ST. XAVIER'S COLLEGE – AUTONOMOUS, MUMBAI

SYLLABUS

FOR SEMESTER I COURSES IN BIOTECHNOLOGY

(JUNE 2019 ONWARDS)

Contents

Syllabus for the following courses:

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSc- SEMESTER I **COURSE CODE: SBTS0701**

TITLE: BIOMOLECULES
No of Hours: 60 (inclusive of self-study)
Credits: 4

Course Objectives:
The objective is to build upon the base knowledge level regarding biomolecules. The course will emphasise upon the structural features and intermolecular interactions. The course will also introduce the students to recent trends in the understanding of biomolecular structure and interactions.

Learning Outcomes:
The student will be able to:

- Demonstrate fundamental knowledge in architecture, function, and purification of biomolecules.
- Apply the knowledge in designing strategies for biomolecular purification
- Demonstrate the understanding of biomolecular organization in cellular membranes.

Skills acquired:

Critical thinking, Application of concepts to solve biological problems, Group discussions and presentations, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms.

UNIT 1: PROTEIN STRUCTURE AND FOLDING 15 lectures

- Primary structure of proteins and their determination – end group analysis; cleavage of disulphide bond; separation, characterization of polypeptide chain; specific peptide cleavage reactions
- Secondary structure – Ramachandran plot, helical structure, beta structure
- Tertiary structure- fibrous (Collagen) and globular (Myoglobin) structure, Protein stability,
- Quaternary structure – (Haemoglobin) subunit interaction, symmetry, subunit composition determination
- Protein folding: The different pathways of protein folding and its co-relation with protein stability, Molecular chaperons
- Effects of misfolding protein on human diseases; unfolded protein response

UNIT 2: PROTEIN PURIFICATION AND DENATURATION 15 lectures

- Protein purification:
  - Separation by Precipitation, protein quantification
  - Non-affinity absorption techniques – IXC, Hydroxyapatite chromatography, HIC;
  - Affinity procedures for purifying proteins - Affinity chromatography, Dye ligand, IMAC
  - Non-absorption techniques for purifying proteins- Size exclusion chromatography
  - Monitoring the purity of protein solutions- Electrophoresis of proteins, PAGE, SDS PAGE
- Protein denaturation – temperature, pH-dependent, pressure induced, pressure induced and chemical denaturation, adaptation of Proteins to extreme Environments.

UNIT 3: **DNA TOPOLOGY** **15 lectures**

- Different forms of DNA, - A/B/C/Z and RL form of double helical DNA, Triple Helix
- Nucleic acid binding protein – Leucine Zipper, Zinc fingers
- OB-fold, Beta Barrel, Helix-turn-helix, Helix-loop-helix
- Linking number, Supercoiling, Topoisomerases
- DNA Packaging: Nucleosomes and Chromatin
- DNA – protein interaction
- Methods to study DNA – protein interaction

UNIT 4: MEMBRANE ARCHITECTURE **15 lectures**

- Membrane Structure and dynamics
  - Composition and Architecture of membrane: lipid types and the lipid bilayer, membrane proteins (integral and peripheral), conformation of membrane proteins, the association of membrane proteins in the lipid bilayer, Hydropathy index
  - Dynamics- lipid movements, flippase, FRAP, Lipid raft, Membrane fusion.
  - Lipid-Protein interactions
  - Liposomes
- Solubilisation of the membrane by using different detergents- Structure and behaviour of detergents, Detergents, and biological membranes

References:

- Amit Kessel and Ner Ben Tal, Introduction to proteins (2011), CRC Press, Taylor & Francis Group
- David E. Metzler, Biochemistry, The chemical reactions of living cells, Volume I and II., Elsevier, 2003
- Donald Voet and Judith Voet. Biochemistry 3rd Ed, John Wiley and sons, Inc publisher, 2004

- J. Berg, J. Tymoczko & L. Stryer, Biochemistry, 5thEd, W. H. Freeman & Company publisher, 2002
- Nelson and Cox, Lehninger's Principles of Biochemistry, fourth edition, Macmillan Worth Publisher, 2004
- Robert K. Scopes, Protein Purification, Springer Science, 1982,
- Philip L. R. Bonner, Protein Purification, Taylor & Francis Group, 2007
- Arthur M Lesk,(1998) Introduction to Protein Science Architecture, Function and Genomics, Oxford publishers,

ASSESSMENT:
Continuous Internal Assessment (CIA) = 40M
CIA I: Theory Exam (20M)

CIA II: Computational tool based assessment on Biomolecules (20M)

ESE Pattern:	**60 M**	
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
	100 Marks:	
4	5 – 1 from each Unit & 1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER I **COURSE CODE: SBTS0702**

TITLE: IMMUNOLOGY

Lectures: 60

Credits: 4

Course Objectives:

The objective is to learn about structural features of components of the immune system as well as their function. The core emphasis will be on the development of the immune system and mechanisms by which the human body elicits an immune response. The course will also introduce the students to recent trends in the field towards diagnostics and therapy.

Learning Outcomes:

The student will be able to:

- Demonstrate basic knowledge of the organization and function of the immune system.
- Differentiate the mechanisms that lead to beneficial immune responses and immune disorders.
- Apply key immunologic concepts and methods to diagnose immune disorders.
- Explain strategies for manipulating the immune system for therapy
- Analyze immune-based case studies.

Skills acquired:

Critical thinking, Application of concepts to solve biological problems, Group discussions and presentations, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: OVERVIEW OF THE IMMUNE SYSTEM **15 lectures**

- Haematopoiesis
- Innate immunity: Cells involved, signal transduction pathways, soluble molecules and membrane-associated receptors (Pattern recognition, TLRs, NLRs), Phagocytosis
- Antigens: immunogens, haptens
- Immunoglobulin:
  - fine structure and superfamily
  - Multigene organization of Ig gene, Variable region gene rearrangement and generation of antibody diversity, Class switching among the constant region
- Synthesis, assembly, and secretion of Immunoglobulins

UNIT 2: IMMUNE EFFECTOR MECHANISMS **15 lectures**

- MHC and Regulation of Immune Response**:**
  - Cellular distribution of MHC molecule
  - Antigen processing and presentation
  - Self - MHC restriction of T cells
  - Presentation of non-peptide antigens
- Activation of B and T lymphocytes
- Complement system: Functions of Complement, Components, Activation, and Regulation.
- Cytokines: Properties, Receptors, Antagonists, Diseases, Therapeutic use of cytokines
- The inflammatory process: the role of neutrophils and other mediators in inflammation, the role of NF-kb and STATs in inflammation, localised, systemic and chronic inflammation and role of anti-inflammatory agents
- Autophagy

UNIT 3: CLINICAL IMMUNOLOGY 15 lectures

- Hypersensitivity: Type I, II, III, IV hypersensitivity
- Autoimmunity: Organ-specific, systemic, mechanism, treatment
- Tolerance
- Transplantation immunology: Basis of Graft rejection, clinical manifestation of graft rejection, Immune tolerance, Immunosuppressive therapy, and clinical transplantation
- Tumour immunology: tumours of the immune system, Tumour antigens and tumour evasion of the immune system
- Immune response to infectious agents**:** Bacteria, Virus, Parasites, and Fungi
- Primary and secondary immunodeficiency

UNIT 4 ADVANCES IN IMMUNOLOGY 15 lectures

- Vaccines: Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity, Active and passive immunization; live, killed, attenuated, subunit vaccines; recombinant DNA and protein based vaccines, peptide vaccines, conjugate vaccines; dendritic cell based vaccines, vaccine against cancer, T cell based vaccine, Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (eg Ebola, Zika).
- Immunotherapy for Clinical conditions
- Ag-Ab interaction assays for understanding immune biology, diagnostics, and therapeutics (ELISA, Flow cytometry, SPR, RIA, Immunoprecipitation, Immunofluorescence - cytochemistry, and histochemistry)

References:

- Abbas, Abul K. & Lichtman, Andrew H.: Cellular and molecular immunology. (5th Ed.) Philadelphia. W.B. Saunders Company, 2003. 0-7216-0008-5--(616.079ABB/LIC)
- Elgert, Klaus D.: Immunology: Understanding the immune system. (2nd edition) Hoboken. John Wiley & Sons, Inc., 2009. 978-0-470-08157-0--(616.079Elg)
- Kuby, Janis: Immunology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-3784-6--(616.079Kub)
- Tizard, Ian R.: Immunology: an introduction. (4th Ed.) Singapore. Thomson Asia Pte Ltd., 2004. 981-243-516-6--(616.079TIZ)
- Janeway, Charles A., Jr.; Murphy, Kenneth & Weaver, Casey: Immunobiology. (9th ed.) New York. Garland Science, 2017. 978-0-8153-4551-0--(616.079Jan)
- Male, David; Brostoff, Jonathan; Roth, David B. & Roitt, Ivan M.: Immunology. (8th ed.) Amsterdam. Elsevier Ltd., 2013. 978-0-7020-4548-6--(616.079Roi)
- Recent trends – research articles.

