

## M. TECH - NANOMEDICINE

The M.Tech in Nanomedicine is a course designed for students to explore in depth the application of nanotechnology to the biomedical area. Such applications include new implant technologies, regenerative engineering, new nanomedicines to combat cancer and drug resistance, targeted medicines for treatment with reduced side effects, diagnostic technologies using nanomaterials etc. To gain strength in this new area the course covers in-depth nanomaterials and their properties, nanosystems design, the physics and chemistry of nanomaterials and applications of nanotechnology to the biomedical area, including engineering of scaffolds and the engineering of devices at the nanoscale for diagnostics and treatment.

The program also offers clinical exposure in one of the many operation theatres of the hospital to help students develop an understanding of the medical applications of nanotechnology. In short, this is a pioneering program that aims to develop an all-round scientist and technologist with interdisciplinary specialization in three areas-- nanotechnology, biotechnology and medical sciences.

## Curriculum

### First Semester

Course Code	Type	Course	LTP	Credits
18MA613	FC	Statistical Data Analysis	101	2
18NS601	FC	Cell Biology	200	2
18MM621	SC	Immunology	300	3
18NS621	SC	Science and Properties of Nanomaterials	300	3
18NS622	SC	Nanomaterials Synthesis	300	3
18NS623	SC	Cell Culture and Animal Lab	101	2
18NS624	SC	Lab: Nanomaterials Lab-I	102	3
18HU601	HU	Amrita Values Program *		P/F
18HU602	HU	Career Competency-I *		P/F
		<b>Total Credits</b>		<b>18</b>

\* Non Credit Course

### Second Semester

Course Code	Type	Course	LTP	Credits
18NS602	FC	Pharmacokinetics and Pharmacodynamics	200	2
18NS603	FC	Bioinformatics and Structure based Drug Design	201	3
18NS604	FC	Regenerative Medicine	300	3
18NS625	SC	Characterization of Nanomaterials	300	3
18NS626	SC	Polymeric Nanomaterials	200	2
18NS627	SC	Nanomedicine and Nanotoxicology	200	2
18NS628	SC	Drug Delivery Systems	200	2
18NS629	SC	Lab: Nanomaterials Lab-II	102	3
18HU603	HU	Career Competency-II	100	1
		<b>Total Credits</b>		<b>21</b>

### Third Semester

Course Code	Type	Course	LTP	Credits
18RM601	FC	Ethics in Research and Research Methodology	101	2
18NS630	SC	Nanosystems in Medical Diagnostics	200	2
18NS631	SC	Scaffolds in Tissue Regeneration	200	2
18NS798	P	Dissertation		8
		<b>Total Credits</b>		<b>14</b>

### Fourth Semester

Course Code	Type	Course	LTP	Credits
18NS799	P	Dissertation		12
			<b>Total Credits</b>	<b>12</b>
			<b>Overall Total Credits</b>	<b>65</b>

## FIRST SEMESTER

**18MA613**

**STATISTICAL DATA ANALYSIS**

**1-0-1-2**

Introduction to Statistics-Need for Statistical Methods –Their uses and Misuses, Types of Variables, Data collection Methods, Population and Sample.

Descriptive Data Analysis Methods- Statistical Tables, Diagrams & Graphs, Measures of Averages, Measures of Dispersion, Correlation Analysis Methods, Regression Analysis Methods.

Theory of probability and Standard Distributions - Binomial, poisson & Negative Binomial, Standard univariate continuous distributions – Normal, Log normal & Exponential. Sampling distributions – Chi- square distribution and F & ‘t’ distributions.

Tests of Significance of Statistical Hypotheses- Concept of Statistical Hypotheses –Null and Alternative hypotheses, Type I and Type II errors, Significance level, Critical region and Power of a test , P- value and its interpretation; Large and Small Sample Test – Normal test, Student’s ‘t’ test, Chi-square tests, Analysis of variance & Non parametric methods.

