

Amrita School of Nanosciences and Molecular Medicine

**Program in the
Master of Science (M.Sc.)
Nanobiotechnology**

2022

Amrita Vishwa Vidyapeetham

M. Sc – NANOBIO TECHNOLOGY

EDUCATIONAL OBJECTIVES:

The M.Sc in Nanobiotechnology 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 via interaction with the clinicians, which 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. This course gives the students hands-on training in state-of-the-art facilities for development and characterization of nanomaterials. Additionally, the students undertake a full one year intensive research study, whereby the student completes a thesis in a topic of choice in nanomedicines, diagnosis, drug delivery, tissue engineering and regenerative medicine.

PROGRAMME EDUCATIONAL OBJECTIVES:

- To apply the principles of nanotechnology in developing more effectual and safe therapeutics and diagnostics to combat diseases, as well as guide the principles of tissue regeneration.
- To advance the learning gathered during the course and undertake research in the broad areas of bioengineering or medical practice, or for advanced study in engineering, medicine, or other related fields.
- To establish careers in their branch of study, ie., Nanotechnology or Nanomedicine, or the interdisciplinary and multidisciplinary fields such as pharmaceuticals, biotechnology polymers/advanced materials, food processing, energy, and environmental engineering.
- To develop altitude of professionalism to function effectively in the complex modern work environment, both as individuals as well as in team, with the ability to assume leadership roles and achieve understanding and appreciation of ethical behavior, social responsibility and diversity.

PROGRAM OUTCOMES

Each graduate will be able to:-

- ☐ apply knowledge of the fundamental aspects of physics, chemistry, biology and engineering principles to analyze and interpret data and design and conduct experiments safely, and also have the ability to design a process that meets desired specifications with consideration of environmental, safety, economic and ethical criteria
- ☐ utilize the education imparted during the program for an effectual understanding of the impact of nanotechnology in the fields of biotechnology and medical sciences and extend the fundamental scientific understanding to related disciplines
- ☐ demonstrate a working knowledge, including safety and environmental aspects of nanomaterials, applicability of nanomaterials in the fields of medicine for disease diagnosis and therapy, drug delivery, tissue engineering and regenerative medicine, biosensors and bioengineering design.
- ☐ have the ability to communicate effectively in written, oral, and graphical forms as well as work as a member of multidisciplinary teams, and have an understanding of team leadership.
- ☐ compete with peers in the field of Nanoscience and technology for competitive positions within or outside the country
- ☐ pursue higher learning in field of nanobiotechnology or medicine, involve in startups, be an entrepreneur or follow an academic or research career

Curriculum

First Semester

Course Number	Subject	Scheme of studies per	Credits
22NBT501	Program Core I - Nanomaterials: Synthesis and Characterization	300	3
22NBT502	Program Core II - Nanomaterials: Science & Properties	300	3
22NBT503	Statistical Data Analysis	200	2
21HU601	Audit Course-Amrita Value Program*		P/F
21HU602	Audit Course-Career Competency-I*		P/F
22NBT581	Laboratory I: Nanomaterials Lab I	004	2
22NBT582	Laboratory II: Cell Culture and Animal Lab	004	2
22AVP103	Mastery Over Mind	102	2
	Elective I (Any One from below)	300	3
22NBT531	Organ systems physiology		
22NBT532	Advanced Cell Biology		
22NBT533	Molecular Biology		
	Elective II (Any One from below)	300	3
22NBT541	Nanobiomaterials & Tissue Interaction		
22NBT542	Computational Methods in in nanomaterial-biological interaction		
	Total Credits		20

* Non Credit Course

Second Semester

Course Number	Course	Scheme of studies	Credits
22NBT511	Program Core III - Nanomedicine: Diagnosis & Therapy	300	3
22NBT512	Program Core IV – Regenerative Medicine & Tissue Engineering	300	3
22NBT513	Ethics in Research and Research Methodology	200	2
22NBT583	Laboratory 3: Microbiology-Immunology Lab	004	2
22NBT584	Laboratory 4:Nanomaterials Lab II	004	2
21HU603	Audit Course: Career Competency-II	0 0 2	1
	Elective I (Any One from below)	300	3
22NBT551	Pharmacokinetics & Pharmacodynamics		
22NBT552	Microbiology & Immunology		
22NBT553	Molecular Basis of Diseases		
	Elective II (Any One from below)	300	3
22NBT561	Cancer Nanotechnology		
22NBT562	Polymeric Nanomaterials		
	Total Credits		19

Third Semester

Course Number	Course	LTP	Credits
22NBT698	Dissertation	0 0 36	18
	Total Credits		18

Fourth Semester

Course Number	Course	LTP	Credits
22NBT699	Dissertation	0 0 36	18
	Total Credits		18
	Overall Total Credits		75

SYLLABUS

CORE SUBJECTS

22NBT501 NANOMATERIALS SYNTHESIS & CHARACTERISATION 3 0 0 3

Pre-requisites: Basic level Physics & Chemistry

Total number of classes: 45

Course Outcomes:

- 1. To understand various chemical synthesis (Bottom-up) of diverse types of nanomaterials (0D, 1D and 2D)*
- 2. To understand various physical methods (Top-down) of fabricating nanomaterials and nanostructures*
- 3. Decipher information on the various class of nanomaterials based on composition, shape and size (1D, 2D, 3/0D nanostructures)*
- 4. To understand the application potential of nanomaterials based on their unique properties and importance of selecting appropriate synthesis methods that will suit the specific application.*
- 5. To learn the fundamental principles of characterizing nanomaterials for their morphology, structure, chemistry and functionality through diverse methods of microscopy, spectroscopy, scattering and diffraction.*

Course content

Nanomaterial Synthesis:

Unit 1 (No. of classes = 5)

Synthesis of nanomaterials: Basic chemistry concepts, Inorganic, organic synthesis and analytical chemistry methods, concepts of precipitation reaction, mechanisms of nanocrystal growth, LaMer theory, Oswald ripening, coalescence

Unit 2 (No. of classes = 5)

Bottom-up synthesis approaches – Nanoprecipitation reaction, synthesis of zero-dimensional metal, metal oxides, semiconductor nanoparticles by nanoprecipitation routes, high-pressure homogenization

Unit 3 (No. of classes = 5)

Bottom-up synthesis approaches- Micro-emulsion route of synthesis, basic concepts of surfactant, emulsion, micelles, reverse micelles, critical micellar concentration, micro-emulsions: water-in-oil and oil-in-water emulsions, double emulsion and applications

Unit 4 (No. of classes = 4)

Bottom-up synthesis approaches: Sol-gel method, hydrolysis and condensation, Self-assembly, Kinetically Confined Synthesis of Nanoparticles

Unit 5 (No. of classes = 4)

Template-based synthesis; Synthesis of one dimensional nanosystems by different routes – VLS and SLS methods, Synthesis of two dimensional nanosystems

Unit 6 (No. of classes = 5)

Top-down approaches: Fundamentals of nano–thin film Growth; Vapor phase deposition methods - Physical and chemical vapor phase methods; Langmuir-Blodgett Films; Electrochemical Deposition; laws of electrolysis and deposition

Characterization:

Unit 7: Structure, Morphology and Surface(No. of classes = 10)

Crystal structure, Lattice parameters, nanoparticle size by Debye-Scherrer's formula. Working principles of the Scanning electron microscope and Transmission electron Microscope, particle size Dynamic Light scattering, Elemental analysis using energy dispersive X-ray analysis, Atomic absorption and Inductively coupled Plasma. Fundamental working principles of scanning probe microscopy (STM) Atomic Force Microscopy, confocal fluorescence microscopy

Unit 8: Spectroscopy(No. of classes = 7)

Fundamentals of spectroscopy, vibrational and rotational spectroscopy, Nanomaterials analysis using UV-VIS, Infrared & Raman spectroscopy, Surface enhanced Raman spectroscopy using nanotechnology. FTIR and NMR spectroscopy, Basic principles and applications of Mass spectrometry, chromatography and High-pressure Liquid chromatography in nanomaterial or nanomedicine characterization.

