MASTER OF SCIENCE
IN
BIONANOTECHNOLOGY

PROGRAM STRUCTURE AND SYLLABUS

2019-20 ADMISSIONS ONWARDS

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)

EXPERT COMMITTEE OF BIOSCIENCE (PG)

MAHATMA GANDHI UNIVERSITY

2019

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Acknowledgement

Primarly, I would like to thank Dr. Mansoor K., Subject Expert and Professor, Center for Nanoscience, AIMS, Cochin, whose valuable guidance has been the one that helped in designing this syllabus and making it full proof success. His suggestions and instructions have served as the major contributor towards the completion of the syllabus.

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Lastly but not the least, I would like to thank and all the staff members of the academic section of Mahatma Gandhi University, Kottayam, especially Sri. Anand Lal Ben, who have helped me a lot in this venture.

Above all I would like to thank God for enabling me to complete this syllabus with success.

Dr. Priya Senan V.

Chairperson

PG Syllabus Revision Expert Committe 2019, Biosciences

Table of Contents

M.Sc. BIONANOTECHNOLOGY

(Mahatma Gandhi University Regulations PGCSS2019 from 2019-20 Academic Year)

1. Aim of the Program

The aim of the programme is to highlight the importance of biological components in the field of nanotechnology. It is designed as to give the student an understanding of the nanostructures existing in nature at cellular and molecular level and to appreciate how this understanding of these self-assembling or multifunctional systems at a nano-scale finds application in diverse fields. The program seeks to provide the following: to advance education and research in Bionanotechnology and explore sustainable solutions for agriculture, environment and energy sectors.

2. Eligibility for Admissions

B.Sc. Chemistry, Physics, Biochemistry, Biotechnology, Bioinformatics, Microbiology, Botany/ Plant Science, Forestry, Zoology/Animal Science,Life Sciences, Nanotechnology, Biophysics, Environmental Science, Food Science, B.Tech Biomedical Engineering, B.Tech. Biotechnology, B. Tech Bioinformatics, B. Tech. Nanotechnology, B.Sc in Medical Laboratory Technology, B.Sc. Electronics, B.Sc. Agriculture, B.Voc. Agriculture, M.B.B.S, B.A.M.S., B.S.M.S. and B.V.Sc. with not less than CGPA of 2.00 out of 4.

3. Medium of Instruction and Assessment

Course of study will be over a period of two academic years under semester system

a. **Scheme of examination**

The examinations for the award of degree consist of theory and practical papers, dissertation and comprehensive viva-voce. There will be examinations at end of each semester for theory and practical courses. Each semester consists of four theory paper and one practical examination for the first three semesters. The fourth semester has project presentation and evaluation and comprehensive viva-voce in addition to one practical examination and three theory papers which are exclusively based on elective courses.

b. Dissertation

Each candidate should submit a dissertation in four copies of the research project undertaken by him/her at the end of fourth semester for evaluation.

c. Comprehensive viva-voce

A comprehensive viva-voce will be held at the end of the fourth semester covering all the courses of the programme taught in the entire four semesters.

4. Faculty under which the Degree is awarded

Faculty of Science

5. Specializations offered, if any

M.Sc. Bionanotechnology

6. Note on compliance with the UGC Minimum Standards for the conduct and award of Post Graduate Degrees

The programme and syllabus is in compliance with the UGC minimum standards for the conduct and award of post graduate degree

7. Duration of the course

Course of study will be over a period of two academic years under semester system.

8. PROGRAMME STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits	Total Credits
FIRST SEMESTER					
BS040101	Introduction to Cell Biology	Core	4	4	19
BS040102	Biomolecules And Metabolism	Core	4	4	
BS040103	Genomics And Molecular Biology	Core	4	4	
BS040104	Bioanalytical Techniques and Bioinformatics	Core	3	3	
BS040105	Laboratory Course I	Core	10	4	
SECOND SEMESTER					
BS040201	Introduction to Bionanotechnology	Core	4	4	19
BS040202	Biomimetics and Bionics	Core	4	4	
BS040203	Bionanofabrication and Tissue Engineering	Core	4	4	
BS040204	Proteomics and Protein Engineering	Core	3	3	
BS040205	Laboratory Course II	Core	10	4	
THIRD SEMESTER					
BS040301	Synthesis, Characterization and Applications of Nanomaterials	Core	4	4	19
BS040302	Research Methodology	Core	4	4	
BS040303	Immunology and Molecular Diagnostics	Core	4	4	
BS040304	Nano-Bio Interactions	Core	3	3	
BS040305	Laboratory Course - III	Core	10	4	

Course Code	Title of the Course		Type of the Course	Hours per week	Credits	Total Credits
FOURTH SEMESTER						
BS890401	Electives Group A	Nanotoxicology	Elective	5	4	23
BS890402		Green Nanotechnology	Elective	5	4	
BS890403		Nanomedicine	Elective	5	4	
BS900401	Electives Group B	IPR & Translational Research	Elective	5	4	
BS900402		Nanotechnology in Forensic Science	Elective	5	4	
BS900403		Bionanotechnology in Food Industry	Elective	5	4	
BS910401	Electives Group C	Industrial Trends and Applications of Nanotechnology	Elective	5	4	
BS910402		Societal Impacts of Nanotechnology	Elective	5	4	
BS910403		Cancer Nanotechnology	Elective	5	4	
BS040401	Laboratory course IV		Core	10	4	
BS040402	Research Project & dissertation		Core		5	
BS040403	Comprehensive Viva-Voce		Core		2	
			TOTAL		80	

8.1 LIST OF ELECTIVE PAPERS

Course Code	Title of the Course	
BS890401	Electives Group A	Nanotoxicology
BS890402		Green Nanotechnology
BS890403		Nanomedicine
BS900401	Electives Group B	IPR & Translational Research
BS900402		Nanotechnology in Forensic Science
BS900403		Bionanotechnology in Food Industry
BS910401	Electives Group C	Industrial Trends and Applications of Nanotechnology
BS910402		Societal Impacts of Nanotechnology
BS910403		Cancer Nanotechnology

9. M.Sc. BIONANOTECHNOLOGY SYLLABUS

SEMESTER I

Course Code	Title of The Course
BS040101	INTRODUCTION TO CELL BIOLOGY
BS040102	BIOMOLECULES AND METABOLISM
BS040103	GENOMICS AND MOLECULAR BIOLOGY
BS040104	BIOANALYTICAL TECHNIQUES AND BIOINFORMATICS
BS040105	LABORATORY COURSE I

BS040101 INTRODUCTION TO CELL BIOLOGY

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course is designed to give a basic understanding of the cell, its evolution and dynamics

2. Course Content:

Unit 1: Cellular Foundations

Domains of life.General methods in cell biology.Structure and dimensions of typical prokaryotic and eukaryotic cell. Cell membrane- Current understanding of membrane structure, composition of cell membrane – membrane lipids and membrane proteins: types, structure and functions. Membrane transport in plants – mechanisms and molecules involved in active and passive transport. (16 Hrs)

Unit 2: Cellular Dynamics

Extra cellular matrix, cytoskeleton. Secretory pathway and organelles involved. Protein trafficking, exocytosis, endocytic pathways.Cell junctions. (12 Hrs)

Unit 3: Subcellular Organelles

Subcellular organelles and their dimensions.Chloroplast – ultra structure and function; Mitochondria- structure and function.Chloroplast mitochondrial interaction. Nucleus – Structure and components. Peroxisomes, glyoxysomes.Plant vacuoles. (14 Hrs)

Unit 4: The Dynamic Cell

General principles of cell signaling. Membrane proteins as cell surface receptors for signaling. Signaling via G-Protein-linked cell-surface receptors and enzyme-linked cell-surface receptors.Second messengers.HRE binding proteins.Cell signaling in plants.Cell cycle and cell cycle regulation in animals and plants.Apoptosis in plant and animal cell. (18 Hrs)

Unit 5: Evolutionary Foundations

Evolution of the Cell: From molecules to the first cell. RNA world.From prokaryotes to eukaryotes.From single cells to multicellular organisms.Endosymbiotic theory. Phylogenetic trees, Homology, Orthology, Paralogy, Xenology; Plant and animal divergence. (12 Hrs)

3. Recommended Text books:

- Berg, J. M., Tymoczko, J. L., Gatto G. J. and Stryer, L. Biochemistry. W H Freeman, New York, 2012.

- Karp, G. Cell and Molecular Biology: Concepts and Experiments Biology. John Wiley & Sons, 2009
- Lodish*et al*. Molecular Cell Biology. W H Freeman, New York, 2016.

4. Recommended References:

- Adams, R.L.P, Knowler, J.T. and Leader, D.P. The Biochemistry of Nucleic Acid. Springer Science+Business Media, B.V., 1992.
- Alberts, B. *et al*. Molecular Biology of the Cell. Garland Science, 2013
- Anal, Anil Kumar, Bionanotechnology: Principles and Applications. CRC Press, 2018.
- Hardin, J. and Bertoni, G.P. Becker's World of the Cell, Pearson, 2016.
- Muray K.R. *et al*. Harper's Illustrated Biochemistry. McGraw Hill Professional, 2009.
- Nelson, D.M. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman, New York, 2013.
- Voet, D. and Voet, J.G. Biochemistry 4e. W. Ross MacDonald School Resource Services Library, 2010.

BS040102BIOMOLECULES AND METABOLISM

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

Course is designed to make the student understand the structural and functional attributes of biomolecules with special reference to nanostructured cellular biomolecules and their dynamics.

2. Course Content:

Unit 1: Carbohydrates and Metabolism

Composition.Basic structure and function of carbohydrates, Mono, di,oligosaccharides, Glycosidic bonds.Glycoproteinsand glycolipids.Polysaccharides- homopolysaccharides, heteropolysaccharides, bacterial polysaccharides and peptidoglycans.Purification and Characterization of polysaccharides.Sugar code.

Metabolism of carbohydrates: Glycolytic pathway, gluconeogenesis, glycogenesis, Kreb's cycle and their regulation. Substrate level phosphorylation, oxidative phosphorylation, electron transport chain.Chemiosmosis ATP synthesis- structural and functional properties of ATP synthesis. Photosynthesis – light and dark reactions. Photorespiration, C_4 and CAM plants.

(20 Hrs)

Unit 2: Lipids and Metabolism

Lipids: Classification,structure and function. Phytosterols.β-oxidation, synthesis of fatty acids, FAS, synthesis of cholesterol, degradation of cholesterol. (14 Hrs)

Unit 3: Proteins and amino acid metabolism

Proteins: Structure of amino acids. Peptide bonds.Primary structure of proteins. Three dimensional structures of proteins: secondary structures, motifs, domains, Ramachandran plot; tertiary structure; quaternary structure, multimeric proteins and holoenzymes. Classification of proteins; Protein-protein interactions.Protein denaturation and folding.Proteins as enzymes, Enzyme nomenclature and classification, Enzyme catalysis, DNA binding proteins – overview of structure, interactions and functions.DNA-binding motifs in gene regulatory proteins.Proteins as molecular motors.

Catabolism and anabolism of individual aminoacids- Regulation.Conversion of aminoacids to histamine, polyamines, serotonin, norepinephrine and gamma amino butyrate. (20 Hrs)

Unit 4: Nucleotide Metabolism

Metabolism of purines and regulation, metabolism of pyrimidines and regulation.Heme synthesis and degradation. (8 Hrs)

Unit 5: Vitamins and Hormones

Fat soluble and water soluble vitamins: structure and function, cofactors and coenzymes: structure and function; NAD, $NADP^+$, FAD, FMN, lipoic acid, TPP, pyridoxal phosphate, biotin and cyanocobalamin;Introduction to hormones in animals; hormones, vitamins and pigments in plants. (10 Hrs)

3. Recommended Text books:

- Berg, J. M., Tymoczko, J. L., Gatto G. J. and Stryer, L. Biochemistry. W H Freeman, New York, 2012.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments Biology. John Wiley & Sons, 2009
- Lodish*et al*. Molecular Cell Biology. W H Freeman, New York, 2016.

4. Recommended References:

- Adams, R.L.P, Knowler, J.T. and Leader, D.P. The Biochemistry of Nucleic Acid. Springer Science+Business Media, B.V., 1992.
- Muray K.R. *et al*. Harper's Illustrated Biochemistry. McGraw Hill Professional, 2009.
- Nelson, D.M. and Cox, M.M. Lehninger Principles of Biochemistry. W H Freeman, New York, 2013
- Voet, D and Voet, J.G. Biochemistry 4e. W. Ross MacDonald School Resource Services Library, 2010
- Nicholas C. Price, Lewis Stevens, and Lewis Stevens.Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins. Oxford University Press, USA, 2000

BS040103 GENOMICS AND MOLECULAR BIOLOGY

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course envisages introducing the student to the various aspects of genetics and genomics, viz., and also the very basics of molecular biology.