Nonparametric methods-Non-parametric methods for estimation, Methods for tests of significance for the independent and correlated samples, Nonparametric Methods for more than two populations.

Multivariate analysis Methods- Principles of Multivariate analysis, Multivariate regression analysis, Multivariate logistic regression analysis.

Practicals- (Statistical Software to be used: SPSS & SAS): (i) Practical in Descriptive Data Analysis Methods, (ii) Practical in Sampling Theory, (iii) Practical in Biostatistical Inference, (iv) Practical in Testing of Hypotheses, (v) Practical in Nonparametric Methods, (vi) Practical in Multivariate Regression Analysis.

### TEXT BOOKS/REFERENCES:

1. *Statistical Techniques for data Analysis: J.K. Taylor & Cheryl C, 2004 Chapman & Hall (CRC).*
2. *Performing Data Analysis Using IBM SPSS: Lawrence S Meyers, 2015, John Wiley.*

**18NS601**

**CELL BIOLOGY**

**2-0-0-2**

Cell Biology: Cell chemistry and biosynthesis: the chemical components of a cell, catalysis and the use of energy by cells, how cells obtain energy from food; Classification and properties of cell: Introduction to different types of cells; Membrane structure: the lipid bilayer, membrane proteins; Membrane transport of small molecules and electrical properties of membranes: principles of membrane transport, active membrane transport, ion channels; Intracellular compartments and protein sorting: compartmentalization of cells, the transport of molecules between the nucleus and cytosol, transport of proteins to different organelle; Intracellular vesicular traffic: molecular mechanisms, transport from the ER through the golgi apparatus, transport from the trans-golgi network to lysosomes, endocytosis, exocytosis; Mechanisms of cell communication: general principles, signaling through GPCRs and enzyme-coupled surface receptors, signaling pathways dependent on regulated proteolysis of latent gene regulatory proteins; Cytoskeleton: self-assembly and dynamic structure of cytoskeletal filaments, molecular motors, cytoskeleton and cell behavior, Cell cycle: an overview, cell cycle control system, control of cell division and cell growth; Apoptosis: cell death, extrinsic and

intrinsic pathways; Cell junctions, cell adhesion and extracellular matrix: cadherins and cell-cell adhesion, tight junctions, passageways from cell to cell, integrins and cell-matrix adhesion, extracellular matrix.

**TEXT BOOK:**

*Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell", Fifth Edition, Garland Publishing Inc. 2008.*

**REFERENCE:**

*Gerald Karp, "Cell and Molecular Biology", Fifth Edition, John Wiley, 2008*

**18MM621**

**IMMUNOLOGY**

**3-0-0-3**

**Basic concepts in immunology:** Cells and organs of the immune system, Principles of innate and adaptive immunity, The effector mechanisms of immunity, The complement system and innate immunity. The induced responses of innate immunity; Pattern recognition by cells of the innate immune system, Induced innate responses to infection.

**Antigen Recognition by B-cell and T-cell Receptors:** The structure of a typical antibody molecule, The interaction of the antibody molecule with specific antigen, Antigen recognition by T cells. Antigen presentation to T lymphocytes: The generation of  $\alpha \beta$  T-cell receptor ligands, The major histocompatibility complex and its function, Generation of ligands for unconventional T-cell subsets. Development of B and T lymphocytes: Development of B lymphocytes, Development of T lymphocytes, Positive and negative selection of T cells.

**T cell mediated Immunity:** Development and function of secondary lymphoid organs, Priming of naive T cells by pathogen-activated dendritic cells, General properties of effector T cells and their cytokines, T-cell-mediated cytotoxicity.

**The humoral immune response:** B-cell activation by antigen and helper T cells, The distributions and functions of immunoglobulin classes, The destruction of antibody-coated pathogens via Fc receptors.

