



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
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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.

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 Briemann 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 (CIA) = 40%

End Semester Assessment (ESE) = 60%

SUBJECT (THEORY): BIOTECHNOLOGY

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.

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 BIOTECHNOLOG

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.
- 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 (CIA) = 40%

End Semester Assessment (ESE) = 60%

- 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 (CIA) = 40%

End Semester Assessment (ESE) = 60%

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.

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 (CIA) = 40%**
- **End Semester Assessment (ESE) = 60%**

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.

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 and 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

End Semester Exam: 120M