2. Course Content:

Unit 1: Fundamentals of Genetics

Fundamentals of Mendelian Genetics; Molecular basis of codomianance, incomplete dominance, epistasis – one example each; Chromosomal basis of inheritance.Works of Morgan and Sturtevant. Chromosome characteristics: Chromosomes as units of inheritance, euchromatin and heterochromatin. Genetic recombination in eukaryotes.Linkage and crossing over; Chromosome mapping - basics.Chromosomal aberrations and their significance in evolution. Basics of quantitative inheritance (14 Hrs)

Unit 2: Organelle and Developmental Genetics

Organelle genetics and cytoplasmic inheritance. Developmental genetics: Model system– *Drosophila*, pattern formation, Maternal effect. Homoetic transformations.Differentiation in plants. (10 Hrs)

Unit 3: Structural Genomics

Organization of genomes: main features of bacterial and eukaryotic genome organization. Coding regions, non coding regions, transposons, introns and repetitive sequences. Strategies for genome sequencing, Sequence assembly. Clone contig and shotgun approaches. Plant genome projects and its applications. (14 Hrs)

Unit 4: Comparitive and Functional Genomics

Annotating genomes: Gene prediction in prokaryotes and eukaryotes, ORF prediction. Functional annotation: sequence based and structure based annotation. Comparative genomics – purpose and methods of comparison.Determination of the functions of genes: gene inactivation (knock-out, anti-sense and RNA interference) and gene over expression. Approaches to analyze global gene expression: transcriptome, microarray and its applications, gene tagging, Metagenomics: Prospecting for novel genes from metagenomes and their biotechnological applications. (12 Hrs)

Unit 5: Replication

DNA replication- prokaryotes and eukaryotes.Mutation, DNA repair. (10 Hrs)

Unit 6: Gene Expression

Gene expression in prokaryotes and eukaryotes - Transcription and Translation; Reverse transcription; Regulation of gene expression. General idea of expression of foreign gene in prokaryotes and eukaryotes (basics of gene cloning). (12 Hrs)

3. Recommended Text books:

- Griffiths A.J.F., Gelbart, W.M., Miller, J.H. and Lewontin, R.C. Modern Genetic Analysis. W. H. Freeman, New York, 1999.
- Karp, G. Cell and Molecular Biology: Concepts and Experiments Biology. John Wiley & Sons, 2009
- Krebs, J.E.; Goldstein, E.S. and Kilpatrick, S.T. Lewin's genes XII. Jones & Bartlett Learning, Burlington, MA, 2018.

4. Recommended References:

- Alberts, B. *et al*. Molecular Biology of the Cell. Garland Science, New York and London, 2013
- Brown, T. A. Genomes 2e. Oxford: Wiley-Liss, 2002.
- Clark, D. P. and Pazdernik, N.J. Molecular Biology. Elsevier, 2012.
- Kurien, J. Konforti, B. and Wemmer, D. Molecules of Life: Physical and chemical properties. Garland Science, New York and London, 2013
- Lodish*et al*. Molecular Cell Biology. W H Freeman, New York, 2016.
- Malthus, T. An Essay on the Principle of Population. 1798
- REA's Problem Solvers in Genetics, Research Education Association, New Jersey, 1993
- Watson *et al*. Molecular Biology of the Gene. Pearson, 2014

BS040104 BIOANALYTICAL TECHNIQUES AND BIOINFORMATICS

Total Credits: 3

Total Hours: 54

1. Objective of the Course:

The course aims to introduce the student to various analytical instruments used in biological and related experiments and to make her/him understand the basic principles of these techniques and their application with respect to nanotechnology. Additionally the course introduces the student into the fundamentals of bioinformatics, its applications and basic tools.

2. Course Content:

Unit 1: Spectroscopy and Microscopy

Spectroscopy – Concepts of spectroscopy, Beer-Lambert's law, Principles and applications of colorimetry. Basics of Visible and UV spectroscopy

Microscopy: Basics of various types of Light and Electron microscopy.TissueProcessing for Light and Electron Microscopy, Micrometry. Applications in Nanotechnology perspective.

(10 Hrs)

Unit 2: Chromoatography, Electrophoresis and Centrifugation

Chromatography – Principles and applications of different chromatography types. Electrophoretic techniques – Principles of electrophoretic separation.Types. Centrifugation – Principle of centrifugation, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, applications, subcellular fractionation. (12 Hrs)

Unit 3: PCR

PCR – Principle of thermal cycler. Steps in amplification by traditional PCR. Types of PCR based on its applications; Digital PCR, applications. Portable PCR; Real time PCR. Microarray – construction, types and applications. (10Hrs)

Unit 4: Introduction to Bioinformatics

Introduction to Bioinformatics, Online databases and search tools, data organization, Biological data bases, structural data bases, DNA and RNA sequence data bases, genomic sequences, protein seq data bases, Distance matrix methods and parsimony. Multiple sequence alignments-tree alignments, star alignments, pattern in pair wise alignment, genetic algorithm.

(12 Hrs)

Unit 5: Bioinformatic tools and applications

Sequence analysis softwares, SS search, BLAST, FASTA, CLUSTAL, Phylogenetic analysis, construction of phylogenetic tree, evolutionary changes in nucleotide and protein

sequences, structure prediction, structural alignment tools, homology modeling, drug design. Applications of Bioinformatics: pharmaceutical industry, immunology, agriculture, forestry, basic research, chemi-informatics in biology, geo-informatics, legal ethical and commercial considerations. (10 Hrs)

3. Recommended Text books:

- Ghosal, S and Sabaria. K. Fundamentals of Bioanalytical Techniques and Instrumentation. PHI, 2010
- Lesk, A.M. Introduction to Bioinformatics. Oxford University Press, 2002.
- Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2010.

4. Recommended References:

- Attwood T.K. and Parry-Smith, D.J. Introduction to Bioinformatics. Pearson. Education 2003
- Hammes G.D. Spectroscopy for the Biological Sciences; Wiley Interscience, USA, 2005.
- Higgs, P. G., Attwood, T. K. Bionformatics and Molecular evolution. By Blackwell Publishing Ltd., 2005.
- Mount, D. Bioinformatics: Sequence and Genome analysis. Cold Spring Harbour Lab Press, New York, 2001.
- Srivastava, M. Bioanalytical Techniques. Alpha Science International Ltd., 2007 .
- Vo-Dinh (Ed.) Bioanalysis Advanced Materials, Methods, and Devices, Springer, 2013.

BS040105 LABORATORY COURSE I

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course:

The course aims to provide the student basic practical experience in analysis and estimation of different macromolecules, solution preparation, in culture, isolation and identification of microbes, in immunology and enzymology and in basic bioinformatics tools.

2. Course content:

Unit 1: Biochemical techniques, analysis and enzymology

1.1. Preparation of Solutions: Molar, Normal and Percentage solutions and calculations

1.2. Calibration of pH meter and determination of pH of solutions

1.3. Preparation of Buffers: Phosphate buffer, Tris- HCl buffer, Citrate buffer, Acetate buffer

1.4. Isolation and Estimation of Proteins: Lowry's method, modified Lowry's method and Bradford method.

1.5. Isolation and Estimation of Total carbohydrates by Anthrone method

1.6. Isolation and Estimation of Reducing sugars by DNS method

1.7. Extraction and Estimation of Total lipids: Wet method: by chloroform/ Methanol extraction., Dry method – by Soxhlet extraction (demonstration)

1.8. Estimation of amino acids by Ninhydrin method

1.9. Enzyme Assays: Isolation and assay of Adenosine triphosphatase (ATPase), Peroxidase (POX). Determination of total enzyme activity and specific activity.

1.10. Factors affecting activity and determination of Kinetics of Peroxidase enzyme (demonstration).

Unit 2: Cytology

2.1. Cell division by mitosis and meiosis

Unit 3: Genomics

3.1. Isolation and purification of Genomic DNA from plant tissue/ blood/ microbial source

3.2. Gel documentation of DNA by agarose gel electrophoresis

3.3. Spectrophotometric quantification of DNA.

Unit 4: Bioinformatics

4.1 Sequence Similarity Searching (NCBI BLAST, FASTA)

4.2. Multiple sequence Alignment (Clustal W/Clustal X)

4.3. ORF Prediction (Using ORF Finder)

4.4. Molecular Phylogeny (PHYLIP, MEGA)

3. Recommended Text books:

- Bujnicki, J.M. Practical Bioinformatics. Springer, 2006.
- Jain, M. and Agarwal, J. and Venkatesh, V. Microbiology Practical Manual. Elsevier India, 2018
- Plummer, D. An Introduction to Practical Biochemistry 3e, McGraw Hill Education, 2017
- Sawhney, S.K. and Singh, R. (Eds). Introductory Practical Biochemistry. Narosa Publications. New Delhi, 1999.
- vanEmon, J.M. Immunoassay and other Bioanalytical Techniques. CRC Press, 2016

4. Recommended References:

- Lesk, A.M. Introduction to Bioinformatics. Oxford University Press, 2002.
- Mackie and Mccartney. Practical Medical Microbiology, Elsevier, 1996.
- Wilson, K. and Walker, J. Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2010.
- Protein Purification – Robert Scoop
- Genetics Conceptual Approach – Benjamin.A.Pierce

SEMESTER II

Course Code	Title of The Course
BS040201	INTRODUCTION TO BIONANOTECHNOLOGY
BS040202	BIOMIMETICS AND BIONICS
BS040203	BIONANOFABRICATION AND TISSUE ENGINEERING
BS040204	PROTEOMICS AND PROTEIN ENGINEERING
BS040205	LABORATORY COURSE II

BS040201 INTRODUCTION TO BIONANOTECHNOLOGY

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The objective of the course is to give the students a basic understanding about materials on the nano-scale. The course is designed to provide an insight into nano-scale devices for photonic, magnetic, mechanical, chemical and biological uses.

2. Course Content:

Unit 1: Basics of Nanotechnology

History of nanotechnology, origins of nanotechnology, beyond Moore's Law. Definitions and scales, size scale effects (effects in optical, electrical and thermal properties). Current state of Nanotechnology, future of Nanotechnology.Nanotechnology in Nature and applications.Tools of trade – seeing the Nano scale, nature of light, electron microscope, scanning probe microscope in seeing the nano scale. (14 Hrs)

Unit 2: Nanomaterials

Molecular building blocks for nanostructure systems, Nanomaterials – formation of materials, carbon nanomaterials, Buckyball, Graphene (2D), Carbon nano tubes, Inorganic nano materials, Zero Dimensional Nano-Structures, One Dimensional Structures, Two Dimensional and three dimensional Structures. (14 Hrs)

Unit 3: Properties of Nanomaterials

Mechanical properties, techniques to study mechanical properties of nanomaterials, adhesion and friction.Thermal properties of nanomaterials.Optical properties of nano materials, surface plasmon resonance and quantum dots, quantum confinement.Electrical properties, conductivity and resistivity.Classification of nanomaterials on the basis of conductivity, magnetic properties.Classification of Magnetic phenomena. (16Hrs)

Unit 4: Bionanotechnology

Definition.Biomolecules, classification and characterization of biological molecules, Nanotechnology in Biology.Mechanism of biological systems at nanoscale, biological motors, Biophotonic devices, Introdution to DNA Nanotechnology, DNA as construction materials. (14Hrs)

Unit 5: Applications, Ethical and Social impacts

Cancer nanotechnology, Nano-regenerative medicine, Nano pharmacology (nanomedicine), Nanotechnology solutions to environmental problems, Application in water purification, Human implants, Nano-enabled defense system, Environmental risks of Nanotechnology, overall risks and precaution, Ethical and social impacts. (14 Hrs)

3. Recommended Text books:

- Horst – Gunter Rubahn, "Basics of Nano Technology", Wiley – VCH VerlagGmbh& Co, 2008.
- Chris Binns, "Introduction to Nanoscience and Nanotechnology", John Wiley and Sons 2010

4. Recommended References:

- Fritz Allhoff, Patrick Lin, and Daniel Moore, "What Is Nanotechnology and Why Does It Matter" WILEY BLACKWELL A John Wiley & Sons, Ltd., Publication, 2010
- SuprioDutta Tutorial on, "Electrical Resistance – an atomistic view", Purdue University, 2004
- Mark A. Reed and Takhee Lee, "Molecular Nano electronics", American Scientific Publishers, 2003.

