Institute of Nano Medical Sciences (INMS)
University Of Delhi

Ordinance relating to M.Sc.-Ph.D. Combined Degree Programme in Nano Medical Sciences

M.Sc-Ph.D. Combined Degree Programme in Nano Medical Sciences:

1. There shall be a M. Sc-Ph.D. combined degree programme in Nanomedical Sciences offered by the Institute of Nanomedical Sciences

2. The programme shall run on a full-time basis for 3-5 calendar years.

   M.Sc.- Ph. D is a three to five years-long dual degree programme that combines MSc and Ph.D. This integrated course rewards a student with a double degree. A M.Sc. is a postgraduate degree in Nano Medical science discipline. Candidates who have completed a B.Sc/B.Tech/B.V.Sc/B.D.S./B.Pharm. /B.A.M.S/M.B.B.S or equivalent degree are eligible for enrolling in M.Sc. or MSc-PhD dual degree in Nano Medical Sciences,

   While a PhD is a doctoral level research degree programme. Candidates who have completed 10+2+3+2 or 10+2+4 level course are eligible for enrolling in the Ph.D. course. The multi-disciplinary curriculum covers the core and elective course modules. M.Sc. Ph. D integrated course is designed to fulfil the requirements of a modern researcher of familiarity with the experimental, clinical and theoretical fields related to Nanomedical Sciences.

3. Subject to the overall control of the Academic Council, the M. Sc-Ph. D (Nanomedical Sciences), combined degree programme will be reviewed by a M.Sc-Ph.D. committee consisting of the Director, and all Professors, Adjunct Professors in India and abroad associated with INMS and such other (including teachers from other departments wherever necessary) recommended by the Dean of Faculty of Medicine, on the advice of the chairman of M.Sc-Ph.D. committee and approved by the Vice-Chancellor. However, total membership of the committee shall not exceed 15. The Heads of the participating department shall be Co-chair of the committee by rotation for a period of 2 years, appointed by the Vice-Chancellor on the recommendation of the Dean of Faculty of Medical Sciences on the advice of the Director (who will be the chairman of the Committee).

This committee shall:

a) Invite and scrutinise applications and make admission to the M.Sc.-Ph.D (Nano Medical Sciences) combined degree programme,
b) Design courses and laydown syllabi for the same;
c) Organise lectures, seminars and supervise the thesis work etc.;
d) Make arrangement to conduct oral/written examination, evaluating performance in day-to-day work including test, seminar, viva-voce etc.

4. The duration of the programme for full-time students shall ordinarily be minimum of five calendar years for students coming from stream B (10+2+3) and four calendar years for the students from stream A (10+2+4). Variation in the duration of the programme may be allowed by the Academic Council on the recommendation of M.Sc.-Ph.D. committee.

5.

a) A candidate seeking admission to M.Sc.-Ph.D. combined degree in Nano Medical Sciences course must have passed the Bachelor of Sciences examination in Life Science/ Zoology/ Botany/ Microbiology/ Chemistry/ Environmental Biology / Biotechnology / Lab techniques/ / B.tech / Bioinformatics/ M.B.B.S / B. Pharma / and B.V.Sc. etc. with at least 55% marks or 6.0 CGPA from university of Delhi or any other examination recognised by the University as equivalent thereto, and also must possess such other qualifications Including passing of an entrance examination written and or practical, and /or oral, as may be prescribed by the Academic Council from time to time.
b) Eligibility of the students from the both streams A&B for admission to M.Sc.-Ph.D. combined programme would be decided by the committee on the basis of their performance in the courses during Ist year of Master's degree in Nanomedical Sciences.
c) However, the minimum qualification for direct admission to the Ph.D. programme shall be a Master's degree in the above-mentioned disciplines of an Indian University, with at least 55% marks or 6.0 CGPA in the aggregate or an equivalent qualification recognised by the Academic Council.

6. **Attendance:** A candidate registered for the above course shall not be deemed to have satisfied the required condition of the attendance unless he/she has attended not less than 75% of the lectures and the practicals separately in each subject in order to be eligible for admission to each examination (Part-I, Part-II, Part III and Part-IV) and after two years for research work minimum of three years residency period is must as per ordinance VI of the University.

   Students shall be required to attend lectures and participate in seminars arranged by the INMS during the programme. The minimum percentage of the lecturers to be attended and seminars to be participated by the students shall be determined by the M.Sc.-Ph.D. committee. But, in no case the minimum requirement shall be less

than 2/3rds of the lecturers delivered and seminars held, separately and satisfactory completion of the thesis work. An advisory committee of 2 to 4 members including the supervisor/s of the candidate will be constituted for each student. The advisory committee will advise the student in his/her studies, seminar work and dissertation work etc.