**Integrated dynamics of innate and adaptive immunity:** Integration of innate and adaptive immunity in response to specific types of pathogens, Effector T cells augment the effector functions of innate immune cells, Immunological memory.

**Manipulation of the immune response:** Treatment of unwanted immune responses, Using the immune response to attack tumors, Fighting infectious diseases with vaccination.

**Modulating the immune system through nanotechnology:** Nanoparticles and the immune system, Nanoscale immune activation, Nanotechnology in vaccination, Nanoparticle-based vaccine carriers, Nanotechnology and immunosuppression, Nanoparticles as vehicles for immunosuppressants.

**TEXT BOOK:**

*Janeway's Immunobiology, Ken Murphy, Paul Travers, Mark Walport, 9th edition, Garland science publishing, 2007.*

**REFERENCE:**

*Cellular and Molecular Immunology, Abul K Abbas, Andrew H. Lichtman, Shiv Pillai 9th edition 2017.*

**18NS621                      SCIENCE AND PROPERTIES OF NANOMATERIALS                      3-0-0-3**

Basic Materials Science:

Materials classification by bonding, amorphous and crystalline materials, crystal lattices, Miller indices, defects in crystal structure, principles of dislocations, theory of diffusion, mechanical properties, phase diagrams, polymeric materials, composite materials, electrical and optical properties

Nanomaterials science:

Types of Nanomaterials, definition of nanoscale, surfaces and particle size, surface energy and surface tension and relation to size, phase transformation in nanomaterials, specific heat and heat capacity of nanomaterials, mechanical properties of nanomaterials, optical properties of nanomaterials, electrical and magnetic properties of nanomaterials.

Inclusion and importance of surface energy, equations of thermodynamics with surface energy  
Equilibrium Particle size, internal pressure and stability, nucleation processes

Kinetics of reactions at nanoscale, Diffusion at nanoscale, ripening among nanoprecipitates.

**TEXTBOOKS:**

1. *Materials Science and Engineering – An Introduction, William D Callister, 12<sup>th</sup> Edition, John Wiley (Available in Amazon India, Rs. 287)*
2. *Nanomaterials – An introduction to synthesis, properties and applications, D. Vollath, Wiley-VCH, Second Edition 2013.*

**18NS622                      NANOMATERIALS SYNTHESIS                      3-0-0-3**

Synthesis Methods of Nanomaterials: Top down : Milling; Bottom up approaches – Synthesis of zero dimensional metal, metal oxides, semiconductor nanoparticles by different routes – Colloidal method,

Sol-gel, Electrodeposition; Kinetically Confined Synthesis of Nanoparticles - Aerosol synthesis, Micellar growth, Spray pyrolysis, Template-based synthesis; Synthesis of one dimensional nanosystems by different routes – VLS and SLS methods, Electrospinning; Synthesis of two dimensional nanosystems – Fundamentals of Film Growth; Vapor phase deposition methods - Physical and chemical methods; Superlattices; Self Assembly; Langmuir-Blodgett Films; Electrochemical Deposition; Special Nanomaterials – Core/shell structures, Carbon-based Nanomaterials, Micro and Mesoporous Materials, Organic-Inorganic Hybrids

### **TEXT BOOK**

*G. Cao, Nanostructures and Nanomaterials – Synthesis, Properties and Applications, Imperial College Press 2006.*

### **REFERENCE**

*Nanostructured materials: Processing, Properties and Potential Applications, Edited by Carl. C. Koch, Noyes Publications, 2002.*

### **18HU601**

### **AMRITA VALUES PROGRAM**

Culture – definition and scope. Values and culture, cultural freedom

Culture and Education

Culture of Research – creativity and responsibility in research

Spirituality and Culture – spirituality as a way of life, spirituality and religion