References

1. *Nanomaterials – An introduction to synthesis, properties and applications*, D. Vollath, Wiley-VCH, Second Edition 2013.
2. *G. Cao, Nanostructures and Nanomaterials – Synthesis, Properties and Applications*, Imperial College Press 2006.
3. *Elements of X-ray Diffraction*, B. D. Cullity and S. R. Stock (Pearson)
4. *Physical Principles of Electron Microscopy*, R.F. Egerton (Springer)

5. *Scanning Probe Microscopy and Spectroscopy*, D. A. Bonnell (Wiley)
6. *Fundamentals of Molecular Spectroscopy*, C. N. Banwell (McGraw Hill)
7. *Nanostructured materials: Processing, Properties and Potential Applications*, Edited by Carl. C. Koch, Noyes Publications, 2002.
8. *Materials Science and Engineering – An Introduction*, William D Callister, 12th Edition, John Wiley (Available in Amazon India, Rs. 287)

22NBT502

NANOMATERIALS: SCIENCE & PROPERTIES

3 0 0 3

Pre-requisites: Basic level Physics & Chemistry

Total number of classes: 45

COURSE OUTCOMES:

Students who complete the course will have demonstrated the following:

- *Relate electronic bonding to material properties and materials classification*
- *Map crystal directions and planes in crystalline structure*
- *Relate crystalline structure to density and ease of deformation*
- *Quantify imperfections in crystalline structure and its role on properties*
- *Quantify diffusion within solids using Fick's First and Second Laws*
- *Quantify Mechanical properties of solids in terms of stress and strain and their relationship to each other*
- *Be able to predict failure from deformation behavior and geometry*
- *Relate composite properties to the individual materials combined and their architecture*
- *Define and quantify unique polymer properties and their relationship to polymer structure*
- *Predict phase composition from composition and temperature*
- *Quantify surface area and volume in nanosystems in comparison with microsystems*
- *To be able to develop and utilize equations for the thermodynamics of nanosystems*
- *Be able to quantitatively derive and relate particle size to physical properties, including, melting point and internal pressure*
- *Predict mechanical properties of nanoparticles and nanocomposites*

- *Quantify structural and mechanical parameters of classical nanomaterials classes.*

COURSE CONTENT:

Unit 1 (No. of classes = 15)

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

Unit 2(No. of classes = 15)

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.

Unit 3(No. of classes = 10)

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

Unit 4(No. of classes = 5)

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

TEXTBOOKS:

1. *Materials Science and Engineering – An Introduction, William D Callister, 12th 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.*

Pre-requisites: Undergraduate level basic maths, physics, chemistry and biology

Total number of classes: 30

COURSE OUTCOMES:

Students who complete the course will understand the following:

- *The basic concepts of statistics and the need for statistical methods in research*
- *Data Analysis Methods*
- *The fundamental theory of probability and standard distributions*
- *Tests of Significance used in Statistical analysis*
- *The different types of multivariate analysis used in research*
- *Practical analysis of data using standard softwares like SPSS, SAS*
- *Practical understanding of Descriptive Data Analysis, Sampling Theory, Biostatistical Inference, Testing of Hypotheses, Nonparametric Methods and Multivariate Regression Analysis*

LECTURE WITH BREAKUP:

Unit-1

6 Lectures

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.

Unit-2

6 Lectures

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.

Unit-3

6 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.

Unit-4

6

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.

Unit-5

6

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.*

21HU601

AMRITA VALUES PROGRAM*

P/F

Pre-requisites: Basic understanding of Indian culture and values

Total number of classes: 15

COURSE OUTCOMES:

Students who complete the course will have demonstrated the following:

- *The basic concept of culture and values*
- *The relationship of culture with education, research, spirituality*
- *How culture is linked with gender, especially women*
- *The influence of media and politics in culture*

LECTURE WITH BREAKUP:

Unit-1

3 Lectures

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

Unit-2

4 Lectures

Culture of Research – creativity and responsibility in research
Spirituality and Culture – spirituality as a way of life, spirituality and religion

Unit-3

4 Lectures

Culture and women – gender oppression, motherhood
Culture and the Media

Unit-4**4 Lectures**

Culture and Politics – national values and political harmony
Philosophy and Culture, epistemology

21HU602**CAREER COMPETENCY- I*****P/F****Pre-requisites:**Basic understanding of the importance of career in life**Total number of classes:** 15**COURSE OUTCOME:**

- Effectively improve employability in the professional world.
- Gives training to assist the student to prepare for interviews

LECTURE WITH BREAKUP:**Unit-1****5 Lectures****Soft Skills**

Introduction to 'campus to corporate transition':

Communication and listening skills: communication process, barriers to communication, verbal and non-verbal communications, elements of effective communication, listening skills, empathetic listening, role of perception in communication.

Assertiveness skills: the concept, assertiveness and self-esteem, advantages of being assertive, assertiveness and organizational effectiveness.

Self-perception and self-confidence: locus of control (internal v/s external), person perception, social perception, attribution theories-self presentation and impression management, the concept of self and self-confidence, how to develop self-confidence.

Goal setting: the concept, personal values and personal goals, goal setting theory, six areas of goal setting, process of goal setting: SMART goals, how to set personal goals

Time management: the value of time, setting goals/ planning and prioritizing, check the time killing habits, procrastination, tools for time management, rules for time management, strategies for effective time management

Presentation skills: the process of presentation, adult learning principles, preparation and planning, practice, delivery, effective use of voice and body language, effective use of audio visual aids, dos and don'ts of effective presentation

Public speaking-an art, language fluency, the domain expertise (Business GK, Current affairs), self-confidence, the audience, learning principles, body language, energy level and conviction, student presentations in teams of five with debriefing

Unit-2**5 Lectures****Verbal**

Vocabulary building: introduction to the methods and practices of learning vocabulary, learning through practice sets to face questions on antonyms, synonyms, spelling error, analogy, wrong form of words, frequently confused words, understanding the nuances of spelling changes and wrong use of words.

Grammar: Analyzing subject verb agreement, pronoun agreement, tense consistency, and misplaced or dangling modifiers, parallel construction, active and passive voices, faulty comparison

Students take a few online practice tests to understand the test taking strategy and work on their specific areas of improvement.

Unit-3

5

Lectures

Aptitude

Introduction to numbers – number line, classification of numbers, prime and composite numbers, co-prime numbers, number of zeros in an expression, LCM, HCF, remainder theorem, rules of divisibility, base system

Basics of equations- introduction to simple and quadratic equations, roots of an equation, word problems, problems on ages, consistency of equations

Percentages, profit and loss: introduction to percentages, percentage change, value appreciation and depreciation, comparison observations, fundamentals concepts of business/commercial terminologies like cost price, selling price, profit, loss, marked price and discount

Ratio proportion and variation/partnership – fundamentals of ratios, duplicate ratio, triplicate ratio, sub duplicate ratio and sub triplicate ratio, direct and inverse proportion, joint variation, partnership and profit sharing

Averages and mixtures – mean, median and mode, measure of central tendency, concept of assumed average and weighted average, AM, GM and HM – relationship between AM, GM and HM, cheaper quantity and dearer quantity, rule of allegation, profit v/s quality of items getting mixed.

