# CHEMICAL SCIENCES, Ph.D.

*Programme Code:* LIFE04*

*Programme Outcome:*

- At the end of the course work pursued, the Ph. D. student will be well versed in the recent advances in crucial areas of Life Sciences such as Immunology, Cell Biology, plant Sciences, Microbiology and Cancer biology, in addition to gaining hands on experience in several techniques related to these fields as well as structural Biology and Bioinformatics. This will help the student to have a broader outlook of their research work and be able to judge and use techniques for a superior outcome and higher impact publications.

** The syllabus for Chemical Sciences is the same as the Board of Studies–approved Life Sciences syllabus*

# DETAILED COURSE COURSES

| CORE COURSES: Total 6 Credits | | | | |
|---|---|---|---|---|
| **Sr. No.** | **Course Code** | **Subject Title** | **Lectures (Hours)** | **Credits** |
| 1 | 05-LIFE04-601-LC* | Principles of Physical Chemistry or Principles of Biochemistry and Molecular Biology | 30 | 2 |
| | 05-LIFE04-601-PC* | | 30 | 2 |
| 2 | 05-LIFE04-602-C | Principles of Advanced Techniques | 15 | 1 |
| 3 | 05-LIFE04-603-C | Structural and Computational Biology | 15 | 1 |
| 4 | 05-LIFE04-604-C | Research Methodology | 15 | 1 |
| 5 | 05-LIFE04-605-C | Research Publication and Ethics | 15L + 30P | 2 |

| Elective Courses (5 to be opted) : Total 5 Credits | | | | |
|---|---|---|---|---|
| **Sr. No.** | **Course Code** | **Subject Title** | **Lectures (Hours)** | **Credits** |
| 1 | 05-LIFE04-606-E | Mass Spectrometry for Omics | 15 | 1 |
| 2 | 05-LIFE04-607-E | Macromolecular Crystallography | 15 | 1 |
| 3 | 05-LIFE04-608-E | Membrane Biophysics and Structural Dynamics of Membrane Proteins | 15 | 1 |
| 4 | 05-LIFE04-609-E | Principles and Applications of NMR and Fluorescence | 15 | 1 |
| 5 | 05-LIFE04-610-E | Imaging Techniques | 15 | 1 |
| 6 | 05-LIFE04-611-E | Macromolecular Structure Determination using Cryo-EM | 15 | 1 |

| | | | | |
|---|---|---|---|---|
| 7 | 05-LIFE04-613-E | Mechanobiology | 15 | 1 |
| 8 | 05-LIFE04-614-E | Chromatin and Epigenetics | 15 | 1 |
| 9 | 05-LIFE04-615-E | Intracellular Trafficking | 15 | 1 |
| 10 | 05-LIFE04-617-E | Nanomaterials | 15 | 1 |
| 11 | 05-LIFE04-618-E | An Introduction to Artificial Intelligence (AI) for Biologists | 15 | 1 |
| 12 | 05-LIFE04-619-E | Drug Discovery: A Modern Day Approach | 15 | 1 |
| 13 | 05-LIFE04-620-E | RNA Biology | 15 | 1 |
| 14 | 05-LIFE04-622-E | Multiscale Modelling and Simulations of Biological Systems | 15 | 1 |
| 15 | 05-LIFE04-624-E | Genomic Regulation of the Immune System | 15 | 1 |
| 16 | 05-LIFE04-625-E | Molecular spectroscopy | 15 | 1 |

*15 h lecture (L) or 30 h Practical (P) = 1 credit (50 marks)*

| **Project: Total 6 Credits** | | | | |
|---|---|---|---|---|
| 1 | 05-LIFE04-623-PR | On one chosen topic from an offered list | 180 | 6 |

*Based on the academic background, a student will be advised one of the core courses:

- 05-LIFE04-601-LC: “Principles of Physical Chemistry” for students with Life Sciences background
- 05-LIFE04-601-PC: “Principles of Biochemistry and Molecular Biology” for students with Physical/ Chemical Sciences background

| **Courses** | **Credits** |
|---|---|
| Core courses | 7 |
| Elective courses | 5 |
| Project | 6 |
| **Total** | 18 |