ASSESSMENT:
Continuous Internal Assessment (CIA) = 40M
CIA I: Test (20M)

CIA II: Summary Writing/ Presentation **(20**M)

ESE Pattern: 60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit & 1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER I **COURSE CODE: SBTS0703**

TITLE: GENETICS

No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:

The core objective is to provide in-depth insight on DNA synthesis and transfer of information from genes to RNA to protein. The course will also help in developing an understanding of regulatory mechanisms governing genome activity. An overview of eukaryotic genetics will be also be included in the course.

Learning Outcomes:
The student will be able to:

- Elucidate the transfer of information from genes to RNA to protein and its regulation in detail.
- Describe the consequences of different mutations and DNA -repair systems.
- Describe the fundamental molecular principles of genetics

Skills acquired:

Critical thinking, Application of concepts to solve biological problems, Group discussions and presentations, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: DNA REPLICATION, REPAIR, AND RECOMBINATION 15 Lectures

- DNA Replication (prokaryotes and eukaryotes) and mutations involved.
- DNA Repair mechanisms
- DNA recombination mechanisms

UNIT 2: TRANSCRIPTION AND TRANSLATION IN PROKARYOTES AND EUKARYOTES 15 Lectures

- DNA-Protein interactions during Transcription Initiation and regulation of transcription initiation
- Synthesis of eukaryotic mRNAs by RNA polymerase II, Intron splicing, Processing of Pre-RNA, Degradation of mRNAs
- Synthesis and processing of Non-coding RNAs: Transcript elongation and termination by RNA polymerases I and III, Introns in eukaryotic pre-rRNA and pre-tRN
- Basic mechanisms of RNA to Protein conversion
- Post-translational Processing

- Processing by proteolytic cleavage
- Processing by chemical modification
- Protein Degradation

UNIT3: REGULATION OF GENE EXPRESSION 15 Lectures

- Regulation in prokaryotes- operons, riboswitches, antisense RNA
- Eukaryotes:
  - Genome rearrangements, Gene silencing by modification of histones and DNA
  - Transcriptional activators, Co-activators & repressors, enhancers and insulators
  - Regulation of Genome Activity during Development: Vulva development in *Caenorhabditis elegans and* Development in *Drosophila melanogaster*
  - Regulation through RNA interference
  - Concept of Epigenetics

UNIT 4: EUKARYOTIC GENETICS 15 lectures

- Yeast genetics**:** Meiotic crosses, tetrad analyses, non-Mendelian and Mendelian ratios, gene conversion, models of genetic recombination, yeast mating type switch; dominant and recessive genes/mutations, suppressor or modifier screens, complementation groups, transposon mutagenesis, synthetic lethality, genetic epistasis.
- Drosophila genetics: Monohybrid & dihybrid crosses, back-crosses, test-crosses, analyses of autosomal and sex linkages, screening of mutations based on phenotypes and mapping the same, hypomorphy, genetic mosaics, genetic epistasis in context of developmental mechanism
- Transmission genetics: single gene inheritance, beyond Mendel's law, genetics of immunity: blood grouping

References:

- Griffiths, Anthony J.F., Wessler, Susan R., Lewontin, Richard C. & Gelbart, William M.: An introduction to genetic analysis. (8th Ed.) New York. W.H. Freeman and Company, 2005. 0-7167-4939-4--(575.1GRI)
- Lodish, Harvey F.; Berk, Arnold; Kaiser, Chris A. & Krieger, Monty: Molecular cell biology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-0981-2--(574.87Lod)
- Snustad, D. Peter & Simmons, Michael J.: Principles of genetics. (5th ed.) Hoboken. John Wiley & Sons, Inc., 2010. 0-470-39842-5--(575.1Snu/Sim)
- Brown, T.A.: Genomes 3. New York. Garland Science Publishing, 2007. 0-8153-4138-5--(575.1Bro)
- Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6thed.) New York. Pearson Education Inc., 2008. 0-321-50781-9--(574.88Wat**)**

- Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter: Molecular Biology of the cell (6th Ed) Garland Science Publishing., 2015
- Lewis (2010) – Human genetics: concepts and applications, 9th Ed, Tata McGraw- Hill Publishing

ASSESSMENT:
Continuous Internal Assessment (CIA) = 40M
CIA I: Test (20M)

CIA II: Group Presentation/Scientific Essay/Assignment (**20**M)

ESE Pattern: 60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit & 1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER I **COURSE CODE: SBTS0704**

TITLE: CELLULAR PROCESSES

No of Hours: 60 (inclusive of self - study)

Credits: 4

Course Objectives:

The objective is to learn about the basic principles and mechanisms involved in cellular transport and communications. The course will also emphasise on understanding the molecular mechanism of the cell cycle and cancer development.

Learning Outcomes:

The student will be able to:

- Demonstrate in-depth knowledge of membrane transport, signal transduction, and cell cycle process.
- Identify the key mechanisms leading to favourable and unfavourable responses.
- Interconnect the various cellular mechanisms.
- Analyse the genetic and molecular basis of cancer.

Skills acquired:

Critical thinking, Application of concepts to solve biological problems, Group discussions and presentations, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: MEMBRANE STUDIES **15 Lectures**

- Membrane functions
- Membrane transport: facilitated diffusion (Glut 1) and Primary and Secondary active transport (P, F, ABC, symporter and antiporter)
- Intracellular membrane transport: Transport of molecules between nucleus and cytosol, Endoplasmic reticulum
- Transport across mitochondria and chloroplast
- Transport related to nutrient uptake.

UNIT 2: BIOSIGNALING **15 Lectures**

- Cell signalling pathways that control gene activity-
  - TGF-Beta and activation of Smads, regulation of TGF-Beta by negative feedback loops, cancer and loss of TGF-Beta signalling

- Activation of gene transcription by seven-spanning cell surface receptors: Wnt and Hedgehog
- Notch, NF-κb signalling

- Sensory transduction in vision, olfaction, and gustation

UNIT 3: NEURONAL COMMUNICATION 15 Lectures

- Organization of brain, Anatomy, and functions of a neuron, Ion conducting channels
- Neuronal pathways and Propagation of nerve impulse: Synapses and gap junction, synaptic transmission, Neuromuscular junction: Physiologic anatomy, molecular biology of acetylcholine formation and release, Drugs enhancing and blocking the transmission at NMJ, Myasthenia Gravis
- Neurotoxins, Neurotransmitters

UNIT 4: CELL CYCLE AND CANCER BIOLOGY 15 Lectures

- Cell cycle phases, Control of mitosis by cyclins, MPF activity and cyclin-dependent kinases, checkpoints in cell cycle regulation
- Apoptosis pathways, its regulation, and techniques to study apoptosis
- Cancer-
  - genetic basis (oncogenes, tumor suppressor genes)
  - Signalling pathways involved (overview)
  - Senescence, telomeres, carcinogens
  - Tumorigenesis, Tumor progression, metastasis
  - EMT

References:

- Karl Branden and John Tooze, introduction to Protein structure, 2nded, garland publishers, 1999.
- Lodish, Harvey F.; Berk, Arnold; Kaiser, Chris A. & Krieger, Monty: Molecular cell biology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-0981-2--(574.87Lod)
- Mathews, Christopher K.; van Holde, K.E. & Ahern, Kevin G.: Biochemistry. (3rd Ed. Indian reprint) Delhi. Pearson Education (Singapore) Pte. Ltd., 2003. 81-297-0215-0--(574.192MAT)
- Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6th ed.) New York. Pearson Education Inc., 2008. 0-321-50781-9--(574.88Wat)

- Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter: Molecular Biology of the cell (6th Ed) Garland Science Publishing., 2015
- David E. Metzler, Biochemistry, The chemical reactions of living cells, Volume I and II., Elsevier, 2003
- Robert A. Weinberg: The Biology of Cancer, 2nd Edition
- John E. Hall, Guyton and Hall Textbook of Medical Physiology (13th Edition)
- Devlin, Thomas M.: Textbook of biochemistry with clinical correlations. [ed. by] (7th ed.) Hoboken. John Wiley & Sons, Inc., 2011. 978-0-470-28173-4--(612.015Dev)

ASSESSMENT:
Continuous Internal Assessment (CIA) = 40M
CIA I: Test (20M)

CIA II: Group presentation/Scientific Essay /Research article presentation **(20**M)

ESE Pattern: 60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit & 1 based on all units	20 marks per question.