Simple interest and compound interest – time value of money, capital/principle, period of investment, rate of return, period of compounding, SAGR and CAGR

Data interpretation – representation of data using tables, bar charts, pie charts, case study, line graph, scatter diagram – analyzing the data for decision making

Venn diagrams- set theory – concept of sets, types of set, forms of set representation, power set, sub set and super set, 2 and 3 variable venn-diagrams, familiarity with words like AND, OR, atleast, atmost, exactly 'n' elements

Cubes – importance of aligning cuts to minimize/maximize the number of pieces of small cubes, painting a cube and cutting the cube, disintegration and integration of cubes, diagonal cutting, volume/LSA/TSA of cubes

References

- Andrew J DuRbin , “Applied Psychology: Individual and organizational effectiveness”, Pearson- Merril Prentice Hall, 2004
- Michael G Aamodt, “An Applied Approach, 6th edition”, Wadsworth Cengage Learning, 2010
- Robert Bolton, Dorothy Grover Bolton, “People Style at Work..and Beyond: Making Bad Relationships Good and Good”, Ridge Associates Inc., 2009
- John Hayes “Interpersonal skills at work”, Routledge, 2003
- Mark J Martinko, “Attribution theory: an organizational perspective”, St. Lucie, 1995
- Stephen Covey, “The habits of highly effective people”, Free press Revised edition, 2004
- Kenneth H Blanchard ,”The 25 Best Time Management Tools & Techniques: How to Get More Done Without Driving Yourself Crazy” , Peak Performance Press, 1st edition 2005
- S. Upendran, “Know Your English”, Universities Press (India) Limited, 2015
- Kaplan, “New GMAT Premier”, Kaplan Publishing, U.K., 2013
- Arun Sharma, “How to Prepare for Data Interpretation for the CAT Common Admission Test”, Tata Mc GrawHills, 3rd Edition, 2015
- R.S. Aggarwal, “A Modern Approach To Verbal & Non-Verbal Reasoning”, S. Chand Publishing, Revised -2015
- SarveshVerma, “Quantitative Aptitude-Quantum CAT”,Arihant Publications, 2016

22NBT581

LABORATORY I: NANOMATERIALS LAB I

0 0 4 2

Course code:

Course name: NANOMATERIALS LAB

Credits: 2

Pre-requisites: Basic understanding of experimental research

Total number of lab sessions: 15

COURSE OUTCOME:

After successful completion of the course, students will be able to:

- *Understand the preparation of standard solutions in different concentration units: Molarity, Molality and Normality*
- *Understand the synthesis of metal nanoparticles.*
- *Learn synthesis of plasmonic silver nanoparticles and observe its color change with varying size & shape of nanoparticles.*
- *Understand the principle and working of UV -Vis absorption spectroscopy technique and relation of absorption peak of silver nanoparticles with size and shape changes.*
- *Understand the synthesis of nanoparticles in non-aqueous route and observe its luminescence under UV lamp to understand quantum confinement effect.*
- *Understand the synthesis of nanoparticles in aqueous route and study the fluorescence properties of nanoparticles using spectrofluorometer*
- *Understand the UV-VIS absorption properties of nanoparticles and estimation of particle size using Brus equation*
- *Understand the principles of Atomic Force Microscope (AFM) and hands on experience in use of AFM in nanoparticle size characterization*
- *Understand the principles of Scanning Electron Microscope (SEM) and its use in characterizing nanoparticles*

Unit 1 (Lab sessions = 4)

Introduction to Nanolab and standard solution preparation, Synthesis of plasmonic silver nanoparticles study its color change with varying size & shape of nanoparticles using UV -Vis absorption spectroscopy

Unit 2 (Lab sessions = 5)

Preparation of metal oxide ZnO nanoparticles (Non-Aqueous route) and observe its luminescence under UV lamp, UV-VIS absorption properties of ZnO nanoparticles and estimation of particle size using Brus equation

Unit 3 (Lab sessions = 2)

Synthesis of Mn doped ZnS nanoparticles in aqueous route and study the fluorescence properties of nanoparticles using spectrofluorometer

Unit 4 (Lab sessions = 4)

Nanoparticle imaging for size and shape analysis using Atomic Force Microscope (AFM) and Scanning Electron Microscope (SEM) characterizing nanoparticles

References:

- A Handbook of Laboratory Solutions, M H Gabb, Scientific Publishers, 2013
- Nanostructures & Nanomaterials: Synthesis, Properties & Applications; Guozhong Cao, Imperial College Press

22NBT582

LABORATORY II: CELL CULTURE AND ANIMAL LAB

0 0 4 2

Course code:

Course name: CELL CULTURE AND ANIMAL LAB

Credits: 2

Pre-requisites: Basic understanding of experimental research

Total number of lab sessions: 15

COURSE OUTCOME:

After successful completion of the course, students will be able to:

- *To demonstrate a general level of understanding towards the function, maintenance and working of Bio-safety Cabinets (BSC) and be able to work in BSCs with a good sterilization technique*
- *To identify culture contamination and methods involved to maintain sterility*
- *Able to prepare media and maintain adherent cells in culture for atleast a week*
- *To recognize the importance of animal and ethical standards of animal use in research and able to handle small animals*

LAB CONTENT:

Unit 1

(Lab sessions = 3)

General lay out of a cell culture lab, physical environment needed for the cell culture, growth media and its composition, BSC and 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.

Unit 2

(Lab sessions = 7)

Hands-on cell culture work, media changes, seeding, splitting adherent cells, cell counting, reseeded, and safe disposal

Unit 3

(Lab sessions = 5)

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

REFERENCES:

- R. Ian Freshney. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th ed. 2010. Wiley-Blackwell.
- CPCSEA Guidelines for Laboratory Animal Facility, 2004.
- Guide for the Care and use of Laboratory Animals – 8th Edition, 2011, The National Academic Press.

MASTERY OVER MIND

22AVP103

Mastery Over Mind (MAOM)

1-0-2 2

Course Overview

Master Over the Mind (MAOM) is an Amrita initiative to implement schemes and organise university-wide programs to enhance health and wellbeing of all faculty, staff, and students (UN SDG -3). This program as part of our efforts for sustainable stress reduction gives an introduction to immediate and long-term benefits and equips every attendee to manage stressful emotions and anxiety facilitating inner peace and harmony.

With a meditation technique offered by Amrita Chancellor and world-renowned humanitarian and spiritual leader, Sri Mata Amritanandamayi Devi (Amma), this course has been planned to be offered to all students of all campuses of AMRITA, starting off with all first years, wherein one hour per week is completely dedicated for guided practical meditation session and one hour on the theory aspects of MAOM. The theory section comprises lecture hours within a structured syllabus and will include invited guest lecture series from eminent personalities from diverse fields of excellence. This course will enhance the understanding of experiential learning based on university's mission: "Education for Life along with Education for Living", and is aimed to allow learners to realize and rediscover the infinite potential of one's true Being and the fulfilment of life's goals.

Course Syllabus

Unit 1 (4 hours)

Causes of Stress: The problem of not being relaxed. Need for meditation -basics of stress management at home and workplace. Traditions and Culture. Principles of meditation– promote a sense of control and autonomy in the Universal Human Value System. Different stages of Meditation. Various Meditation Models. Various practices of Meditation techniques in different schools of philosophy and Indian Knowledge System.

Unit 2 (4 hours)

Improving work and study performance. Meditation in daily life. Cultivating compassion and good mental health with an attitude of openness and acceptance. Research and Science of

Meditation: Significance of practising meditation and perspectives from diverse fields like science, medicine, technology, philosophy, culture, arts, management, sports, economics, healthcare, environment etc. The role of meditation for stress and anxiety reduction in one's life with insights based on recent cutting-edge technology. The effect of practicing meditation for the wholesome wellbeing of an individual.

Unit 3 (4 hours)

Communications: principles of conscious communication. Relationships and empathy: meditative approach in managing and maintaining better relationships in life during the interactions in the world, role of MAOM in developing compassion, empathy and responsibility, instilling interest, and orientation to humanitarian projects as a key to harness intelligence and compassion in youth. Methodologies to evaluate effective awareness and relaxation gained from meditation. Evaluating the global transformation through meditation by instilling human values which leads to service learning and compassion driven research.

TEXT BOOKS:

- 1.Mata Amritanandamayi Devi, "Cultivating Strength and vitality," published by Mata Amritanandamayi Math, Dec 2019
- 2.Swami Amritaswarupananda Puri ,"The Color of Rainbow " published by MAM, Amritapuri.

REFERENCES:

- 1.Craig Groeschel, "Winning the War in Your Mind: Change Your Thinking, Change Your Life" Zondervan Publishers, February 2019
- 2.R Nagarathna et al, "New Perspectives in Stress Management "Swami Vivekananda Yoga Prakashana publications, Jan 1986
- 3.Swami Amritaswarupananda Puri "Awaken Children Vol 1, 5 and 7 - Dialogues with Amma on Meditation", August 2019
- 4.Swami Amritaswarupananda Puri "From Amma's Heart - Amma's answer to questions raised during world tours" March 2018
- 5.Secret of Inner Peace- Swami Ramakrishnananda Puri, Amrita Books, Jan 2018.
6. Mata Amritanandamayi Devi "Compassion :The only way to Peace:Paris Speech", MA Center, April 2016.
- 7.Mata Amritanandamayi Devi "Understanding and collaboration between Religions", MA Center, April 2016.
- 8.Mata Amritanandamayi Devi "Awakening of Universal Motherhood: Geneva Speech" M A center, April 2016.