7. Once the candidate qualifies 60 credits, required for M.Sc. degree, he/she will be recommended for the award of Master's degree by the University and immediately thereafter, the M.Sc.-Ph.D. committee will recommend to the Departmental Research Committee (DRC) to forward his/her application for Ph.D, registration to the Board of Research Studies (BRS) in the Faculty of Medical Sciences or any other faculty.

8. **Minimum requirements for establishing M.Sc.-Ph.D. Degree Candidacy**

Annexure I

	Credits
Required Courses Semester I	16
Core Courses (Semester-II & III)	22
Specialization Courses Semester-IV (Comprehensive Examinations or Thesis)	20
Advance Courses (for M.Sc.-Ph.D/Ph.D)	12
Non-Course Requirement	
Residence Requirement	
Research Proposals Defence	
Colloquium Presentation	6
Doctoral Dissertation (take 3 times)	20
Viva-Voce	4
Total	**100**

Note: Students must consult their advisors when selecting course, because of the composition of the comprehensive examination for each speciality area.

9. Scheme of Examination

At the end of each semester, there will be a three-hour examination for each course. The M.Sc.-Ph.D. Examination shall be held by the committee in five parts as follows:

Part-I: Students will be required to opt for required papers (14 credits) enlisted in the Annexure I. The exanimation shall be held at the end of the semester I.

Part-II: After passing the required course in semester I, a student shall select out of the core course offered (see Annexure II) for at least 9 credits (semester II).

Part-III: After Passing the examination in the 1 year (Part-I and Part-II), a student shall be required to select 9 credits from core courses (see Annexure II) and another 4 credits of specialization courses (see Annexure III) on a subject approved by the advisory committee under the supervision the supervisor/s appointed for the purpose.

Part-IV: Candidates who are selected for direct M.Sc.-Ph.D. combined programme will be required to pass 9 credits out of advance specially required Ph.D., (see Annexure IV) as well as rest of the credits (5) from the specialization course, (see Annexure III).

Part-V: From fifth semester, a student shall be required to work on research topic on a subject approved the advisory committee under the supervision of the supervisor/s appointed for the purpose. The thesis will be submitted only when the supervisor/s concerned is/are satisfied that the thesis is worthy for the completion of the M.Sc.-Ph.D degree. Provided that the application for submission of thesis shall also be countersigned by the Director of the Institute. The thesis should include results of original research, a fresh interpretation of the existing facts and data, a review of upto data literature.

Thesis Requirement

Each doctoral student must complete the results of extended research and make an original contribution to the field. This work should give evidence of the candidate's ability to conduct independent investigation and to interpret the results in an acceptance manner.

The thesis advisor (two co-advisor for the interdisciplinary option, described next) serves as chairman of the thesis committee, which consists of no fewer than six members appointed by the Director of the program. The selection of an advisor is by mutual consent of the student and a member of the faculty, with the approval of the Director. At least two members of the committee must be faculty members of the University, and at least one must be from outside the Department or even abroad. To ensure high quality of the thesis, the director of the program may appoint additional outside referees or experts. Individuals are chosen for their expertise in the student's area of research. The student's research progress will be evaluated by this advisory committee, which meets no less than once a year; at each meeting the student presents both a written and an oral progress report. Low productivity or unsatisfactory work may result in the student's dismissal from the program at any time. A thesis advisor should normally be selected within four months of joining the course and the student is expected to begin research and demonstrate satisfactory proficiency in the laboratory.

Interdisciplinary Option

An interdisciplinary option is available to the students in the Nanomedical Science M.Sc.-Ph.D. program. The option is intended to meet the needs of students interested

in combining courses and skills from two areas of specialization. At least one of the specialization areas selected must come from within the institute. The second area may come from another department or Institute in India or abroad, such as Regenerative Medicine, Stem cell Engineering, Biology, Chemistry, or Engineering etc. Thesis co advisors are arranged for student who select this option. Students may begin to consider its option by discussing it with a faculty member in the institute who represents one of their areas of interest and by informing the M.Sc.-Ph.D. Program Director's office.

The two areas of academic consideration are reflected in the course work, cumulative exams, and thesis work undertaken. Students take the required courses and the remaining course will be selected with the help and approval of the co advisors. Students selecting the interdisciplinary option must fulfil the same requirements as all the other Ph.D. candidates and will be governed by the ordinance VI of the University.

Research proposal defence

After completing the qualifying examination, student with the approval of the advisory committee or thesis committee, will prepare a written proposal and defend it orally to the committee before submitting the synopsis of the thesis to the committee of courses. The signed proposal form should be submitted to the Ph.D. program Director's office.