BS040202 BIOMIMETICS & BIONICS

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course aims to make the student understand the basics of biomimeticswhich is an interdisciplinary field in which principles from engineering, chemistry and biology are applied to the synthesis of materials, synthetic systems or machines that have functions that mimic biological processes. The course also encompasses basics of bionics.

2. Course Content:

Unit 1: Introduction to Biomimetics

Biomimetics- Introduction, Confluence of Nanotechnology and Biomimetics, Mimicking biological structures using inorganic materials- Gecko Tape, Bone Tissue Regeneration and Artificial Photosynthesis.Utilizing nature on the molecular scale- Biological Self Assembly, Viral Construction, Protein Motors. (16 Hrs)

Unit 2: Case study of the molecular level structures of biological materials

Principle of biological materials as protein based robust materials- collagens, keratins, spider webs, silks, bio- adhesives. Principle of biological materials as hierarchal nanostructures- bones, sea shells, diatoms, sponges. Principle of biological materials in optical applications- butterfly wings and insect eyes. Design principle to develop novel functional materials and devices.

(16 Hrs)

Unit 3: Case study of the artificial nanomaterials and devices inspired by Nature

Recently developed nanostructures- Quantum dots, nanowires, nanotubes.Recently developed devices- biosensor, bio nanoelectronic devices.Nanomedicine and Bioimaging.

(12 Hrs)

Unit 4: Bionics and its Applications

History and Introduction to Bionics, Challenges and future of Bionic Technology.Applications of Bionics in engineering- Sonar, Radar and Medical Ultrasound; in Computer Science- Artificial Neural Networks and Swarm Intelligence.in medicines- Myoelectric control.

(14 Hrs)

Unit 5: Biomimetics and DNA Nanotechnology

History and Introduction; Applications of DNA Nanotechnology: DNA based artificial membrane channel, membrane floating proteins, artificial organelles, artificial cells. Biomimetic fabrication of DNA based metallic Nanowires and Networks. Future prospects. (14 Hrs)

3. Recommended Text books:

- Jelinek, R. (2013). Biomimetics: A molecular perspective. Walter de Gruyter.
- Mano, J. F. (Ed.). (2013). Biomimetic approaches for biomaterials development. John Wiley & Sons
- Shen, H., Wang, Y., Wang, J., Li, Z., & Yuan, Q. (2018). Emerging biomimetic applications of DNA nanotechnology. ACS applied materials & interfaces, 11(15), 13859-13873.

4. Recommended References:

- Lee, D. (2011). Biomimicry: Inventions Inspired by Nature. Kids Can Press Ltd.
- National Research Council. (2008). Inspired by biology: from molecules to materials to machines. National Academies Press (US).
- Bar-Cohen, Y. (2005). Biomimetics: biologically inspired technologies. CRC Press.
- Habib, M. (Ed.). (2017). Handbook of Research on Biomimetics and Biomedical Robotics. IGI Global.
- Roco, Mihail C. "Nanotechnology: convergence of modern biology with medicine." Current Opinion in Biotechnology 2003: 337-346.

BS040203 BIONANOFABRICATION & TISSUE ENGINEERING

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course envisages to introduce the student to the field of bionanofabrication, as a unique approach for the manufacturing of nanostructures and materials with potential applications ranging from nanoelectronics, sensor devices to nanomedicine. Also basics of plant and animal tissue culture is included with a unit dedicated to tissue engineering.

2. Course Content:

Unit 1:Nanofabrication

Bottom-up approach of nanofabrication, Wet-chemical synthesis of nanomaterials, Self-assembly as an approach to nanofabrication: Self-assembly for fabrication of nanoscale materials, mechanisms by which self-assembly can occur –the natural forces – chemical, physical, thermodynamic.Designing polymers, biomolecules to produce nanoscale structures.Basic kinetics and thermodynamics of formation of these structures.Scaffolds for tissue engineering. (12 Hrs)

Unit 2: Top-down nanofabrication

Basic concept of Top-down nanofabrication methods, Overview of top-down nanoscale fabrication methods – electron beam lithography and 3D nanofabrication methodology, UV lithography, scanning probe methods – dip pen nanolithography, soft lithography methods. General epitaxial methods. (10Hrs)

Unit 3: Nanocharacterization

Surface analysis methodology- including atomic force microscopy, chemical surface analysis methods. Integration of top down and bottom up methods. Advantages. (10Hrs)

Unit 4: Basics of Plant and Animal Cell Culture

Introduction to plant tissue culture- totipotency, nutrient media, growth hormones, explants, techniques of micro-propagation, suspension culture, callus development, application in production of secondary metabolites.

Introduction to animal cell culture – basic concept, Laboratory setup and equipments, types of cell culture media, types of cell lines, techniques in animal cell culture. (14Hrs)

Unit 5: Introduction to tissue engineering

Basic definition; current scope of development; use in therapeutics, cells as therapeutic agents, cell numbers and growth rates, measurement of cell characteristics morphology, number

viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

Tissue types and Tissue components, Tissue repair, Engineering wound healing and sequence of events. Basic wound healing. Applications of growth factors: VEGF/angiogenesisRationale for employing selected growth factors. Basic biology of stem cells. (14 Hrs)

Unit 6: Biomaterials

Biomaterials: Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, example of biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials.

(12 Hrs)

3. Recommended Text books:

- Bernhard O.Palsson, SangeetaN.Bhatia,"Tissue Engineering" Pearson Publishers 2009.
- Meyer, U.; Meyer, Th.; Handschel, J.; Wiesmann, H.P. Fundamentals of Tissue Engineering and Regenerative Medicine.2009.

4. Recommended References:

- Bernard N. Kennedy (editor). New York : Nova Science Publishers, 2008.Stem cell transplantation, tissue engineering, and cancer applications
- Raphael Gorodetsky, Richard Schäfer. Cambridge : RSC Publishing, c2011.Stem cell based tissue repair.
- R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Handbook of Stem Cells, TwoVolume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Fetal Stem Cells, 2004, Academic Press.
- R. Lanza, J. Gearhart etal (Eds), Essential of Stem Cell Biology, 2006, ElsevierAcademic press.
- J. J. Mao, G. Vunjak-Novakovic*et al* (Eds), Translational Approaches In Tissue Engineering &Regenrative Medicine" 2008, Artech House, INC Publications.
- Naggy N. Habib, M.Y. Levicar, , L. G. Jiao,.and N. Fisk, Stem Cell Repair and Regeneration, volume-2, 2007, Imperial College Press

BS040204 PROTEOMICS AND PROTEIN ENGINEERING

Total Credits: 3

Total Hours: 54

1. Objective of the Course:

Proteins form the crux of cellular functions and the course envisages introducing the student this vast and important field. Understanding proteins have naturally lead to the new field of protein engineering where Synthetic protein structures and functions are designed and this is also included in the course.

2. Course Content:

Unit 1: Proteomes and Proteomics

Genomics to proteomics: sequential phenomena in Bionanotechnology;Classification of proteomics: Structural proteomics,functional proteomics – tags and ligands in isolating multiprotein complexes, quantitative proteomics – labelling of proteins, SILAC, radiolabelling; Interactome, methods: protein affinity chromatography, immunoprecipitation, and phage display; expression proteomics. (12 Hrs)

Unit 2: Protein Engineering Methods

Definition and general approach of protein engineering; Protein engineering methods: Rational design as nanomaterials, Directed evolution of protein designing as nanomaterials. (10Hrs)

Unit 3: Applications of Protein Engineering

Applications in food,Medical applications,Environmental applications, Biopolymericnanomaterials and their functionalities. (8 Hrs)

Unit 4: Techniques in Proteomics – Basic Techniques

Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, Protein fractionation; Affinity purification –Combined Fractional Diagonal: Chromatography (COFRADIC); Removal of interfering compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents; Preparation of Sample; Sample handling and storage. (12 Hrs)

Unit 5: Techniques in Proteomics

Advanced TechniquesTechnology of proteomics and isolation: 1 –D Gel Electrophoresis 2-D Gel Electrophoresis; acquisition of Protein Structural Information; Edman Sequencing, Mass Spectrometry. Western Blotting, Immunoblotting, ELISA, Flow cytometry. (12 Hrs)

3. Recommended Text books:

- Anal, Anil Kumar, Bionanotechnology: Principles and Applications. CRC Press, 2018.
- Twyman, R.M. Principles of Proteomics. BIOS Scientific Publisher, New York. 2004.

- Singer M and Berg P Genes and Genomes: A Changing Perspective; University Science Books, CA, USA, 1991.

4. Recommended References:

- Liebler, D.C. Introduction to Proteomics: Tools for the New Biology. Human Press, Totowa NJ. 2002.
- Buchanan B, Gruissem G, and Jones R Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA, 2000.
- Hammes GD. Spectroscopy for the Biological Sciences; Wiley Interscience, USA, 2005.
- Harlow and Lane D (Eds.). Antibodies – A Laboratory Manual; Cold Spring Harbor Laboratory, USA, 1988.
- Lieber DC. Introduction to Proteomics: Tools for New Biology; Humana Press, NJ., 2006
- Pennington SR, Dunn MJ (Eds.). Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, 2002.

BS040205 Laboratory Course II

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course:

The course is designed to impart a basic practical knowledge in nanomaterial synthesis including metal nanoparticles, metal oxides and semiconductors as well as synthesis of polymer and protein nanoparticles

2. Course content:

Unit 1: Nanomaterial Synthesis – Metal Nanoparticles and Metal Oxides

1.1: Synthesis of Gold and silver nanoparticles

1.2: Synthesis of ZnO and TiO_2 nanoparticles

Unit 2: Nanomaterial Synthesis – Semiconductors

2.1: Synthesis of Iron oxide

2.2: Synthesis of ZnS

Unit 3: Polymer and Protein Nanoparticle Synthesis

3.1 Micro-emulsion preparation of PLGA nanoparticles

3.2 Aqueous phase preparation of chitosan nanoparticles

3.3. Preperation of protein (albumin) nanoparticles

3. Recommended Text books:

- Guozhong, Cao. Nanostructures and nanomaterials: synthesis, properties and applications. World scientific, 2004.
- Naito, M. *et al* (Eds.). Nanoparticle Technology Handbook - 3rd Edition – Elsevier, 2018.

SEMESTER III

Course Code	Title of The Course
BS040301	SYNTHESIS, CHARACTERIZATION AND APPLICATIONS OFNANOMATERIALS
BS040302	RESEARCH METHODOLOGY
BS040303	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS
BS040304	NANO-BIO INTERACTIONS
BS040305	LABORATORY COURSE III

BS040301 SYNTHESIS, CHARACTERIZATION AND APPLICATIONS OF NANOMATERIALS

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course is designed to make the student understand various approaches and methods involved in synthesis and characterization of nanomaterials and its applications mainly in therapeutics.

2. Course content:

Unit 1: Chemical approaches

Colloidal nano-precipitation Sol-gel processing, Solvothermal, hydrothermal, co-precipitation, Spray pyrolysis, sonochemical method, Electro spraying and spin coating routes, Self-assembly, self-assembled monolayers, gas phase synthesis. Langmuir-Blodgett (LB) films, micro emulsion polymerization- templated synthesis. (14 Hrs)

Unit 2: Synthesis of biological nanoparticles

Synthesis of nucleic acid (DNA & RNA), protein and viral nanoparticles and their applications. Applications of inorganic nanomaterials in biology- examples: silver and gold nanoparticles. (12 Hrs)

Unit 3: Biological Methods

Use of natural plants for synthesis of nanoparticles- synthesis of metal nanoparticles using phytochemicals.Materials and fabrication of nanoparticles for drug delivery, Nano-encapsulation for Drug Delivery, Encapsulation Methods. (14 Hrs)

Unit 4: Nanostructured Materials Characterization Techniques

Surface Plasmon Resonance Spectroscopy, X-ray diffraction (XRD), SEM, EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer, Nanomechanical Characterization using Nanoindentation, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermo gravimetric Analysis (TGA), TEM, X-ray Photoelectron Spectroscopy (XPS), Scanning Probe Microscopy (SPM), Electrochemcial Characterization measurements, Dynamic Light Scattering, Zeta (potential). (16 Hrs)

Unit 5: Therapeutic Applications

Concept of nanomedicine, nanoparticles for controlled drug delivery, general requirements for use of nanoparticles, magnetic nanoparticles for targeting cancer cells.New designs and applications for therapeutic nanoparticles and nanocapsules.Therapeutic application in infectious diseases, degenerative and autoimmune diseases.Nanoparticles for delivery of drugs, targeted drug delivery, advantages. Ocular applications of nanocarrier drug delivery.