# CORE COURSES COORDINATOR

| Core Courses | | |
|---|---|---|
| **Course** | **Coordinators** | **Email ID** |
| Principles of Physical Chemistry | Prof Sangram Bagh,<br>Prof. Padmaja Prasad Mishra | sangram.bagh@saha.ac.in,<br>padmaja.mishra@saha.ac.in |
| Principles of Biochemistry and Molecular Biology | | |
| Principles of Advanced Techniques | | |
| Structural and Computational Biology | | |
| Research Methodology | | |
| Research and Publication Ethics (Taught part of the course is common for Biophysical and Physical Sc.) | | |

# ELECTIVE COURSES COORDINATOR

| Elective Courses | | |
|---|---|---|
| **Course** | **Coordinators** | **Email ID** |
| Mass Spectrometry for Omics | Prof Sangram Bagh,<br><br>Prof. Padmaja Prasad Mishra | sangram.bagh@saha.ac.in,<br><br>padmaja.mishra@saha.ac.in |
| Macromolecular Crystallography | | |
| Membrane Biophysics and Structural Dynamics of Membrane Proteins | | |
| Principles and Applications of NMR and Fluorescence | | |
| Imaging Techniques | | |
| Macromolecular Structure Determination using Cryo-EM | | |
| Mechanobiology | | |
| Chromatin and Epigenetics | | |
| Intracellular Trafficking | | |
| Nanomaterials | | |
| An Introduction to Artificial Intelligence (AI) for Biologists | | |
| Drug Discovery: A Modern Day Approach | | |
| RNA Biology | | |
| Multiscale Modelling and Simulations of Biological Systems | | |

# CORE COURSE

## 05-LIFE04-601-LC: Principles of Physical Chemistry (30L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details (For students from Life Sciences background):***

- Definition of life from chemical and physical perspective, Basics of thermodynamics and its applications, Kinetics and its application in biological processes.
- Chemical equilibrium of reactions in gas & solution phase and reaction rate theory.
- Diffusion, Osmosis, Osmotic pressure, osmoregulation, surface tension, dialysis, adsorption, viscosity, thermal conduction, colloids, sedimentation.
- Introduction to quantum mechanics, Properties of particles and waves, Quantum mechanical description of atoms and molecules, Schrödinger equation, applications to simple systems—the particle in a box and the hydrogen atom, Statistical thermodynamics, Boltzmann distribution law, Concept of ensembles.

***Course Outcomes:***

- Basic knowledge about thermodynamics, kinetics and quantum mechanics

**References:**

1. Physical Chemistry by P. C. Rakshit
2. Physical Chemistry, A molecular approach by D. A. McQuarrie and J. D. Simon
3. Physical Chemistry by P. Atkins and J. de Paula
4. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash
5. Physical Chemistry-Gilbert W. Castellan
6. Quantum Chemistry (2nd Edition) By Donald A. McQuarrie

## 05-LIFE04-601-PC: Principles of Biochemistry and Molecular Biology (30L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details (For students from Physical/Chemical Sciences background):***

- Basic Biochemistry and metabolic pathways in health and disease.
- Cell as a basic unit of life, Identification, characterisation, and functions of cellular organelles, Cell-cell communication, Cell-signalling, Cell cycle.
- DNA as the genetic material, Mutations in the genetic material, Mendelian inheritance, Chromosomal inheritance, Eukaryotic genome organization and gene regulation, Replication, Transcription and Translation.

***Course Outcomes:***

- Basic knowledge about biomolecules, metabolism, cell and molecular biology

**References:**

1. The Cell by Cooper
2. Cell Biology by Pollard and Earnshaw
3. Molecular cell Biology by Darnell
4. Molecular Biology of the Cell by Bruce Alberts , Rebecca Heald , Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter , John Wilson, Tim Hunt

## 05-LIFE04-602-C: Principles of Advanced Techniques (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- **Biochemistry techniques**
  PAGE, Western Blotting, Iso-electric focusing, Protein purification and detection, Hydrodynamics method: fundamental principles and applications, Cell disruption and homogenization methods; Centrifugation, Ultracentrifugation and their applications.

- **Molecular biology techniques**
  A detection, RNA detection, Cloning, PCR and qRT-PCR, CRISPR-Cas9.

- **Spectroscopic techniques**
  Basic Principles of Molecular Spectroscopy, Excited state properties of molecules, Electronic, Rotational and Vibrational spectroscopy. Circular dichroism.

