Mass spectroscopy MOLDI TOF
4. Gel filtrations chromatography
5. Affinity chromatography
6. To find out capacity & nature of the given ion exchange resin
7. Effect of pH, temperature on activity or stability of protein
8. Protein structure prediction by bioinformatics
9. Protein structure prediction and classification
10. Application of Bioinformatics tools in support of protein research
11. Searching protein sequence databases
12. Protein structure visualization
13. Secondary structure prediction
14. Protein structure prediction
15. Structural prediction through homology modelling
16. Ant other exercise based on theory paper content

#### **Suggested Readings:-**

1. Carl Brandon & John Tooze, "Introduction to Protein Structure," "2nd Edition" Garland Publishing, 1999
2. Paul R. Carey, "Protein Engineering and Design," Academic Press, 1996.
3. Daniel C. Liebler, "Introduction to Proteomics – Tools for the New Biology," Humana Press, 2001

  
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4. C. Branden, T. Tooze. 1999. Introduction to Protein Structure (2nd Ed.), Garland Science, Taylor and Francis Group, New York, USA.
5. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties (3rd Ed.), W.H. Freeman and Company, New York, USA.
6. R. H. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England. 5. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007.
7. S. Lutz, U. T. Bornscheuer. 2008. Protein Engineering Handbook, Wiley-VCH, Weinheim, Germany.
8. D. W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, Plainview, New York, USA.
9. V. N. Uversky, A.L. Fink. 2006. Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews), Springer, New York, USA.
10. M. Zvelebil, J.O. Baum. 2007. Understanding Bioinformatics (1s Ed.), Garland Science, Taylor and Francis Group, New York, USA.

### **BTH D02:PE: Proteomics and Genomics**

**Genomics:** Genome sequencing strategies and programs, new technologies for highthroughput sequencing, methods for sequence alignment and gene annotation; Approaches to analyze differential expression of genes - ESTs, SAGE, microarrays and their applications; gene tagging; gene and promoter trapping; knockout and knock-down mutants; dynamic modulation of protein structure and function , chip in chip.


15

Genome and Gene databases, Brief Outlook of Various Plant Genome Projects and their Outcome (**Arabidopsis, Tomato, Potato, Rice**), Non- coding RNAs ,Transcriptomics, RNA interference and gene silencing, genome imprinting, small RNAs-biogenesis and functions, role of small RNAs in heterochromatin formation and gene silencing, tools to study methylome and histone modifications Humane and Mouse.

15

**Proteomics:** Analysis of proteins by different biochemical and biophysical procedures like CD (Circular Dichroism), NMR, UV/Visible and fluorescent spectroscopy, protein identification and analysis on ExPASy server, other protein related databases, 1-D and 2-D gel electrophoresis for proteome analysis, Sample preparation, gel resolution and staining.

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Mass spectrometry based method for protein identification like PMF (protein mass fingerprinting) and LCMS, (Image analysis of 2D gels) Data acquisition, spot detection & quantitation, gel matching, data analysis, presentation, databases, conclusions; DIGE (Differential In Gel Electrophoresis), alternatives to 2-DE for protein expression analysis; Analysis of post-translational modifications and protein-protein interactions; protein chips and arrays, future directions in proteomics, scope of functional proteomics, and Protein databases, Protein- protein interaction, Interactome.

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## **Elective Practical Lab BTH D12: Proteomics & Genomics**