Culture and women – gender oppression, motherhood

Culture and the Media

Culture and Politics – national values and political harmony

Philosophy and Culture, epistemology

### **18NS623**

### **CELL CULTURE AND ANIMAL LAB**

**1-0-1-2**

Cell culture module introduces the students to the basics of cell culture. The course provides students with sufficient knowledge and laboratory skills needed in the academia and industry for carrying out basic cell culture techniques properly and safely. On completion of the course, the student should be able to: account at a general level for the function, maintenance and working of Bio-safety Cabinets (BSC) and be able to work in BSCs with a good sterilization technique, account for different preventive measures to avoid contamination of cell cultures and how a contaminated cell culture may be treated, account in detail for sterilization equipment and sterilization techniques, account for different cell-culture media and important components in the media; be able to apply basic cell-culture techniques, such as cell counting using hemocytometer and harvesting of cells. Explain different factors of significance in the cultivation of cells *in vitro* and be able to maintain cell lines in culture for a longer period of time without contamination.

**Contents-**The course starts with theory i.e. basic lecture about a general lay out of a cell culture lab, physical environment needed for the cell culture, growth media and its composition, Biosafety cabinets (BSC), its use in cell culture and how to work in a BSC, contamination during cell culture and how to control it, culturing and splitting of cell lines, cryopreservation of cells and cell viability

assays. After qualifying the Biosafety examination, students start working in the cell culture lab. The laboratory work starts in small groups. In the practical laboratory work, the students will have hands-on experience in counting, harvesting, culturing and maintaining cell lines.

**Animal handling techniques** – animal feed, gavage, different routes of injection, ethical treatment of animals and Institutional Animal Ethics Committee policies.

**TEXT BOOK:**

*R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6<sup>th</sup> ed. 2010. Wiley-Blackwell.*

**REFERENCES:**

1. *CPCSEA Guidelines for Laboratory Animal Facility, 2004.*
2. *Guide for the Care and use of Laboratory Animals – 8<sup>th</sup> Edition, 2011, The National Academic Press.*

**18NS624**

**LAB: NANOMATERIALSLAB-I**

**1-0-2-3**

1. Metal Nanoparticles : Synthesis of plasmonic silver nanoparticles
2. Metal-oxide Nanoparticles: Synthesis of ZnO nanoparticles through non-aqueous route.
3. Absorption Spectroscopy of metal oxide (ZnO) nanoparticles and particle size calculation using Brus equation
4. Semiconductor Nanoparticles: Synthesis of doped ZnS nanoparticles through aqueous method; characterize fluorescence property using spectrofluorimeter
5. Silica Nanospheres: Synthesis and characterization by sol-gel chemistry
6. Surface Plasmon Resonance (SPR) analysis of differently shaped and sized gold nanoparticles by absorption spectroscopy
7. Nanoparticle imaging by Atomic Force Microscope for size and shape analysis

**SECOND SEMESTER**

**18NS602**

**PHARMACOKINETICS AND PHARMACODYNAMICS**

**2-0-0-2**

Nature of drugs, drug-body interactions, permeation of drugs, drug groups, macromolecular nature of drug receptors, drug concentration and response, drug distribution and elimination of single and multiple drugs in single and multi-compartment models, derivation of relationships between various pharmacokinetic parameters like clearance, volume of distribution, elimination rate constant, half-life etc. Fundamental principles guiding absorption, distribution, metabolism and elimination of drug molecules, basics of population pharmacokinetics, pharmacogenomics, and single-gene pharmacokinetic disorder. Pharmacodynamic concepts related to affinity and efficacy of drug molecules, drug binding, receptor actions, transport proteins, enzyme action, ion channel function and extrusion mechanisms using specific drugs – acetaminophen, warfarin, certain antibiotics, and anti-malignant drugs. Mechanism of action of selected drugs will be discussed.