- **Computational techniques**
  Bioinformatics for biologists: Sequence alignment, BLAST, genomics and proteomics tools, Phylogenetic tree; Homology model building for biomolecules.

***Course Outcomes:***

- Introductory knowledge about various biochemical, cell and molecular biological, spectroscopic and computational techniques

**References:**

1. Biochemistry by Donald Voet and Judith G. Voet; 4th Edition
2. Molecular Cell Biology by Harvey Lodish and others; 5th Edition
3. Cell and Molecular Biology (Concepts and Experiments) by Gerald Karp; 6th Edition
4. The Cell: A Molecular approach by Jeoffrey M. Cooper and Robert E. Hausman; 4th Edition
5. Molecular Biology of The Cell by Bruce Alberts and others; 5th Edition

## 05-LIFE04-603-C: Structural and Computational Biology (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Nucleic acids, Watson-Crick and non-Watson Crick base pair, DNA double helical and multistranded structures, RNA structural features.
- External and internal coordinate system, non-covalent interactions stabilizing biomolecules, amino acids, peptide, proteins, secondary, tertiary, quaternary structure of protein.
- Basics of Crystallography, NMR, Cryo-EM and single particle analysis. Site-directed spin labelling and EPR (SDSL-EPR). Macromolecular visualization tools like PyMol, VMD, Chimera etc.

***Course Outcomes:***

- Understanding structure-function relationships of biomolecules
- Knowledge on techniques for determining high-resolution structures and structural models

**References:**

1. Biochemistry by Berg, Tymoczko, Gatto Jr, and Stryer, WH Freeman and Company publishing, 8th edition
2. Single-particle Cryo-EM of Biological Macromolecules, Biophysical Society-IOP publishing 2021, Edited by Glaeser, Nogales, Chiu
3. NMR of Proteins and Nucleic Acids; Kurt Wuthrich.

## 05-LIFE04-604-C: Research Methodology (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Objectives of research, Research design, Importance of critical literature review, observation and facts, laws and theories, and prediction, Models vs. reality, Pros and Cons of AI tools in research.

- Biostatistics: Significant figures, Limitations of analytical methods, Data and error analyses, Hypothesis testing, Correction for multiple comparisons, Sample size calculations.

***Course Outcomes:***

- Understanding the importance of research design, literature survey and experimental models
- Introductory and essential knowledge on biostatistics

**References:**

1) An Introduction to Error Analysis by John R Taylor (2nd edition, 1997)
2) Fundamentals of Biostatistics by Bernard Rosner (8th edition, 2015)
3) Introduction to Biostatistics by Pranab Kumar Banerjee (4th edition, 2011)
4) Introduction to Biostatistics by Larry Winner (2004)

## 05-LIFE04-605-C: Research Publication and Ethics (15L + 30 Practical)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Literature review for a particular research topic. Structure and components of a manuscript, Thesis writing, Plagiarism, Making a presentation, Bioethics, Copyright and Intellectual property rights.

***Course Outcomes:***

- Idea about doctoral research, manuscript and thesis writing, plagiarism and making a presentation.
- Ethics of scientific research and intellectual property rights.

## 05-LIFE04-606-C: Laboratory Course (30L Practical)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Idea, demonstration and hands on experience with various research laboratory equipment, techniques, processes and computational methods.

***Course Outcomes:***

- Idea and hands on experience with various laboratory techniques.

**References:**

1. Hands-on training of instruments
2. A Primer on Scientific Programming with Python (Primary), Hans Petter Langtangen , Springer, **2nd Edition**, **2016**
3. Numerical Recipes (Primary), William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press, **3rd Edition**, **2007**
4. Computational Science and Engineering (Primary), Gilbert Strang, Wellesley–Cambridge Press, **1st Edition**, **2007**.
5. MATLAB for Engineers (Supplementary), Brian Hahn, Daniel Valentine, Pearson, **5th Edition**, **2017**
6. Scientific Computing (Supplementary), David Kincaid, Ward Cheney, American Mathematical Society, **3rd Edition**, **2009**

# ELECTIVE COURSE

(To choose any 5 courses from the following)

## 05-LIFE04-606-E: Mass Spectrometry for Omics (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Working principles (ion source, analyzer and detectors), peptide fingerprinting, proteomics, metabolomics, lipidomics, glycomics, volatomics, and imaging mass spectrometry.

