M.Sc. Microbiology 2 Years 4 Semesters

SEMESTER 1

Biochemistry BTMSc 501 Credits 3

Course Objectives: The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. T he course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes: On completion of this course, students should be able to: • Gain fundamental knowledge in biochemistry; • Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Unit I (7 lectures)

Chemical basis of life Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies.

Unit II (4 lectures)

Protein structure Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin etc.; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit III (5 lectures)

Enzyme kinetics Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase;

regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit IV (2 lectures)

Glycobiology Sugars - mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules - glycoproteins and glycolipids; lipids - structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit V (3 lectures)

Structure and functions of DNA & RNA and lipids Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit VI (8 lectures)

Bioenergetics Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane; Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation.

Unit VII (12 lectures)

Role of vitamins & cofactors in metabolism Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway;

elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; target of rapamycin (TOR) & Autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

Recommended Textbooks and References:

1. Stryer, L. (2015). Biochemistry. (8th ed.) New York: Freeman.

2. Lehninger, A. L. (2012). Principles of Biochemistry (6th ed.). New York, NY: Worth.

3. Voet, D., & Voet, J. G. (2016). Biochemistry (5th ed.). Hoboken, NJ: J. Wiley & Sons.

4. Dobson, C. M. (2003). Protein Folding and Misfolding. Nature, 426(6968), 884-890. doi:10.1038/nature02261.

5. Richards, F. M. (1991). The Protein Folding Problem. Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

Cell and Molecular Biology BTMSc 503 Credits 3

Course Objectives:

The objectives of this course are to sensitize the students to the fact that as we go down the scale of magnitude from cells to organelles to molecules, the understanding of various biological processes becomes deeper and inclusive.

Student Learning Outcomes:

Student should be equipped to understand three fundamental aspects in biological phenomenon: a) what to seek; b) how to seek; c) why to seek?

Unit I (6 lectures)

Dynamic organization of cell Universal features of cells; cell chemistry and biosynthesis: chemical organization of cells; internal organization of the cell - cell membranes: structure of cell membranes and concepts related to compartmentalization in eukaryotic cells; intracellular organelles: endoplasmic reticulum and Golgi apparatus, lysosomes and peroxisomes, ribosomes, cellular cytoskeleton, mitochondria, chloroplasts and cell energetics; nuclear compartment: nucleus, nucleolus and chromosomes.

Unit II (12 lectures)

Chromatin structure and dynamics Chromatin organization - histone and DNA interactome: structure and assembly of eukaryotic and prokaryotic DNA polymerases, DNA-replication, repair and recombination; chromatin control: gene transcription and silencing by chromatinWriters,-Readers and –Erasers; Transcriptional control: Structure and assembly of eukaryotic and prokaryotic RNA Polymerases, promoters and enhancers, transcription factors as activators and repressors, trancriptional initiation, elongation and termination; post-transcriptional control: splicing and addition of cap and tail, mRNA flow through nuclear envelope into cytoplasm, breakdown of selective and specific mRNAs through interference by small non-coding RNAs (miRNAs and siRNAs), protein translation machinery, ribosomes-composition and assembly; universal genetic codes, degeneracy of codons, Wobble hypothesis; Iso-accepting tRNA; mechanism of initiation, elongation and termination; co- and post-translational modifications, mitochondrial genetic code translation product cleavage, modification and activation.

Unit III (3 lectures)

Cellular signalling, transport and trafficking Molecular mechanisms of membrane transport, nuclear transport, transport across mitochondria and chloroplasts; intracellular vesicular trafficking from endoplasmic reticulum through Golgi apparatus to lysosomes/cell exterior.

Unit IV (8 lectures)

Cellular processes Cell cycle and its regulation; cell division: mitosis, meiosis and cytokinesis; cell differentiation: stem cells, their differentiation into different cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell receptors and transmembrane signalling; cell motility and migration; cell death: different modes of cell death and their regulation.

Unit V (3 lectures)

Manipulating and studying cells Isolation of cells and basics of cell culture; observing cells under a microscope, different types of microscopy; analyzing and manipulating DNA, RNA and proteins.

Unit VI (8 lectures)

Genome instability and cell transformation Mutations, proto-oncogenes, oncogenes and tumour suppressor genes, physical, chemical and biological mutagens; types of mutations; intra-genic and inter-genic suppression; transpositions- transposable genetic elements in prokaryotes and eukaryotes, role of transposons in genome; viral and cellular oncogenes; tumor suppressor genes; structure, function and mechanism of action; activation and suppression of tumor suppressor genes; oncogenes as transcriptional activators.

Recommended Textbooks and References:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2008). Molecular Biology of the Cell (5th Ed.). New York: Garland Science.

2. Lodish, H. F. (2016). Molecular Cell Biology (8th Ed.). New York: W.H. Freeman.

3. Krebs, J. E., Lewin, B., Kilpatrick, S. T., & Goldstein, E. S. (2014). Lewin's Genes XI. Burlington, MA: Jones & Bartlett Learning.

4. Cooper, G. M., & Hausman, R. E. (2013). The Cell: a Molecular Approach (6th Ed.). Washington: ASM ; Sunderland.

5. Hardin, J., Bertoni, G., Kleinsmith, L. J., & Becker, W. M. (2012). Becker's World of the Cell. Boston (8th Ed.). Benjamin Cummings. 6. Watson, J. D. (2008). Molecular Biology of the Gene (5th ed.). Menlo Park, CA: Benjamin/Cummings.

Microbiology BTMSc 507 Credits 2

Course Objectives:

The objectives of this course are to introduce field of microbiology with special emphasis on microbial diversity, morphology, physiology and nutrition; methods for control of microbes and hostmicrobe interactions.

Student Learning Outcomes:

Students should be able to: • Identify major categories of microorganisms and analyze their classification, diversity, and ubiquity; • Identify and demonstrate structural, physiological, genetic similarities and differences of major categories of microorganisms; • Identify and demonstrate how to control microbial growth; • Demonstrate and evaluate interactions between microbes, hosts and environment.

Unit I

Microbial characteristics 6 lectures Introduction to microbiology and microbes, history & scope of microbiology, morphology, structure, growth and nutrition of bacteria, bacterial growth curve, bacterial culture methods; bacterial genetics: mutation and recombination in bacteria, plasmids, transformation, transduction and conjugation; antimicrobial resistance.

Unit II (9 lectures)

Microbial diversity Microbial taxonomy and evolution of diversity, classification of microorganisms, criteria for classification; classification of bacteria; Cyanobacteria, acetic acid bacteria, Pseudomonads, lactic and propionic acid bacteria, endospore forming bacteria, Mycobacteria and Mycoplasma. Archaea: Halophiles, Methanogens, Hyperthermophilic archae,

Thermoplasm; eukarya: algae, fungi, slime molds and protozoa; extremophiles and unculturable microbes.