Nanoparticle drug delivery for neuro-inflammatory diseases, nanoparticle delivery for cancer therapy, nanoparticle delivery of natural product therapies. (16 Hrs)

3. Recommended Text Books:

- Synthesis, Properties, and Applications of Oxide Nanomaterials, edited by José A. Rodriguez,Marcos Fernández-García
- Nanochemistry: A Chemical Approach to Nanomaterials, By Geoffrey A. Ozin, André C.Arsenault, LudovicoCademartiri
- Nanomaterials, Nanotechnologies and Design: An Introduction for Engineers. Daniel L.Schodek, Paulo Ferreira, Michael F. Ashby
- Nanomaterial Interfaces in Biology: Methods and Protocols, Paolo Bergese, Kimberly Hamad- Schifferli
- Optical Properties and Spectroscopy of Nanomaterials, Jin Z. Zhang

4. Recommended References:

- Nanomaterials: Mechanics and Mechanisms, By K.T. Ramesh
- Nanoscience and Nanomaterials: Synthesis, Manufacturing and Industry Impacts, by Wei-Hong Zhong
- Nanoparticles: Synthesis, Stabilization, Passivation, and Functionalization. American Chemical Society Meeting
- Handbook of Semiconductor Manufacturing Technology, Second Edition, edited by YoshioNishi, Robert Doering
- Handbook of Immunological Properties of Engineered Nanomaterials, By Marina A.Dobrovolskaia, Scott E. McNeil
- Biomimetic and BioinspiredNanomaterials, edited by Challa S. S. R. Kumar
- Nanoscale Spectroscopy with Applications, edited by Sarhan M. Musa
- Applied Spectroscopy and the Science of Nanomaterials, edited by PrabhakarMisra
- Nanomaterials Imaging Techniques, Surface Studies, and Applications, edited by OlenaFesenko, Leonid Yatsenko, MikhayloBrodin

BS040302 RESEARCH METHODOLOGY

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

Post graduate courses in general are designed to encourage the students to further their knowledge through research activities. The course aims to introduce the student to the philosophy in research and accepted methodologies followed in due course and importance and methods of communicating science effectively. Also a basic understanding regarding biostatistics is also included.

2. Course content:

Unit 1: Creativity, thinking skills and outlooks on research

Various views on creativity.Critical thinking.Problem solving strategies.Logical thinking – common logical fallacies; Types of research – pure and applied, incremental and innovative, qualitative and quantitative. Philosophy of science: the scientific method, Research process. Development of research hypothesis and setting of research questions.The raw data-experimental designs, measurement and recording.Collection, analysis and interpretation of data.Ethics in scientific research and academics plagiarism. (14 Hrs)

Unit 2: Research papers

Format of a science research paper.Reference citing styles.Literature collection and report writing.Proof reading and editing.Publication process. Peer review – single/ double blind and open. Plagiarism. Open Access Publications; Google scholar and Scopus. Bibliometrics and Webometrics – impact factors, h-, h b-, g- indices, Drawbacks in interpreting impact. Reference management tools. Current awareness: RSS feed, TOC alerts, DB alerts. (16 Hrs)

Unit 3: Biostatistics

The mean, the range, the standard deviation, standard error, student t-test, student t-distribution, chi-square test, correlation, probability. Parametric and nonparametric tests. Basic statistics-averages statistics of dispersion, coefficient of variation and analysis of variance ANOVA,.R software for statistical computing and graphics.SPSS and EXCEL. (14 Hrs)

Unit 4: Science Communication

Fundamentals of Science communication.History of Science communication, Science communication in India.Entrepreneurship in Science communication.Science communication in the information age. (16 Hrs)

Unit 5: Practicing Science Communication

Effective science communication. – speaking and writing skills. Communication skills for scientists.Different modes of science communication and popularisation. Visualizing science for communication..Making effective multi-media and poster presentations.Science diplomacy and public understanding of science. (12 Hrs)

3. Recommended Text books:

- Antonisamy, B. *et al*. Principles and Practice of Biostatistics. Elsevier India, 2017.
- BijuDharmapalan. Scientific Research Methodology. Alpha Science Int. Ltd., 2012.
- Holliman, R. *et al*. Practising Science Communication in the Information Age: Theorizing Professional Practice, Oxford University Press, 2009
- Kothari C. R. and Gaurav G. Research Methodology: Methods and Techniques. New Age Publishers, 2019.
- Wilson, A. (Ed). Handbook of Science Communication. Routledge, 1998.

4. Recommended References:

- Bagla, P. and Binoy, V. V. (Eds.) Bridging the Communication Gap in Science and Technology Lessons from India, Springer, 2017.
- Bassham, G., Irwin, W., Nardone, H. and Wallace, J.: Critical Thinking: A Students Introduction, Tata McGraw Hill, 2008
- Bennett, D.J. *et al*. Successful Science Communication. Cambridge University Press, 2012.
- Charles Pavitt. The Philosophy of Science and Communication. Nova Science Publications, 2001.
- Davies, S. R., Maja, H. Science Communication Culture, Identity and Citizenship. Palgrave Macmillan, 2016
- Day, R.A. How to Write and Publish a Scientific Paper. Greenwood Press, 2011
- Holliman, R., *et al*. Investigating Science Communication in the Information Age: Implications for Public Engagement and Popular Media. Oxford, 2009.
- Martin W. Bauer Journalism, Science and Society: Science Communication Between News and Public Relations. Routlledge, 2007
- Olson, R. Don't Be Such a Scientist: Talking Substance in an Age of Style. Island Press, 2010

- Pagano, M. and Gauvreau, K. Principles of Biostatistics. Chapman and Hall, 2018.
- Patairiya, M. Science Journalism in India. Pantaneto Press, UK. http://pantaneto.co.uk/science-journalism-in-india-manoj-patairiya/
- Rowena Murray. How to Write a Thesis, Tata McGraw Hill, 2010.

BS040303 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS

Total Credits: 4

Total Hours: 72

1. Objective of the Course:

The course introduces the student to the field of immunology and then on how human immune system responds to biomaterials and nanoparticles and then envisages to introduce the student to molecular diagnostics and immunotherapeutics.

2. Course Content:

Unit 1: Introduction to Immunology

Immune system, basic concepts, Cells and organs of immune system, Types of immunity, Antigen, Antibody structure, classification, Monoclonal antibodies, Recombinant antibodies, Antigen–Antibody Interaction andImmunoassays, Complement system, mechanisms of immune response. (16 Hrs)

Unit 2:Immune response to Biomaterials and Nanoparticles

Introduction to immune response towards biomaterialsand nanoparticles.Effects of biomaterials with micro/nanotopographies on immune cells, Macrophage-based immunomodulation for biomaterials.Reticulo-endothelial system based clearance of nanomaterials. Cytokine and chemokine response, cellular response. (14 Hrs)

Unit 3: Nanoparticles in Regulating Immune System

Cellular -machinery targeted by nanodrugs, Aspirin: targeting in the inflammatory response pathway, Taxol: disabling the cell division nanomachinery (tubulin). Anti-inflammatory nanodrugs – eg: curcumin (nanocurcumin) (12 Hrs)

Unit 4: Molecular Diagnostics

Nanocapsules and bioreactors with active elements, Nanotechnology for genetic screening and therapy.Diagnostic use of native and recombinant antigen.Detection of TB (bacterial), SARS, chikungunya, dengue (viral), cancer – EGFR BRCA 1 &2 HPV.Nanosensor particle systems for *in vivo* and *in vitro* diagnostics, Surface Plasmon Resonance for biosensing, nanoparticle bioconjugation with antibody for sensing.Diagnostic applications of antibody-based bioconjugates. (16 Hrs)

Unit 5:Nanovaccines and Immunotherapeutics

Nanoparticles for vaccines, DNA/RNA/peptide vaccines. Nanoparticle based vaccine delivery. Basics of cancer immunotherapy and emerging trends.Use of nanoparticles for anti-cancer immunotherapy, Immunotoxicity of engineered nanoparticles, activation of immune system using nanoparticles. (14 Hrs)

3. Recommended Text Books:

- Anil Kumar Anal (2018) Bionanotechnology : Principles and applications. CRC Press, Taylor and Francis group
- Harry F Tibbals (2011) Medical Nanotechnology and Nanomedicine. In Perspectives in Nanotechnology. Gabor L. Hornyak(Ed)CRC Press, Taylor and Francis.

4. Recommended References:

- NihalEnginVrana (Ed) (2019) Biomaterials and Immune response : Complications, Mechanisms and ImmunomodulationCRC Press, Taylor and Francis
- MousumiDebnath, GBKS Prasad, Prakash S Bisen (2010) Molecular Diagnostics: Promises and Possibilities. Springer science and Business Media
- MahendraRai and KaterynaKon (Eds) (2015) Nanotechnology in diagnosis, treatment and prophylaxis of infectious diseases. Academic Press. Elsevier.

BS040304 NANO-BIO INTERACTIONS

Total Credits: 3

Total Hours: 54

1. Objective of the Course:

The objective of the course is to give the students an in depth understanding about interaction of nanomaterials with cellular components. The course is designed to provide an insight into the nano sized components of the cellular system and their functions

2. Course Content:

Unit 1: Biological Interactions with Materials

Introduction, Biocompatibility, Cellular uptake mechanisms Toxicity, Cytotoxicity, Hypersensitivity, Carcinogenicity, , Inflammation, Granulation Tissue Formation, Foreign body reaction, Fibrosis, Blood-Biomaterial interactions, , Interactions with Proteins, , The Vroman Effect, Fibrous Capsule Formation, Safety Testing of Biomaterials. (16 Hrs)

Unit 2: Biocompatibility of Nanomaterials

Surface and Bulk Properties of Bio materials.Nanobiomaterials, NanoCeramics, Nanopolymers, Nano Silica, Hydroxy apatite. Carbon Based nanomaterials, Surface modification.Textured and Porous Materials. Surface immobilized biomolecules. *In vitro* and *in vivo* assessment of bio compatibility. (14 Hrs)

Unit 3: Models of Bionanosystems

Lipid Bilayers,liposomes, neosomes, Phytosomes, Polysacharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes - Biomolecular motors: linear, rotary mortors.Immunotoxins,Membrane transporters and pumps, Antibodies, monoclonal Antibodies, immunoconjugates. Limitations of natural biomolecules. (14 Hrs)

Unit 4: Bioaccumulation of Nanosystems

Exposure mechanisms, Subcellular localization, biodistribution, clearance mechanism, metabolism and excretion of nanomaterials. (10 Hrs)

3. Recommended Text books:

- Molecular Cell Biology,HarveyLodish, Published by W.H. Freeman & Company
- Biomaterials: A Nano Approach,S Ramakrishna, M Ramalingam, T.S. Sampath Kumar, Winston O. Soboyejo,Published by CRC Press
- Bionanotechnology: Lessons from Nature, D S. Goodsell, by John Wiley & Sons, Inc.
- Nanobiotechnology: Concepts, Applications and Perspectives,(edited by C. M. Niemeyer and C. A. Mirkin), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim,

- Nanobiotechnology: Concepts, Applications and Perspectives,Edited by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH, 2004.

4. Recommended References:

- Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications, and Impact. C. S. S. R. Kumar, J. Hormes, C. Leuschner, 2005, WILEY -VCH Verlag GmbH & Co. KGaA
- Nanoscale Technology in Biological Systems, Edited by Ralph S. Greco, Fritz B. Prinz, R. Lane Smith, CRC PRESS, Boca Raton London New York Washington, D.C. Copyright © 2005 by Taylor & Francis
- Nanoparticulates Drug Carriers, Edited by Vladimir P Torchilin, 2006, Imperial College Press, 57 Shelton Street, Covent Garden.

BS040305 LABORATORY COURSE III

Total Credits: 4

Total Hours: 10 hours/ week

1. Objective of the Course:

The course is designed to impart a practical knowledge in basic molecular biology techniques and also on methods of characterization of nanomaterials.

2. Course content:

Unit 1: Genomics and Molecular Biology

1.1; RNA isolation

1.2: Designing of Primers

1.3: TA cloning (demonstration)

1.4: Plasmid isolation

Unit 2: Characterization of Nanomaterials

2.1: UV-Vis spectrometry of nanomaterials

2.2: FTIR spectroscopy (demonstration)

2.3: DLS/ Zeta potential of Nanoparticles

2.4: PCR, RT-PCR, Real-time PCR

2.5: Western Blot

2.6: ELISA – different types.