ELECTIVE I (Any ONE from below)

22NBT531

ORGAN SYSTEMS PHYSIOLOGY

3 0 0 3

Pre-requisites: Basic level physiology

Total number of classes: 45

COURSE OBJECTIVES

- *To understand and clearly articulate individual organ systems and their specific functions*
- *To understand how tissue and cellular processes in individual organ system contributes to overall organ function*
- *To understand downstream effects of cell and tissue failure in terms of organ dysfunction*
- *To be familiar with current biomedical advancements in terms of devices and interventions in specific organ systems*

LECTURE WITH BREAKUP:

Unit-1

5 lectures

Introduction, body water and distribution, regulation of water within extracellular, transcellular, and intracellular compartments, determination of compartmental fluid volumes, electrolyte distribution and their role in cell membrane potential

Unit-2

4 lectures

Blood and its components, serum, plasma, the coagulation process and dyscrasias, advancement in blood substitutes and their principle, and the lymphatic system

Unit-3

6 lectures

Cardiovascular system and the vascular tree, cardiac electrophysiology, arrhythmias, pressure and volume changes in the ventricular chambers, cardiac cycle, valve kinetics, cardiac muscle physiology and calcium regulation, and cardiac biomedical technology

Unit-4

4 lectures

Pulmonary system, mechanics of ventilation, bronchial and alveolar cell functions, pulmonary function tests and assisted respiration technology

Unit-5

6 lectures

Hepatobiliary system, pancreas and the gut, hepatocyte architecture and function, blood-bile dynamics, pancreatic acini function, advancement in artificial liver and pancreas development, and gut physiology

Unit-6

6 lectures

Renal physiology, function of nephron, process of urine formation, pressures across the Bowmans membrane, and developments in body fluid dialysis

Unit-7

10 lectures

Nerve function, introductory neurophysiology, synapse physiology, neural circuits, signal processing in the special sense organs, cognition, and brain machine interface

Unit-1**5 lectures**

Reproductive and endocrine system, hormonal axis, and regulation in various endocrine glands

TEXTBOOK

John E. Hall, "Guyton and Hall Textbook of Medical Physiology", 13e Elsevier, 2015

22NBT532**ADVANCED CELL BIOLOGY****3 0 0 3**

Pre-requisites: Basic level biology

Total number of classes: 45

COURSE OUTCOMES:

After completion of course, student would be able:

- *To comprehend cell as the basic unit of life by studying the universal features of cells that distinguish the living and nonliving*
- *To understand the internal organization of cells, molecular bases of membrane transport, intracellular membrane traffic, cell communication, cytoskeleton and cell death*
- *To perceive about a cell in its social context by studying cell – cell adhesions and cell – matrix associations*
- *To understand cancer as a microevolutionary process from a cellular perspective*
- *To appreciate the ability of cells to reproduce and sustain genetic diversity on earth*
- *To understand how cells undergo dynamic changes during development to attain shape and form*

LECTURE WITH BREAKUP:**Unit-1****8 Lectures**

Cellular basis of life: Universal features of cells and how these features separate the living world from non-living world, Cells and laws of thermodynamics; Cell membrane: Membrane structure and how it supported origin of life, Role of membrane asymmetry in cellular functions, Membrane proteins and how they support cellular diversity, Transport of small molecules across the membranes and electrical properties of membranes, Types of membrane transport and examples of molecular mechanisms involved in transport;

Unit-2**9 Lectures**

Internal organization of cells: Intracellular compartments and protein sorting: Compartmentalization of cells, Transport of proteins between intracellular compartments, Molecular mechanisms underlying protein sorting and transport across intracellular compartments, Glycosylation and its significance; Intracellular membrane traffic: Intracellular vesicular transport and underlying molecular mechanisms, Maintenance of

compartmental diversity, Molecular mechanisms underlying specificity of molecular transport, Molecular mechanisms underlying transport into the cell from the plasma membrane and transport from trans-golgi network to cell exterior;

Unit-3

8 Lectures

Communication between cells and the exterior: Cell signaling: General principles governing cell signaling, Types of cell communication, Negative feedback, Positive feedback, Signaling through GPCRs and enzyme-coupled surface receptors; Cytoskeleton: Types of cytoskeletal filaments, Molecular mechanisms involved in self-assembly and dynamic structure of cytoskeletal filaments, Polymerization and depolymerization of cytoskeletal filaments coupled to cellular functions, Molecular motors and their significance in intracellular transport, Cytoskeleton in cell division;

Unit-4

8 Lectures

Cellular reproduction, the basis of sustenance of life on earth: Cell cycle: Role of templated polymerization of DNA in cellular reproduction and sustenance of life, Cell cycle control system in each phase of cell cycle, Regulation of cell cycle control system in different phases of cell cycle, Molecular mechanisms underlying cell cycle regulation, Control of cell growth; Apoptosis: Different types of cell death, Molecular pathways underlying cell death, Biological significance of cell death; Cancer from a cell's perspective: Cancer as a microevolutionary process resulting from failure of cellular surveillance system;

Unit-5

4 Lectures

Cells in their social context: Contacts between cell to cell and cells to extracellular matrix: Cell adhesions, Extracellular matrix, Types of junctions between cells and cells and matrix, Role of junctions in tissue formation and functions of organs;

Unit-6

4 Lectures

How cells ensure continuity of life as well as genetic diversity on earth: Germ cells and sexual reproduction: Germ cells as the cells equipped to transfer genetic information between generations, Sexual reproduction as a cellular process ensuring genetic diversity at the organismal levels

Unit-7

4 Lectures

Cells during development: Developmental dynamics of cells: How cells undergo commitment, specification and lineage diversification during development, Contribution of cells in pattern formation, Developmental biology of cells from the perspective of diseases and tissue maintenance;

TEXT BOOK:

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

REFERENCE:

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

Pre-requisites: Basic level biology

Total number of classes: 45

LECTURE WITH BREAKUP:

Unit I

Lectures 10

DNA: Structure and function, Chromosome and chromatin, Genetic code, wobble hypothesis, RNA and types of RNA, Proteins and their structure

Unit II

Lectures 10

DNA replication and its regulation, Homologous and site specific recombination, DNA repair

Unit III

Lectures 10

Transcription and its regulation, Translation and its regulation, Gene structure, Repeats and clusters, Gene expression regulations: operon, Epigenetics

Unit IV

Lectures 5

Types of mutations, Genetic system of mitochondria

Unit V

Lectures 10

Gene identification, promoter identification, Molecular biology techniques: Isolation and Quantification of DNA/RNA, PCR, Reverse transcriptase PCR, Real Time PCR, DNA Sequence analysis, hybridization (southern, northern and western) and Sanger sequencing.

TEXT BOOK:

Lewin's Essential Genes, Jocelyn E. Krebs, Benjamin Lewin, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Publishers, 2013 - Science - 847 pages

REFERENCES

Molecular Biology of the Gene, Seventh Edition, James D. Watson, Cold Spring Harbor Laboratory; Tania A. Baker, Massachusetts Institute of Technology; Alexander Gann, Cold Spring Harbor Laboratory; Michael Levine, University of California, Berkeley; Richard Losick, Harvard University, 2013

ELECTIVE II (Any ONE from below)

22NBT542 COMPUTATIONAL METHODS IN NANOMATERIAL-BIOLOGICAL INTERACTIONS 3 0 3

Course code:

Course name: COMPUTATIONAL METHODS IN NANOMATERIAL-BIOLOGICAL INTERACTIONS

Credits: 3

Pre-requisites: Basic level biology and chemistry

Total number of classes: 45

COURSE OUTCOMES:

Students who complete this course would demonstrate:

- *Basic understanding of the Nanoinformatics concepts; Size, structure and properties of different nanoparticles. Databases related to nanobiotechnology*
- *Application of different databases in Nanoinformatics and nanomaterial/biological interactions; knowledge of open source and other knowledgebase.*
- *Skills in working in Linux environment; Linux operating system update. Different linux commands and linux editor will be taught.*
- *Knowledge in using different software in Nanobioinformatics; Simulation challenges in nanobio docking, drug carrier and delivery. Importance of nanobioinformatics in modern nanomedicine program.*
- *Machine learning and Artificial intelligence applications in Nanobiotechnology.*

Unit-1

15

Introduction to Nanoinformation technology, Structure of different nanoparticles, Databases related to Nanobiotechnology (OECD, Nanomaterial-Biological Interactions and characterizations etc.), Mining Nanoinformatics repositories and open access sources

Unit-2

15

Nanomaterial- Biological Interactions Knowledgebase, Basic linux/unix commands, Software relevant to Nanobioinformatics, Computational techniques/challenges in nanobio drug carrier and delivery, Importance of Nanobioinformatics in modern drug discovery program.