Unit III (3 lectures)

Control of microorganisms Sterilization, disinfection and antisepsis: physical and chemical methods for control of microorganisms, antibiotics, antiviral and antifungal drugs, biological control of microorganisms.

Unit IV (5 lectures)

Virology Virus and bacteriophages, general properties of viruses, viral structure, taxonomy of virus, viral replication, cultivation and identification of viruses; sub-viral particles – viroids and prions.

Unit V (5 lectures)

Host-microbes interaction Host-pathogen interaction, ecological impact of microbes; symbiosis (Nitrogen fixation and ruminant symbiosis); microbes and nutrient cycles; microbial communication system; bacterial quorum sensing; microbial fuel cells; prebiotics and probiotics.

Recommended Textbooks and References:

1. Pelczar, M. J., Reid, R. D., & Chan, E. C. (2001). Microbiology (5th ed.). New York: McGraw-Hill. 2. Willey, J. M., Sherwood, L., Woolverton, C. J., Prescott, L. M., & Willey, J. M. (2011). Prescott's Microbiology. New York: McGraw-Hill.

3. Matthai, W., Berg, C. Y., & Black, J. G. (2005). Microbiology, Principles and E xplorations. Boston, MA: John Wiley & Sons.

Bioinformatics BTMSc 531 Credits 3

Course Objectives:

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

Student Learning Outcomes:

Student should be able to : • Develop an understanding of basic theory of these computational tools; • Gain working knowledge of these computational tools and methods; • Appreciate their relevance for investigating specific contemporary biological questions; • Critically analyse and interpret results of their study.

Unit I (5 lectures)

Bioinformatics basics: Computers in biology and medicine; Introduction to Unix and Linux systems and basic commands; Database concepts; Protein and nucleic acid databases; Structural databases; Biological XML DTD's; pattern matching algorithm basics; databases and search tools: biological background for sequence analysis; Identification of protein sequence from DNA sequence; searching of databases similar sequence; NCBI; publicly available tools; resources at EBI; resources on web; database mining tools.

Unit II (5 lectures)

DNA sequence analysis DNA sequence analysis: gene bank sequence database; submitting DNA sequences to databases and database searching; sequence alignment; pairwise alignment techniques; motif discovery and gene prediction; local structural variants of DNA, their relevance in molecular level processes, and their identification; assembly of data from genome sequencing.

Unit III (5 lectures)

Multiple sequence analysis; multiple sequence alignment; flexible sequence similarity searching with the FASTA3 program package; use of CLUSTALW and CLUSTALX for multiple sequence alignment; submitting DNA protein sequence to databases: where and how to submit, SEQUIN, genome centres; submitting aligned sets of sequences, updating submitted sequences, methods of phylogenetic analysis.

Unit IV (5 lectures)

Protein modelling: introduction; force field methods; energy, buried and exposed residues; side chains and neighbours; fixed regions; hydrogen bonds; mapping properties onto surfaces; fitting monomers; RMS fit of conformers; assigning secondary structures; sequence alignment-methods, evaluation, scoring; protein completion: backbone construction and side chain addition; small peptide methodology; software accessibility; building peptides; protein displays; substructure manipulations, annealing.

Unit V (6 lectures)

Protein structure prediction Protein structure prediction: protein folding and model generation; secondary structure prediction; analyzing secondary structures; protein loop searching; loop generating methods; homology modelling: potential applications, description, methodology, homologous sequence identification; align structures, align model sequence; construction of variable and conserved regions; threading techniques; topology fingerprint approach for prediction; evaluation of alternate models; structure prediction on a mystery sequence; structure aided sequence techniques of structure prediction; structural profiles, alignment algorithms, mutation tables, prediction, validation, sequence based methods of structure prediction, prediction using inverse folding, fold prediction; significance analysis, scoring techniques,

sequence-sequence scoring; protein function prediction; elements of in silico drug design;Virtual library: Searching PubMed, current content, science citation index and current awareness services, electronic journals, grants and funding information.

Recommended Textbooks and References:

1. Lesk, A. M. (2002). Introduction to Bioinformatics. Oxford: Oxford University Press.

2. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

3. Baxevanis, A. D., & Ouellette, B. F. (2001). Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins. New York: Wiley-Interscience.

4. Pevsner, J. (2015). Bioinformatics and Functional Genomics. Hoboken, NJ.: Wiley-Blackwell.

5. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.

6. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

Nanobiotechnology BTMSc 533 Credits 3

Course Objectives:

The course aims at providing a general and broad introduction to the multi-disciplinary field of nanotechnology. It will familiarize students with the combination of the top-down approach of microelectronics and micromechanics with the bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve our everyday life.

Student Learning Outcomes:

On successful completion of this course, students should be able to describe basic science behind the properties of materials at nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

Unit I (5 lectures)

Introduction to Nanobiotechnology: Concepts, historical perspective, Different formats of nanomaterials and applications with examples, Cellular nanostructures, Nanopores, Biomolecular motors, Bio-inspired nanostructures, Synthesis and characterization of different nanomaterials

Unit II – (5 lectures)

Nano-films: Thin films, Colloidal nanostructures, Self-assembly, Nanovesicles, Nanospheres, Nanocapsules and their characterization.

Unit III – (5 lectures)

Nano-particles: Nanoparticles for drug delivery, Optimization of nanoparticle propertie, Suitability of administration via various routes, Cellular internalization and long circulation,Strategies for enhanced permeation through anatomical barriers

Unit IV – (5 lectures)

Applications of Nano-particles :Nanoparticles for diagnostics and imaging (theranostics), Smart stimuli-responsive nanoparticles, Applications in cancer therapy, Nanodevices for biosensor development

Unit V – (5 lectures)

Nano-materials: Nanomaterials for catalysis, Development and characterization of nanobiocatalysts, Application of nanoscalefolds in synthesis, Applications in drug and drug intermediate production

Unit VI – (5 lectures)

Nano-toxicity: Safety of nanomaterials, Basics of nanotoxicity, Models and assays for nanotoxicity assessment, Fate of nanomaterials in different environments, Ecotoxicity models and Life Cycle Assessment (LCA)

Recommended Textbooks and References:

Gero Decher, Joseph B. Schlenoff (2003) – Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA

David S. Goodsell (2004) – Bionanotechnology: Lessons from Nature, Wiley-Liss

Neelina H. Malsch (2005) – Biomedical Nanotechnology, CRC Press

Greg T. Hermanson (2013) – Bioconjugate Techniques, 3rd Edition

Claudio Nicolini - Nanobiotechnology and nanobiosciences volume 1

Microbial Genetics BTMSc 535 Credits 2

Course objective:

- To Understand the Genetic constitutents of bacteria with special emphasis on inheritance and mutations
- To understand the mechanism of genetic transfers in microbes
- To understand different techniques used to study the microbial genetics and utilizing the microbial phenomenon in different biotechnological applications