**TEXT BOOK**

*Katzung B.G., Masters S.B., Trevor A.J., "Basic and Clinical Pharmacology", 13<sup>th</sup> Edition, McGraw Hill, 2014*

**REFERENCE:**

*Malcolm Rowland, Thomas Tozer, "Clinical Pharmacokinetics and Pharmacodynamics, Concepts and Applications", 4<sup>th</sup> Edition, WoltersKluver, 2011*

**18NS603      BIOINFORMATICS AND STRUCTURE BASED DRUG DESIGN      2-0-1-3**

Introduction to Concept of Genomics, Proteomics and Bioinformatics; Databases on web: Genome, Proteome and Molecular biology; Sequence alignment: Near-optimal sequence alignment; Global pair wise sequence alignment; Multiple sequence alignment; Genome rearrangement; Evolutionary Bioinformatics: Phylogenetic tree construction and analysis. Different methods used for protein evolution; Protein Modeling: Protein structure prediction and analysis, Protein visualization software, Protein dynamics and Protein structure validation tools.

Cheminformatics: Basic idea of molecule design, Visualization and generation of 2D and 3D molecular structures, Chemical databases and its implications, Pharmacophore model, Virtual screening, Ligand based and structure-based molecular design; Commands and Languages: Basic Unix and Linux commands, Extensible markup language and its use in Bioinformatics; Sequence similarity and database search: Pattern recognition and matching; Quantitative and probabilistic pattern matching; Sequence pattern databases, Spectral pattern matching, String matching algorithm. Pharmacy Informatics: Medical databases and clinically relevant drug-drug interactions, Pharmacy information system, Telemedicine and Telehealth.

**Lab course work:**

Basic linux commands and linux editors, X-windows and linux environment used for learning different linux commands and text editors like vi, xedit etc. Exposure to different useful databases, virtual screening and Data mining, Different biologically important databases were explored. Structural similarity search of drug like molecules were mined from different small molecular databases. Sequence alignment studies of protein family using BLAST software.

**TEXT BOOK:**

*Mount D W, "Bioinformatics Sequence and Genome Analysis", Cbs Publishers & Distributors (2003), ISBN: 8123909985*

**REFERENCE:**

*Practical Bioinformatics; Editors: Bujnicki, Janusz M. (Ed.), Series: Nucleic Acids and Molecular Biology, Springer publisher, 10.1007/978-3-540-74268-5, 2008.*

**18NS604****REGENERATIVE MEDICINE****3-0-0-3**

Biologic and molecular basis for regenerative medicine: Molecular organisation of cells, Cell -extracellular matrix interactions in repair and regeneration, How cells change their phenotype, Somatic cloning and epigenetic reprogramming in mammals.

Cells and tissue development: Embryonic stem cells; derivation and properties, Induced pluripotent stem cells, Mesenchymal stem cells in regenerative medicine, Multipotent adult progenitor cells, Hematopoietic stem cell properties, markers, and therapeutics, Cardiac stem cells: biology and therapeutic applications, Skeletal muscle stem Cells, Stem cells derived from fat, Peripheral blood stem cells, Pancreatic stem cells, Determinants of tissue development, Angiogenesis, Morphogenesis of bone, Physical stress as a factor in tissue growth and remodeling, organoids.

Inherent regenerative mechanisms: Blood regeneration, Wound healing and skin regeneration, Bone regeneration, Liver regeneration, Peripheral nerve regeneration, The multifactorial role of peripheral nervous system in bone growth.

Decellularized scaffolds in tissue regeneration: Decellularization of tissues and organs, Repopulation of decellularized scaffolds using stem cells, Decellularized scaffolds as a platform for regenerating tissues and organs.

Therapeutic applications: Cell therapy for bone repair and regeneration, Cell therapy for articular cartilage regeneration, Cell therapy for heart diseases, Bone marrow transplantation, Myoblast transplantation in skeletal muscles, Islet transplantation, Stem cell derived secretome. Exosomes for regenerative medicine.