SUBJECT (PRACTICALS): BIOTECHNOLOGY

CLASS: MSC- SEMESTER I **COURSE CODE: MSBTS07PR**

Techniques in Biotechnology and Scientific Communication Skills

Credits: 8

Course Objectives: The course is designed to teach students the utility of a set of experimental methods in biotechnology in a problem-oriented manner. This course will introduce the students to basic laboratory skills, good laboratory practices and different techniques commonly used in biotechnology experimentation. It will also orient students to learn the basic techniques of separation, quantification, purification, and characterisation of proteins and study the theoretical aspects of proteins and nucleotides using computational tools.

Learning outcomes:

On completion of this course, students should be able to:

- Utilise basic laboratory instruments and understand the principle of measurements using those instruments with experiments in biotechnology.
- Utilise basic biotechnological experiments to answer research queries.
- Read a scientific paper effectively and understand the methods of scientific communication
- Plan and execute experiments and analyse the data obtained.

Skills acquired:

Laboratory skills in microbiology, molecular biology, protein separation and purification, computational tools, Biosafety, handling instruments , validating instruments Research and development skills, Laboratory management, Data analysis and Interpretation, Scientific communication skills- oral and written

COURSE CODE: MSBTS07PR

Techniques in Biotechnology and Scientific communication Skills

Contents:

1. Introduction to good laboratory practices
2. Laboratory techniques and quality assurances
    - Preparation of solutions and buffers
    - Calibration of instruments: pHmeter, analytical balance, UV-spectrophotometer, colorimeter
    - Calibration of apparatus used for measuring: glass pipettes, auto pipettes and measuring cylinders
    - Validation: Autoclave, Laminar air flow
    - Introduction to principles of Quality assurance and Quality control
3. Microbial techniques: Identification of microorganisms, Sterility testing
4. Nucleic Acid extraction techniques:
    - Extraction of Genomic DNA Extraction from Bacteria, Yeast, human samples (Cheek cells, Blood) and quantification of biomolecules using UV (nucleic acids and proteins)
    - Isolation of RNA from yeast/ E. coli

5. Immunological techniques:
   - Isoagglutination titre study
   - Single Radial Immunodiffusion
   - Dot-ELISA/ Antibody/ antigen capture ELISA
   - Western Blot Technique
6. Techniques in Protein Chemistry:
   - Protein Estimation using the following methods:
     - ✓ Biuret assay
     - ✓ Bradford's assay
     - ✓ Folin-Lowry assay
   - Protein Separation and Purification techniques:
   - ✓ Polyacrylamide gel electrophoresis (native and SDS)
   - ✓ Horizontal gel electrophoresis (Slide and Slab)
   - Protein gel staining techniques:
   - ✓ Coomassie brilliant blue, Silver staining, TCA and Ponceau staining
   - ✓ Activity staining: LDH
   - Protein Purification techniques:
     - ✓ Protein Precipitation
     - ✓ Ion exchange Chromatography
     - ✓ Gel filtration
     - ✓ Affinity Chromatography
     - ✓ Study of purified Immunoglobulins using SDS PAGE
7. Introduction to computational tools in biology:
   - Retrieval of protein, nucleotide and protein structural data for analysis
   - Protein sequence analysis
   - Primary protein sequence analysis
   - Secondary sequence analysis
   - Tertiary structure analysis
8. Scientific communication:
   - Gathering scientific data from various sources.
   - Written communication: Guide to clear writing, forms and styles of writing
   - Scientific publication writing
   - Oral communication variants
   - Concept of Plagiarism

References:

1. Rodney Boyer, Biochemistry Laboratory (2nd Ed, 2012), Pearson's Publication
2. Sheppler J and Cassin P, Biotechnology explorations (2000), ASM Press
3. Segel, Irwin H.: Biochemical calculations: how to solve mathematical problems in general biochemistry. (2nd Ed.) Singapore. John Wiley & Sons (Asia) Pte. Ltd., 2004. 9812-53-149-1--(574.1920151SEG)

4. Wilson, Keith & Walker, John: Principles and techniques of biochemistry and molecular biology. [ed. by] (7th ed.) Cambridge. Cambridge University Press, 2010 (2013). 978-0-521-73167-6--(574.19285Wil/Wal)
5. Anthony Wilson, Handbook of Science Communication, IOP Publishing Ltd. CRC Press (1999)
6. Online resources
7. Relevant SOPs from USP and IP

Assessment:
CIA: 80M (Continuous assessment based on lab skills and problem solving)
ESE: 120M

Experiment based- 70 M

Viva/Quiz/ Problem solving- 50M

St. Xavier's College – Autonomous, Mumbai

Syllabus

For Semester II Courses in M.Sc. in Biotechnology

(November 2019 onwards)

Contents

Syllabus for the following courses:

THEORY COURSES

SBTS0801 METABOLISM
SBTS0802 ANIMAL BIOTECHNOLOGY
SBTS0803 MOLECULAR BIOTECHNOLOGY
SBTS0804 ADVANCED ANALYTICAL TECHNIQUES

PRACTICAL COURSE

SBTS08PR BIOTECHNOLOGY

SUBJECT (THEORY): BIOTECHNOLOGY
CLASS: MSC- SEMESTER II **COURSE CODE: SBTS0801**
TITLE: METABOLISM
No of Hours: 60 (inclusive of self-study)
Credits: 4

Course Objectives:

The objective is to build upon the base knowledge level regarding biochemical principles with emphasis on different metabolic pathways in microbes, animals and plant systems.

The course will introduce students to the concept of pathway modulations for diagnostics and industrial applications.

Learning Outcomes:

The student will be able to:

- Demonstrate an understanding of various biochemical pathways in the prokaryotes and eukaryotes.
- Apply the knowledge in designing strategies for the diagnosis of human diseases and industrial production of favourable metabolites.

Skills acquired:

Critical thinking, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: PHOTOSYNTHESIS **15 lectures**

- Overview of Photosynthesis, light absorption and energy conversions, electron pathways in chloroplast membranes, ATP synthesis, organisation and regulation of photosynthetic complexes.
- Carbon dioxide fixation, regulation (Calvin -Benson cycle), and variations in fixation mechanisms.
- Respiration and Photorespiration

UNIT 2: PLANT METABOLISM **15 lectures**

- Metabolism: Types of metabolic pathways, the main class of metabolic reactions (using few already studied pathways)
- Carbohydrate metabolism in plants (sucrose and Starch)
- Overview of plant secondary metabolism - Main Secondary metabolites, Function of Secondary Metabolites (alkaloid, terpenoids, phenolics)
- Compartmentation of SMs biosynthesis- Cytosol, Mitochondria, Vesicles, Endoplasmic reticulum: chloroplast

UNIT 3: ANIMAL METABOLIC PATHWAYS AND THEIR CLINICAL RELEVANCE **15 lectures**

- Pentose phosphate pathway
- Uronic acid production and importance
- Metabolism of other important sugars – fructose
- Nucleotide metabolism: purine and pyrimidine
- Essential fatty acids – Sources, Biosynthesis, actions of EFAs and their metabolites (cell membrane fluidity, second messenger action, EFAs in various pathological processes etc)
- Biochemical role of vitamins and minerals as coenzymes and cofactors

UNIT 4: MICROBIAL METABOLISM AND ITS SIGNIFICANCE 15 lectures

- Amino acid metabolism and metabolic intermediates
- Integration of amino acid metabolites into the central metabolic pathway
- Systems /metabolic engineering strategies for the production of amino acids
    - Pathway-focused approaches; Systems biology-based approaches; Evolutionary approaches e.g.: Amino acids like threonine, glutamate, lysine, and tryptophan using microbial systems.
- Integration of fatty acid metabolism into central metabolic pathways.
- Mechanism of Nitrogen fixation using a bacterial system
- Overview of glycan metabolism and importance

References:

- Cseke L.J., Kirakosyan A., Kaufman P.B., Warber S.L., Duke J.A. and Brielmann H.L. Natural Products from Plants, 2nd edition, Taylor & Francis group, 2006.
- Voet, Donald & Voet, Judith G.: Biochemistry. (4th ed.) Hoboken. John Wiley & Sons (Asia) Pte. Ltd., 2011. 1-1180-25024--(574.192Voe/Voe)
- Stryer, Lubert; Berg, Jeremy M.; Tymoczko, John L. & Gatto, Gregory J.: Biochemistry. (7th ed.) New York. W.H. Freeman and Company, 2012. 1-4292-7635-5--(574.192Str)
- Buchanan B; Gruissem W *et al* (2nd Ed.) Biochemistry and Molecular Biology of Plants John Wiley & Sons 2015,
- Lehninger, Albert L.: Principles of Biochemistry. (6th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4292-3414-6--(574.192Leh)
- Rodwell, Victor W.; Bender, David A.; Botham, Kathleen M. & Kennelly, Peter J.: Harper's Illustrated Biochemistry. (30th ed.) New York. Mcgraw-Hill, 2015.978-1-25-925286-0--(612.015Har)
- Devlin, Thomas M.: Textbook of biochemistry with clinical correlations. [ed. by] (7th ed.) Hoboken. John Wiley & Sons, Inc., 2011. 978-0-470-28173-4--(612.015Dev)

ASSESSMENT:
Continuous Internal assessment = 40Marks

CIA I: Test (20M) **CIA II:** Quiz (20M)

SUBJECT (THEORY): BIOTECHNOLOGY

End Semester Exam Pattern:60 Marks		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

CLASS: MSC- SEMESTER II **COURSE CODE: SBTS0802**

TITLE: ANIMAL BIOTECHNOLOGY

No of Hours: 60 (inclusive of self-study)

Credits: 4

Course Objectives:

The course will provide an overarching view of concepts in cell development. It will also illustrate the potential of animal cells, organ engineering, and genetic engineering in therapeutics.