Thesis Defence

The final oral examination will be taken after the completion of all other requirements for the degree. The examination deals with the subject matter of the Doctoral dissertation, significant developments in the field of the thesis, and the students background knowledge in the field of specialization. The thesis committee will conduct the final oral examination. The Director of the Nano Medical Sciences of M.Sc.-Ph.D. program, in consultation with the supervisor may appoint any other additional members considered necessary by this committee.

The award of the degree of Doctor of Philosophy shall be granted in the M.Sc.-Ph.D. combined programme of Institute of Nano Medical Sciences according to the Ordinance VI of the University of Delhi.

Advanced Courses: requirements for M.Sc-Ph.D. combined degree programme

The Doctor of Philosophy degree program in Nanomedical Science offers specializations in Regenerative Medicine, Stem Cell Research, Nano biosafety, and nano taxology, cancer nano medicine, pharmokinetics and pharmodynamics , biosensors, industrial pharmacy, nano vaccines, nano- medical laboratory science, nano- medical biotechnology, nano-pharmaceutics, nano-pharmacology, and nanotechnology. These specializations may be taken on an interdisciplinary basis. Candidates should complete their degree in three to five years, depending on their motivations and progress of their research. Doctoral candidates may look forward to careers in research, industry, education, and hospital settings.

The students' advisors, and co-advisor select nine credits of specialization courses and eight credits of general electives, which focus on area of concentrations. The selection of courses is approved by the Director of the Nano Medical Sciences Ph.D program.

General Nano Medical Sciences

This master's program will attract research technician clinical laboratory workers science teachers, science administrators, and students interested in pursuing in doctoral degree.

Nano Medical Laboratory Science (M.Sc.-Ph.D.)

This Master's program will serve students from a variety of academic and professional backgrounds. Some of students working or who have worked as medical technologists in hospitals and in industry, or others will come from the specialized training certification. Many of our students may seek to increase their potentials for employment and advancement. Concentration options include clinical chemistry, hematology, immunology and clinical microbiology.

Professional Requirements:

- Students be eligible to write, the examination in nano medical laboratory technology in one of the categorical or specialist certifications given by the National Medical Commission, National Board of Examiners, National Certification Agency for Medical Laboratory personnel, or the examination given by the National Board of Clinical Chemistry or any other examination given by equivalent Board.
- Students intending to complete professional requirements in an approved hospital or medical school must apply directly to the Director or Institute of Nano Medical Sciences, University of Delhi.
- Some students may be given the opportunity to complete the professional requirement through a hospital affiliated to Delhi University or any other hospital in India or abroad recognised by the Medical Council of India/National Medical Commission. On the basis of the merit, students will be selected for overseas training. Students completing the professional requirements through the University may receive a maximum of four credits of graduate credit contingent upon approval of the program Director of Institute of Nano Medical Sciences.

Qualifying Examinations. A qualifying examination will be administered to students in the Ph.D. program twice each academic year in order to test student's knowledge and skills in both required courses and specific scientific areas. Students are expected to take this examinations within two years of admission. The examination is composed of three parts.

- general and specialization written examinations
- general oral examination to be given approximately two weeks after completion of the written exams
- presentations and defence of a specific research proposals different from the student's thesis project.

The three parts of the examination should be completed before the viva-voce examination.

The general portion of the written exam contains questions from the required core courses and additional courses in the following proportions.

- Biomolecules and Biomacromolecules for Nanomedicine
- Introduction to Nanomaterials: Types and Synthesis
- Basic Properties and Characterization of Nanoparticles
- Basics of Cell Biology and Organ System
- Nanomaterials for Diagnostics and Therapeutic Applications
- Interaction of Nanomaterials with Biological System
- Biosensors
- Experimental Design and Biometrics
- Nano Medical Analysis
- Cancer Nanomedicine
- Research Methodology, IPR aspects
- Ethics in Research; Responsibilities to Society, Science and Self
- Law in Nano Medical Science
- International collaborations in Nano Medical Science
- Technology Promotion and Science Diplomacy
- Clinical trials and Translational nanomedicine
- Nano-vaccine
- Nano medicine in Regenerative medicine

The Ph.D. Qualifying Examinations Committee may judge the general exam as satisfactory (a grade of 60 or higher) or unsatisfactory (below 60). Students who pass the general exam will be allowed to sit for the specialization exams starting no later than four weeks after the general portion has been administered. Students who fail the general exam will be given one opportunity to retake it. Students who fail to pass the general exam twice are deemed to have failed the Ph.D. Qualifying exam and will be required to withdraw from the Ph.D. program.

The specialization portion of the exam is cumulative in nature. Six Separate sets of questions will be prepared by appropriate faculty members. Each of these six exams take three to four hours to complete and will be scheduled within two weeks of each other. The exams are graded by the questions provider (s). Students are required to

pass at least three of the six exams. Students who fail four exams are required to withdraw from the Ph.D. program.