**TEXT BOOK**

*Principles of Regenerative Medicine, Anthony Atala, Robert Lanza James, Thomson Robert Nerem, 2nd Edition, Elsevier -2010*

**18NS625****CHARACTERIZATION OF NANOMATERIALS****3-0-0-3**

X-ray diffraction and Reciprocal lattice, Bragg's law, Ewald's sphere construction, XRD of nanolayers, effects of nanosize and shape anisotropy of nanostructures, texture and strain measurements, SEM: scattering of electrons, secondary and backscattered electrons, electron sources, imaging modes in SEM and its use for nanomaterials size and shape analysis, TEM: Interaction of high energy electrons with matter, elastic and inelastic scattering, TEM instrumentation, imaging and diffraction modes of operation, imaging and contrast in TEM, HRTEM, Energy dispersive analysis of x-rays, Nanomaterials size and size distribution analysis, shape and structural analysis, SPM: Principle of operation, contact and non-contact AFM, dynamic force microscopy, and various other modes of SPM including STM. Chemical Characterization – Optical Spectroscopy, IR spectroscopy: vibrational modes, theory of IR spectroscopy, infrared spectrometers, single and group frequencies, advantages of FTIR. Raman spectroscopy, surface enhanced Raman spectroscopy, X-ray photoelectron spectroscopy. Use of these techniques for nanomaterials and biomaterials analysis.

**TEXT BOOKS**

1. *Harold P. Klug and Leroy E. Alexander, "X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials", Second Edition, Wiley-Interscience, 1974*
2. *C. N. Banwell and E. McCash, Fundamentals of Molecular Spectroscopy, McGraw Hill Education (2017).*

**REFERENCE:**

N. Yao and Z. L. Wang, *Handbook of Microscopy for Nanotechnology*, Springer Science and Business Media (2005).

**18NS626****POLYMERIC NANOMATERIALS****2-0-0-2**

**Basic Concepts of Polymer Science**-Classification of polymers–chain polymerization–mechanism of free radical, cationic, anionic and co-ordination polymerization–ring opening polymerization–Copolymerization-preparation of block and graft copolymers, Techniques of polymerization–bulk, solution, emulsion, suspension, interfacial, gas phase and melt polycondensation.

**Biopolymers**-Natural and Synthetic biopolymers; Biopolymer composites-both degradable and non-degradable; Dendrimers-Structure, Preparation; Types of hydrogels, in situ/injectable hydrogels, thermo-sensitive polymers-LCST properties.

**Polymeric Nanomaterials**-Polymeric nanoparticles-preparation methods; Nanogels-Preparation methods; Different types Nanofibers and nanocomposite scaffolds preparations. Biomedical applications of nanoparticles, nanogels, nanofibers and nanocomposite scaffolds.

**TEXT BOOK**

V. R. Gowariker, N. V. Viswanathan and JayadevSreedhar, “*Polymer Science*” New Age International (p) Ltd., New Delhi, 2015.

**REFERENCES**

1. Michael Niaounakis , “*Biopolymers: Applications and Trends*”, 1<sup>st</sup> Edition, Elsevier, 2015.
2. Challa S. S. R. Kumar, “*Polymeric Nanomaterials*”, Wiley, 2011.

**18NS627****NANOMEDICINE AND NANOTOXICOLOGY****2-0-0-2**

Nanomedicine: Basic concepts in the design of nanomedicine, specification and desired features of nanomedicine, nanomaterials and general process steps involved in the preparation of nanomedicines. Nanomedicines for various disease conditions: infectious diseases, neurological diseases: (challenges of blood brain barrier), pulmonary disorders, cardiovascular diseases, cancer: nano-chemotherapy, -radiation therapy, -immunotherapy, -nuclear medicine therapy, -photodynamic therapy, -photothermal and RF hyperthermia therapy, -scintillation therapy, gene-therapy: DNA, RNA delivery. Theranosticnanomedicines: Basic concept, multifunctional nanomedicines for theragnosis.