Course Outcomes :

- Student capable of explaining process involved in genetic changes and mutations
- The identification of genetic regulatory mechanism and distinguishing different mechanism of gene regulation
- The design of different techniques based on utilizing the genetic mechansism of microbes

Unit 1 (10 lectures)
Genetic analysis of bacteria: Importance and uses of mutation analysis. Inheritance in bacteria, types of mutations, spontaneous and induced mutagenesis, isolating mutants, selecting mutants, mutant enrichment. Reversions versus suppression. Complementation tests, recombination tests and gene replacements. Cloning genes by complementation. Cloning genes by marker rescue

Unit 2 (10 lectures)

Gene transfer by conjugation, transformation and transduction: Molecular mechanism of gene transfers by conjugation, genes and proteins involved. Regulation of gene transfer by conjugation, Hfr strains. Natural transformation and competence. Molecular basis of natural transformation: DNA uptake competence systems in gram positive and gram negative bacteria. Regulation of competence in B. subtilis. Importance of natural transformation. Artificially induced competence. Generalized versus specialized transduction T4 and lambda phage. Phase variation system in pathogenic bacteria.

Unit 3 (10 lectures)

Overexpression of recombinant proteins: Overexpression and tagging of recombinant proteins in E.coli, driven by lac, T7 and Tet-regulatable promoters. Overexpression systems in S.cerevisiae, P.pastoris. Baculovirus overexpression system.

Analysis of protein-DNA and protein-protein interactions: Gel retardation assay, DNA footprinting by DNase I, yeast one-hybrid assay, ChIP-chips. Yeast two hybrids, system. Co-immunoprecipitations, pull-downs and Far-Westerns.
Recommended Textbooks and References:

1. Molecular Genetics of Bacteria by Larry Snyder and Wendy Champness, 3rd edition; ASM press; 2007.

2. Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
3. Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987.

4. Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.

Basics of Mathematics and Biostatistics BTMA445 Credits 3

Course Objectives:

The objective of this course is to give conceptual exposure of essential contents of mathematics and statistics to students.

Student Learning Outcomes:

On completion of this course, students should be able to : • Gain broad understanding in mathematics and statistics; • Recognize importance and value of mathematical and statistical thinking, training, and approach to problem solving, on a diverse variety of disciplines.

Unit I (12 lectures)

Algebra Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; constructing linear models in biological systems; quadratic equations (solving, graphing, features of, interpreting quadratic models etc.), introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, basics of trigonometric functions, Pythagorean theory, graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, basics of vectors, introduction to matrices.

Unit II (8 lectures)

Calculus Differential calculus (limits, derivatives), integral calculus (integrals, sequences and series etc.).

Unit III (10 lectures)

Mathematical models in biology Population dynamics; oscillations, circadian rhythms, developmental patterns, symmetry in biological systems, fractal geometries, size-limits & scaling in biology, modeling chemical reaction networks and metabolic networks.

Unit IV (10 lectures)

Statistics Probability: counting, conditional probability, discrete and continuous random variables; Error propagation; Populations and samples, expectation, parametric tests of statistical significance, nonparametric hypothesis tests, linear regression, correlation & causality, analysis of variance, factorial experiment design.

Recommended Textbooks and References:

1. Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. New York, NY: Palgrave Macmillan.

2. Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for Biological Scientists. Garland Science.

3. Billingsley, P. (1986). Probability and Measure. New York: Wiley.

4. Rosner, B. (2000). Fundamentals of Biostatistics. Boston, MA: Duxbury Press. 5. Daniel, W. W. (1987). Biostatistics, a Foundation for Analysis in the Health Sciences. New York: Wiley.

LABORATORIES SEMESTER 1

Biochemistry and Analytical Techniques BTMSC 513 Credits 3

Course Objectives :

T he objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach students the utility of set of experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes On completion of this course, students should be able to: • To elaborate concepts of biochemistry with easy to run experiments; • To familiarize with basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biochemistry.

Syllabus 1. Preparing various stock solutions and working solutions that will be needed for the course.

2. To prepare an Acetic-Na Acetate Buffer and validate the Henderson-Hasselbach equation.

3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-Vis Spectrophotometer and validating the Beer- Lambert's Law.

4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.

5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of the institution's choice).

a) Preparation of cell-free lysates b)Ammonium Sulfate precipitation c) Ion-exchange Chromatography d)Gel Filtration e)Affinity Chromatography f) Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method g) Generating a Purification Table (protein concentration, amount of total protein; Computing specific activity of the enzyme preparation at each stage of purification) h) Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis i) Enzyme Kinetic Parameters: Km, Vmax and Kcat.

6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA. reversal of the same following DNA renaturation. Kinetics of DNA renaturation as a function of DNA size.

7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)

8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).

9. Determination of mass of small molecules and fragmentation patterns by Mass

Microbiology lab BTMSc 515 Credit 3

Course Objectives:

The objective of this laboratory course is to provide practical skills in basic microbiological techniques.

Student Learning Outcomes:

On completion of this laboratory course, students should be able to: • Isolate, characterize and identify common bacterial organisms; • Determine bacterial load of different samples; • Perform antimicrobial sensitivity test; • Preserve bacterial cultures.

Syllabus

Basic techniques

1. Sterilization, disinfection and safety in microbiological laboratory, good laboratory practices
2. Preparation of media for cultivation of bacteria, liquid and agar. Syllabus Culture techniques 1. Spread plate method 2. Pour plate method
3. Streaking
4. Bacterial growth curve
5. Bacterial plate count method
6. Maintenance of stock cultures: slants, stabs and glycerol stock cultures.

Syllabus Staining techniques

1. Preparation of bacterial smear and Gram's staining
2. Acid fast staining
3. Endospore staining
4. Capsule staining
5. Negative staining
6. Flagellar staining.

Syllabus Microscopy-related techniques

1. Bright field light microscopy
2. Hanging drop slide preparation
3. Motility of bacteria
4. Dark field light microscopy
5. Phase contrast microscopy
6. Fluorescence microscopy.

Syllabus Biochemical and antibiotic tests

1. MR test
2. VP test
3. Sucrose fermentation
4. Lactose fermentation
5. Indole test
6. Antimicrobial sensitivity test and demonstration of drug resistance
7. Zone of clearance, zone of inhibition.

Syllabus Environmental factors

1. Effect of pH and temperature on microbial growth
2. Determination of phenol co-efficient of antimicrobial agents
3. Determination of Minimum Inhibitory Concentration (MIC)
4. Isolation and identification of bacteria from soil/water samples.

Recommended Textbooks and References:

1. Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin -Cummings Publishing Company.

2. LM Prescott, JP Harley, DA Klein, (2002), Laboratory Exercises in Microbiology.

Bioinformatics lab BTMSc 537 Credits 2

Course Objectives :

T he aim of this course is to provide practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

Student Learning Outcomes :

On completion of this course, students should be able to: • Describe contents and properties of most important bioinformatics databases; • Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge; • Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming; • Predict secondary and tertiary structures of protein sequences.