Learning Outcomes:

The student will be able to:

- Demonstrate an understanding of human developmental biology, basics of animal cell culture and its applications.
- Demonstrate Systematic understanding of knowledge in the specialised area of Biopharmaceuticals design and synthesis

Skills acquired:

Critical thinking, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: BIOLOGY OF CELL DEVELOPMENT **15 lectures**

- Cell differentiation into cell types and organization into specialized tissues; cell-ECM and cell-cell interactions; cell motility and migration;
- Embryonic development stages [fertilisation, post fertilisation, Implantation]
- Establishment of germ layers and their fate
- Immune response to developing embryo

UNIT 2: ANIMAL CELL CULTURE 15 lectures

- Biology of cultured cells, Transformation, immortalisation, and Differentiation
- Primary Culture and development of cell lines – normal and tumor
- Characterisation of cells in culture and maintenance of cells in culture: subculture, contamination, and cryopreservation
- 3-D culture: organ culture, histiotypic culture, and organotypic culture

UNIT 3: STEM CELLS AND TISSUE ENGINEERING 15 lectures

- Types of stem cells: ES, Adult, IPSCs, Cancer stem cells
- Characterisation of stem cells
- Applications of stem cells in therapeutics
- Ethical issues and regulations in stem cell research
- Fundamentals of tissue engineering: Growth Factors, morphogens, Extracellular Matrix, Cell adhesion and migration, Inflammatory and Immune responses to tissue engineered devices
- Biomaterials: Polymeric scaffolds, Calcium Phosphate Ceramics, Biomimetic materials
- Introduction of 3-D organ printing, organ on chip
- Applications of tissue engineering

UNIT 4: ADVANCES IN ANIMAL BIOTECHNOLOGY 15 lectures

- Cell line models in biomedical research
- *In vitro* testing (cytotoxicity)
- Scale up in cell culture (types of bioreactors for suspension and monolayer cultures and process control)
- Therapeutic peptides/ Biosimilars- Production methodology
  - Insulin
  - Tissue plasminogen activator
  - Interferon – alpha, Erythropoietin
  - Vaccines
  - Monoclonal antibodies (Antibody engineering)
- Animal models in biomedical research

References:

- Lodish, Harvey F.; Berk, Arnold; Kaiser, Chris A. & Krieger, Monty: Molecular cell biology. (7th ed.) New York. W.H. Freeman and Company, 2013. 978-1-4641-0981-2--(574.87Lod)
- Alberts, Bruce, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter: Molecular Biology of the cell (6th Ed) Garland Science Publishing., 2015

- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
- Daan J. A. Crommelin, Robert D. Sindelar. (2002) Pharmaceutical Biotechnology: An Introduction for Pharmacists and Pharmaceutical Scientists. Taylor & Francis.
- Gary Stein and Maria B *et al*. (2011) Human Stem Cell Technology and Biology. Wiley Blackwell.
- GordanaVunjak-Novakovic, R. Ian Freshney. (2006) Culture of Cells for Tissue Engineering. John Wiley & Sons.
- Inderbir Singh & GP Pal. (2007) Human Embryology. MacMillan Publishers.
- Kaushik Deb and Satish Totey. (2009) Stem Cells Basics and Applications. Tata McGraw Hill.
- Freshney, R. Ian. (2010) Culture of animal cells : a manual of basic technique and specialized applications, 6th ed. Wiley Blackwell Publications.
- R. Ian Freshney, Glyn N. Stacey, Jonathan M. Auerbach. (2007) Culture of Human Stem Cells. John Wiley & Sons
- Robert Lanza, Robert Langer, Joseph P. Vacanti. (2011) Principles of Tissue Engineering. Academic Press.
- Scott F Gilbert. (2000) Developmental Biology, 6th edition. Sinauer Associates.
- Thomas W. Sadler. (2009) Langman's Medical Embryology. Lippincott Williams & Wilkins.

ASSESSMENT:
Continuous Internal Assessment: 40M

CIA I & CIA II: Review Article (Written Assignment) and Presentation

End Semester Exam Pattern:60 Marks		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER II **COURSE CODE: SBTS0803**

TITLE: MOLECULAR BIOTECHNOLOGY

No of Hours: 60 (inclusive of self-study)

Credits: 4

Course Objectives:

The important structural and functional aspects of the genome will be illustrated to the students through this course. The objective of this course is to introduce various approaches to conducting genetic engineering and their applications in biological research as well as in biotechnology industries.

Learning Outcomes:

The student will be able to:

- Interconnect the concepts of genome analysis and manipulation of the genome for beneficial responses.
- Design strategies for gene manipulation to obtain beneficial products for society.

Skills acquired:

Critical thinking, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: GENOMES AND GENOME MAPPING 15 Lectures

- A brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria, and chloroplast
- Genome mapping: molecular markers; physical mapping methods (sequencing, RM, STS), cytogenetic techniques, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping
- Methods of genome analysis: Polymorphisms in DNA sequence, Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing of large genomes
- Genome sequencing projects**:** Human Genome Project, genome sequencing projects for microbes, plants, and animals, accessing and retrieving genome project information from the web

UNIT 2: GENOME ANALYSIS 15 Lectures

- Comparative genomics: Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand the evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in the genome sequence
- Functional genomics - Transcriptome analysis for identification and functional annotation of the gene, Contig assembly, chromosome walking and characterization of chromosomes, mining functional genes in a genome, gene function- forward and reverse genetics
- Model organisms: *S. cerevisiae, C. elegans, D. melanogaster, M. musculus, D. rerio*

- Genomics and medicine

UNIT 3: TOOLS FOR GENE MANIPULATION 15 lectures

- Cloning tools:
    - Enzymes
    - Vectors: Expression vectors, Vectors for making RNA probes, Tools for cloning and expression in prokaryotic and eukaryotic systems
    - PCR techniques
- 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, genome editing using enzymes

UNIT 4: APPLICATION OF MOLECULAR BIOTECHNOLOGY 15 lectures

- Plant engineering: abiotic and biotic stress, modification of nutrient content
- Synthesis of commercial products - Restriction Endonucleases
- Chloroplast engineering
- Protein Engineering- rational and random

References:

- Lewin, Benjamin; Krebs, Jocelyn E.; Goldstein, Elliott S. & Kilpatrick, Stephen T.: Genes XI. New Delhi. Jones and Bartlett India Pvt. Ltd., 2015. 978-93-80853-71-0--(575.1Lew)
- Glick, Bernard R., Pasternak, Jack J. & Patten, Cheryl L.: Molecular biotechnology: principles and applications of recombinant DNA. (4th ed.) Washington, D.C. ASM Press, 2010. 1-55581-498-4--(660.6Gli)
- Cooper, Geoffrey M. & Hausman, Robert E.: The cell: a molecular approach. (6th ed.) Sunderland. Sinauer Associates, Inc., 2013. 978-0-87893-964-0--(574.87Coo/Hua)
- Primrose, S.B. & Twyman, R.M.: Principles of gene manipulation and genomics. (7th ed.) Malden. Blackwell Publishing, 2006. 1-4051-3544-3--(575.1Pri/Twy)
- Sambrook, Joseph & Russell, David W.: Molecular cloning: a laboratory manual. [Vol.1-3] (3rd Ed.) Cold Spring Harbor. Cold Spring Harbor Laboratory Press, 2001. 0-87969-577-3--(574.873224SAM/RUS)
- Brown, T.A.: Gene cloning and DNA analysis: an introduction. (7th ed.) Chichester. John Wiley & Sons Ltd., 2016. 978-1-119-07256-0--(574.873282Bro)
- Watson, James D., Baker, Tania A., Bell, Stephen P. & Gann, Alexander: Molecular biology of the gene. (6th ed.) New York. Pearson Education Inc., 2008. 0-321-50781-9--(574.88Wat)
- Relevant current research articles
- Suggested reading: My genome by Craig Venter

ASSESSMENT:

Continuous Internal Assessment: 40M

CIA I: Test (20M) CIA II: Writing of a review article (20M)

End Semester Exam Pattern:60 Marks		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER II COURSE CODE: SBTS0804

TITLE: ADVANCED ANALYTICAL TECHNIQUES

No of Hours: 60 (inclusive of self-study)

Credits: 4

Course Objectives:

The course is broad-based inclusive of several new techniques that current experimental researchers are employing to answer complex questions in biology.