Nanotoxicology: basics of cellular and organ level toxicity, effect of nanosize, shape, surface properties and composition on toxicity of nanomedicines, Case studies: Ag, ZnO, TiO<sub>2</sub>, Quantumdots, carbon-basednanomaterials, polymeric, protein and lipid nanoparticles.

**TEXT BOOK**

*Understanding Nanomedicine: An Introductory Textbook* Rob Burgess, CRC Press, 2012.

**REFERENCE:**

1. *Nanomedicine for Cancer Therapy: From Chemotherapeutic to Hyperthermia-Based Therapy*, Springer, Piyush Kumar, RohitSrivastava, 2017
2. *Nanotoxicology, Materials, Methodologies, and Assessments*, Editors: Durán, Nelson, Guterres, Silvia S., Alves, OswaldoLuiz (Eds.),

**18NS628**

**DRUG DELIVERY SYSTEMS**

**2-0-0-2**

Different types of Drug Delivery Systems based on the Administration Routes: Oral Drug Delivery, Features of Gastrointestinal tract (GI), Targeting of drugs in the GI tract, Design and fabrication of oral systems - Dissolution controlled, diffusion controlled, osmotic controlled, chemically controlled release, Intravenous Drug Delivery - Factors controlling pharmacokinetics of IV formulations, Concept of opsonization, Transdermal Drug Delivery, Structure of human skin and theoretical advantages of the transdermal route, Transdermal penetration of drugs, adhesion, bioactivity, Examples of transdermal drug delivery systems, Intranasal Drug Delivery - Nasal physiology and intranasal Drug Administration, Nasal drug delivery devices, examples, Ocular Drug Delivery: Structure of human eye, Examples of Ocular Drug Delivery devices; Miscellaneous Drug Delivery Strategies for Advanced Drug Delivery: Concept of Drug Targeting; Prodrug and Bioconjugation; Nanoscale Drug Delivery Systems - Advantages of nanodrug delivery – Improvements in pharmacokinetics, bioavailability, biodistribution; Concepts of controlled and sustained drug delivery, How nanoparticles pass barriers; Surface modification of nanoparticulate carriers; Nanocarriers for drug delivery - Lipid based pharmaceutical nanoparticles – Liposomes, Solid Lipid Nanoparticles, Nanostructured Lipid Carriers, Cubosomes and Hexosomes, Polymeric Micelles, DNA- Based Nanomaterials, Dendrimers, Polymeric nanoparticles, Inorganic nanoparticles, Hydrogels for controlled drug delivery; Active and passive nanocarriers – Concept of targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules, Stimuli-Responsive Target Strategies; Implants; Protein and Peptide Drug Delivery; Delivery of Nucleic Acids; Delivery of Vaccines; Aptamers in Advanced Drug Delivery; Biomimetic Self-Assembling Nanoparticles Nanotechnology Challenges; Regulatory Considerations and Clinical Issues in Advanced Drug Delivery

**TEXTBOOKS:**

1. *Drug Delivery Systems*, Pieter Stroeve and MortezaMahmoudi, World Scientific Series: From Biomaterials towards Medical Devices, Vol I, 2018.
2. *Nanoparticulates as Drug Carriers*, Vladimir Torchillin, Imperial College Press, 2006

**REFERENCE:**

*Drug Delivery Systems, Third Edition*, Vasant V Ranade, John B. Cannon, by CRC Press, 2011

1. Polymeric Nanoparticles: Synthesis of alginate nano and micro particles; characterization of particle size by Dynamic Light Scattering (DLS) and Zeta analysis
2. Fourier Transform Infra-red Spectroscopy(FTIR): Preparation of Chitosan Nanoparticles and characterization using FTIR
3. Electrospinning: Fabrication of electrospun PVA nanofibres and microfibers; characterization of fibers morphology and diameter using SEM
4. Thermal characterization of polymers using Thermogravimetric – Differential thermal Analysis (TGA-DTA)
5. X-ray diffraction spectrometer (XRD): Structural characterization of crystalline and amorphous nanomaterials
6. Raman spectroscopy: Characterization of polymeric and inorganic samples using Raman Spectroscopy
7. Mechanical Testing and Rheology: Characterization of materials mechanical properties by studying stress-strain curve.