Unit-3

15

Machine learning in Nanobiotechnology, nanoQSAR, Predictive models in Nanomedicine, Artificial Intelligence in Nanosafety.

TEXT BOOKS

- 1) Nanotechnology: A Gentle Introduction to the Next Big Idea. By Mark Ratner, Daniel Ratner
- 2) Nanoinformatics- 2020 Roadmap (2011), Published by National Nanomanufacturing network, Amherst, MA 01003.
- 3) Nanobioinformatics/Nanobiotechnology research articles, related websites and software.

REFERENCES:

- 1) Nanomaterial Synthesis Insights from Machine Learning of Scientific Articles by Extracting, Structuring, and Visualizing Knowledge, Anna M. Hiszpanski et. al. Journal of Chemical Information and Modeling. 2020, 60 (6), 2876-2887.
- 2) Artificial Intelligence and Machine Learning in Computational Nanotoxicology: Unlocking and Empowering Nanomedicine. Ajay VS et al. Advanced Healthcare Materials. 2020.

22NBT541

NANOBIMATERIALS AND TISSUE INTERACTIONS

3 0 0 3

Pre-requisites: Undergraduate level basic physics, chemistry and biology

Total number of classes: 45

COURSE OUTCOMES:

Students on completion of this course will –

- *Understand the basic concept of a biomaterial and its applications in medicine*
- *Comprehend the different types of biomaterials useful in diverse biomedical applications, with their specific properties*
- *Decipher the interactions of biomaterials with tissues and how nanoscale size effects influence the biological interactions*
- *Learn about the diverse biofabrication techniques for developing biomaterial scaffolds*

LECTURE WITH BREAKUP:

UNIT I:

15 lectures

Introduction to Biomaterials: Basic concepts of biomaterials science, definition, Concept of biocompatibility.

Classes of biomaterials in Medicine: Metals, Ceramics, Polymers, Composites; Bioresorbable; Bioinert, Bioactive and Biomimetic Materials, Materials at the Nanoscale – nanoparticles, nanofibers, nanocomposites

UNIT II: **15 lectures**

Biomaterials Fabrication: Solvent casting, salt leaching and lyophilisation, Electrospinning, Hydrogels, Cryogels, Surface modified biomaterials, 3D printing, 3D bioprinting-Cell encapsulation, Current advances and challenges in 3D printing.

UNIT III: **15 lectures**

Material-tissue interactions: Protein and Cell-Material interactions, Blood - material interactions, Inflammatory and immune response to biomaterials, Angiogenic response to biomaterials

Influence of Nanoscale Properties on Cellular Interactions - Porosity, Mechanical strength, Surface characteristics & modifications, Degradation

TEXTBOOKS/REFERENCES:

1. Biomaterials Science: An Introduction to Materials in Medicine, Edited by Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons. 2013

2. Ying Deng and Jordan Kuiper, Functional 3D Tissue Engineering Scaffolds: Materials, Technologies, and Applications (Woodhead Publishing Series in Biomaterials), 2017

3. Cato T. Laurencin, Lakshmi S. Nair. Nanotechnology and Regenerative Engineering: The Scaffold, Second Edition, CRC Press 2017

SECOND SEMESTER

22NBT511

NANOMEDICINE: DIAGNOSIS & THERAPY

3 0 0

3

Pre-requisites: Basic level physics, chemistry and biology

Total number of classes: 45

COURSE OUTCOMES:

Upon successful completion, students will have the knowledge and skills to:

- *Understand the fundamental concepts of nanomedicine*
- *Comprehend the factors controlling the pharmacokinetics of various drug formulations*
- *Understand the benefits of nanodrug delivery*
- *Various types of advanced drug delivery systems based on nanotechnology*
- *Concepts of targeted drug delivery*
- *An overview of the medical diagnostic tools*
- *Introduction to the nanomaterials in medical diagnostics*
- *Understanding about various nano bio-sensors and microfluidic sensors*
- *Understanding the current status of nanotechnology based diagnostic devices commercially available and under clinical trials*

LECTURE WITH BREAKUP:

Unit-1 **15 lectures**

Concepts of Nanomedicine – Basic concepts of controlled drug delivery, Physicochemical Properties of Drugs and its impact on their the biopharmaceutical behavior, Advantages of nanotechnology in drug delivery, Improvements in pharmacokinetics, bioavailability, biodistribution; Design, fabrication, evaluation and applications of the nanodrug delivery systems – Polymeric Nanoparticles, Liposomes, Micelles, Solid Lipid Nanoparticles, Microspheres, Emulsions, Dendrimers, Hydrogels, Implants and inserts

Unit-2 **10 Lectures**

Routes of Drug Delivery: Oral Drug Delivery -Concepts of Mucoadhesion; Intravenous Drug Delivery - Concept of opsonisation; Transdermal Drug Delivery; Intranasal Drug Delivery; Ocular Drug Delivery; Miscellaneous Drug Delivery, Strategies for Advanced Drug Delivery:- Prodrug and Bioconjugation; Active and Passive Targeting, Concept of Drug Targeting, Site Specific Drug delivery utilizing Monoclonal Antibodies, Peptides, Other Biomolecules

Unit-3 **10 Lectures**

Medical Diagnosis- from biomarkers to cells and tissues; Clinical diagnostic imaging tools: MRI, PET, CT, Ultrasound, Nuclear and Optical imaging –an overview; Diagnostic nanoscale materials in imaging; Molecular imaging techniques

Unit-4 **10 lectures**

Nanobiosensors in diagnosis- electrochemical sensors, enzymatic and non-enzymatic sensors, cantilever based sensors, piezoelectric biosensors, Lab-on-a-chip concept, Microfluidics, surface enhanced Raman spectroscopy based diagnostics, surface plasmon based biosensors; Current nanotechnology based diagnostics in use and under clinical trials.

TEXT BOOKS/ REFERENCES:

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*
3. *Emerging nanotechnologies for diagnostics, drug delivery and medical devices, Kishore Cholkar, AbhirupMandal, AshimMitra, Elsevier (2017)*
4. *Nanobiosensors and Nanobioanalyses, Vestergaard MC, Kerman K, Hsing IM, Tamiya E, Springer 2015*
5. *Current Medical Diagnosis and Treatment, Maxine A Papadakis, McGraw Hill Education, 2017*

22NBT512

REGENERATIVE MEDICINE & TISSUE ENGINEERING

3 0 0 3

Course code:

Course name: REGENERATIVE MEDICINE & TISSUE ENGINEERING

Credits: 3

Pre-requisites: Undergraduate level basic physics, chemistry and biology

Total number of classes: 45

COURSE OUTCOMES:

Upon successful completion, students will have the

- *Understanding on the molecules and signalling pathways that regulate epithelial and mesenchymal states of tissues and cell – extracellular matrix interactions*
- *Knowledge on the various types and sources of stem cells and their role in tissue growth, repair and regeneration*
- *Understanding on the importance of vascularisation and the challenges associated with establishing vascularisation in tissue engineered constructs*
- *Knowledge on the inherent regenerative mechanisms in human body*
- *Knowledge on the therapeutic applications of cells, and cells derived products in regenerative medicine*

LECTURE WITH BREAKUP:

Unit-1

9 Lectures

Biologic and Molecular Basis for Regenerative Medicine; Current perspectives in Regenerative Medicine/Introduction: Types of Tissues, Tissue Repair and Regeneration;

Different stages of Tissue Regeneration, Molecular organisation of cells, Cell extra-cellular matrix interactions in repair and regeneration, How cells change their phenotype

Unit-2

9 Lectures

Cellular aspect of regenerative medicine; Stem cells and progenitors; Basic biology and characteristics, Types of stem cells, Embryonic stem cells, induced pluripotent stem cells, Mesenchymal stem cells, Hematopoietic stem cells, Cardiac stem cells, Skeletal muscle stem Cells, Stem cells derived from fat, Peripheral blood stem cells and Pancreatic stem cells

Unit-3

12 Lectures

Architecture of Cells, Tissues, Organs and body's inherent regenerative mechanisms; Basic cell structure and functions, tissue organisation and functions, organ structure and functions, Blood regeneration, Blood vessel regeneration, Wound healing and skin regeneration, Bone regeneration, Liver regeneration, Peripheral nerve regeneration, The multifactorial role of peripheral nervous system in bone growth

Unit-4

15 Lectures

Tissue Engineering: General strategies in tissue engineering, scaffolds; types and characteristics, cells, growth factors. Role of tissue engineering in regenerative medicine, *Case Studies* – Ectoderm derived tissues; *Nerve tissue, Cornea*, Endoderm derived tissues; Liver, Pancreas, Tubular structures, Mesoderm; Bone, Cartilage, Muscle, blood vessels, Bone marrow, ligament, Tendon. Recent advances in biofabrication ; 3D bioprinting

TEXT BOOK

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

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*

22NBT513

ETHICS IN RESEARCH AND RESEARCH METHODOLOGY

2 0 0 2

Pre-requisites: Basic level biology

Total number of classes: 30

COURSE OUTCOMES:

Students on completion of this course will –

- *Understand the basic concepts of ethics in proper conduct of research*
- *Understand about plagiarism in research and how it should be avoided*
- *Gain a clear idea about the importance of proper data documentation*
- *Students will have a clear idea about the research methodologies that need to be adopted during their research*

LECTURE WITH BREAKUP:

Unit-1

15 Lectures

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

Unit-2

15 Lectures

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

TEXTBOOKS:

Research Ethics for Scientists, C. Neal Stewart Jr., Wiley-Backwell Publishers, 2011

Ethics in Science, Ethical Misconduct in Scientific Research, John D'Angelo, CRC Press, 2012

22NBT583

LABORATORY III : MICROBIOLOGY-IMMUNOLOGY LAB

0 0 4 2

Course code:

Course name: MICROBIOLOGY-IMMUNOLOGY LAB

Credits: 2

Pre-requisites: Basic understanding of experimental research

Total number of lab sessions: 15

COURSE OUTCOME:

- *Provide the students the knowledge about practical skills on basic microbiology.*
- *Students will learn about different antimicrobial activity assays.*
- *Students will develop an understanding about components of immune system and their function.*
- *The students will learn about different antigen and antibody interaction assays.*

Lab Contents:

Unit 1 (Lab sessions = 2)

Bacterial and fungal culture medium preparation, Pure culture technique (eg: streaking and sub culturing), Gram staining, Fungal staining, Motility assay

Unit 2 (Lab sessions = 3)

Bacterial conjugation, transduction and transformation; bacterial growth curve by measuring turbidity and viable count

Unit 3 (Lab sessions = 5)

Antibiotic sensitivity assay; MIC and MBC determination, Biofilm assay, MBIC and MBEC determination, Ames test, Phage titration assay

Unit 4 (Lab sessions = 5)

Giemsa staining of blood smear, blood grouping, double diffusion, immunoelectrophoresis, radial immunodiffusion, IgG purification, ELISA

TEXT BOOKS:

1. Practical Handbook of Microbiology- Lorrence H Green, Emanuel Goldman by CRC Press, 4th Edition, ISBN 9780367567637
2. Practical Immunology-Frank C. Hay, Olwyn M.R. Westwood, Fourth Edition,Blackwell Science.

22NBT584

LABORATORY IV: NANOMATERIALSLAB-II

0 0 4 2

Course code:

Course name: NANOCHARACTERIZATION LAB

Credits: 2

Pre-requisites: Basic understanding of experimental research

Total number of lab sessions: 15

COURSE OUTCOME:

After successful completion of the course, students will be able to:

- *Understand the synthesis of polymeric nanoparticles and the role of reaction parameters that varies the particle size*

- *Understand the principles of Dynamic Light Scattering technique in estimating the particle size and zeta potential. How zeta potential is related to the particle stability*
- *Understand the basics of vibrational spectroscopy (FTIR & Raman) in characterizing samples and how the spectral data can be interpreted.*
- *Understand the electrospinning technique and parameters that influence the formation of micro and nano sized fibers.*
- *Understand the thermal and mechanical characterization of polymeric samples*
- *Understand the basics of XRD in characterizing crystalline and amorphous samples.*

Lab Content:

Unit 1 (Lab sessions = 5)

Polymeric Nanoparticles: Synthesis of alginate nano and micro particles; characterization of particle size by Dynamic Light Scattering (DLS) and Zeta analysis

Electrospinning: Fabrication of electrospun PVA nanofibres and microfibers; characterization of fibers morphology and diameter using SEM

Unit 2 (Lab sessions = 5)

Structural characterization of crystalline and amorphous nanomaterials using X-ray diffraction spectrometer (XRD), Characterization of polymeric and inorganic samples using Raman Spectroscopy Using Raman spectroscopy

Unit 3 (Lab sessions = 5)

Thermal characterization of polymers using Thermogravimetric – Differential thermal Analysis (TGA-DTA), Characterization of materials properties by studying stress-strain curve using Rheometer.

References:

- Polymer Nanoparticles for Nanomedicines: A Guide for their Design, Preparation and Development; Christine Vauthier, Springer
- Nano: The Essentials; T. Pradeep, Tata McGraw-Hill
- Nanostructures & Nanomaterials: Synthesis, Properties & Applications; Guozhong Cao, Imperial College Press
- Rheology and Processing of Polymer Nanocomposites; Sabu Thomas, Wiley Publishers

AUDIT COURSE:

21HU603

CAREER COMPETENCY – II

0 0 2 1

Pre-requisites: NONE

Total number of classes: 30

COURSE OUTCOME:

- To provide skills and techniques to clear an interview to get employed.
- Gives training to assist the student to prepare resumes and attending of interviews

LECTURE WITH BREAKUP:

Unit-1

10 Lectures

Soft Skills

Interpersonal skill: ability to manage conflict, flexibility, empathetic listening, assertiveness, stress management, problem solving, understanding one's own interpersonal needs, role of effective team work in organizations

Group problem solving: the process, the challenges, the skills and knowledge required for the same.

Conflict management: the concept, its impact and importance in personal and professional lives, (activity to identify personal style of conflict management, developing insights that helps in future conflict management situations.)

Team building and working effectively in teams: the concept of groups (teams), different stages of group formation, process of team building, group dynamics, characteristics of effective team, role of leadership in team effectiveness. (Exercise to demonstrate the process of emergence of leadership in a group, debrief and reflection), group discussions.

Interview skills: what is the purpose of a job interview, types of job interviews, how to prepare for an interview, dos and don'ts of interview, One on one mock interview sessions with each student

Unit-2

10 Lectures

Verbal

Reasoning: Introduction to higher order thinking skills and deductive reasoning through critical thinking and syllogisms exercises. Students are trained to think critically and analyze an argument critically. They practice these skills extensively.

Logical ordering of sentences: to improve logical thinking and ability to put ideas cohesively.

Reading comprehension: intermediate & advanced level reading passages are provided to the students for practice. Students are taught techniques to read a dense passage in a fast & accurate manner.

Punctuation and e-mail writing: students hone their e-mail writing skills and are taught the essentials of punctuation and e-mail etiquette.

Unit-3

10 Lectures

Aptitude

Time and distance: speed, distance, displacement, relative speed, average speed, races, boats and streams-upstream and down-stream movement, problems on trains, concept of relative speed, motion in circular track – clockwise and anti-clockwise rotations.