Syllabus 1. Using NCBI and Uniprot web resources.

2. Introduction and use of various genome databases.

3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.

4. Similarity searches using tools like BLAST and interpretation of results.

5. Multiple sequence alignment using ClustalW.

6. Phylogenetic analysis of protein and nucleotide sequences.

7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).

8. Using RNA structure prediction tools.

9. Use of various primer designing and restriction site prediction tools.

10. Use of different protein structure prediction databases (PDB, SCOP, CATH).

11. Construction and study of protein structures using Deepview/PyMol.

12. Homology modelling of proteins.

13. Use of tools for mutation and analysis of the energy minimization of protein structures.

14. Use of miRNA prediction, designing and target prediction tools.

SEMESTER 2

Genetic Engineering BTMSc 502 Credits 3

Course Objectives:

The objectives of this course are to teach students with various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries. Genetic engineering is a technology that has been developed based on our fundamental understanding of the principles of molecular biology and this is reflected in the contents of this course.

Student Learning Outcomes:

Given the impact of genetic engineering in modern society, the students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

Unit I (6 lectures)

Introduction and tools for genetic engineering Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymeric tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization.

Unit II (7 lectures)

Different types of vectors Plasmids; Bacteriophages; M13 mp vectors; PUC19 and Bluescript vectors, hagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies;

mammalian expression and replicating vectors; Baculovirus and Pichia vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit III (7 lectures)

Different types of PCR techniques Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; reverse-transcription PCR, real time PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, cloning of PCR products; T-vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit IV (7 lectures)

Gene manipulation and protein-DNA interaction Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein-DNA interactions: electrophoretic mobility shift assay; DNase footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit V (13 lectures)

Gene silencing and genome editing technologies Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies(Drosophila), worms (C. elegans), frogs (Xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials.

Recommended Textbooks and References:

1. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.

2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

3. Brown, T. A. (2006). Genomes (3rd ed.). New York: Garland Science Pub.

4. Selected papers from scientific journals, particularly Nature & Science.

5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

Immunology BTMSc 504 Credits 3

Course Objectives:

The objectives of this course are to learn about structural features of components of immune system as well as their function. T he major emphasis of this course will be on development of immune system and mechanisms by which our body elicits immune response. This will be imperative for students as it will help them to predict about nature of immune response that develops against bacterial, viral or parasitic infection, and prove it by designing new experiments.

Student Learning Outcomes:

On completion of this course, students should be able to: • Evaluate usefulness of immunology in different pharmaceutical companies; • Identify proper research lab working in area of their own interests; • Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in the setting of infection (viral or bacterial).

Unit I (5 lectures)

Immunology: fundamental concepts and overview of the immune system Components of innate and acquired immunity; phagocytosis; complement and inflammatory responses; pathogen recognition receptors (PRR) and pathogen associated molecular pattern (PAMP); innate immune response; mucosal immunity; antigens: immunogens, haptens; Major Histocompatibility Complex: MHC genes, MHC and immune responsiveness and disease susceptibility, Organs of immune system, primary and secondary lymphoid organs.

Unit II (8 lectures)

Immune responses generated by B and T lymphocytes Immunoglobulins - basic structure, classes & subclasses of immunoglobulins, antigenic determinants; multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; principles of cell signaling; basis of self & non-self discrimination; kinetics of immune response, memory; B cell maturation, activation and differentiation; generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; functional T Cell subsets; cell-mediated immune responses, ADCC; cytokines: properties, receptors and therapeutic uses; antigen

processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; cell-cell co-operation, Hapten-carrier system.

Unit III (6 lectures)

Antigen-antibody interactions Precipitation, agglutination and complement mediated immune reactions; advanced immunological techniques: RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence microscopy, flow cytometry and immunoelectron microscopy; surface plasmon resonance, biosensor assays for assessing ligand –receptor interaction; CMI techniques: lymphoproliferation assay, mixed lymphocyte reaction, cell cytotoxicity assays, apoptosis, microarrays, transgenic mice, gene knock outs.

Unit IV (8 lectures)

Vaccinology Active and passive immunization; live, killed, attenuated, subunit vaccines; vaccine technology: role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; peptide vaccines, conjugate vaccines; antibody genes and antibody engineering:chimeric, generation of monoclonal antibodies, hybrid monoclonal antibodies; catalytic antibodies and generation of immunoglobulin gene libraries, idiotypic vaccines and marker vaccines, viral-like particles (VLPs), dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, edible vaccine and therapeutic vaccine.

Unit V (8 lectures)

Clinical immunology Immunity to infection : bacteria, viral, fungal and parasitic infections (with examples from each group); hypersensitivity: Type I-IV; autoimmunity; types of autoimmune diseases; mechanism and role of CD4+ T cells; MHC and TCR in autoimmunity; treatment of autoimmune diseases; transplantation: immunological basis of graft rejection; clinical transplantation and immunosuppressive therapy; tumor immunology: tumor antigens; immune response to tumors and tumor evasion of the immune system, cancer immunotherapy; immunodeficiency: primary immunodeficiencies, acquired or secondary immunodeficiencies, autoimmune disorder, anaphylactic shock, immunosenescence, immune exhaustion in chronic viral infection, immune tolerance, NK cells in chronic viral infection and malignancy.

Unit VI (5 lectures)

Immunogenetics Major histocompatibility complex genes and their role in autoimmune and infectious diseases, HLA typing, human major histocompatibility complex (MHC), Complement genes of the human major histocompatibility complex: implication for linkage disequilibrium and disease associations, genetic studies of rheumatoid arthritis, systemic lupus erythematosus and multiple sclerosis, genetics of human immunoglobulin, immunogenetics of spontaneous control of HIV, KIR complex.

Recommended Textbooks and References:

1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., & Kuby, J. (2006). Kuby Immunology. New York: W.H. Freeman.

2. Brostoff, J., Seaddin, J. K., Male, D., & Roitt, I. M. (2002). Clinical Immunology. London: Gower Medical Pub.

3. Murphy, K., Travers, P., Walport, M., & Janeway, C. (2012). Janeway's Immunobiology. New York: Garland Science.

4. Paul, W. E. (2012). Fundamental Immunology. New York: Raven Press.

5. Goding, J. W. (1996). Monoclonal Antibodies: Principles and Practice: Production and Application of Monoclonal Antibodies in Cell Biology, Biochemistry, and Immunology. London: Academic Press.