The oral examining committee consists of the dissertation adviser, two other member of the faculty, and one expert from outside University and selected by the Program Director and approved by the University. Students must pass the written portion (both general and specialization exams) in order to take the oral examination at the scheduled time. Students who fail the orals are given one opportunity to retake them. Students failing the oral examinations twice are withdrawn from the program.

Reservation Policy:

Reservation in admission of SC/ST/OBC/EWS candidates will be implemented as per the University rules/policy of Government of India.

Foreign Students:

Foreign students will be admitted as per the guidelines of the University rules/policy of Government of India.

Number of Candidates to be admitted: 30 seats

Note:

As per the New Education Policy (NEP) students pursuing master's degree at Institute of Nano Medical Sciences or at a partner institution in India or abroad approved by the University may be permitted to pursue Ph.D. degree jointly with any partner institutions in India or abroad with an approved supervisor.

Annexure I

MSc-Ph.D. Nanomedical Sciences

Duration 5 years

Semester I:

S. No.	Paper name	Paper topic	Credits
1	Core 1	Biomolecules and Biomacromolecules for Nanomedicine	4
2	Core 2	Introduction to Nanomaterials: Types and Synthesis	4
3	Core 3	Basic properties and Characterization of Nanopartilces	4
4	Practical 1	A) Basic nanoparticle synthesis B) Characterization studies of nanoparticles	4

Total Credit: 16

Semester II:

S. No.	Paper name	Paper topic	Credits
1	Core 4	Basics of cell biology and organ system	4
2.	Core 5	Nanomaterials for Diagnostics and therapeutic applications	4
3	Core 6	Interaction of nanomaterials with biological system	4
4	Practical 2	A)Basic nanoparticle interactions-Imaging B) *in vitro* studies using nanoparticles	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Nanomaterials in regenerative medicine	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4.	Elective 4*	Nanobiosafety and nanotoxicology	4

Total Credit: 16 + Elective 4 + Open Elective 2 = 22

Semester III:

S. No.	Paper name	Paper topic	Credits
1	Elective 1*	Nanomaterials for antimicrobial applications	4
2	Elective 2*	Immune System and Innate Immunity	4
3	Elective 3*	Pharmacokinetics and Pharmacodynamics	4
4	Elective 4*	Nanobiosafety and Nanotoxicology	4
5	Elective 5*	Recombinant DNA technology and non-viral gene therapy	4
6.	Elective 6*	Cancer nanomedicine	4

6	Open elective 1	Ethics in Research: Responsibilities to Society, Science, and Self	2
5	Practical 3	Immunotechniques, Biotechniques, *in vivo* studies using nanoparticles	

* Any two

Semester IV:

S. No.	**Paper name**	**Paper topic**	**Credits**
1	Elective 7*	Biosensors	4
2	Elective 8*	Nanomedicine for neurological diseases	4
3	Elective 9*	Nanomedicine for pulmonary, hepatic and nephrological diseases	4
4	Elective 10*	Nanomaterials in regenerative medicine	4
5.	Elective 11*	Nanovaccines	4
6.	Elective 12*	Industrial Pharmacy	4
	Practical	Synthesis of micropartcles for vaccines, Immune responses in *in vivo* studies	4
	Semester IV		4
4	Open Elective 2	IPR aspects, clinical trials and translational nanomedicine	2
5	Project work	Six months	20

* Any two

Annexure -II

Core 1: Biomolecules and Bio-macromolecules for Nanomedicine

Duration: 60 hrs

Unit I: Nature, Properties and Function of Carbohydrates: Sugars-dissacharides, trioses, tetroses, pentoses, hexoses – stereoisomers – amino sugars, phosphosugars, sugar derivatives, deoxysugars - Oligossacharides-polyssacharides - homo and hetero polyssacharides, amylose, amylopectin, dextrans, limit dextran – starch - glycogensynthesis and degradation-glycolysis, TCA cycle, glycosyl moieties, cell wall polyssacharides – cellulose, chitin.

Unit II: Nature, Properties and Function of Lipids: Fats, Oils, Waxes; Fatty acids:
types, saturated, unsaturated, essential, short and long chain; triglycerides, lipids and cholesterol; Biosynthesis of fatty acid/triglyceride/cholesterol and Biological oxidation/degradation of alpha, beta and omega fatty acids.

Unit III: Nature, Properties and Function of Proteins: Amino acids: Essential and non-essential amino acids, dipeptides, oligipeptides, polypeptides. monomers, dimers, oligomers; fibrous proteins and globulins; primary, secondary, tertiary, quarternary structures; disulfides, hydrogen bonds, Schiff's base- amino and carboxy termini - alpha helix and beta plates; triple helix; Ramachandran plots.