Learning Outcomes:

The student will be able to:

- Understand the application of various techniques in experimental biology.
- Interpret data generated and its implications.
- Demonstrate knowledge of fundamental concepts of proteomics.

Skills acquired:

Critical thinking, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: ANALYTICAL TECHNIQUES 15 lectures

Basic principles, instrumentation, and applications of the following:

- Fluorescence spectroscopy
- ORD, CD spectroscopy
- NMR and ESR
- X-Ray Crystallography: Principles, instrumentation, and application

UNIT 2: ADVANCED ANALYTICAL TECHNIQUES 15 lectures

- Advanced Microscopy: Different versions of advanced microscopy, electron microscopy, and confocal microscopy
- Advances in Chromatography
- Biosensors: applications in diagnostics, environment and industry
- Molecular diagnostics: PCR and Hybridisation based

UNIT 3: NANOTECHNOLOGY IN MEDICINE 15 lectures

- Introduction to nanotechnology: nanotechnology and bio-nanotechnology, important nano-particles / materials, bio nanorobots/molecular motors nanomotors and their uses
- Synthesis and characterization of nanoparticles: Common Strategies with examples
- Applications of nanotechnology:
    - Medical nanotechnology, Nano-diagnostics: Nanoparticles for the detection and treatment of cancer, Nanoarrays for molecular diagnostics, Nanoparticles for Molecular Diagnostics, Nano barcode
    - Nanopharmaceuticals: Nanobiotechnology for drug discovery and drug delivery
    - Role of nanotechnology in biological therapy, nanodevices in medicine and surgery

UNIT 4: PROTEOMICS 15 lectures

- Aims, strategies, and challenges in proteomics; proteomics technologies: 2D-PAGE DIGE, isoelectric focusing, mass spectrometry (iTrac, SELDI , LCMS), MALDI-TOF, proteome databases.
- Protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics

References:

- Bartlett & Stirling, PCR protocols, 2nded., Humana publishers
- Daniel M, Basic Biophysics 2004, Student Edition
- David Spector and Robert Goldman, Basic methods in microscopy. Cold spring harbour laboratory press, 2006
- Voet, Donald & Voet, Judith G.: Biochemistry. (4th ed.) Hoboken. John Wiley & Sons (Asia) Pte. Ltd., 2011. 1-1180-25024--(574.192Voe/Voe)
- Chandler, Douglas E. & Roberson, Robert W.: Bioimaging: current concepts in light and electron microscopy. Sudbury. Jones and Bartlett Publishers, 2009. 0-7637-3874-7--(578Cha/Rob)
- Cotterill, Rodney M.J.: Biophysics: an introduction. Singapore. John Wiley & Sons (Asia) Pte. Ltd., 2003. 9812-53-008-8--(574.191COT)

- Skoog, Douglas A.; Holler, F. James & Crouch, Stanley R.: Principles of instrumental analysis. (6th ed. Indian Reprint) Delhi. Cengage Learning India Private Limited, 2007(2015). 978-81-315-2557-9--(543.08Sko)

ASSESSMENT:
Continuous Internal assessment (40M)
CIA I: Test (20M) CIA II: Primary paper presentation (20M)

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (PRACTICALS): BIOTECHNOLOGY

CLASS: MSC- SEMESTER II **COURSE CODE: SBTS08PR**
TITLE: Biotechnology **Credits: 8**

- **Course Objectives:**

The course is designed to teach students the utility of set of experimental methods in biotechnology in a problem-oriented manner. This course will introduce the students to learn the basic techniques for understanding metabolism, recombinant DNA technology and basic techniques in animal cell culture.

Learning outcomes:
On completion of this course, students should be able to:
- Utilise experimental models for understanding metabolism aspects.
- Utilise R.DNA techniques and animal cell culture techniques to answer research queries.
- Utilize computational biology to explore, analyse and interpret the biological questions
- Plan and execute experiments and analyse the data obtained.

Skills acquired:

Proficiency in Molecular biology techniques, Animal cell culture techniques, Research and development skills, Laboratory management, Data analysis and Interpretation

Contents:

I. Experimental aspects in Metabolism

1. Study of Vitamins as Participants of Enzyme Reactions
2. Study of Biological oxidation – e.g.: NADH-dehydrogenase activity determination
3. Study of Krebs Cycle intermediates, enzymes, Glucose-6-phosphate dehydrogenase activity

4. Oxidative metabolism – ATP detection, ATPase activity determination
5. Nucleotide metabolism – Uric acid determination
6. Factors influencing/ affecting the intermediate metabolism in microbes
7. Alcohol production
8. Plant metabolism study –
    a. Chloroplast separation
    b. Pigment separation and quantification of plant pigments
    c. Proton uptake assays
9. Secondary metabolite study
10. Study of fatty acids

II. Molecular Biology

1. Creation of genomic library: Isolation of genomic DNA and Plasmid DNA, Restriction Digestion, Ligation and Transformation
2. Expression of recombinant proteins
3. PCR amplification of 16srRNA
4. RFLP analysis
5. Preparation of glycerol stocks

III. Animal Cell Culture:

1. General aseptic techniques and preparation for ACC
2. Media preparation for ACC
3. Primary culture using chick embryo
4. Subculture of cell lines
5. Karyotyping and G- Banding using human blood cells. Data interpretation

IV. Data interpretation of the following techniques

1. HPLC and Gas chromatography
2. 2D /DIGE electrophoresis
3. Mass spectrometry

V. Genome study:

- Exploration of metabolic pathway databases e.g.: KEGG, Reactome
- Exploration of enzyme databases
- DNA sequencing study – Nucleotide, Gene sequences databases
- Gene/nucleotide sequence analysis- gene finding, DNA motif analysis, intron-exon finder, Using Bioedit for nucleotide sequence analysis

- Molecular biology experiments
    - Primer designing and validation – Primer validation
    - Study of *in silico* restriction digestion
    - Study of Cloning vectors
- Exploration of genome databases
- Exploration of proteome databases

References:

- Molecular Cloning: Laboratory Manual Vol I, 2001, Joseph Sambrook, David William Russel, CHL Press
- Freshney, R. Ian: Culture of animal cells: a manual of basic technique and specialized applications. (6th ed.) Hoboken. John Wiley & Sons, Inc., 2010. 978-0-470-52812-9--(591.0724Fre)
- Wilson, Keith & Walker, John: Principles and techniques of biochemistry and molecular biology. [ed. by] (7th ed.) Cambridge. Cambridge University Press, 2010(2013).
- 978-0-521-73167-6--(574.19285Wil/Wal)
- Godkar, Praful B. & Godkar, Darshan P.: Textbook of medical laboratory technology: Clinical laboratory science and molecular diagnosis. [Vol. I & II, ed. by] (3rd ed.) Mumbai. Bhalani Publishing House, 2014. 978-93-81496-19-0--(616.01God/God)
- Boyer, Rodney F.: Modern experimental biochemistry. (3rd ed.) Delhi. Pearson Education, Inc., 2000. 81-7808-239-X--(574.19285BOY)
- Wilson, Keith & Walker, John: Principles and techniques of biochemistry and molecular biology. [ed. by] (7th ed.) Cambridge. Cambridge University Press, 2010(2013). 978-0-521-73167-6--(574.19285Wil/Wal)
- Online resources

ASSESSMENT:

CIA: 80M (Continuous assessment based on lab skills and problem-solving)
End Semester Exam: 120M

Experiment based- 70 M

Viva/Quiz/ Problem solving- 50M

St. Xavier's College – Autonomous, Mumbai

Syllabus

For Semester III Courses in M.Sc. in Biotechnology

(June 2019 onwards)

Contents

Syllabus for the following courses:

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER III **COURSE CODE: SBTS0901**

TITLE: BIOSTATISTICS AND BIOINFORMATICS
No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:
The Biostatistics module will introduce students to the science of collecting and analysing numerical data for study designs and basic methods for testing the various hypothesis with emphasis on parametric and nonparametric tests. The Bioinformatics module is designed to provide theory and practical experience of the use of computational tools and databases to investigate molecular biology and evolution related concepts.