6. Parham, P. (2005). The Immune System. New York: Garland Science.

Bioprocess Engineering and Technology BTMSc 552 Credits: 3

Course Objectives:

The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Student Learning Outcomes:

Students should be able to: • Appreciate relevance of microorgan isms from industrial context; • Carry out stoichiometric calculations and specify models of their growth; • Give an account of design and opera- tions of various fermenters; • Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products; • Calculate yield and production rates in a biological production process, and also interpret data; • Calculate the need for oxygen and oxy- gen transfer in a bioproduction process; • Critically analyze any bioprocess from an economics/market point of view; • Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Unit I (4 lectures)

Basic principles of biochemical engineering Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics.

Unit II (6 lectures)

Stoichiometry and models of microbial growth Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth, MATLAB basics for modelling and solving the equations.

Unit III (8 lectures)

Bioreactor design and analysis Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation vs biotransformations; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.

Unit IV (4 lectures)

Downstream processing and process economics Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; f inal purification: drying; crystallization; storage and packaging.

Unit V (4 lectures)

Applications of enzyme technology in food processing Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g. starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.

Unit VI (4 lectures)

Applications of microbial technology in food processing and biorefineries Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria: production and applications in food preservation; biofuels and biorefinery; production of antibiotics in a reactor; single cell protein; probiotics and prebiotics.

Unit VII (12 lectures)

Applications of biotechnology in production of biologicals Industrial production of penicillin via fungal route, insulin from recombinant E. coli; Production of metabolites such as shikonin using plant cell culture, astaxanthin from algae, and biotransformation routes for novel/specialty chemicals; Production of HBsAg using yeast cultures, erythropoietin using CHO cells, monoclonal antibodies such as Humira using mammalian cells.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.

2. Stanbury, P. F., & Whitaker, A. (1997). Principles of Fermentation Technology. Oxford: Pergamon Press.

3. Pauline Doran (1995) Bioprocess Engineering Principles. Elsevier Science & Technology Books

4. Mansi EMTEL, Bryce CFA. Fermentation Microbiology and Biotechnology, 2nd Edition, Taylor & Francis Ltd, UK, 2007

5. Harrison, R.G., Todd, P., Rudge, S.R., and Petrides, D.P. (2015). Bioseparations Science and Engineering. 2nd Edition. Oxford University Press.)

Downstream Processing in Biotechnology BTMSc 554 Credits 3

Course Objectives:

The objective of this course is to provide an overview of various aspects of recovery and processing of biological products.

Student Learning Outcomes Students should be able to identify and design relevant unit operations for recovery of a biological product.

Unit I

Biomass removal 3 lectures Characteristics of biological materials: pretreatment methods; Separation of cell mass: centrifugation, sedimentation, flocculation and filtration; Continuous operation.

Unit II

Cell disruption 4 lectures Mechanical approaches: sonication, bead mills, homogenizers; non-mechanical approaches: freeze/thaw, osmotic shock, chemical lysis, enzymatic lysis; measurement of cell disruption.

Unit III

Membrane processes Filtration theory; Micro and ultrafiltration; Reverse osmosis; dialysis; electrodialysis, diafiltration; pervaporation; perstraction; Multistage and continuous operation.

Unit IV

Adsorption and chromatography 5 lectures Adsorption equilibrium, Van Deemter equation; Chromatography: size, charge, polarity, shape, hydrophobic interactions; Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds).

Unit V

Extraction processes 5 lectures Solvent extraction: phase equilibrium and distribution, counter-current operation, dissociative extraction, multiple stage analysis; Reciprocating-plate and centrifugal extractors; Reverse micellar extraction; Aqueous two phase, Supercritical fluid extraction; Aqueous two-phase extraction.

Unit VI

Concentration steps 8 lectures Precipitation: effect of size and charge, solvent effects, ionic strength effects, precipitate growth and aging models. Crystallization: nucleation and growth aspects; Drying: solvent removal aspects, dryers (vacuum, freeze, spray); Scale up aspects. Unit VII Product characterization 4 lectures Biophysical characterization, chemical characterization, modern spectroscopy, QbD, stability Bioassays: Cell based assay, receptor mediated assay, in vivo evaluation, immunogenicity.

Unit VIII

Process design 8 lectures Process synthesis: Identification and ordering of unit operations relevant for a case study. Analysis: comparison of different process synthesis steps. Case studies such as production and recovery of therapeutics, metabolites and antibodies. Bioreactor Operations

Recommended Textbooks and References:

1. Harrison, R.G., Todd, P., Rudge, S.R., and Petrides, D.P. (2015). Bioseparations Science and Engineering. 2nd Edition. Oxford University Press.

2. Ladisch, M. (2000). Bioseparations Engineering: Principles, Practice, and Economics. Wiley.

3. Doran P. (2013). Bioprocess Engineering Principles. 2nd Edition. Oxford. Academic Press.

4. P.A. Belter, E.L. Cussler and Wei-Shou Hu., (1988), Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication**.**

Virology BTMSc 556 Credits 3

Unit 1 (12 lectures)

Introduction: History and principles of virology. Virus structure and morphology, viruses of veterinary importance and plant viruses. The Function and Formation of Virus Particles. Capsid Symmetry and Virus Architecture. Enveloped Viruses. Complex Virus Structures. Protein-Nucleic Acid Interactions and Genome Packaging. Viral Genomes: The Structure and Complexity of virus Genomes. Viral Genetics. Virus Mutants. Genetic Interactions between Viruses. Non-genetic Interactions between Viruses. Positive-Strand RNA Viruses. Negative-Strand RNA Viruses. Segmented and multipartite Virus Genomes. Baltimore Classification

Unit 2 (8 lectures)

Virus-cell Interaction: Cellular receptors and virus entry: Definition, structure and methods of discovery of viral receptors (polio, herpes, VSV, HIV). Cellular interactions—clathrin coated pits, lipid rafts, caveolae, endocytosis and virus uncoating mechanisms Nuclear localization signals and nuclear pore transit, virus – cytoskeletal interactions, chaperons.

Unit 3 (8 lectures)

Viral Replication: General strategies, replication of plus stranded RNA virus (polio), negative strandRNA viruses (VSV and influenza).Replication of double stranded RNA virus (rota), andretroviruses (HIV and HTLV). DNA viruses Replication of double stranded DNA viruses (SV40, pox), ssDNA virus (AAV) proteins, replication of plant virus.

Unit 4 (12 lectures)

Viral gene expression: Initiation of transcription,Viral regulation of transcription, capping and tailing, premRNA splicing. Post-transcriptional Gene Silencing, Regulation of translation during viral infection

Unit 5 (lectures)

Intracellular trafficking and exit of virus: Import of viral proteins, assembly, selective packaging, release of virus particle

Unit 6 (lectures)

Viral Diseases: Viral Diarrhoea: Clinical course, disease burden, risk factors, epidemiology, prevention, and treatment. Rotavirus. Viral Cancers: Role of papilloma, HIV, Epstein Barr Virus, HTLV and herpes in pathogenesis of cancers, diagnosis, prevention. Viral Hepatitis: Structure & genomic organization, Viral respiratory diseases (Biology of respiratory viruses). HIV-AIDS, Genetic Engineering Plants for Virus Resistance

Text Books: 1. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses. S. J. Flint, V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka Latest edition / Pub. Date: December 2003 Publisher: American Society Microbiology.