Unit IV: Nature, Properties and Function of Nucleic acids: Nitrogen bases-purines, pyrimidines, nucleosides and nucleotides-oligonucleotides - base paring- DNA, RNA-tRnNA, mRNA, rRNA, antisense RNA-linear and circular forms, single and double stranded; hypo and hyperchromicity-extra chromosomal DNA- mitochondrial, choloroplastic, plasmid and viral – microsatellites – DNA varieties – A, B, and Z – Okazaki fragment – palindrome-concatenation- polymorphism – mutation – strand breaks – genes – promoters, enhancers, structural genes - gene expression – gene silencing - transposons – telomeres.

Core 2: Introduction to Nanomaterials: Types and Synthesis

Duration: 60 hrs

Unit I: Types of nanomaterials: polymeric, Liposomes, Micelles, lipid-based, hydrogels, metal-based, semiconductor-based, hybrid, Dendrimers, Quantum dots etc.

Unit II: Nanomaterial synthesis: Microemulsion, templated synthesis, hot colloidal method, sol-gel method, co-precipitation methods, etc. Phase-transfer and surface coating/bioconjugation. Basic characterization using electron microscopy, IR and optical spectroscopy, elemental analysis, x-ray diffraction, etc.

Unit III: Properties of nanomaterials in Medicine, Properties of Materials: Bulk Properties of Materials, Surface Properties of Materials. Classes of Materials Used in Medicine: Structure and Properties of Metals, Ceramics, Glasses, and Glass-Ceramics, Polymers, Hydrogels, Family of Carbon Nanomaterials, Bioresorbable and Bioerodible Materials, Composites, Thin Films, Grafts and Coatings, Biologically Functional Materials.

Unit IV: Materials classification by bonding, amorphous and crystalline materials, crystal lattices, Miller Indices, Bragg's Law, Defects in crystal structure, principles of dislocations, theory of diffusion, mechanical properties, phase diagrams, polymeric materials, composite materials, corrosion, electrical and optical properties, types of nanomaterials, surfaces and particle size, surface energy and surface tension and relation to size, phase transformations in nanomaterials, specific heat and heat capacity of nanomaterials, mechanical properties of nanomaterials, optical properties of nanomaterials, electrical and magnetic properties of nanomaterials, carbon-based nanomatertials.

Core 3: Basic properties and Characterization of Nanoparticles

Duration: 60 hrs

Unit I: State of the art techniques for measuring nanoparticle size distribution Basics of transmission and scanning electron microscopy, instrumentation, sample preparation, negative staining, data analysis and interpretation, selected area electron diffraction (SAED).

Unit II: Characterization techniques of nanomaterials: Basic principles of dynamic light scattering (DLS), diffusion coefficients, size determination using Stokes-Einstein equation. X-ray diffraction techniques, Bragg's law, Miller indices, Scherrer equation. UV-visible-NIR absorbance, fluorescence, and photoluminescence (PL) spectroscopies, Lambert Beer's law, quenching of fluorescence, Stern-Volmer's equation, fluorescence resonance energy transfer (FRET).

Unit III: Basics of functional group analysis: using IR, FTIR and NMR spectroscopies. Elemental analysis using Energy dispersive X-ray (EDX) and x-ray photoelectron (XPS) spectroscopies. Analysis of magnetic properties using vibrating-sample magnetometer (VSM) or superconducting quantum interference device (SQUID) magnetometer.

Unit IV: Surface and porosity analysis using BET technique. BJH isotherm for pore-size analysis; Basics of DTA, TGA, and DSC techniques.

Core 4: Basics of cell biology and organ system

Duration: 60 hrs

Section A: Biology of Cell and Cell Function:

Unit I: Cell as unit of life. Prokaryotes and Eukaryotes cells- Structure and functions. Ultrastructure of plant, animal and microbial cells. Types of cells: Glial, Astrocytes, Oligodendroglia, Fibroblasts;

Unit II: Cell cycle and regulation: The cell cycle and its control system, Interphase, Mitosis, Cytokinesis and molecular regulation, cell transformation, cell death and apoptosis. Unit **Intercellular communication**: Transport mechanisms across membrane, Cell signaling, Cell junctions, Cell adhesion and the extracellular matrix, Specialized cells, tissues, **Cell proliferation and differentiation**: pluripotency, totipotency, progenitor cells, differentiated cells; Membrane transport, nuclear transport, transcription, translation; Cell communication and Cell signalling-hormones, cytokines-natural products.

Section B: Human Physiology and Pathophysiology

Unit III: Introduces major topics in human physiology, emphasizing knowledge essential to health-related laboratory research. Topics include neurophysiology, immunology, cardiovascular, respiratory, renal, and gastrointestinal physiology and endocrinology.