Time and work- unitary method, concept of man-days, efficiency in task completion, sharing of wages proportionately, questions on pipes and cisterns.

Geometry, mensuration-line/ray/angles, length of segments, area and properties of geometrical figures, properties of angles, diagonals, LSA, TSA and volume of solids.

Seating arrangements/ puzzles- linear arrangements, circular arrangements, selection, comparison and distribution of objects under given constraints, analysing given constraints and present definitive or probable solutions for a given problem.

Permutations and combinations- fundamental principle of counting-selection and arrangement of objects, factorial notations, permutations with/without repetition, rank of a word, sum of all permutations, team formation with certain constraints

Probability- chances, odds in favour and odds against favour, events-independent and mutually exclusive types, conditional probability

Nonverbal reasoning – picture based series, mirror image, water image, paper folding, paper cutting, grouping of figures, figure matrix

Quant Based Reasoning – case study, application oriented problems

References

- Brian Cole Miller, “Quick Team-Building Activities for Busy Managers: 50 Exercises That Get Results in Just 15 Minutes”, AMACOM; 1 edition, 2003.
- Patrick Lencioni, “The Five Dysfunctions of a Team: A Leadership Fable”, Jossey-Bass, 1st Edition, 2002
- Kaplan GMAT 2012 & 13
- www.campusgate.co.in
- www.indiabix.com
- R.S. Aggarwal, “Quantitative Aptitude For Competitive Examinations”, S. Chand Publishing , 2015
- R.S. Aggarwal, “A Modern Approach To Verbal & Non-Verbal Reasoning”, S. Chand Publishing, Revised -2015
- SarveshVerma, “Quantitative Aptitude-Quantum CAT”, ArihantPublications , 2016

ELECTIVE III (Any ONE from below)

22NBT551

PHARMACOKINETICS & PHARMACODYNAMICS

3 0 0 3

Course code:

Course name: PHARMACOKINETICS & PHARMACODYNAMICS

Credits: 3

Pre-requisites: Basic level biology

Total number of lab sessions: 45

COURSE OBJECTIVES

- *Be able to articulate the drug-intrinsic and extrinsic factors that determine drug molecule movement across biological membranes*
- *To demonstrate understanding in concepts that determine dosage, absorption, distribution, and excretions of drugs, along with model systems connected with these concepts and apply pharmacokinetic principles to explain variation in drug disposition*
- *To demonstrate ability to describe functional outcome of drugs due to drug-cell interactions*
- *To demonstrate understanding of signaling pathways that link drug-receptor interaction and cell response, along with an understanding of toxicological response and ways to quantify and describe drug-induced toxic effects*

LECTURE WITH BREAKUP:

Unit-1

12 lectures

Introduction to pharmacology, body compartments and their volumes, principles of pharmacokinetics, movement of drug molecules across biological membranes via diffusion, features of drug absorption, distribution, metabolism, and elimination, model systems in pharmacokinetics.

Unit-2

14 lectures

Molecular mechanisms of drug action, principles of pharmacodynamics, drug toxicity and poisoning, membrane transporters and drug response, concepts in drug agonism and antagonism

Unit-3

6 lectures

Drug metabolism and pharmacogenetics

Unit-4

8 lectures

Neuropharmacology, muscarinic and nicotinic drug systems, adrenergic, serotonergic, and dopaminergic agonists and antagonism, pharmacotherapies in neural disorders

Unit-5

5 lectures

Pharmacotherapy of neoplastic disease

TEXT BOOK

Goodman and Gilman's 'The Pharmacological Basis of therapeutics' ""13th Edition, McGraw Hill

Malcolm Rowland, Thomas Tozer, "Clinical Pharmacokinetics and Pharmacodynamics, Concepts and Applications", 4th Edition, Wolters Kluver

22NBT552

MICROBIOLOGY & IMMUNOLOGY

3 0 0 3

Pre-requisites: Basic level biology

Total number of classes: 45

COURSE OUTCOMES:

Upon successful completion, students will have the knowledge and skills to:

- *Knowledge about the historical events in microbiology, basic skills in aseptic/sterilization techniques: physical and chemical agents/methods for sterilization, dry and moist heat etc*
- *Students will learn the composition of human microbiome and their role in maintaining normal gut function*
- *The students will know about the disease-causing micro-organisms (bacteria, fungus, virus and parasites)*
- *Will gain knowledge about human diseases caused by bacteria: Staphylococcus, Streptococcus, Enterococcus and Pneumococcus, Pseudomonas, Chlamydiae, Clostridium, Mycobacterium, Salmonella, Neisseria, Vibrio and Helicobacter etc: virulence factors, clinical manifestations, epidemiology and laboratory diagnosis*
- *Gain knowledge about human diseases caused by virus: Hepatitis, HIV, HPV, dengue: pathogenesis, virulence factors, clinical manifestations, epidemiology and laboratory diagnosis and treatment*
- *Will gain knowledge about principles of innate and adaptive immune system, the antigen receptor structure and the mechanisms of antigen recognition by B-cell and T-cells*
- *Mechanism of immunoglobulin, B-and T-cell receptor gene rearrangements*
- *Scientific principles behind T and B Cell-Mediated immune Response; Gain knowledge about the major histocompatibility complex and its functions*

- *Gain knowledge about host immune response against infectious agents, tumor cells and inherited immunodeficiency diseases*
- *Gain knowledge about the mechanism of allergic responses, hypersensitivity reactions, autoimmunity and transplantation*
- *The students will know about the importance for immunization and manipulation of the immune system to fight disease*

LECTURE WITH BREAKUP:

Unit-1 **3 Lectures**
 General properties of microbes, sterilization, disinfection, control of microbes by physical and chemical agents; culture media, culture methods and growth.

Unit-2 **2Lectures**
 Mechanism of action of common antimicrobial agents, molecular mechanism of drug resistance.

Unit-3 **2Lectures**
 Human microbiome from skin, mouth, respiratory tract, intestinal tract, urogenital tract.

Unit-4 **9 Lectures**
 Human diseases caused by bacteria, fungus, virus and parasites (Example pathogenesis of Staphylococcus, Pneumococcus, Pseudomonas, Chlamydiae, Clostridium, Mycobacterium, Salmonella, Streptococcus, Neisseria, Vibrio, Helicobacter, Hepatitis, HIV, HPV, Dengue, filaria and Malaria etc).

Unit 5 **2 lectures**
Basic Concepts in Immunology, cells and organs of the immune system

Unit 6 **2 lectures**
Innate Immunity, pattern recognition by cells of the innate immune system, induced innate responses to infection, complement system.

Unit 7 **4 lectures**
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.

Unit 8 **2 lectures**

The Generation of Lymphocyte Antigen Receptors, the generation of diversity in immunoglobulins, T-cell receptor gene rearrangement, Structural variation in immunoglobulin constant regions.

Unit 9 **2 lectures**

Antigen presentation to T Lymphocytes, the generation of T-cell receptor ligands. The major histocompatibility complex and its functions.

Unit 10 **2 lectures**

Signaling through immune system receptors, general principles of transmembrane signaling, Antigen receptor structure and signaling pathways.

Unit 11 **3 lectures**

The development and survival of Lymphocytes: Generation of lymphocytes in bone marrow and thymus, the rearrangement of antigen-receptor gene segments controls lymphocyte development, interaction with self-antigens selects some lymphocytes for survival but eliminates others, survival and maturation of lymphocytes in peripheral lymphoid tissues.

Unit 12 **2 lectures**

T cell-mediated immunity, the production of armed effector T cells, General properties of armed effector T cells, T cell-mediated cytotoxicity, Macrophage activation by armed CD4 TH1 cells.

Unit 13 **2 lectures**

The humoral immune response: B-cell activation by armed helper T cells, the distribution and functions of immunoglobulin isotypes, the destruction of antibody-coated pathogens via Fc receptors.

Unit 14 **2 lectures**

14. Adaptive Immunity to Infection: Infectious agents and how they cause disease, the course of the adaptive response to infection, the mucosal immune system, immunological memory.

Unit 15 **3 lectures**

Failures of Host Defense Mechanisms: Pathogens have evolved various means of evading or subverting normal host defenses, inherited immunodeficiency diseases, acquired immune deficiency syndrome.