Microbial Diversity and Metgenomics BTMSc 542 Credits 2

Unit 1

Introduction to microbes their genetics and genomics: Prokaryotic cell structure, Microbial

nutrition, transport metabolism, the measure of growth, microbial genetics and genomics. Introduction

to Viruses, Algae, Fungi and protozoa

Unit 2

Microbial diversity: Different types of bacteria on the basis of nutrition, environment halophiles,

psychrophiles, barophiles etc. Microbial evolution, taxonomy, phenetic and phylogenetic

classification, phylogeny, microbial ecology, Archaebacteria

Unit 3.

Introduction to metagenomics: sequence and function-based metagenomics, metagenomics in

microbial diversity, molecular markers, Molecular techniques for characterization of microbial

communities e.g., PCR, DGGE, ARDRA, rRNA operon, the repetitive sequence for bacterial

identification. Next Generation Sequencing in metagenomics, GT metagenomics, SARST

metagenomics, transcriptomics,

Unit 4

In silico tools for metagenome analysis: (1) Functional Metagenome dataset (DNASTAR, ORF

FINDER, BLAST etc), (2) Sequenced Metagenome dataset (FASTQC, FASTQP, METAQC), (3) 16S rRNA gene datasets (QIIME, MEGAN, MOTHUR etc), (4) Whole genome datasets(MGRAST,

SEED, METAPATH), Geochip, Phylochip.

Metagenomics in the screening of novel antimicrobials, Antibiotic resistome, Human Gut Microbiota,

Soil microbiome etc

Suggested Reading:

1 Microbiology by Prescott, Harley and kleins

2.Microbial biotechnology by Alexander Frazier

3. Handbook of Molecular Microbial ecology I Metagenomics and complementary approaches

by Frans J de Bruijn

4. Handbook of Molecular Microbial ecology II Metagenomics and complementary approaches

by Frans J de Bruijn

5. Minning of microbial wealth and metagenomics By Kalia, Purohit, Rahi Springer

6. Metagenomics: Application of Genomics to Uncultured Microorganisms Jo Handelsman**.**

Microbiology and mol biology reviews 2004.

7. Screening for novel enzymes from metagenome and SIGEX, as a way to improve it Jiae Yun and Sangryeol Ryu. Microbial cell factories 2005

8 Metagenomic analysis and interpretation, NR Chauhan. https://doi.org/10.1016/B978-0-12-816548-5.00010-1

DSE I

1. **Computational Biology BTMSc 516 Credits 2**
2. **Microbial Physiology BTMSc 558 Credits 2**
3. **Protein Engineering BTMSc 526 Credits 2**

LABORATORIES SEMESTER 2

Immunology and Genetic Engineering Lab BTMSc 562 Credit 3

Course Objectives

The objectives of this course are to provide students with experimental knowledge of molecular biology and genetic engineering. The objectives of this laboratory course are to develop an understanding about practical aspects of components of immune system as well as their function. Basic as well as advanced methods will be taught to detect different antigen and antibody interactions, isolation of different lymphocyte cells etc. and how they can be used in respective research work.

Student Learning Outcomes:

Students should be able to gain hands- on experience in gene cloning, protein expression and purification. This experience would enable them to begin a career in industry that engages in genetic engineering as

• Evaluate usefulness of immunology in different pharmaceutical companies;

• Identify proper research lab working in area of their own interests;

• Apply their knowledge and design immunological experiments to demonstrate innate, humoral or cytotoxic T lymphocyte responses and figure out kind of immune responses in setting of infection (viral or bacterial) by well as in research laboratories conducting fundamental research. Students should be able to:looking at cytokine profile.

Genetic Enginering

1. Plasmid DNA isolation and DNA quantitation.
2. Restriction Enzyme digestion of plasmid DNA.
3. Agarose gel electrophoresis.
4. Polymerase Chain reaction.

5. DNA Ligation.

6. Preparation of competent cells.

7. Transformation of E.coli with standard plasmids, Calculation of transformation efficiency.

Immunology

1. Handling of animals like rabbits, mice.

2. Preparation of antigens, immunization and methods of blood collection, serum separation and storage.

3. Antibody titre by ELISA method.

4. Double diffusion, Immunoelectrophoresis and Radial Immuno diffusion.

5. Complement fixation test.

6. Isolation and purification of IgG from serum or IgY from chicken egg.

Bioprocess lab BTMSc 560 Credits 3

Course Objectives:

The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.

Student Learning Outcomes:

• Investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems; • Apply skills and knowledge gained will be useful in solving problems typical of bio industries and research.

Syllabus

1. Basic Microbiology techniques a) Scale up from frozen vial to agar plate to shake flask culture. b) c) Instrumentation: Microplate reader, spectrophotometer, microscopy. Isolation of microorganisms from soil samples.

2. Experimental set-up a) Assembly of bioreactor and sterilization. b) Growth kinetics c) Substrate and product inhibitions d) Measurement of residual substrates.

3. Data Analysis a) Introduction to Metabolic Flux Analysis (MFA).

4. Fermentation a) Batch b) Fed-batch. c) Continuous.

5. Unit operations a) Microfiltrations: Separation of cells from broth. b) Bioseparations: Various chromatographic techniques and extractions.

6. Bioanalytics a) Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.

2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.

3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.

4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.

5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Franci

SEMESTER 3

Bioentrepreneurship BTMSc 607 Credits 3

Course Objectives

Bioentrepreneurship Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Student Learning Outcomes:

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. T he knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

Unit I(8 lectures)

Innovation and entrepreneurship in bio-business 8 lectures Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g. pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II (8 lectures)

Bio markets - business strategy and marketing Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III (8 lectures)

Finance and accounting Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV (8 lectures)

Technology management Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Textbooks and References:

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.

2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.

3.Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.

4. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

Intellectual Property Rights, Biosafety and Bioethics BTMSc 609 Credits 2

Course Objectives:

The objectives of this course are: Intellectual Property Rights, Biosafety and Bioethics Credits 2

- To provide basic knowledge on intellectual property rights and their implications in

biological research and product development; • To become familiar with India's IPR Policy; • To learn biosafety and risk assessment of products derived from biotechnolo gy and regulation of such products; • To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing. Student Learning Outcomes On completion of this course, students should be able to: • Understand the rationale for and against IPR and especially patents; • Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; • Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents; • Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations; • Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Unit I (5 lectures)

Introduction to IPR Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit II (5 lectures)

Patenting Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-requirement, procedures and costs; financial assistance for patentingintroduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

Unit III (5 lectures)

Biosafety Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV (5 lectures)

National and international regulations International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

Unit V (5 lectures)

Bioethics Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Recommended Textbooks and References:

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.