Learning Outcomes:
The student will be able to:

- Recognise the importance of statistical thinking and approach to problem-solving across biological studies
- Gain working knowledge of computational tools and methodology for investigating specific biological questions

Skills acquired:

Statistical analysis and usage of computational tools in the field of Biotechnology,Critical thinking, Application of concepts to solve Biological problems, reviewing scientific literature and analysis of the same, Scientific Communication skills

UNIT 1: INTRODUCTION TO BIOSTATISTICS **15 lectures**

- Measure of central tendency (mean, median and mode)
- Measure of dispersion (Standard deviation, variance, and coefficient of variance)
- Z- test (one mean, two means and paired)
- t-Test (one mean, two mean, paired and Cochran's)
- χ^2test (test of homogeneity, Independence Goodness of fit)
- P- value for all tests (Reading tables)
- Regression
- ANOVA

UNIT 2: APPLIED BIO-STATISTICS **15 lectures**

- Statistical Experimentation: Introduction, test, control
- Experimental design and terms
- Theory of probability, density function (Estimation etc.)

- The standard Normal distribution
- Hypothesis Testing: step, errors
- Non-parametric tests: Sign, Wilcoxon, and Mann- Whitney test
- Use of R programme

UNIT 3: DATABASES AND SEQUENCE ALIGNMENT 15 lectures

- Introduction to Programming Languages in Bioinformatics
- Biological databases:
  - Study of biological databases - Concept of databases, classification
  - Submission of sequences to the databases
  - Biological data retrieval and study of data formats
  - Pitfalls of biological databases and annotations of biological data File formats and
  - The biological database management system
- Sequence alignment:
  - Pairwise sequence alignment, Multiple sequence alignment, Phylogenetic analysis and importance

UNIT 4 PROTEIN SEQUENCE AND STRUCTURE ANALYSIS 15 lectures

- Protein secondary and tertiary structures
- Protein structure analysis
  - Protein structure databases, Structure descriptors, protein structures
  - Protein structure visualization, comparison and importance
- Protein functions
  - Analysing structure-function relationships, classification and assignment of protein function: The Enzyme Commission; The Gene Ontology Consortium protein function classification , Allergenic Protein Databases and Protein-Allergenicity Prediction , Prediction of Post-Translational Modification and Sorting

Reference Books:

- Wayne W Daniel (1999), Biostatistics: a foundation for analysis in health sciences, John Wiley and sons
- N Gurumani (2004), Introduction to Biostatistics, MJP Publishers.
- David Mount (2004) Bioinformatics: Sequence and Genome Analysis. 2nd edition, Cold Spring Harbor Laboratory Press, New York.
- Jonathan Pevsner (2009) Bioinformatics and Functional Genomics. 2nd edition, John Wiley and Sons, New Jersey.
- Teresa K. Attwood and D. J. Parry Smith (1999) Introduction to Bioinformatics. 1stedition, Pearson Education Limited, England
- Andreas D. Baxevanis and B. F. Francis Ouellette (2001) Bioinformatics A Practical Guide to the Analysis of Genes and Proteins. 2ndedition, A John Wiley & Sons, Inc., Publication
- Arthur M. Lesk (2005) Introduction to Bioinformatics, 2nd edition Oxford University Press
- Jian Xiong (2006), Essential Bioinformatics, 1st edition, Cambridge university press,

ASSESSMENT:
Continuous Internal assessment (40M)
CIA I and II: Problem Solving using computational tools and Biostatistics tools

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY
CLASS: MSC- SEMESTER III **COURSE CODE: SBTS0902**
TITLE: DRUG DEVELOPMENT

No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:
The course will provide an insight into the research and development carried out in drug discovery. The core of this course will encompass the journey of a drug from bench to bedside.

Learning Outcomes:
The student will be able to:

- Demonstrate fundamental knowledge in the process of drug discovery.
- Evaluate the balance between medical benefit, the risk involved, economic reward and risk in the decision-making process of drug development.
- Demonstrate competency in biopharmaceutical clinical trial research designs and regulatory affairs management to meet the health and medical needs of current and future
- Demonstrate the ability to use evidence-based approaches to guide decision making in drug discovery and development.

Skills acquired:

Critical thinking, Application of concepts to solve biological problems, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: DRUG DEVELOPMENT **15 lectures**

- Drug discovery
  - Steps involved in drug discovery, Production and characterization, Preclinical studies and Validation studies
- Computer-aided drug designing and docking
  - General Principles of CADD
  - Types of drug designing
  - Ligand-based molecular interactions
  - Structure-based Drug designing
  - Examples of Ligand and structure-based drug designing
- Applications and importance of CADD

UNIT 2: PRECLINICAL ASPECTS OF DRUG DEVELOPMENT **15 Lectures**

- Principles of pharmacokinetics and pharmacodynamics
  - intestinal absorption, metabolic stability, drug-drug interactions, plasma protein binding assays, metabolite profile studies
- Principles of toxicology: Reproductive toxicity and teratogenicity, Mutagenicity, carcinogenicity and other tests

- Experimental design for preclinical and clinical PK/PD studies
    - *In vitro* preclinical tests
    - Selection of animal model
    - The scope of GLP, SOP for the conduct of clinical & non-clinical testing

UNIT 3: CONSIDERATIONS DURING BIOPHARMACEUTICALS MANUFACTURING 15 lectures

- Guides to good manufacturing practice
  The manufacturing facility, Clean rooms, Cleaning, decontamination and sanitation (CDS), Water for biopharmaceutical processing
- Microbiological considerations and Excipients
- Delivery systems
- Product analysis:
    - Protein-based contaminants
    - Removal of altered forms of the protein of interest from the product stream
    - Detection of protein-based product impurities
    - Immunological approaches to detection of contaminants
    - Endotoxin and other pyrogenic contaminants
    - Microbial and viral contaminants
    - Miscellaneous contaminants
    - Validation studies
- Labelling and Packaging

UNIT 4: CLINICAL RESEARCH AND REGULATORY AFFAIRS 15 lectures

- Introduction, Good clinical practice guidelines, Ethical aspects of clinical research
- Clinical research methodologies and data management, Regulatory requirements
- Pharmacovigilance: Adverse Events and Classifications, Pharmacovigilance methods Adverse drug reaction reporting
- Drug safety : the role of FDA and ICH, Investigational New Drug Applications

References:

- Ed. Hardman G Limbird LE (2001) "Goodman Gillman's The Pharmacological Basis of Therapeutics" McGraw Hill Press
- Daan J. A. Crommelin, Robert D. Sindelar. (2002) Pharmaceutical Biotechnology: An Introduction for Pharmacists and Pharmaceutical Scientists. Taylor & Francis.
- Gary Walsh. (2006) Biopharmaceuticals: Biochemistry and Biotechnology. John Wiley & Sons.
- Gary Walsh. (2007) Pharmaceutical Biotechnology Concepts and Applications John Wiley & Sons.
- Oliver Kayser, Rainer H. Müller. (2006) Pharmaceutical Biotechnology. John Wiley & Sons.

- Thomas M. Jacobsen, Albert I. Wertheimer. (2010) Modern Pharmaceutical Industry: Primer. Jones & Bartlett Publishers.
- Tommy Liljefors, Povl Krogsgaard-Larsen, Ulf Madsen. (2010) Textbook of Drug Design and Discovery. 4th Edition. CRC Press
- https://www.who.int/biologicals/good_manufacturing_practice

ASSESSMENT:
Continuous Internal assessment (40M)
CIA I & II : Review Writing and Group presentation.

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY

CLASS: MSC- SEMESTER III **COURSE CODE: SBTS0903**

TITLE: BIOPROCESS TECHNOLOGY

No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:
The course aims at educating students about the strategies employed in process industries and its implementation into biological systems to produce valuable biotech-based metabolites. The engineering concepts including cell growth kinetics, process design, and transport operation will be covered during the course.

Learning Outcomes:
The student will be able to:

- Appreciate relevance of microorganisms from an industrial context
- Demonstrate the knowledge of fundamental principles for basic methods in production technique for bio-based products.
- Demonstrate the understanding of relevant calculations of process engineering

Skills acquired:

- Critical thinking, Application of concepts to solve Biological problems, reviewing scientific literature and analysis of the same, Scientific Communication skills-oral and written forms

UNIT 1: PRINCIPLES OF BIOPROCESS TECHNOLOGY **15 lectures**

- Industrial substrates and stoichiometry
- Kinetics of microbial growth, substrate utilization, and product formation: Batch, Fed-Batch and continuous processes
- Scale up concepts with respect to fermenter design and product formation
- Solid state fermentation
- Processes using recombinant organisms: hosts, vectors, genetic instability.