3. Recommended text books:

- Frederick. M.A., Roger. B.R., David. D. M., Seidman. J. G., John A. S., Kevin. S. Current Protocols in Molecular Biology. John Wiley and Son, Inc., 2003.
- Sambrook, J., Russell, D. W., & Russell, D. W. Molecular Cloning: A Laboratory Manual (3-volume set). CSLP, 2001.
- Naito, M. *et al* (Eds.). Nanoparticle Technology Handbook - 3rd Edition – Elsevier, 2018.

SEMESTER IV

Course Code	Title of the Course	
ELETIVES		
BS890401	Electives Group A	Nanotoxicology
BS890402		Green Nanotechnology
BS890403		Nanomedicine
BS900401	Electives Group B	IPR & Translational Research
BS900402		Nanotechnology in Forensic Science
BS900403		Bionanotechnology in Food Industry
BS910401	Electives Group C	Industrial Trends and Applications of Nanotechnology
BS910402		Societal Impacts of Nanotechnology
BS910403		Cancer Nanotechnology
BS040401	Laboratory course IV	
BS040402	Research Project & dissertation	
BS040403	Comprehensive Viva-Voce	

ELECTIVES

GROUP A

Course Code	Title of the Course
BS890401	NANOTOXICOLOGY
BS890402	GREEN NANOTECHNOLOGY
BS890403	NANOMEDICINE

BS890401 NANOTOXICOLOGY

Total Credits: 4

Total Hours: 90

1. Objective of the Course:

The course aims to impart in the student the awareness and understanding the potential for human and environmental exposure, hazard and risk associated with the use and development of nano-structured materials.

2. Course Content:

Unit 1: Introduction to Nanotoxicology

Concept of Nanotoxicology, Effect of size scale in toxicology, Laboratory rodent studies, Ecotoxicologic studies, Methodology for Nanotoxicology, *in vitro* and *in vivo* toxicity testing. (16Hrs)

Unit 2: Mechanism of Nanotoxicity

Mechanism of nanosize particle toxicity, Reactive oxygen species meditated NSP toxicity, Interactions between Nanoparticles and Living Organisms: Mechanisms and Health Effects,Interactions of Nanoparticles with Cells and their Cellular Nanotoxicology, Cytotoxicity of Ultrafine Particles, Cytotoxicity and Potential Mechanism of Nanomaterials, Immunotoxicity. (18 Hrs)

Unit 3: Pollution

Nanopollution, Nanomaterials in Environment, Toxicology of Airborne Manufactured nanomaterials in the environment, Physicochemical characteristics of nanomaterials. (12 Hrs)

Unit 4:Human exposure to Nanosized Materials

Biological Activities of Nanomaterials and Nanoparticles , nanoparticles interaction withbiological membrane, Entry routes into the human body, Disposition of NSPs in the respiratory, Disposition of NSPs in the respiratory, Epithelial translocation , Translocation to the circulatory system, Neuronal uptake and translocation, Translocation of NSPs in the blood circulation to bone marrow in mice, Studies of neuronal translocation of UFPs from respiratory tract, Exposure via GI Tract and Skin, toxicity of nanoparticles in the eye. (24 Hrs)

Unit 5: Risk Assessment and Execution

Portals of entry and target tissue, Risk assessment, Ethical – Legal and Social Implications - Nanoparticle Toxicology and Ecotoxicology, The Role of Oxidative Stress, Development of Test Protocols for Nanomaterials, Regulation of Engineered Nanomaterials in Europe and USA, Nanoregulatory guidelines in India. (20 Hrs)

3. Recommended Text Books:

- N. Duran, S.S. Guterres, O.L. Alves, Nanotoxicology: Materials, Methodologies, andAssessments, Springer, Newyork, 2014.

- Nancy A. Monteiro-Riviere, C. Lang Tran, Nanotoxicology: Progress towards Nanomedicine, Second edition, CRC Press, Taylor and Franscis, Boca Raton, 2014.

4. Recommended References:

- T. Otsuki, Y. Yoshioka, A. Holian, Biological Effects of Fibrous and ParticulateSubstances,Springer, 2016.
- A.M. Gatti, S. Montanari, Case Studies in Nanotoxicology and Particle Toxicology, Academic Press, UK, 2015.
- G. Ramachandran, Assessing Nanoparticle Risks to Human Health, William Andrew, Elsevier, USA, 2011.
- J. Njuguna, K. Pielichowski, H. Zhu, Health and Environmental Safety of Nanomaterials:Polymer Nancomposites and other material containing nanoparticles, Woodhead Publishing,Elsevier, UK, 2014.
- Harry Salem, Sidney A. Katz, Inhalation Toxicology, Third Edition, CRC Press, London, 2015.

BS890402 GREEN NANOTECHNOLOGY

Total Credits: 4

Total Hours: 90

1. Objective of the Course:

At the end of the course, student will be familiar with the field of traditional manufacturing to green manufacturing and also with various processing of sustainable green manufacturing techniques. The course aims at making the students able to improve the knowledge about Industrial ecology

2. Course Content:

Unit 1: Green Manufacturing Trends

Green Manufacturing - Fundamentals and Applications, Basic definitions, Issues surrounding green manufacturing at the process, machine and system, , Economic issues surrounding green manufacturing, Semiconductor and medical areas, Supply chain and packaging areas. (18 Hrs)

Unit 2: Sustainable Green Manufacturing

Green manufacturing sustainability - processes - requirements, and risk, The sustainable lean and green audit process, International green manufacturing standards and compliance, Alternative energy resources, Sustainable green manufacturing system design (16 Hrs)

Unit 3: Waste Management

Sustainability and global conditions, Material and solid waste management, Energy management, Chemical waste management and green chemistry, Climate change, air emissions management, Supply water and waste water management, Environmental business management, Present atmosphere and challenges. (20 Hrs)

Unit 4: Industrial Ecology

Introduction - Material flows in chemical manufacturing - Industrial parks, Assessing opportunities for waste exchangesand by product synergies, Life cycle concepts. Regulatory, social and business environment for green manufacturing, Present state of green manufacturing. (16 Hrs)

Unit 5: Nanomaterials for "Green" Systems

Green materials, including biomaterials, biopolymers, Green materials, including bioplastics, and composites, Nanotech Materials for truly Sustainable Construction: Windows, Skylights, and Lighting, Nanotech Materials for truly Sustainable Construction: Paints, Roofs, Walls, and Cooling, Multifunctional Gas Sensors and biomimetic Sensor, Multifunctional Optical

Interference Sensors, Thermo-light responsive Nanomaterials, Stimulus-responsive Nanomaterials. (20 Hrs)

3. Recommended Text books:

- David Dornfeld, "Green manufacturing fundamental and applications" Prentice hall, 2002
- Sammy Shinga G., "Green electronics design and manufacturing", Prince Publications, 2008
- Frank Kreith, George Tchobanoglous, "Solid waste management", McGraw Hill, 2002
- Stevens E.S., "Green plastics", Princeton University press, 2002
- Robert Ayres U., "A Handbook of Industrial Ecology", Edward Elgar publishing, 2002.
- Ashby M.F., Daniel L. Schodek, "Nanomaterials, nanotechnologies and design: an introduction for engineers", CRC Press, 2010

4. Recommended References:

- David Allen T., David R.S., "Green engineering", Prentice Hall NJ, 2002.
- James Clark, "Green chemistry", Blackwell publishing, 2008
- Paulo Davim," Sustainable manufacturing", Wiley publications, 2010.

BS890403 NANOMEDICINE

Total Credits: 4

Total Hours: 90

1. Objective of the Course:

The course deals with the development and application of materials and devices to study biological processes and to treat disease at the level of single molecules and atoms.

2. Course Content:

Unit 1: Introduction to Nanomedicine

Nanomolecular Diagnostics, Nano pharmaceuticals, Generation and significance of Nano pharmaceuticals like nanosuspensions, nanogels, nanocarrier systems - Nano formulation – Nano encapsulation – Enhancement of drug therapy epitaxy. (22 Hrs)

Unit 2: Role of Nanotechnology in Biological Therapies

Nanodevice for medicine and surgery, Nano oncology, Nano neurology, Nanocardiology, Nano-orthopediacs, Infectious diseases. Liposomes for drug delivery and targeting: Classification and preparation of liposomal nanoparticles. (20 Hrs)

Unit 3: Targeted Nanoparticles for drug delivery

Nanoparticle surface modification, bioconjugation, pegylation, antibodies cell- specific targeting and controlled drug release, Multi- Functional Gold Nanoparticles for Drug Delivery, Virus based nanoparticles. Dentrimer as Nanoparticular Drug Carriers: Synthesis- Nanoscale containers- Nanoscaffoled- Gene transfection- Biocompatibility Polymer Micelles as Drug carriers, Polymer Nanotubes- Magnetic Nanoparticles as Drug Carriers. (26 Hrs)

Unit 4: Application of Nanobiotechnology

Application in ophthalmology, Regenerative medicine and Tissue Engineering, Worldwide development and commercialization of Nanomedicine, Research and Educational Nanomedicine, Future of Nanomedicine.Concept of GMP (Good Manufacturing Practie) and cGMP. (22 Hrs)

3.Recommended Text books:

- Nanomedicines, vol .1: Basic capabilities :- Robert .A.Freitas
- Nanomedicine:- Bhattachary
- The Handbook of Nanomedicine:-Jain, Kewal.
- Springer handbook of Nanotechnology:-Bushan

4. Recommended References:

- Dendrimer-based nanomedicine:- IstvanMajoros
- Nanomedicine, Volume IIA: Biocompatibility by Robert A. Freitas Jr.

ELECTIVES

GROUP B

Course Code	Title of the Course
BS900401	IPR & TRANSLATIONAL RESEARCH
BS900402	NANOTECHNOLOGY IN FORENSIC SCIENCES
BS900403	NANOTECHNOLOGY IN FOOD INDUSTRY

BS900401 IPR AND TRANSLATIONAL RESEARCH

Total Credits: 4

Total Hours: 90

1. Objective of the Course:

Research and need for improvisations necessitates the need for development of new technologies, products and processes. The course is designed to make the student aware of legal and other issues involved in their pursuit of academic goals in terms of intellectual property rights, patents, and related acts and laws, and bioethics. Also the course has a unit on translational research which aims to impart in the student the idea that the research ultimately has to reach the masses through innovations in fields of medicine and agriculture.

2. Course Content

Unit 1: IPR

Intellectual Property Right (IPR) and Protection (IPP): About Intellectual Property and Intellectual Property Right, their scope and duration of protection, choice of intellectual property protection, IPR and Plant Genetic Resources (PGR), GATT and TRIPs. (16 Hrs)

Unit 2: Patents

Patents in biotechnology: Patentable subject matter, procedure of patenting, products and processes, novelty, non-obviousness, utility, enablement, disclosure, prior approval before applying for IPR. Patenting of biological material- worldwide and Indian context, International conventions, patent applications, implication of patenting of higher plants, patenting transgenic organisms, genes and DNA sequences, IPR in agriculture: Plant variety protection, plant patents and utility patents, Plant breeders right (PBRs) and Farmers Rights. Environmental laws of India and Biological Diversity Act. (20 Hrs)

Unit 3: Biotechnology and Society

Perceptions of the consumers, government, industry and civil society.Biotechnology and globalization, role of international economic and regulatory regimes.

Bioethics: Codes of ethics in history, UN Declaration on bioethics and human rights, implications; Research and regulatory ethics: Responsible Conduct of Research, misconduct, Falsification, fabrication, plagiarism, conflict of interest, regulatory misconduct, implications for public trust in biotechnology. (18 Hrs)

Unit 4: Biosafety

Biosafety: Concepts, biosafety in the laboratory, institution and outside, regulatory regime through institutional, state and national biosafety bodies, biosafety in rDNA work, hospitals, fields etc. International biosafety dimensions: Cartagena Protocol, biological warfare

and bioterrorism. Food safety and environmental safety evaluation of genetically modified microbes, crops, animals. (18 Hrs)

Unit 5: Translational research

Significance of plant translational research- significance, avenues, case studies. Challenges and future prospects; Product development and Entrepreneurship programmes – process, possibilities, schemes and legalities involved; Strategies and case studies in herbal drug development. (18 Hrs)

3. Recommended Text books:

- Cornish, W. R. Intellectual property: Patents, Copyright, Trade marks, and Allied rights. Sweet & Maxwell, 1999

4. Recommended References:

- Ahuja, V.K. Law Relating to Intellectual Property Rights. Lexis Nexis, 2017.
- Ashok Soni. Complete reference of Intellectual property rights laws- 2 vols.
- Mittal, D.P. Indian Patents Law. Taxmann, 1999
- TIFAC New Delhi: Intellectual Property Rights Bulletin.