2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI

3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct. 4. Kuhse, H. (2010). Bioethics: an Anthology. Malden, MA: Blackwell.

5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/

6. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press

7. World Trade Organisation. http://www.wto.org

8. World Intellectual Property Organisation. http://www.wipo.int

9. International Union for the Protection of New Varieties of Plants. http://www.upov.int

10. National Portal of India. http://www.archive.india.gov.in

11. National Biodiversity Authority. http://www.nbaindia.org

12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf

13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F . (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9

14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8

15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008. 16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp

17. Alonso, G. M. (2013). Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure “Fit for Purpose” Risk Assessments. Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews

Microbial Pathogenesis and Diagnosis BTMSc 643 Credits 3

Course objectives:

The crucial role of microbes in various diseases is known. The objective of course is to understand the mechanism of pathogenesis used by different bacterial and viral pathogens. In addition, the course includes methods available for diagnosis their basis and advances in diagnosis with the advances in next generation sequencing.

Course outcomes:

Upon completion of course, students would know:

The mechanism of pathogenesis used by different pathogens

How pathogens interact with host and fails host immune response

Various diagnostic tools available

Recent advances in area of microbial diagnostics

Unit I ((10 lectures)

Molecular basis of Infectious Diseases Principles of Infectious Diseases: general principles of microbial interactions with humans that result in infection and diseases; examples of bacterial, viral, fungal and parasitological pathogens with special emphasis in developing countries; molecular basis of bacterial pathogenesis: Role of virulence factors, adhesins, pathogenicity island, protein and DNA secreting systems in pathogenicity and disease;

Unit II (10 lectures)

Modulation of host signaling system in response to infection: molecular and cellular basis of viral infections: key examples of RNA and DNA viruses of humans causing diseases; molecular biology of tumor viruses; mechanisms of viral carcinogenesis;

Unit III (8 lectures)

Host - Microbe Relationships: Microbial Colonization of Epithelial Surfaces; bacterial biofilms and Quorum Sensing in health and disease. Epithelial host defense: sensors of extracellular colonization by bacteria, intracellular invasion; signaling pathways and effectors of innate immune system, mechanisms of immune tolerance and its relationships with host commensals; case studies: Host microbe relationships in inflammatory Bowel Disease, obesity and others.

Unit IV (10 lectures)

Microbial Mol Diagnostics: Introduction to clinical microbiology and diagnosis, Microscopy, Culture based methods, Antigen-antibody based methods, Spectroscopic Methods for the Detection of Microbial Pathogens and Diagnostics of Infectious Diseases, MALDI-ToF, molecular biology of diagnosis, PCR based methods, real time PCR, digital PCR, LAMP, NGS, Clinical metagenomics,

CRISPR in diagnosis

Recommended Textbooks and References

1. Bacterial Pathogenesis: A Molecualr Approach: 3 rd Edition. Abigail A Salyers. ASM Press.

2. Emerging infectious Diseases. Vol. 14. CDC Press

3. Molecular Diagnostics of Infectious Diseases. By Harald H. Kesslar.

4. Medical Microbiology: An Introduction to Infectious Diseases. By John C. Sherris, Kenneth J Ryan et al. Elsivier publication.

5. Bacteriology of Humans: An Ecological Perspective by Michael Wilson. Publisher: Wiley Blackwell; 1 edition (May 6, 2008)

6. Clinical microbiology in detection and identification of emerging microbial pathogens: past, present

and future (Review 2022)

7. From Species to Genes: A New Diagnostic Paradigm (Review 2024)

8. Advances in the application of molecular diagnostic techniques for the detection of infectious disease pathogens (Review 2023)

9. Versatility of reverse transcriptase loop-mediated isothermal amplification (RT-LAMP) from diagnosis of early pathological infection (Review 2024)

Vaccine Research and Development BTMSc 645 Credits 3

Unit 1**:** (8 Lectures)

History and Relevance of Immunology, Components of Innate and acquired immunity, Organs and cells of immune system, Lymphocyte circulation; Lymphocyte homing; Mucosal and Cutaneous associated Lymphoid tissue.(MALT&CALT);, Antigens- immunogens, haptens; antigenic determinants/epitopes, Antibody structure and function, Immunoglobulins-basic structure, classes and subclasses of immunoglobulins. Connection between innate and acquired immunity, Inflammation, soluble and membrane associated receptor, Toll Like Receptor (TLR). cells type of innate immunity, signal transduction pathway (TLR only)

Unit 2 (8 Lectures)

Overview of Vaccine Strategies: History of vaccines, bacterial, viral and parasitic vaccines, overview of conventional vaccine strategies, designing of live attenuated or killed whole

organism-based vaccines sub-unit vaccines, DNA vaccines, recombinant vaccines, adjuvants, peptides, immune-modulators (cytokines). Vaccine delivery systems, mucosal vaccines, parental vaccines, edible vaccines, monoclonal antibodies as vaccines. The advantages and disadvantages of each approach, eluding to various considerations, such as efficacy, safety and cost of production. General specifications and pharmaceuticals release criteria for the existing vaccines, Cold chain management of vaccines.

Unit 3**:** (8 Lectures)

Genetic engineering in vaccine designing: Designing of peptide/epitope-based vaccines, T cell and B cell epitope prediction, screening and selection of the vaccine composition, structural approaches for vaccine designing, Reverse vaccinology and immunoinformatics, Databases in Immunology, Principles of B-cell and T-cell epitope prediction.

Unit 4**:** (8 Lectures)

New strategies for vaccine development**:** Reverse genetic and temperature-sensitive mutation, reassortment, Viral recombinant and deletion mutants, codon deoptimization, increased replication fidelity, replication vector recombined with gene from pathogens, Replication-defective VLPs, DNA plasmid, reverse vaccinology, Prime boost, Fusion proteins, Gene delivery by invasive bacteria,, Inmmune refococusing, Transcriptomics, proteomics, DNA shuffling, transcutaneous vaccination, adjuvant.

Unit 5**:** (8 Lectures)

Latest Research articles each related to (i) Bacterial vaccine Research (ii) Fungal vaccine research (ii) Parasite vaccine research (iv) viral vaccine research (v) Immunoinformatics research.

Recommended Textbooks and References

1. Vaccine Design: Innovative Approaches and Novel Strategies Publisher: Caister Academic Press, Editor: Rino Rappuoli and Fabio

2. Vaccines, 4th Edition by Stanley A. Plotkin, Elsevier publication

3. Vaccines and Immunotherapy by Stanley J. Cryz Elsevier science publishing co.

4. Review: Vaccines: the fourth century by Stanley Plotkin

5. Latest Research articles from pubmed.

Research Methodology BTMSc 647 Credits 2

Course Objectives :

The objectives of this course are to give background on history of science, emphasizing methodologies used to do research, use framework of these methodologies for understanding effective lab practices and scientific communication and appreciate scientific ethics.