UNIT 2: PROCESS DYNAMICS AND OPERATIONS **15 lectures**

- Gas exchange and mass transfer: O_2 transfer, critical oxygen concentration, determining the oxygen uptake rate, Heat transfer, Sterilization – processes, thermal death curve, *in situ* sterilization
- Enzyme Technology in Food manufacture and Processing: Mechanisms of enzymatic reactions and bioconversions (e.g. hydrolysed protein); associated downstream processing (e.g. de-oxygenation and de-sugaring); case studies (e.g. Cheese making)

- Microbial technology in food production process and operations: Role of microbial fermentation in food and beverages; food ingredients and additives prepared via microbial fermentation, bioconversion from food wastes to useful products; food preservation via microbes

UNIT 3: DOWNSTREAM PROCESSING **15 lectures**

- Flocculation and floatation
- Filtration
- Centrifugation
- Cell disruption
- Liquid extraction
- Precipitation and Adsorption
- Dialysis and Reverse osmosis
- Chromatography
- Crystallization and drying

UNIT 4: INDUSTRIAL PRODUCTS **15 lectures**

- Polysaccharides/ biopolymers/micro-polymers- Xanthan gum, Dextran
- Enzymes – proteases, amylases, pectinases, lipases
- Antibiotics
- Vitamin B_{12}
- Amino acids and alcohols
- *Invitro* systems and bioprocess technology for industrial production of secondary metabolites-

  Cell suspension cultures (Bioreactors), Immobilized cell systems, Hairy root cultures, enhancement of SM yield

References:

- Glazer A.N. & Nikaido H. (1995) Microbial Biotechnology: Fundamentals of Applied Microbiology. W.H. Freeman & Company, New York.
- Michael L. Shuler, Fikret Kargı (1992) Bioprocess Engineering: basic concepts. Prentice Hall Publishers. New York.
- Stanbury P.F., Whitaker A, Hall S.J. (1999) Principles of Fermentation Technology. 2nd edition, Butterworth-Heinemann
- Wulf Crueger and Anneliese Crueger (1990) Biotechnology: A Textbook of Industrial Microbiology. Panima Publishers. New Delhi
- Karl-Hermann Neumann, Ashwani Kumar, Jafargholi Imani, 2009, Plant Cell and Tissue Culture - A Tool in Biotechnology, Basics, and Application, Springer-Verlag Berlin Heidelberg
- Razdan, M.K.: Introduction to plant tissue culture. (2nd Ed.) New Delhi. Oxford & IBH Publishing Co. Pvt. Ltd., 2003. 81-204-1571-X--(581.0724RAZ)

ASSESSMENT:

Continuous Internal assessment (40M)
CIA I: Theory Exam (20M) CIA II: Scientific Essay /Review Writing (20M)

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (THEORY): BIOTECHNOLOGY
CLASS: MSC- SEMESTER III **COURSE CODE: SBTS0904**
TITLE: ENVIRONMENTAL BIOTECHNOLOGY
No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:
The course includes biotechnology-based solution aspects for environmental issues. An overview of quality, ethical and safety aspects of genetically modified products is also included in the coursework. The course aims for the student to understand concepts and strategies related to nutraceutical and functional foods production and applications.

Learning Outcomes:
The student will be able to:

- Understand the use of microbiological, molecular and analytical methods for detection and control of environmental pollution.
- Strategize sustainable approaches for environment management.
- Demonstrate knowledge of concepts in nutraceutical and functional foods.
- Evaluate biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms,
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Skills acquired:

Exposure to EIA and biosafety documentation that will help in Quality and hazard analysis aspects of a biotcehnology industry,Critical thinking, Application of concepts to solve biological problems, Group discussions , reviewing scientific literature and analysis of the same, Scientific Communication skills

UNIT 1: ENVIRONMENTAL POLLUTION AND BIOREMEDIATION 15 lectures

- Environmental pollution: urban aspects (biomedical waste, e waste, solid waste)
- Environmental Monitoring: concepts, strategies, and applications of nanotechnology
- Biofouling and biodeterioration: agents and protection methods
- Bioremediation: Biodegradation and bioconversion of natural and xenobiotic compounds
- Phytoremediation overview, microbially assisted phytoremediation, phytoremediation of saline soil, genetic strategies for advancing phytoremediation potential in plants.
- Heavy Metal Bioremediation- conventional and advanced methods
- Oil pollution remediation.

UNIT 2: ENVIRONMENTAL SUSTAINABILITY 15 lectures

- Concept of sustainability, carbon footprint and credits
- Biomass management
- Sustainability in agriculture: Bio-pesticides, Bio-fertilizers and Integrated Pest management
- Energy and Environment: Bioenergy
- Metagenomics: concept, strategies, and applications in environmental biotechnology

UNIT 3: GM CROPS AND NUTRACEUTICALS 15 lectures

- GM crops- national and global scenario (*Bt* based & others and fallacies associated)
- GM based phytonutrients
- Food security dilemma- GM food Vs Organic food
- Nutraceuticals and Functional Foods: Nutraceuticals and Functional Foods- Definition, characteristic features, and classification; Sources (with examples e.g. microbes, plants, algae); Applications of nutraceuticals in human health and nutrition- health effects of commonly used nutraceuticals and functional foods (case studies), Safety and Regulatory guidelines

UNIT 4: SAFETY, ETHICS AND QA ASPECTS IN BIOTECHNOLOGY 15 lectures

- Biosafety- history, Need for containment and levels (microorganisms, plants and animals – both GMOs and LMOs), primary containment of biohazards, BSCs, Clean Room technology
- Regulatory guidelines: both national and International for food and food ingredients produced using GMOs, GM crops and livestock
    - Cartagena Protocol, Role of IBSC, RCGM, GEAC, and others

  - Safety and Environment Impact concerns with respect to GMOs, LMOs, GM foods, Crops and Livestock, Risk assessment, management and communication including GMP, GLP, and HACCP, Generally, Recognised as Safe (GRAS)
- Bioethical conflicts in Biotechnology: ELSI of HGP, Ethical concerns in GM utilized for consumption, agricultural benefits or human therapy.
- Quality assurance and validation: concept, documentation – SOPs
- ISO aspects

Reference Books:

- A.G. Murugesan and C. Rajakumari (2006) Environmental Science and Biotechnology Theory and techniques MJP Publishers, Chennai
- Alan H. Scragg (2006) Environmental Biotechnology, 1st edition, Oxford University Press
- Alexander N. Glazer and Hiroshi Nikaido (2010) Microbial Biotechnology, 2nd edition, Cambridge University Press.
- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.
- Rajul K Gupta (2017) Food Safety in the 21st Century: Public Health Perspective, Academic Press.
- Biosafety in Microbiology and biomedical laboratories, 5th Ed. (2009): CDC, NIH publication. HHS publication (21-1112)
- Gareth M. Evans and Judith C. Furlong (2003) Environmental Biotechnology Theory and Application, John Wiley & Sons Inc.
- Gwendolyn Holmes Bruce *et al*, (2000), Handbook of Environmental management and technology, Wiley Interscience Publishers
- http://dbtbiosafety.nic.in
- Humberto Vega-Mercado, Michael Dekleva, Rizwan Sharnez, and Luis Baez, May 2003, HACCP: A Process Validation Tool for Ensuring Quality of Biotech and Pharmaceutical Products, *Bioprocess technology*
- Indu Shekhar Thakur (2006) Environmental Biotechnology: Basic Concepts and Applications, I. K. International Pvt Ltd, 2006
- N. Alexandrova, K. Georgieva & A. Atanassov (2005) Biosafety Regulations of GMOs: National and International Aspects and Regional Cooperation, Biotechnology & Biotechnological Equipment, 19:sup3, 153-172.
- S.K. Agarwal (2007) Environmental Biotechnology, APH Publishing Co-operation New Delhi
- Secretariat of the Convention on Biological Diversity (2000). Cartagena Protocol on Biosafety to the Convention on Biological Diversity: text and annexes. Montreal.
- Traavik. T and Lim Li Ching, (2007): Biosafety first. Tapir Academic Press
- Recent research articles.

ASSESSMENT:

Continuous Internal assessment (40M)

CIA I & CIA II: Content preparation (Video/Presentation/Field Study Report) and Presentation

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

SUBJECT (PRACTICALS): BIOTECHNOLOGY
CLASS: MSC- SEMESTER III
COURSE CODE: SBTS09PR

TITLE: BIOINFORMATICS AND RESEARCH METHODOLOGY

Credits: 8

- **Course Objectives:**
  The course is designed to teach the basics of *in - silico* analysis of biological data and experimental design for *invitro* assays in a problem-oriented manner. The course will introduce the process of research designs from its inception to documentation.