BS900402 NANOTECHNOLOGY IN FORENSIC SCIENCES

Total Credits: 4

Total Hours: 90

1. Objective of the Course:

The course introduces fundamental and applied aspects of forensic nanotechnology

2. Course content:

Unit 1: Nanotechnology in Forensic Sciences

Introduction to Forensic Sciences and its scope, Limitations in conventional methods employed in fields of forensic sciences, Nano analytical techniques used in detection of crimes – SEM, TEM, AFM, DLS and Raman Microscopy. (18 Hrs)

Unit 2:Forensic DNA analysis

Application of DNA analysis in forensic sciences, Microfluidic devices for forensic DNA analysis, Forensic DNA typing: silica based magnetic nanoparticles, magnetic nanoparticles, and copper nanoparticles for high quality DNA extraction, gold nanoparticles for enhancing PCR efficiency. (18 Hrs)

Unit 3: Forensic toxicological analysis

Rationale of employing nanotechnology for drug/toxin detection, Application of Gold, silver and Titanium oxide nanoparticles for enhancing the detection limit, Case studies and recent research findings with respect to forensic toxicological drug screening – detection of codeine (COD) sulfate and clonazepam, nanosensors for forensic toxicological analysis. (20 Hrs)

Unit 4: Nano-Fingerprint Residue Visualization and Explosive Detection

Nanopowders for finger print development, Application of micro-X-ray fluorescence (MXRF) to visualize latent fingerprints - Principle and Advantages, Use of AFM to ascertain the time of death, Nanostructures as sensors and other instrumental techniques for detection of explosives and gunshot residues. (18 Hrs)

Unit 5: Future aspects of Nanotechnology in Forensic Science

Advanced and effective approaches to prevent crime and augment security to the society, Nanoplatform for improved evidence analysis procedure, Nanodevices for residual evidences analysis.Ethical, legal and social issues. (16 Hrs)

3. Recommended Text Books and References

- Shukla R.K. and Pandya A. (Eds.) Introduction of Forensic Nanotechnology as Future Armour, Nova Science Publishers, NY, 2019.
- Carmichael L. E. Discover Forensic Science. Lerner Publications. 2016.

BS900403 NANOTECHNOLOGY IN FOOD INDUSTRY

Total credits: 4

Total Hours: 90

1. Objective of the Course:

The course envisages introducing the student to various applications of nanotechnology in different realms of food industry

2. Course content:

Unit 1: Nanotechnology in Food industry

Introduction to natural food nano substances and nanostructure – carbohydrate, protein, emulsion.Nanotechnology for improving food quality, detection of contaminants. (18 Hrs)

Unit 2: Nano Ingredients, additives and nano food processing

Nano materials for food applications- metal oxides, functionalized nanomaterials, nano additives, encapsulation and release efficiency of nanoparticles, applications of nanoencapsualtion in food industry, importance of nanotechnology in food processing in terms of food texture, appearance and taste, nutritional value and shelf-life, Nanopartiles as ingredients and additives in nutrients and food supplements. (20 Hrs)

Unit 3: Nano technology in packaging

Nano technology in food packaging, nano composites, nano coatings.Role in active packaging, intelligent packaging.Nano sensor – for deteting presence of contaminants, mycotoxins, and microorganisms in food, Nanomaterials for preventing and killing food microbes, Nano membrane, Nanobarcodes. (18 Hrs)

Unit 4: Potential Benefits and hazards

Industrial benefits, consumer benefits, Detection and characterization of nanoparticles in food, potential hazards. (16 Hrs)

Unit 5: Risks associated and Regulations

ENP, health risks- toxins, metabolism action etc. Risk governance – principle.General regulations, safety aspects in different regions, Regulation aspects of nano scale food ingredients, additives, FCMS. (18 Hrs)

3. Recommended Text Books:

- Introduction to nanotechnology - Charles P. Poole; Frank J. Owens – 2008 – Wiley.
- Nanotechnologies in Food – QasimChaudhary, Laurence Castle, Richard Watkins -2010- RSC Publishing Data Book.

4. Recommended References:

- Q. Huang -Nanotechnology in the Food, Beverage and Nutraceutical Industries. Woodhead Publishing Limited - 2010
- Lestie prey, “Nanotech in food products”, Wiley publications 2010.
- Pandua W., “Nanotech research methods for foods and bioproducts”, Wiley publications 2012.

ELECTIVES

GROUP C

Course Code	Title of the Course
BS910401	INDUSTRIAL TRENDS AND APPLICATIONS OF NANOTECHNOLOGY
BS910402	SOCIETAL IMPACTS OF NANOTECHNOLOGY
BS910403	CANCER NANOTECHNOLOGY

BS910401 INDUSTRIAL TRENDS AND APPLICATIONS OF NANOTECHNOLOGY

Total credits: 4

Total Hours: 90

1. Objective of the Course:

The course envisages introducing the student to industrial trends and applications of nanotechnology in different realms, viz. agriculture. food sector, textiles, cosmetics, defense and aerospace.

2. Course content:

Unit1: Nanotechnology in Biomedical Industry

Nanoparticles and Micro–organism- Biosensors-Bioreceptors and their properties - Biochips-Integrated nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis – Tissue Engineering – Neuroscience -Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Protein Engineering – Nanosensor in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.

(20 Hrs)

Unit 2: Nanotechnology in Agriculture and Food Sector

Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- - Information and communication technology- Sensors- RF identification- Food safety- Nanomaterials based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers. (24 Hrs)

Unit 3: Nanotechnology in Textiles and Cosmetics

Nanofibre production – Electrospinning and charge injection method – morphological control- yarns and polymidenanofibers- Carbon Nanotube and Nanofibre Reinforced Polymer Fibers multifunctional polymer nanocomposite- Improvement of polymer functionality- Nylon-6 nanocomposite from polymerization- Dyeable Polypropylene - nanocoatings and surface modifications - Nano-filled polypropylene fibers - UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear textiles- Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners–Nanomaterials in Sun-screen UV protection – Color cosmetics. (24 Hr)

Unit 4: Nanotechnology in Defence and Aerospace

Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical micro sensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space mission. (22 Hrs)

3. Recommended Text Books:

- Mark. A, Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
- Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes & Noble 2004
- Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.
- Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers 2010.

4. Recommended References:

- Jennifer Kuzma and Peter VerHage, "Nanotechnology in agriculture and food production", Woodrow Wilson International Center, 2006
- Lynn. J, Frewer, WillehmNorde. R. H, Fischer and Kampers. W. H "Nanotechnology in the Agri- food sector", Wiley-VCH Verlag, 2011.
- Brown. P. J and Stevens. K "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007
- Mai. Y-W "Polymer Nano composites", Woodhead publishing, 2006
- Chang. W.N "Nanofibers fabrication, performance and applications", Nova Science Publishers Inc, 2009
- Helvajian H and Robinson. E.Y "micro and nanotechnology for space systems "the aerospace corporation, Micrograph, 1997
- Margaret. E, Kosal "Nanotechnology for Chemical and Biological defence, Springer 2009.

BS910402 SOCIETAL IMPACTS OF NANOTECHNOLOGY

Total credits: 4

Total Hours: 90

1. Objective of the Course:

The course envisages introducing the student to various societal impacts of nanotechnology.

2. Course content:

Unit 1: Protection & Regulation for Nanotechnology

Patentability requirements-riding the patent office pony-infringement issues-nanotech patents outside the united states-copyright requirements-nanotech creation as artist works-Delegation of power of agencies-Examples of regulation of nanotechnology- environmental regulations-regulation of exports-political and judicial control over Agency action. (18 Hrs)

Unit 2: Liability Legal Aspects of Nanotechnology

The applications of civil &criminal laws-civil liability, application of negligence to nanotechnology, strict liability for nanotechnology products - warranty - class actions - nanotechnology business organization-criminal liability. (14Hrs)

Unit 3: Economic Impacts and Commercialization of Nanotechnology & Social Scenarios

Introduction-Socio-Economic Impact of Nanoscale Science: Initial Results and Nanobank-Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria -The Emerging NanoEconomy: Key Drivers, Challenges, and Opportunities-Transcending Moore's Law with Molecular Electronics and Nanotechnology- Navigating Nanotechnology Through Society - Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research-Nanotechnology: Societal Implications: Individual Perspectives- Nanotechnology and Social Trends-Five Nanotech. (22Hrs)

Unit 4: Ethics, Law & Governance

Ethics and Law - Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions-Ethics and Nano: A Survey-Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology -The Ethics of Ethics -Negotiations over Quality of Life in the Nanotechnology Initiative. Governance-Problems of Governance of Nanotechnology -Societal Implications of Emerging Science and Technologies: A Research Agenda for Science and Technology Studies (STS)-Institutional Impacts of Government Science Initiatives - Nanotechnology for National Security. (18 Hrs)

Unit 5: - Public Perceptions & Education

Public Perceptions- Societal Implications of Nanoscience: An Agenda for Public Interaction Research- Communicating Nanotechnological Risks- A Proposal to Advance Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering - Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology- Nanotechnology: Societal Implications — Individual Perspectives-Historical Comparisons for Anticipating Public Reactions to Nanotechnology.

(18 Hrs)

3. Recommended Text Books:

- Mihail. C, Roco and William Sims Bainbridge "Nanotechnology: Societal Implications II-Individual Perspectives", Springer, 2007
- Geoffrey Hunt and Michael D, Mehta "Nanotechnology: Risk, Ethics and Law", Earth scan/James & James publication, 2006.

4. Recommended References:

- Jurgen Schulte "Nanotechnology: Global Strategies, Industry Trends and Applications", John Wiley & Sons Ltd, 2005.
- Mark. R, Weisner and Jean-YvesBottero. Environmental Nanotechnology applications and impact of Nanomaterial, The McGraw-Hill Companies, 2007.

BS910403 CANCER NANOTECHNOLOGY

Total credits: 4

Total Hours: 90

1. Objective of the Course:

Cancer is a group of diseases driven by inherently nanostructural problems. As such, there are obvious benefits to treatments employing nanoscale structures and processes. With this aspect the course is designed to introduce the student to basics of cancer biology and different therapeutic arena where nanoscience is having an impact

2. Course Content:

Unit 1: The Biology of Cancer

The nature of cancer; Tumor viruses; Cellular oncogenes; Growth factors; Growth factor receptors &cancer ; Cytoplasmic signaling circuitry programs: cancer traits ; Tumor suppressor genes ; Control of the cell cycle clock; P53 & apoptosis: master guardian and executioner. (18 Hrs)

Unit 2: Cancer Development

Cell immortalization; Tumorigenesis& cancer development ; The biology of angiogenesis; Invasion & metastasis ; Types of cancers; Stem cells and cancer ; Molecular genetics of cancer: chemical modifications of chromatinassociated proteins; Genetic alterations in cancer cells: mutations; Chromosomal abnormalities. (16 Hrs)

Unit 3: Cancer Theranostics

Theranostic cancer biomarkers; Molecular imaging in cancer theranostics; Imaging-guided cancer therapy; Theranostic platforms, proteomics-based theranostics; Radionuclide imaging of cancer therapy; Bioluminescence imaging of cancer therapy; Magnetic resonance imaging of cancer therapy ; Ultrasound imaging of cancer therapy. (16 Hrs)

Unit 4: Nanotechnology in Cancer Diagnosis and Therapy

Magnetic nanoparticles as contrast agents for MRI application and therapeutic application; Ultrasound-responsive nanoparticles as drug and gene delivery carriers; Noble metal nanoparticle platform; Cancer theranostics with carbon-based nanoplatforms and silica nanoparticle platform ; Polymer- and protein-based nanotechnologies for cancer theranostics; Scale-up production of theranostic nanoparticles; Market considerations; Nanotechnology and nanomedicine patenting systems. (20 Hrs)

Unit 5: Case Studies

Pancreatic cancer stem cells as new targets for diagnostics and therapy; Nanomedicine approaches for cancer stem cell targeting; Personalized cancer treatment and targeted iron oxide nanocomplex as a theranostic agent; Local cancer therapy with magnetic nanoparticles;

Parameters influencing the efficacy of magnetic heating of small breast tumors; Galectins as targets for novel and specific antibody therapies in gynecologic cancer therapies; Glycans and mucins as targets for novel and specific antibody therapies in gynecologic cancer therapies; Commercial development of antibodies as drugs. (20 Hrs)

3. Recommended Text Books:

- Robert A. Weinberg, " The Biology of Cancer", Garland Science, 2010.
- Raymond W. Ruddon, "Cancer Biology", Oxford University press, 2007.
- Chen &Wong, "Cancer Theranostics", Academic Press, 2014 4. Alexiou C. (Erlangen), "Nanomedicine - Basic and Clinical Applications in Diagnostics and Therapy", Karger, 2011

BS040401 LABORATORY COURSE IV

Total credits: 4

Total Hours:10hrs/week

1. Objective of the Course:

The goal of this course is to provide an insight into the fundamentals of nanotechnology in biological and biomedical research. It will also guide the students to understand how nanomaterials can be used for a diversity of analytical and medicinal rationales

2. Course Content:

1. Isolation and bioconjugation of DNA with nanoparticles

2. Estimation of surface charge (w.r.t. zeta potential) with DNA, RNA and peptide biofunctionalizations.

3. Surface Plasmon Resonance (SPR) on gold nanoparticles with protein nanoparticles

4. Functionalization of nanoparticles for drug delivery – folic acid

5. Effect of nanoparticles on biomolecules

6. Synthesis of polymeric scaffold

7. Quantitative estimation of biomolecule- conjugated quantum dots.

3. Recommended Text Books and References:

- Nanobiotechnology Laboratory course material, 2016
- Andrew Collins, “Nanotechnology Cookbook: Practical, Reliable and Jargon-free Experimental Procedures”, Elsevier, 2012
- Challa, “Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact”, Wiley – VCH, 2005.