### THIRD SEMESTER

#### 18RM601 ETHICS IN RESEARCH AND RESEARCH METHODOLOGY 1-0-1-2

Plagiarism, regulatory principles, safety in research, ethics in stem cell research, ethics in clinical research, ethics in nanomaterials based research

Principles of data documentation, protocol development, research questions and hypothesis driven research.

#### TEXTBOOKS:

1. *Research Ethics for Scientists*, C. Neal Stewart Jr., Wiley-Backwell Publishers, 2011
2. *Ethics in Science, Ethical Misconduct in Scientific Research*, John D'Angelo, CRC Press, 2012.

#### 18NS630 NANOSYSTEMS IN MEDICAL DIAGNOSTICS 2-0-0-2

Module I-Medical Diagnosis- from biomarkers to cells and tissues, Classical clinical diagnostic imaging tools: MRI, PET, CT, Ultrasound, Optical- principles, methods and challenges; Molecular techniques- principles, methods and challenges

Module II-Bringing in nanoscale materials and devices for diagnosis: Application in MRI, CT, NIR, Ultrasound, Nuclear and Optical imaging; Nanobio-sensors in diagnosis- cantilever based sensors, enzymatic and non-enzymatic sensors, electrochemical sensors, piezo electric biosensors, Lab-on-a-chip concept, Bio- microelectromechanical systems (Bio-MEMS), Microfluidics, surface enhanced Raman spectroscopy based diagnostics, surface plasmon based bio sensors; Current nanotechnology based diagnostics in use and under clinical trials.

**TEXT BOOKS/ REFERENCES:**

1. Ying Deng and Jordan Kuiper, *Functional 3D Tissue Engineering Scaffolds: Materials, Technologies, and Applications (Woodhead Publishing Series in Biomaterials)*, 2017
2. *Emerging nanotechnologies for diagnostics, drug delivery and medical devices*, Kishore Cholkar, AbhirupMandal, AshimMitra, Elsevier (2017)
3. *Nanobiosensors and Nanobioanalyses*, Vestergaard MC, Kerman K, Hsing IM, Tamiya E, Springer 2015
4. *Current Medical Diagnosis and Treatment*, Maxine A Papadakis, McGraw Hill Education, 2017

**18NS631****SCAFFOLDS IN TISSUE REGENERATION****2-0-0-2**

Definition and requirements of a scaffold, functions of a scaffold, structure of a scaffold, materials for scaffolds and their influence on scaffold properties, scaffold structure. Use of nanomaterial in scaffolds, scaffold influence on cellular behavior- role of scaffoldporosity, mechanical strength, surface chemistry, scaffold rigidity; surface topography, hydrophobicity/hydrophilicity, degradation behavior.

Fundamental aspects of tissue response to nanomaterials-Protein adsorption on nanomaterials, Cellular response to nanomaterials; Blood-material interactions, Inflammatory and immune response to nanomaterials, Angiogenic response to nanomaterials.

Biocompatibility of nanomaterials, *In vitro* and *in vivo* biocompatibility tests as per ISO

Case Studies-Applications of nanomaterials in Skin regeneration, Bone regeneration, Liver regeneration, Vascular tissue regeneration, Cartilage regeneration

**TEXT BOOKS/ REFERENCES:**

1. Ying Deng and Jordan Kuiper, *Functional 3D Tissue Engineering Scaffolds: Materials, Technologies, and Applications (Woodhead Publishing Series in Biomaterials)*, 2017
2. Cato T. Laurencin, Lakshmi S. Nair. *Nanotechnology and Regenerative Engineering: The Scaffold*, Second Edition, CRC Press 2017