Learning outcomes:
On completion of this course, students should be able to:

- Utilize bioinformatics tools to explore, analyse and interpret the biological questions.
- Design, plan, execute and analyse the data obtained for the research project.
- Propose and analyse ad-hoc solutions derived from the research project.
- Document the project using academic writing principles.

Skills acquired:

Bioinformatics tools and computational methods in Genomics and Proteomics, Project and team work skills, Research and development skills,Laboratory management,Data analysis and Interpretation, Proposal and Scientific Report Writing skills

Contents:

I. Bioinformatics

- Study of databases – primary, secondary, specialised databases
- Sequence annotations -
- Sequence alignment and phylogenetic analysis
- Protein sequence and structure analysis

II. Exploring *In Vitro* (Cell Line Based) Assays

III. Research Methodology (Bioprocess and Environment Biotechnology aspects to be explored for projects)

References:

- C.R. Kothari, Research methodology: methods and techniques, 2nd edition, New Age International Publishers, 2004
- David Mount (2004) Bioinformatics: Sequence and Genome Analysis. 2nd edition, Cold Spring Harbor Laboratory Press, New York.
- Hansmauder Schmauder, Methods in Biotechnology (1997), Taylor and Francis Publications

- James Morris, A students guide to writing in the life sciences, The President and Fellows of Harvard University, 2007
- R Ian Freshney, Culture of Animal Cells, Wiley Publications, 5th / 6th Ed

ASSESSMENT:

CIA: 80M (Continuous assessment based on lab skills and problem-solving)

END SEMESTER EXAM: 120M

Experiment based/ Quiz/ Problem solving - 60 M

Viva/ Report/ Presentation- 60M

St. Xavier's College – Autonomous, Mumbai

Syllabus

For Semester IV Courses in M.Sc. in Biotechnology

(November 2019 onwards)

Contents

Syllabus for the following courses:

COURSES

SUBJECT (THEORY): BIOTECHNOLOGY
CLASS: MSC- SEMESTER IV **COURSE CODE: SBTS1001**
TITLE: ENTREPRENEURSHIP AND IPR
No of Hours: 60 (inclusive of self-study)
Credits: 4
Course Objectives:

The course aims to educate students concepts of entrepreneurship including identifying a business opportunity, gathering funds, launching a business and management principles within a business. The Intellectual Property Rights module will encompass concepts and their implications on biological research.

Learning Outcomes:

The student will be able to:

- Identify scope for entrepreneurship in Biosciences and utilize the schemes promoted through various governmental and non-governmental agencies.
- Apply intellectual property law principles to biotechnology research and product generation.

Skills acquired:

Critical thinking, entrepreneurial Skills, , reviewing scientific literature and patent documents and analysis of the same,

UNIT 1: MANAGEMENT PRINCIPLE AND ENTREPRENEURSHIP 15 lectures

- Marketing Management:
  - Understanding the role of marketing in Organizations
  - Marketing Research and its importance
  - Understanding the Micro Environment (Strengths and Weaknesses vis-à-vis your company and its competition) and the Macro Environment (Opportunities and Threats – PEST Analysis)
  - Exit strategy
  - Brief Introduction to Demand Forecasting
  - Market Segmentation and Target Markets; 5P's (Product, Price, Place, Promotion, People)
- Finance Management:
  - Understanding the role of finance in Organizations
  - Financial Statements; Taxes
  - Interest Rates
  - Break-even analysis
- Human Resource Management
  - Understanding the role of an HR Manager in Organizations
  - Interviews
  - Team building and organizational management

- Entrepreneurship
  - The concept, meaning of entrepreneurship
  - Functions, types of entrepreneurship
  - Stages of the entrepreneurial process.
  - The contribution of notable entrepreneurs in the field of biotechnology and applied biology. (Case studies)

UNIT 2: BUSINESS OF BIOTECHNOLOGY 15 lectures

- Project areas in biotechnology and applied biology
- Business concept: Idea selection, brainstorming, project planning, conceptualization and feasibility report, Idea generation and Product planning, process design, IP generation, Project cost estimate, project profits
- Biotechnology companies, their care and nurturing
- Management in biotechnology
- Growth of the biotechnology industry in India
  - Rules & Regulations for the set-up of Biotech companies
  - Government schemes and benefits for SME
  - Strategic Management & International market (Examples of companies and strategies adopted for their market)

UNIT 3: BASIC CONCEPTS OF PATENTING 15 lectures

- Biotechnology and the law: objective, evolution, Commercial potential of biotech inventions, rational for IPR protection, Permissible and non-permissible Biotechnology patenting in India
- Patenting biotech inventions: objectives, concepts of novelty and concepts of inventive step, microorganisms, and moral issues in patenting biotech inventions
- Patenting issues related to Biosimilars
- Patent reviews and Case studies
- Searching and analysing Patents

UNIT 4: RIGHTS, GI AND TRADITIONAL KNOWLEDGE: CONCEPTS AND CASE STUDIES 15 lectures

- Protection of geographical indications: objectives, justification, international position, multilateral treaties, national level, the Indian position
- Protection of traditional knowledge: objective, the concept of traditional knowledge, holders, issue concerning, bio-prospecting and bio-piracy, alternative ways, protectability, need for a sui generis regime, traditional knowledge on the international arena, traditional knowledge at WTO, traditional knowledge at the national level, traditional knowledge digital library
- Plant varieties protection: objectives, justification, criteria for protection, international position, plant varieties protection in India, plant varieties protection under TRIPs

- Case studies

Reference books:

- Alexandra George (2006) Globalisation and Intellectual Property, Ashgate publishing company
- Colin Ratledge and Bjorn Kristiansen Basic Biotechnology, Cambridge University Press- 2nd Ed,2001
- David Pressman (2016) Patent It Yourself 18th edition, Nolo Publishers
- Maarten Bode, (2008) Taking traditional knowledge to the market, Orient Longman Publishers
- Poornima M Charanthmath, "Entrepreneurship Development – small Business Enterprises", Pearson Education – 2005
- Prabudha Ganguly, (2001) Intellectual Property rights- unleashing the knowledge economy, Tata McGraw Hill Publishing Company Ltd.
- Sudeep Chaudhuri (2005), the WTO and India's Pharmaceutical industry, Oxford University Press.
- Vandana Shiva (2002), Protect or Plunder? Understanding Intellectual Property Rights, Zed Books.
- Vasant Desai, Dynamics of Entrepreneurial Development & Management, Himalaya Publishing House

ASSESSMENT:
Continuous Internal assessment (40M)
CIA I: Market survey – Biotech/ pharma-related (20M)

CIA II: Patent Review (20M)

End Semester Exam Pattern:60 Marks:		
No. of Units	No. of Questions	Marks per Question
4	4 (1 from each Unit)	15 marks per question.
100 Marks:		
No. of Units	No. of Questions	Marks per Question
4	5 – 1 from each Unit &1 based on all units	20 marks per question.

COURSE CODE: SBTS1001PR TITLE: BUSINESS PLAN
Credits: 4

Learning Outcomes:

The student will be able to:

- Gain awareness of current research areas and biotech industrial landscape worldwide.
- Develop the competencies needed to recognise and explore a biotechnology-based business opportunity.
- Support development of self and team and articulate skill development through reflective practices.
- Research, produce and present a business plan to venture capitalists and funding agencies.

Skills Acquired:

The student will be able to acquire the following skill sets:

- Connect Biotechnology for social benefits.
- Risk assessment and bearing skills
- Networking skills
- Leadership and Managerial skills
- Proficiency in Business Ethics.

Content:

Business Proposal for a Biotechnology based Start-up

COURSE CODE: SBTS1002PR TITLE: RESEARCH PROJECT

Credits: 16

Learning Outcomes:

The student will be able to:

- Identify a research query based on the knowledge acquired across the 3 semesters and relevant scientific literature.
- Design the research study, plan and execute the research project.
- Validate the methods for reliability and reproducibility.
- Collect relevant data, analyse and represent it appropriately.
- Apply ethical principles of scientific research.
- Critically evaluate the data obtained and compare it with existing scientific literature with regard to validity and applicability.
- Proficiently document the research work based on the principles of scientific writing.

- Skills acquired: Project management skills, Laboratory management, Data analysis and interpretation, Project Proposal and Dissertation Writing skills.

Content

- Project for 5-6 months with Dissertation

ASSESSMENT

CIA	
1001PR	40M
1002 PR	160M
ESE	
1001PR	60M
1002PR	240 M