Unit IV: Systems Physiology: General introduction to systems physiology. Homeostasis, function, and common pathological conditions in various human organ systems including: Cardiovascular and circulatory system, nervous system, renal system, gastrointestinal and hepatobiliary system, reproductive system, skin, pulmonary system, vision and auditory systems, ear, nose and throat, and the musculoskeletal system.

Core 5: Nanomaterials for diagnostics and therapeutics

Duration: 60 hrs

Section A: Diagnostics

Unit I: Application of core or probe-loaded nanoparticles in plasmonic, optical Imaging applications. Plasmonic nanoparticles and surface plasmon resonance (SPR) imaging, Fluorophore-loaded nanoparticles in advanced optical imaging.

Unit II: Cell Imaging, Multimodal bioimaging using nanoparticles. *In vitro* diagnostics and high throughput screening of disease biomarkers from body fluids. Nanomaterials in microfluidics.

Unit III: Magnetic nanoparticles in MRI imaging. Doping of diagnostic probes (e.g. gadolinium ions) with nanomaterials. Unique effects of drug interaction with nanomaterials: e.g. aggregation-enhanced emission.

Unit IV: Radio diagnostics: Radiochemistry and Radio Pharmacy; Introduction to Nuclear Medicine; Nanoparticles for PET and SPECT imaging; X-ray activated radiation diagnostics, CT imaging.

Section B: Therapeutics

Unit I: Drug encapsulation: Entrapment Efficiency, Loading Efficiency, surface conjugation (covalent *versus* non-covalent). Hydrophilic *versus* lipophilic drugs. Loading, retention and release studies. Enzyme-entrapment within nanomaterials. Fabrication of multifunctional nanoparticles. Stimuli-sensitive nanoparticles; Externally activated therapies such as photodynamic therapy (PDT), photothermal therapy (PTT) and magnetic hyperthermia therapy (MHT).

Unit II: Drug Delivery: Active *vs* passive, Controlled, Sustained and targeted drug delivery. Inorganic Nanoparticles; Lipid Nanoparticles; Peptide/DNA Coupled Nanoparticles for Drug Delivery; Metal/Metal Oxide Nanoparticles (antibacterial/anti-fungal/anti-viral); Anisotropic and Magnetic Particles (Hyperthermia). Interaction of nanomaterials with active agents such as drugs, photosensitizers and genes.

Unit III: Nuclear therapy: Nanoparticles loaded with radioisotopes (e.g. alpha or beta emitters); X-ray activated radiation therapy, Particle therapy involving interaction of ion beams with nanoparticles. Image-guided therapeutics and theranostic applications involving nanoparticles.

Core 6: Interaction of nanomaterials with biological system

Duration: 60 hrs

Unit I: Biophysicochemical influences on the interface between nanomaterials and biological systems: Size, shape, surface area, Surface charge, energy, roughness and porosity, Valence and conductance states. Functional groups, Ligands, Crystallinity and defects; Hydrophobicity and hydrophilicity.

Unit II: Suspending media: Water molecules; Acids and bases; Salts and multivalent ions Natural organic matter (humics, proteins, lipids) Surfactants; Polymers; Polyelectrolytes; **solid–liquid interface**: Surface hydration and dehydration; Surface reconstruction and release of free surface energy; Ion adsorption and charge neutralization; Electrical double-layer formation, zeta potential, isoelectric point; Sorption of stearic molecules and toxins; Electrostatic, stearic and electrostearic interactions Aggregation, dispersion and dissolution;

Unit III: Probing nano-bio interface interactions between NPs and cell membrane: specific and nonspecific forces; Receptor–ligand binding interactions Membrane wrapping: resistive and promotive forces; Biomolecule interactions (lipids, proteins, DNA) leading to structural and functional effects; Free energy transfer to biomolecules; Conformational change in biomolecules; Oxidant injury to biomolecules; Mitochondrial and lysosomal damage, decrease in ATP.

Unit IV: Routes of cellular entry: Protein corona; endocytosis, pinocytosis, phagocytosis, etc. Intracellular distribution and accumulation of nanoparticles.

Discipline Specific Electives

Elective 1: Nanomaterials for antimicrobial applications

Duration: 60 hrs

Interaction of nanomaterials with bacterial, viral, fungal strains. Antibacterial function of metal nanoparticles. Amphotericin-B loaded nanoparticles for treating fungal infections. Drug and gene-loaded nanoparticles for treating viral diseases. Light and magnetic-field activated nanoparticles for hyperthermia-based microbial decontamination. Nanoparticle-based bandages for treating infected wounds. Analysis of pre-clinical evaluation of antimicrobial effects of nanoparticles.