Unit 16 **2 lectures**

Allergy and Hypersensitivity: The production of IgE, effector mechanisms in allergic reactions, hypersensitivity diseases.

Unit 17 **2 lectures**

Autoimmunity and Transplantation: Autoimmune responses are directed against self antigens, responses to alloantigens and transplant rejection, self-tolerance and its loss.

Unit 18 **3 lectures**

Manipulation of the Immune Response: Extrinsic regulation of unwanted immune responses, using the immune response to attack tumors, manipulating the immune response to fight infection. Currently available vaccines.

TEXT BOOK:

1. Alcamo's fundamentals of microbiology / Jeffrey C. Pommerville. — 9th edition.
2. Janeway's Immunobiology, Ken Murphy, Paul Travers, Mark Walport, 9th edition.

REFERENCE:

1. Prescott's Microbiology 11th Edition.
2. Cellular and Molecular Immunology, Abul K Abbas, Andrew H. Lichtman, Shiv Pillai 9th edition 2017.

22NBT553

MOLECULAR BASIS OF DISEASE

3-0-0-3

Course code:

Course name: MOLECULAR BASIS OF DISEASE

Credits: 3

Pre-requisites: Basic understanding of biology and biochemistry

Total number of classes: 45

Course Outcome

CO1: To demonstrate ability to approach a scientific report in a systematic manner

CO2: To be able to identify scientific hypothesis and understand the rationale behind the research approach in a scientific report

CO3: Be able to summarize disease pathogenesis and connect it to clinical signs and symptoms associated with the particular disease

CO4: Be able to work with team and put together in depth information related to disease mechanism at the cellular and molecular level, treatment options and current developments in the field

LECTURE WITH BREAKUP:

Unit 1

(Lectures 5)

Introduction to disease pathogenesis, clinical terminologies, concept of prognosis, evidence-based treatment approach, bench-to-bedside approach in medicine, and introduction to a holistic approach in treating diseases

Unit 2

(Lectures 6)

Regeneration, cellular differentiation, and cell adaptations in the context of tissue healing secondary to injury

Unit 3

(Lectures 6)

Cellular and biochemical basis of glucose intolerance and subsequent changes in hyperglycemia associated protein changes and signaling pathways, leading to organ damage

Unit 4

(Lectures 5)

Epidemiology, etiology, and pathogenesis of diseases associated with vascular wall dysfunction and flow

Unit 5

(Lectures 6)

Diseases associated with dysfunction in gas exchange across the alveolar membrane, flow-volume loops, and inflammatory response in the pulmonary system

Unit 6

(Lectures 6)

Cellular changes and their consequence in chronic neuropathic pain conditions, behavioral response in pain, role of glia and neural changes in the CNS in pain conditions

Unit 7

(Lectures 6)

Circadian rhythm and its role in peripheral cells, CLOCK proteins, and their connection with inflammatory disorders

Unit 8

(Lectures 5)

Mental health diseases, known mechanisms and prospects

TEXT BOOK

Robbins Basic Pathology, 9th edition, Kumar, Abbas, Fausto and Mitchell; Saunders, Publication, ISBN-13: 978-1437717815.

Selected research articles will be provided before each class

ELECTIVE IV (Any ONE from below)

22NBT561

CANCER NANOTECHNOLOGY

3 0 0 3

Pre-requisites: Undergraduate level Physics, Chemistry, & Biology

Total number of classes: 45

Course objectives

- *To understand distinguishing features of normal medicine versus nanomedicine*
- *To understand design aspects of nanomedicine, considering cancer as a model disease*

- *To understand various types of nanomedicines depending on the cancer types and their methods of preparation*
- *To understand methods of studying the safety aspects of nanomedicines*
- *Decipher information about how nanomedicine formulations are regulated by Govt agencies for its safe application in human after preclinical and clinical trials*
- *Case studies on currently used nanomedicines for various cancer types*

Course content

Unit 1 (No. of classes = 5)

Nanomedicine: Basic concepts in the design of nanomedicine, Basics of cancer biology, treatment options, desired specifications and features of cancer-nanomedicine

Unit 2 (No. of classes = 5)

Nanomedicines for chemotherapy, cytotoxic drugs for cancer therapy, their merits and demerits, how nanomedicines improve efficacy and safety of cytotoxic drugs, case studies: AbraxanemDoxil, Daunosome,

Unit 3 (No. of classes = 5)

Importance considerations of nanomaterials used for cancer-nanomedicine: Nanomedicines using polymers, lipids, liposomes, proteins, inorganic material systems, anano-injectables, oral delivery systems, nano-implants, case study: nano-implant/gel for brain tumor

Unit 4: (No. of classes = 5)

Nanomedicine using Molecularly targeted drugs, methods of targeting multiple cancer mechanisms using single nanomedicines, Case study: Core-shell systems for leukemia and liver cancer

Unit 5 (No. of classes = 5)

Nanomedicine for radiation therapy: Basics of radiation therapy, mechanisms, image guided radiation therapy, IGMRT, methods of improving radiation therapy using nanoparticles

Unit 6 (No. of classes = 5)

Nano-photodynamic therapy, nano-photothermal therapy and nano-RF hyperthermia therapy, nano-scintillation therapy,

Unit 7: (No. of classes = 5)

Nanoparticles based cancer immunotherapy, basic immunology, nanoparticle-vaccines, mRNA and Peptide vaccines, emerging trends in nano-immunotherapy of cancer

Unit 8: (No. of classes = 5)

Nano-bio-therapeutics in cancer, nanoparticle mediated cell therapy, CART cell DC vaccines, use of nanoparticles in gene-therapy: DNA, RNA delivery.

Unit 9: (No. of classes = 5)

Safety aspects of nanomedicine: How to study safety of nanomedicines, *in vitro*, *in vivo*, toxicity assays, cell based assays, MTT, reactive oxygen stress, genotoxicity, reproductive toxicology, carcinogenesis, regulatory guidelines

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, Oswaldo Luiz

22NBT562**POLYMERIC NANOMATERIALS****3 0 0 3****Course code:****Course name:** POLYMERIC NANOMATERIALS**Credits:** 3**Pre-requisites:** Basic level chemistry**Total number of lab sessions:** 45**COURSE OUTCOMES:**

Students on completion of this course will –

- *To understand the basic concept of polymer science, polymer synthesis and preparation techniques*
- *Learn about characterization and thermal properties of polymeric materials*
- *To understand about biopolymer composites degradable and non-degradable polymers, hydrogel, dendrimers, hydrogels and thermos-sensitive polymers.*
- *Learn about the different type of polymeric nanomaterials fabrication and their applications in biomedical field.*

LECTURE WITH BREAKUP:**Unit-1****15 Hours**

Introduction and Basic Concepts of Polymer Science-Classification of polymers, polymer properties, Polymer synthesis, chain polymerization–mechanism of free radical, cationic,

anionic and co-ordination polymerization–ring opening polymerization-Copolymerization-preparation of block and graft copolymers, cross-linked polymers, conductive polymers and their composites.

Unit-2

15 Hours

Techniques of polymerization–bulk, solution, emulsion, suspension, interfacial, gas phase and melt polycondensation and Determination polymer molecular weight and size.

Thermal properties of polymers-Glassy and Rubbery state, glass transition temperature, Factors affecting Tg and crystallinity of polymers, Determination of Tg and Tm – polymer characterization – TGA, DTA and DSC of polymers.

Unit-3

15 Hours

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 nanoparticles and nanogel-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.

REFERENCE

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

THIRD SEMESTER

22NBT798

DISSERTATION

Credits: 10

Initiation of research on a selected research topic under the guidance of a faculty, with meticulous experimentation for the generation of data. Manuscript writing on the research work conducted thus far, for a possible publication by the end of the final semester. Mid-thesis presentation to judge the progress of the research work done.

FOURTH SEMESTER

22NBT799

DISSERTATION

Credits: 18

Full-time research on the proposed research, meticulous experimentation, generation of data, interpretation of data and conclusion of the research outcome. Manuscript writing on the research work conducted for publication, followed by manuscript submission by the end of the semester. Dissertation preparation and presentations.