Student Learning Outcomes :

Students should be able to: • Understand history and methodologies of scientific research, applying these to recent published papers; • Understand and practice scientific reading, writing and presentations; • Appreciate scientific ethics through case studies.

Unit I (5 Lectures)

History of science and science methodologies; scientific method; manipulative experiments and controls; deductive and inductive reasoning; descriptive science; reductionist vs holistic biology.

Unit II (5 Lectures)

Preparation for research s Choosing a mentor, lab and research question; maintaining a lab notebook.

Unit III (10 Lectures)

Process of communication Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; barriers to effective communication; non-verbal communication-interpreting non-verbal cues; importance of body language, power of effective listening; recognizing cultural differences; Presentation skills - formal presentation skills; preparing and presenting using overhead projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; hidden Web and its importance in scientific research; internet as a medium of interaction between scientists; effective email strategy using the right tone and conciseness.

Unit IV (10 Lectures)

Scientific communication Technical writing skills - types of reports; layout of a formal report; scientific writing skills - importance of communicating science; problems while writing a scientific document; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; drafting titles and framing abstracts; publishing scientific papers - peer review process and problems, recent developments such as open access and nonblind review;

plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct.

Recommended Textbooks and References:

1. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.

2. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.

3. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558.

4. Mohan, K., & Singh, N. P. (2010). Speaking English Effectively. Delhi: Macmillan India. 5. Movie: Naturally Obsessed, The Making of a Scientist.

Seminar BTMSc 613 Credit 1

DSE2

1. **System and Synthetics Biology BTMSc 649 Credit 2**

Course Objectives:

1. To understand the fundamental principles of systems and synthetic biology.
2. To explore the design and application of genetic circuits, synthetic gene networks, and genome editing tools.
3. To examine real-world applications in biotechnology, medicine, and bioengineering.

Course outcome: The main aim of the course is to promote curiosity and thinking in Synthetic and System Biology while presenting the foundations of how to modify biological systems.

Unit 1 (5 Lectures)

Introduction to Systems and Synthetic Biology: Overview of systems biology: definition, goals, and significance, historical context and key contributors, levels of biological organization and emergence in complex systems. Definition and scope of synthetic biology, historical context, key concepts and principles.

Unit 2 Molecular Biology Basics: (5 Lectures)

DNA, RNA, and protein structure and function, Genetic code and gene expression, Enzymes and their role in molecular biology, and DNA sequencing and synthesis techniques.

Unit 3 (5 Lectures)

Systems Biology in Medicine and Biotechnology: Applications of systems biology in personalized medicine, Drug target identification, biomarker discovery, and therapeutic strategies, and Ethical considerations in applying systems biology to healthcare.

Unit 4 (8 Lectures)

Synthetic Biology Building Blocks: Standard biological parts (BioBricks), Genetic Circuits and Synthetic Networks: Design and modeling of genetic circuits: logic gates and switches. Oscillators and toggle switches in synthetic biology, Promoters, terminators, and ribosome binding sites. DNA synthesis methods (oligo synthesis, gene synthesis), DNA assembly techniques (Gibson assembly, Golden Gate assembly). Synthetic Genomes: Projects of virus, *E. coli*, and Yeast.

Unit 5 (5 Lectures)

Emerging Trends and Applications: Systems and Synthetic biology for healthcare and medicine, Environmental applications and bioremediation, Synthetic materials and biomaterials, and Future prospects and challenges in systems and synthetic biology.

Unit 6 (2 Lectures)

Ethical, Legal, and Societal Implications: Ethical considerations in designing and using systems biology and synthetic organisms.

1.Recommended Textbooks and References:

2.An Introduction to Systems Biology: Design Principles of Biological Circuits (Chapman & Hall/CRC Mathematical and Computational Biology) by Uri Alon.

3.Synthetic Biology: Tools and Applications. (H. Zhao, ed.) Academic Press, 2013 .Pretorius IS, Boeke JD.

4.Yeast 2.0-connecting the dots in the construction of the world's first functional synthetic eukaryotic genome. FEMS Yeast Res. 2018 Jun 1;18(4):foy032. doi: 10.1093/femsyr/foy032. PMID: 29648592; PMCID: PMC5894084.

5.Synthetic yeast genome reveals its versatility. nature, news & views, article,NEWS AND VIEWS, 22 May 2018.

6.Voigt, C.A. Synthetic biology 2020–2030: six commercially-available products that are changing our world. *Nat Commun* 11, 6379 (2020). https://doi.org/10.1038/s41467-020-20122-2

7.Venter JC, Glass JI, Hutchison CA 3rd, Vashee S. Synthetic chromosomes, genomes, viruses, and cells. Cell. 2022 Jul 21;185(15):2708-2724. doi: 10.1016/j.cell.2022.06.046. PMID: 35868275; PMCID: PMC9347161.

8. Synthetic Biology - Final Report, Ribarits A., Stepanek W., Wögerbauer M., Peterseil V., Kuffner M., Topitschnig C., Brüller W., Hochegger R., Gansberger M., Widhalm I. und Leonhardt C. (2014); Synthetic Biology. Bundesministerium für Gesundheit, Wien. Ribarits A., Stepanek W., Wögerbauer M., Peterseil V., Kuffner M., Topitschnig C., Brüller W., Hochegger R., Gansberger M., Widhalm I. und Leonhardt C. (2014) Synthetic Biology. Federal Ministry of Health, Vienna.
9. https://www.cbd.int/doc/emerging-issues/UK-submission-2011-013-Synthetic_biology-en.pdf.
10. Selected research papers and reviews from Nature Biotechnology, Science, and Cell.

2. **Microbiology Quality control in Pharma and food Industry BTMSc 653**
3. **Fundamentals of Antimicrobial Resistance BTMSc 657**

LABORATORY SEMESTER 3

Advance Microbial Techniques BTMSc 655 Credit 3

1. Confirmation of the cloning by colony PCR, Miniprep of recombinant plasmid DNA, and Restriction mapping.

2. Expression profiling of recombinant protein in *E.coli* and its SDS PAGE analysis

3. Concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis

4. Purification of His-Tagged protein on Ni-NTA columns

5. Analysis of the purified recombinant protein with SDS-PAGE

6. To investigate the kinetic parameters governing microbial substrate consumption, biomass growth, and metabolite production under controlled conditions,.

7. Solid State Fermentation for Enzyme or Bioactive Compound Production

8. Simulation of Fermentation Process Using MATLAB

9. Determination of minimal inhibitory concentration of antimicrobials

10. Study and differentiate bacteriostatic/fungistatic or bactericidal/fungicidal effect of antimicrobials

11. Validation of drug inhibition through plate assays.

Dissertation I BTMSc 619 Credits 4

SEMESTER 4

Dissertation II BTMSc 602 Credits 22