Elective 2: Immune System & Innate Immunity

Duration: 60 hrs

Unit I: Introduction to the Immune System & Innate Immunity: Primary and secondary lymphoid organs; Cells of the immune system; Innate Immunity as first line of host defense, distinction between self and non-self, complement system- classical and alternative, Types of innate immune cells and their functions in immune responses, Molecules of innate cells, Response of the innate immune systems to pathogens.

Unit II: Molecules & Cells of the Adaptive Immune System: Antigens: chemical and molecular nature, adjuvants and their functions; Recognition of antigen by B-cell and T-cell Receptors; Generation of lymphocyte antigen receptors (antibodies and TCR), Antigen presentation by Major histocompatibility complex molecules. Antigen receptor structure and signaling pathways, Generation of lymphocytes in bone marrow and thymus, Survival and maturation of lymphocytes in peripheral lymphoid tissues.Adaptive Immune Response: T Cell-Mediated Immunity, the production of armed effector T cells, General properties of armed effector T cells, T cell-mediated cytotoxicity; Humoral immune response, B-cell activation by armed helper T cells, Adaptive immunity to infection, Infectious agents and how they cause disease, The course of the adaptive response to infection, mucosal immune system, Immunological memory

Unit III: Immune System in Health and Disease: Pathogen response to immune system, Immunodeficiency diseases, Allergy and hypersensitivity; Autoimmunity and transplantation; Disorders of immune response: IBD and MS: a case study; Cancer immunology.

Unit IV: Immunotechniques: Principles of immunization, techniques for analysis of immune response, antibody related techniques; Hybridoma, epitope mapping; Immuno assays: RIA, ELISA, Immunoblotting, ELISPOT,

Immunofluorescence and live cell imaging; Flow cytometry, live cell tracking techniques; Vaccine development principles and rationale of vaccine design, different types of vaccines; Immunotherapy: rational, technology development; Development of monoclonal antibodies, applications in diseases including cancer therapy; Gene editing technology in designing antibody and applications; Designing antibody library for immunotherapy.

Elective 3: Pharmacokinetics and Pharmacodynamics

Duration: 60 hrs

Unit I: Pharmacokinetics (PK) and pharmacodynamics (PD) of drug-loaded nanomaterials in the human body (One- and two-compartment linear and nonlinear pharmacokinetics; Compartmental modelling with plasma and/or urinary data, Physiologically Based Compartment Models). Routes of excretion.

Unit II: Routes of administration of drug-loaded nanomaterials *in vivo*. Principles and methods of metabolic biotransformation; Disposition of xenobiotics in biological system

Unit III: PK describes a drug's exposure by characterizing its **ADME (Absorption, Distribution, Metabolism & Excretion)** properties and bioavailability as a function of time, PD describes a drug's response in terms of biochemical or molecular interactions. PK/PD together can be thought of as an exposure/response relationship.

Unit IV: PBPK models

PK and PD analyses are important because they help us understand how drugs behave in the body and how the body reacts to drugs, respectively. Drug developers use insights gained from PK and PD analyses to design better clinical studies (i.e., what dose to use or how different drugs interact with each other in the body). Clinicians use the information from PK and PD analyses (as presented in the drug label or package insert) to treat different types of patients (e.g., patients with and without renal impairment or elderly versus younger patients).

Elective 4: Nanobiosafety and nanotoxicology

Duration: 60 hrs

Unit I: Nanobiosafety: Opportunities, challenges and strategies for biosafety of nanomaterials; Biocompatibility, Toxicity, Safety Testing of nanomaterials in food, agriculture, environment and health. The safety of Manufactured Nanomaterials is an important concern impacting regulatory bodies throughout the world. Due to their size, Manufactured Nanomaterials may require additional testing beyond the standard suite of tests used for other chemicals, to ensure that the impact on human health and the environment is fully understood.

Unit II: Mechanisms Involved in Nanotoxicity: Hypersensitivity, Interaction of Materials with Soft Tissues, Inflammation, Granulation Tissue Formation, Foreign Body Reaction, Fibrosis, Cell Adhesion, Interactions with Hard Tissues, The Vroman Effect, Adhesion of Osteoblasts, Osseointegration, Fibrous Capsule Formation, Modification of Blood-Biomaterial Interactions: Interaction with Blood by Heparin, Interactions with Proteins,

Unit III: Organ toxicity: Systemic toxicity, Hepatotoxicity, cardiotoxicity, Renal toxicity, Crossing Blood Brain Barrier.