10. MODEL QUESTION PAPERS

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

Faculty of Science

Introduction to Cell Biology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Describe the structural peculiarities of prokaryotic organization.
2. What is cytoskeleton ?
3. Define cell cycle and Name the phases of cell cycle with its significance
4. What is ubiquitin? Discuss its role in cell cycle.
5. Give an example of membrane receptors and explain its structure.
6. Discuss the role of Ca^{2+} as second messenger.
7. Define extracellular matrix.
8. Define programmed cell death.
9. Explain phylogenetic tree and its significance in evolution.
10. What is endosymbiotic theory? Explain with suitable examples.

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. "Structural complexity of eukaryotes is reflected in their subcellular structures" Justify.
12. Make a comparison of three main components of the cytoskeleton : microtubules, intermediate filaments and microfilaments.
13. Comment on the complicated process of cell cycle regulation.

14. Describe the different types of membrane receptors
15. Elaborate the different stages in apoptosis
16. p53 is referred to as 'guardian of genome'. Justify the concept.
17. Discuss in detail on the ultrastructure of chloroplast and its functions.
18. Explain the different types of protein trafficking.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Describe the ultrastructure and function of cell organelles in an animal cell.
20. Analyze the significance of cyclins and cyclin dependent kinases in the regulation of cell cycle.
21. Discuss the mechanism of signal transduction by GPCR
22. How are Bcl2 proteins, caspases and other death proteins involved in programmed cell death?

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

Faculty of Science

Biomolecules andMetabolism

(2019 admissions onwards)

Time: 3hours Maximum weightage: 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Differentiate between epimerism and anomerism with one example
2. Describe the formation of glycosides with one example
3. Explain the structure of cephalin
4. Differentiate between cofators and coenzymes
5. What are enantiomers? Give an example
6. What is PUFA
7. What is photosystem
8. Explain the structure of ATP
9. Explain the terms essential fatty acids
10. What is basic amino acid? Give one example (8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Give an account on disaacharides
12. Explain Glycosaminoglycans with structure and functions
13. Synthetic polysaccharides and their uses
14. Give an account on phospholipid with one example
15. Explain oxidative phosphorylation

16. Give an account on noncyclic electron transport chain

17. Explain Ramachandran plot

18. Describe de novo pathway for pyrimidine biosynthesis (6 x 2 = 12)

Part C

Essay type questions, 5 weightage each

(Answer 2 questions)

(2 × 5= 10)

19. Briefly discuss about aerobic oxidation of glucose. Mention about the energetics and regulatory mechanism

20. Give an account on classification of lipids

21. Discuss about structural level classification of protein

22. Explain about classification of vitamins

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

Faculty of Science

Genomics and Molecular Biology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Euchromatin and heterochromatin
2. Transposons
3. Quantitative inheritance
4. Origin of replication
5. Okazaki fragments
6. Central dogma of Molecular Biology
7. Trancription factors
8. Reverse transcription
9. Gene tagging
10. Coding strand and non-coding strands

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain the major post transcriptional modifications in prokaryotes
12. Explain microarray and its applications
13. Illustrate genetic recombination and its significance

14. Describe the methods for gene inactivation with suitable examples
15. Comment on the major DNA polymerases in eukaryotes
16. What is developmental genetics, explain with the example of *Drosophila*
17. Describe any five DNA repair mechanisms
18. Explain plant genome projects and its applications

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Illustrate the replication process in prokaryotes with a detailed outline of the enzymes involved
20. Explain translation in eukaryotes and the major post-translational modifications
21. Explain genome sequencing methods.
22. Explain the major approaches to analyze global gene expression

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

Faculty of Science

Bioanalytical Techniques and Bioinformatics

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Beer-Lambert's law
2. What is the basic principle of chromatography?
3. Polymerase Chain Reaction
4. Differentiate RPM and RCF
5. Protein data seq database
6. Homology modeling
7. HPLC
8. Differentiate light and electron microscopy
9. Multiple sequence alignments
10. Chemiinformatics

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain the construction of phylogenetic trees
12. Explain the principle of centrifugation. Differentiate density gradient centrifugation and ultra-centrifugation.
13. Differentiate BLAST and FASTA
14. Explain microarray,its construction, types and applications
15. Principle and procedure of electrophoresis

16. Explain UV-Visible spectroscopy

17. Illustrate the applications of spectroscopy in Nanotechnology

18. Real Time PCR and its applications

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain the principle, procedure and various types of PCR

20. Illustrate the applications of bioinformatics in various industries

21. Explain on multiple sequence alignments

22. Illustrate the classification of chromatography and the applications of each

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) *Reg. No. .....*

Name .....

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

First Semester

Faculty of Science

BS010105 Laboratory Course I

(2019 admissions onwards)

Time: *Max. Weight: 15*

1. Major experiment	(5 weight.)
2. Minor experiment 1	(2 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(3 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

Faculty of Science

Introduction to Bionanotechnology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Moore's Law
2. Electron microscope
3. Carbon nano tubes
4. Quantum dots
5. Biophotonic devices
6. Give a short note on nano-regenerative medicine
7. What is DNA nanotechnology?
8. Inorganic nanomaterials
9. Biological motors
10. Define quantum confinement (8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Illustrate the principles and applications of electron microscope and electron microscope and scanning probe microscope in studying nanoparticles

12. What are the major environmental risks of nanotechnology
13. Illustrate the classification of nanomaterials on the basis of magnetic properties and conductivity
14. What is the mechanism of biological systems at nanoscale
15. Describe how nanotechnology is applied in water purification
16. What are the major ethical impacts of nanotechnology?
17. Describe about nanomedicine and its applications
18. Differentiate zero dimensional and one dimensional nanostrutures

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Describe the major properties of nanomaterials
20. Illustrate the major applications of bionanotechnology
21. Elaborate on the different types of nanomaterials and their applications
22. Explain the significance of nanotechnology in biological systems with reference to biological motors and biophotonic devices

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

Faculty of Science

Biomimetics and Bionics

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Biomimetics
2. Gecko tape
3. Bio-adhesives
4. Bionics
5. Biosensors
6. Swarm intelligence
7. Diatoms and sponges
8. Butterfly wings
9. Insect eyes
10. Quantum dots

(8 x 1= 8)

Part B

Short essay type questions, 2 weightage each

(Answer any *six*)

Briefly explain the following:-

11. Nanomedicine and bioimaging
12. Artificial neural networks
13. Myoelectric control

14. Biomimetic fabrication of DNA based metallic nanowires and networks.
15. Artificial photosynthesis
16. Tissue regeneration
17. Protein motors
18. Principle of biological materials in optical applications.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain briefly the applications of DNA nanotechnology.
20. Explain principle of biological materials as hierarchal nanostructures.
21. Design principle to develop novel functional materials and devices.
22. Explain the applications of bionics in engineering.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bioanotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

Faculty of Science

Bionanofabrication and Tissue Engineering

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Top-down nanofabrication
2. Micropropagation
3. Tissue repair
4. Growth factors
5. Totipotency
6. Suspension cultures
7. Secondary metabolites
8. Biopolymers
9. Self-assembly approach to nanofabrication
10. Electron beam lithography

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain the methods of callus culture and its applications
12. Explain wet chemical synthesis of nanomaterials
13. Explain the methods of tissue repair

14. Applications of growth factors

15. Explain the major components of plant tissue culture media

16. Biomolecules to produce nanoscale structures

17. Explain the measurement of tissue characteristics, appearance and mechanical properties

18. Types of cell culture media for animal cell culture

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5)

19. Explain the various protocols for animal cell culture

20. Explain the application of plant tissue culture in producing secondary metabolites

21. Explain the various nanoscale fabrication methods

22. Write down the applications of biomaterials

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

Faculty of Science

Protein Engineering and Proteomics

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. What is SILAC
2. Give an account on flow cytometry
3. What is interactone
4. Give the structure of proteasomes
5. Write any three applications of proteomic analysis
6. Explain the principle for separation of protein by affinity biotechnology
7. Explain Edman sequencing
8. Give the importance of Hsp 70 chaperone system
9. Write any two environmental application of protein engineering
10. Difference between 1-D and 2-D electrophoresis

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. How to apply liquid chromatography in proteomics for protein separation?
12. Write a short note on the second dimension strategies for protein separation.
13. Briefly discuss about immune blotting
14. Write a short note on application of protein engineering in food industry

15. Discuss about various protein solubilization techniques

16. What are the basic principles of protein engineering

17. What are the techniques to identify protein-protein interactions

18. Write a short note on quantitative proteomics

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Give the method, importance and identification using mass spectrometry

20. Explain the methods for detection of proteins in polyacrylamide gels

21. Give an account on major challenges of proteomics?

22. Discuss about various methods for protein engineering and their applications

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) *Reg. No. .....*

Name .....

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Second Semester

Faculty of Science

Laboratory Course II

(2019 admissions onwards)

Time: *Max. Weight: 15*

1. Major experiment	(5 weight.)
2. Minor experiment 1	(2 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(3 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

Faculty of Science

Synthesis, Characterization and Applications of Nanomaterials

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Explain the concept of Langmuir-Blodgett (LB) films.
2. Write down about the application of gold nanoparticles.
3. What is Dynamic light scattering?
4. Write a short note on Nanocapsules.
5. What is slo-gel processing?
6. Explain self-assembly in the context of nanomaterial synthesis.
7. What are the applications of Magnetic nanoparticles?
8. Explain briefly on elemental mapping.
9. Define Zeta potential and elaborate on its significance in nanomaterial characterization.
10. What are Silver nanoparticles? Give applications.

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain on the significance of nanoparticle delivery of natural product therapies.
12. Elaborate on the steps involved in the synthesis of viral nanoparticles.
13. Discuss on the different encapsulation methods involved in nanoencapsulation for drug delivery.