### **Suggested Laboratory Exercises:**

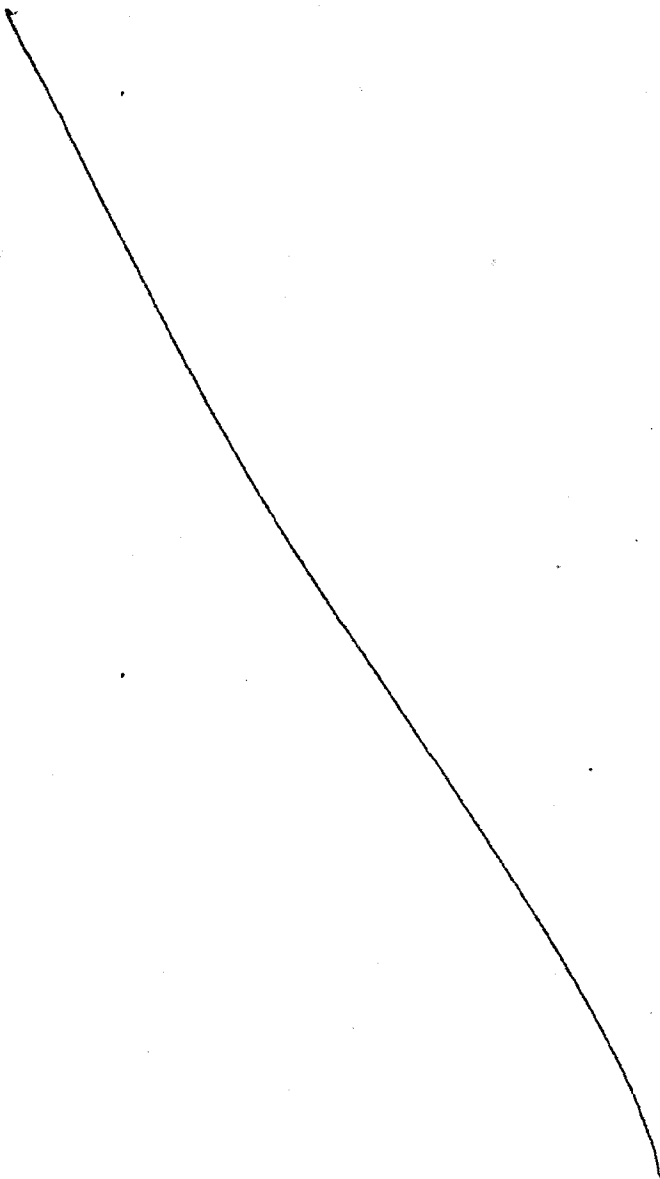
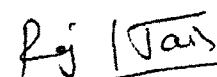
1. Demonstration and listing of sequence retrieval online tools.
2. Demonstration and listing of sequence submission online tools.
3. Listing and demonstration of Protein and DNA Sequence Databases and their utilities.
4. Demonstration of DNA and Protein Array Technology and applications.
5. Reverse transcription-PCR to examine gene expression.
6. Real-time PCR to quantify gene expression.
7. Northern and Western Blotting analysis.
8. Demonstration of Instrumentation (MALDI/TOF, LC-MS-MS, 2DGE) by visit or audio-visual medium.
9. Protein separation techniques (Chromatography-Ion-Exchange, Gel Filtration, Affinity; Ultrafiltration, Recombinant protein separation techniques).
10. Comparison of Next-generation sequencing methods (by Chart/ poster preparation).
11. Any other exercises designed by course teacher as per the syllabus.

### **SUGGESTED READINGS:**

1. Buchanan B, Gruissem G, and Jones R (2000) *Biochemistry and Molecular Biology of Plants*, American Society of Plant Physiologists, USA.
2. Hammes GD (2005) *Spectroscopy for the Biological Sciences*; Wiley Interscience, USA.
3. Harlow and Lane D (Eds.) (1988) *Antibodies – A Laboratory Manual*; Cold Spring Harbor Laboratory, USA.

  
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4. Lieber DC (2006) Introduction to Proteomics: Tools for New Biology; Humana Press, NJ.
5. Pennington SR, Dunn MJ (Eds.) (2002) Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.
6. Sambrook J and Russell DW (2001). Molecular Cloning – A Laboratory Manual, Vols I – III, Cold Spring Harbor Laboratory, USA.
7. Singer M and Berg P (1991). Genes and Genomes: A Changing Perspective; University Science Books, CA, USA.

  
  
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