Unit IV: Assays for evaluation of Nanotoxicity: Cytotoxicity, ROS generation, Immunogenicity, Carcinogenicity, Genotoxicity; 3D microfluidics, 3D cultures, 3D Printing, 3D organ scaffolds, Skin Ethenic models

Elective 5: Cancer nanomedicine

Duration: 60 hrs

Unit I: Introduction to nanomedicine: Nanomedicine in drug delivery and detoxification; Nanomedicine in immunotherapy; Nanomedicine in diagnostics and bioimaging: multimodal diagnostics for the detection of cancer; Drug administration and transport by fluid motion; Drug dispersion and diffusion in biological systems; Drug permeation through biological barriers; Pharmacokinetics and biodistribution; Ligand-receptor engineering and targeted delivery; Drug loading and quantification; Controlled and responsive release; Combinatorial therapy and delivery; From bench to bedside translation; Case studies in nanomedicine

Unit III: Advanced drug and gene delivery: Passive versus active targeting. Surface modification of nanoparticles for targeting cancer. Externally activated therapies such as PDT, PTT, MHT, radiation therapy, etc., for the treatment of cancer. Nanoparticles overcoming the MDR effect of cancer. Image guided drug delivery and theranostics in cancer. Cancer immunotherapy using nanoparticles. Analysis of pre-clinical and clinical case studies for cancer treatment using nanoparticles.

Elective 6: Recombinant DNA technology and non-viral gene therapy

Duration: 60 hrs

Unit I: Recombinant DNA technology: Introduction, mutagenesis, cutting and re-joining. Polymerase chain reaction, Isolation and amplification of genes, gene expression genetic recombination: Transfer of characters, genetic recombination, phage crosses, and gene transfer mechanism.

Unit II: Genetic disorders and gene therapy: Single gene disorders, its molecular genetics, common diseases, auto-immune diseases, cancer, cardiovascular diseases, nervous disorders. Gene therapy: current Gene therapy of genetic disorders like cystic fibrosis, Thalassaemia, Neuroblastoma, hepatitis, AIDS, diabetes, haemophilia B etc.

Elective 7: Biosensors

Duration: 60 hrs

Unit I: Introduction: Definition, History, Properties of biosensors, Design features of biosensors, The biological component.

Unit II: Biomedical Sensors: Sensors and transducers: an overview, measurement systems, Classification of biomedical sensors and transducers, Why do we need Biomedical sensors and transducers. Important design considerations and system calibration. Commercial Examples of Biosensors: Opportunities and obstacles.

Unit III: Miniaturized devices in nanobiotechnology - types and applications, MEMS, Lab on a chip concept. Future of Biosensors and Transducers: Sensing Layer: The importance of computers in sensor and transducer technology,

Unit IV: Recent engineering solutions to health care using biosensors and transducers, Modern health care solutions.

Elective 8: Nanomedicine for neurological diseases

Duration: 60 hrs

Delivery of drug-loaded nanoparticles into the brain across the blood-brain barrier. Systemic versus localized (e.g. stereotaxic) delivery. Nanoparticles for the treatment of neurodegenerative disease such as Parkinson's Alzheimer's. Nanoparticles in the management of stroke. Image-guided surgery in the

brain. Analysis of pre-clinical and clinical case studies involving nanomedicine for treating neurological diseases.

Elective 9: Nanomedicine for pulmonary, hepatic and nephrological diseases

Duration: 60 hrs

Unit I: Pulmonary: Delivery of nanoparticles: Targeted drug delivery, non-invasive vs invasive administration; Concept of first-pass metabolism, Aerosolized delivery of drug-loaded nanoparticles in the deep lungs (alveoli), systemic absorption of drug. Nanoparticles in the treatment of asthama, bronchitis,

Unit II: Strategies Used in Nanoparticle Delivery in the GI tract: Time dependent, pH dependent; pressure dependent, enzyme dependent; Theragonostic Strategies,

Unit III: Accumulation of nanoparticles in Liver and Kidneys: hepatitis, etc. Image-guided surgery of kidney stones.

Elective 10: Nanomaterials in regenerative medicine

Duration: 60 hrs

Biodegradable nanomaterials as scaffolds in tissue engineering. Nanomaterials for stimulating stem and progenitor cells for differentiating into desired tissue types. Tissue repair and regeneration using nanoparticles. Analysis of pre-clinical and clinical case studies involving nanoparticle-mediated regenerative medicine.

Elective 11: Nanovaccines

Duration: 60 hrs

Elective 12: Industrial Pharmacy

Duration: 60 hrs

Open Elective 1:

Ethics in Research: Responsibilities to Society, Science, and Self

Credit: 2; Duration: 30 hrs

Open Elective 2:

IPR aspects, clinical trials and translational nanomedicine

Credit: 2; Duration: 30 hrs

Basic concepts of patents and intellectual property rights (IPR) involving nanoparticles for biomedical applications. History of nanoparticles in pre-clinical and clinical trials: case studies. Nanoformulations for biomedical applications in the market (e.g. abraxane).