14. Explain the working principle of surface plasmon resonance spectroscopy and its application in characterization of nanomaterials.
15. Discuss on the ocular applications of nanocarrier drug delivery.
16. Metal nanoparticles can be synthesized with phytochemicals. Justify the statement with suitable examples.
17. Discuss on the use of scanning probe microscopy in characterization of nanomaterials.
18. Illustrate on the steps involved in the synthesis of nucleic acid and protein nanoparticles and their applications.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain in detail on the therapeutic applications of nanoparticles with emphasis on cancer therapy.
20. Discuss on any two techniques used for the characterization of nanostructured material.
21. Elaborate on the materials and fabrication of nanoparticles for drug delivery.
22. Explain the different chemical methods of synthesis of nanomaterials.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

Faculty of Science

Research Methodology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. SPSS
2. Variables
3. Type II errors
4. Pie chart
5. Documentation
6. 't' test
7. Sampling
8. Hypothesis
9. Raw data
10. Biliometrics and webometrics

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Standard deviation and standard error
12. Design of variation
13. Reference management tools
14. Chi-squre test
15. Correlation analysis

16. Academic plagiarism

17. Types of research

18. Science diplomacy

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(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain descriptive and experiment type of research

20. Give an account on interpretations and precautions to be taken for interpretation of data

21. Explain measures of central tendency

22. Discuss about different modes of science communication and popularization

(2x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

Faculty of Science

Immunology and Molecular Diagnostics

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Antigen
2. HAT medium
3. Cytokine
4. Immuno-toxins
5. RNA vaccines
6. Mono nuclear phagocytic cells
7. MAC
8. Immuno tolerance
9. Adjuvant
10. TCR

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Tumor specific transplantation antigen
12. Classical pathway for complement system activation
13. MHC
14. Immunomodulation
15. RIA

16. Hybridoma technology

17. Effects of biomaterials with nanotopographics in immune cells

18. Detection method of dengue

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain nano particle based drug delivery

20. Give an account on cancer immune therapy

21. Discuss about cells and organs of immune system

22. Explain types of immunity

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

Faculty of Science

Nano-Bio Interactions

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Cytotoxicity
2. Nanobiomaterials
3. Vroman effect
4. Hydroxy apatite
5. Biocompatability
6. Nanopolymers
7. Immunotoxins
8. Biodistribution
9. Hypersensitivity
10. Granular tissue formation

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Lipid bilayers
12. Cellular uptake mechanism
13. Safety testing of biomaterials
14. Neosomes and liposomes

15. Subcellular localization

16. Fibrous capsule formation

17. Blood biomaterial interaction

18. Foreign body reaction

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain briefly about in vitro and in vivo assessment of biocompatibility.

20. Explain DNA scaffolds and the limitations of natural biomolecules.

21. Explain models of bionanosystems.

22. Explain metabolism and clearance mechanism of nanomaterials.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) *Reg. No. .....*

Name .....

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Third Semester

Faculty of Science

Laboratory Course III

(2019 admissions onwards)

Time: *Max. Weight: 15*

1. Major experiment	(5 weight.)
2. Minor experiment 1	(2 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(3 weight.)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Nanotoxicology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Discuss on the In vitro toxicity testing.
2. What is nanopollution ?
3. What are the ethical and social implications of nanoparticle toxicology?
4. Explain the significance of reactive oxygen species in nanotoxicity.
5. Which are the entry routes into the human body for nanoparticles?
6. Define immunotoxicity.
7. Explain nanotoxicology and its significance.
8. Define ecotoxicology.
9. What are the airborne manufactured nanomaterials?
10. Explain risk assessment.

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain in detail on the methodology for nanotoxicology.
12. Discuss on the mechanism of nanosize particle toxicity.
13. Comment on the role of oxidative stress in nanotoxicology.
14. Explain in detail on the biological activities of nanomaterials and nanoparticles.

15. What is the toxicity of nanoparticles on the eye and skin?
16. How are the test protocols for nanomaterials been developed? Explain in detail.
17. What are the physicochemical characteristics of nanomaterials?
18. Discuss on the interactions of nanoparticles with cells and the resultant toxicity.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Comment on the nanoregulatory guidelines in India.
20. Explain in detail on human exposure to Nanosized materials.
21. What are the different aspects of nanopollution and the presence of nanomaterials in environment?
22. Discuss on the different mechanisms involved in nanotoxicology ?

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Green Nanotechnology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Give an account on green materials for construction
2. Give a brief description on
3. Define industrial parks
4. What are economic issues surrounding green manufacturing?
5. Define green supply chains
6. What are bioplastics?
7. What is green rapid prototyping?
8. Give a brief idea about life cycle concepts
9. What are sensors? Give examples
10. Define climate change (8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Give an account on alternative energy resources.
12. What are supply water and waste water management?
13. What are nanomaterials? Explain with examples.
14. Give an overview of green manufacturing.

15. Explain environmental business management

16. Elaborate on the concept of industrial ecology

17. Give a brief idea about air emissions management

18. Give a brief description of sustainable system design

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain material and solid waste management

20. Explain sustainability of green manufacturing and the processes involved

21. Briefly explain the government motivations for green manufacturing

22. Explain green flexible automation systems

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Nanomedicine

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. What are nanomolecular diagnostics?
2. Define nanogels with examples.
3. What is nanoencapsulation? Explain its significance.
4. Explain application of nanoparticles in tissue engineering.
5. What are nanoscaffolds?
6. Explain the basic concepts of nanoneurology.
7. Elaborate on virus based nanoparticles with examples.
8. Explain the application of gene transfection in nanomedicine.
9. What are nanodevices? How are they applied in medicine or surgery?
10. Define the use of polymer nanotubes in nanomedicine

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Discuss on the enhancement of drug therapy epitaxy.
12. Write a short note on nanooncology.
13. Discuss on the concept of good manufacturing practice.
14. Explain the use of nanoparticles as drug carriers with suitable examples.

15. Comment on the future of Nanomedicine.

16. What are the different types of nanoparticle surface modification s?

17. What are the different mechanisms involved in targeted and controlled drug release?

18. Explain the significance of the application of nanoscience to the therapy of cardiology.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Give a detailed account on the applications of nanobiotechnology.

20. Comment on the use of targeting nanoparticles for drug delivery

21. Write in detail on types and formulations of nanopharmaceuticals.

22. Explain the details of liposomes for drug delivery and targeting.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

IPR and Translational Research

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. IPR
2. IPP
3. GATT
4. Cartagena protocol
5. Plant genetic resources
6. Bioterrorism
7. TRIPs
8. Bioethics
9. Transgenic organisms
10. PBR

(8 x 1 = 8)

Part B

Short essay type questions, 2 weightage each

(Answer any *six*)

11. What are the implications for public trust in biotechnology.
12. Explain international biosafety dimensions.
13. Explain the procedure of patenting briefly.
14. Explain briefly the areas in which biosafety is required.

15. Briefly explain biosafety practises involved in laboratory.

16. Briefly explain biological warfare.

17. What are the implications of patenting of higher plants.

18. Explain Entrepreneurship programmes

Section C

(Answer any two questions. Each question carries a weight of 5)

19. Explain the strategies and case studies involved in herbal drug development.

20. Explain food safety and environmental safety evaluation of genetically modified crops.

21. Explain patenting of biological materials- worldwide and Indian context.

22. Explain the environmental laws in India and biological diversity act.

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Nanotechnology in Forensic Science

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. SEM
2. Raman microscopy
3. AFM
4. Blood group substances
5. Magnetic nanoparticles
6. VNTR
7. Shadow band
8. Difference between silica based magnetic nanoparticles and magnetic nanoparticles
9. Detection method for codeine
10. Gruesome analysis

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. List out limitations in conventional methods employed in the field of forensic science
12. Discuss about Role of nanotechnology in forensic investigation
13. Estimation of time since death
14. Application of DNA analysis in forensic analysis

15. Rationale of employing nanotechnology for drug detection
16. Importance of gold nano particle for enhancing PCR efficiency
17. Human identity testing using STRs
18. Gunshot residua analysis in forensic science

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5)

19. Explain application of nano sensors for forensic toxicological analysis
20. Discuss about nano devices for residual evidence analysis. Ethical, legal and social issues
21. Account on principle, applications and advantages of micro- X ray fluorescence to visualize latent fingerprinting
22. Discuss about application of DNA analysis in forensic sciences

(2 x 5= 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Bionanotechnology in Food Industry

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Nano membrane
2. Nano barcodes
3. Emulsion
4. FCMS
5. Encapsulation
6. Nano coating
7. Nano composites
8. Active packaging
9. Intelligent packaging
10. Hazards

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Write down the role of nanotechnology for improving food quality.
12. Write down the importance of nanotechnology in food processing.
13. Write down the role of nanotechnology in detection of food adulterants/contaminants.

14. Briefly explain the role of nano technology in food packaging.
15. Explain briefly functionalized nanomaterials.
16. Briefly explain role of nanotechnology in killing food microbes.
17. Briefly explain encapsulation and release mechanism.
18. Write down the regulation aspects of nano scale food ingredients.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain the regulations and risk associated with the use of nanotechnology in food industry.
20. Explain the role of nanoparticles as additives in food supplements.
21. Explain the role of nanotechnology in food packaging.
22. Explain the applications of nanosensors.

(2x5=10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Industrial Trends and Applications of Nanotechnology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Nano robotics
2. Nano engineered food ingredients
3. Photodynamic therapy
4. Bioreceptors
5. Biosensors
6. Tissue engineering
7. Precision farming
8. Nano fertilizers
9. Protein engineering
10. Neuro electronic interfaces

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Briefly explain the role of nanotechnology in agriculture.
12. Briefly explain electrospinning and charge injection method.
13. Briefly explain potential risk of nanofoods to consumers.
14. Explain smart delivery system.

15. Explain briefly DNA based biosensors and diagnostics.

16. Write down the role of nanotechnology in cosmetics industry.

17. Write down the role of nanotechnology in dentistry.

18. Write down the properties of bioreceptors.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain the role of nanotechnology in defence and aerospace.

20. Explain the role of nanotechnology in textile industry.

21. Explain the role of nanotechnology in agriculture sector.

22. Explain the role of nanotechnology in biomedical industry.

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Societal Impacts of Nanotechnology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Transcending Moore's law
2. STS
3. Nano economy
4. Patent
5. Criminal liability
6. Copyright
7. Surveillance
8. Civil liability
9. Ethics
10. Infringement

(8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Write down the environmental regulations of nanotechnology.
12. Write down the use of nanotechnology for national security.
13. What are the key challenges and oppurtunities of nanobanking.
14. Write down the ethical issues in nanoscience.

15. What are the nano tech patents outside the United States.
16. Briefly explain role of nanotechnology in surveillance.
17. Briefly explain Malcolm Baldrige national quality criteria.
18. What are the individual perspectives based on historical comparisions for anticipating public reactions to nanotechnology.

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. Explain liability and legal aspects of nanotechnology.
20. Explain public perceptions and education about nanotechnology.
21. Explain the various ethical issues in nanoscience.
22. Explain the commercialization of nanotechnology and its social scenarios.

(2x5=10)

Model Question Paper

QP Code (to be assigned by Exam Section) Reg. No. ……

Name …….

M.Sc. Nanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science (Elective)

Cancer Nanotechnology

(2019 admissions onwards)

Time :Three Hour Maximum Weight : 30

Section- A

(Answer any eight questions. Each question carries a weight of 1)

1. Cellular oncogenes
2. Cell cycle clock
3. Magnetic nanoparticles
4. Apoptosis
5. Glycans and mucins
6. Cancer stem cell targeting
7. Bioluminescence imaging
8. Chromatin associated proteins
9. Gene delivery carriers
10. Nanomedicine (8 x 1 = 8)

Section B

(Answer any six questions. Each question carries a weight of 2)

11. Explain on theranostic cancer biomarkers
12. Explain the process of angiogenesis, invasion and metastasis
13. Illustrate genetic alterations in cancer cells

14. Illustrate nanomedicine patenting systems

15. Explain radionuclide imaging in cancer therapy

16. Explain the commercial development of antibodies as drugs

17. Explain the applications of magnetic resonance imaging in cancer therapy

18. Explain mutations and chromosomal abnormalities

(6 x 2 = 12)

Section C

(Answer any two questions. Each question carries a weight of 5.)

19. What is apoptosis? Explain the mechanism of apoptotic cell death

20. Illustrate the patenting systems in nanomedicine and nanotechology

21. Illustrate the various theranostic mechanisms in cancer treatment

22. Nanomedicine approach to cancer stem cell therapy

(2 x 5 = 10)

Model Question Paper

QP Code (to be assigned by Exam Section) *Reg. No. .....*

Name .....

M.Sc. Bionanotechnology Degree (C.S.S.) Examination, Month, Year

Fourth Semester

Faculty of Science

Laboratory Course IV

(2019 admissions onwards)

Time: *Max. Weight: 15*

1. Major experiment	(5 weight.)
2. Minor experiment 1	(2 weight.)
3. Minor experiment 2	(1 weight.)
4. Minor experiment 3	(1 weight.)
5. Record	(3 weight.)
6. Viva	(3 weight.)

11. FORMAT OF AWARDS TO BE ISSUED TO STUDENTS

11.1 GRADE CARDS/ MARK CUM GRADE CARDS FOR EACH SEMESTER

11.2 CONSOLIDATED GRADE CARD

11.3 PROVISIONAL CERTIFICATE

11.4 DEGREE CERTIFICATE