***Course Outcomes:***

- Detailed understanding of various approaches in mass spectrometry in biology

**References:**

1) 'Mass Spectrometry: Principles and Applications' by Edmond de Hoffmann, Vincent Stroobant, John Wiley & Sons, Inc. 2007
2) 'Fundamentals of Contemporary Mass Spectrometry' by Chhabil Dass, John Wiley & Sons, Inc. 2007
3) 'Mass Spectrometry Data Analysis in Proteomics' edited by Rune Matthiesen, Humana Press Inc, 2007
4) 'Mass Spectrometry in Metabolomics: Methods and Protocols' edited by Daniel Raftery, Humana Press Inc, 2014
5) 'Lipidomics: Comprehensive Mass Spectrometry of Lipids' by Xianlin Han, Wiley, 2016

## 05-LIFE04-607-E: Macromolecular Crystallography (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Crystallization techniques, handling protein crystals using cryo techniques, diffraction data collection, electron density map interpretation, crystallographic data analysis.

- Structure factors, Atomic scattering factor, Temperature factor, Structure factor calculation, Phase problem and electron density calculation. Advanced phasing techniques (like MAD/SAD). Phasing by MR, Model building and refinement. Fiber Diffraction.

- High throughput crystallography, Cryo-crystallography and its application in trapping reaction intermediates, X-ray crystallography to elucidate structure-function relationship for some important biological pathways, Crystallography of large macromolecular assembly.

***Course Outcomes:***

- Advanced knowledge on various aspects of macromolecular crystallization techniques and their application, data collection, model building and refinement to elucidate three- dimensional high resolution structure.

**References:**

1. Topical research papers on developments in X-ray crystallography

## LIFE04-608-E: Membrane Biophysics and Structural Dynamics of Membrane Proteins (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in), Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Models of bio membranes, Hydrophobic effect, Membrane organization and dynamics, Diffusion of membrane components, Phase transition of membranes.
- Model membranes: micelles, reverse micelles, liposomes, Nano discs and SMALP. Tools in membrane biology. Membrane domains and lipid rafts: membrane biophysics to cell biology.
- Membrane asymmetry and lipid polymorphism, Membrane cholesterol and its relevance in health and disease.
- How membranes shape protein structures? Lipid-protein interactions, Hydrophobic match/mismatch Structures of membrane proteins: Ion channels, Transporters and G-protein coupled receptors.

***Course Outcomes:***

- In-depth knowledge on historical aspects of membrane research, membrane biophysics, tools in modern membrane biology, lipid-protein interactions and structural biology of membrane proteins.

**References:**

1. Topical research papers using biophysical techniques

## 05-LIFE04-609-E: Principles and Applications of NMR and Fluorescence (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Basics and applications of high-field NMR in protein research. Time-resolved fluorescence: History of fluorescence, Decay of fluorescence emission, Relationship between fluorescence quenching and lifetimes, Time Correlated Single Photon Counting (TCSPC), Lifetimes and distributions, Maximum Entropy Method (MEM), Fluorescence lifetime imaging (FLIM).

***Course Outcomes:***

- Advanced level knowledge on the basics and applications of high field NMR and time- resolved fluorescence in protein research.

**References:**

1. Advanced Course: Biophysical chemistry - part I,II,III: Cantor and Schimmel.
2. Protein NMR Spectroscopy (Principles and Practice)
3. Authors: JOHN CAVANAGH, WAYNE J. FAIRBROTHER, NICHOLAS J. SKELTON
4. Topical research papers using biophysical techniques

## 05-LIFE04-610-E: Imaging Techniques (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Concepts in Microscopy and imaging: Basic Principle of Optics, Family of Microscopes, Optical Microscope Aberrations, Polarized light and its interaction with matter, Detection system image formation and image analysis, Point spread function.

- Principle of TEM & SEM: Development, architecture, vacuum system, power supply, Sample preparation techniques and applications.

- Single molecule detection by fluorescence: Single molecule fluorescence spectroscopy /Microscopy, Technical Challenges, Methods in single molecule detection, smFRET, Total Internal reflection (TIR) spectroscopy, Data Processing, analysis and interpretation.

- Principles of Optical trapping, Design Considerations, Trapping force, Microscope, Objective, Position detection.

***Course Outcomes:***

- In-depth understanding of concepts in various types of microscopy and imaging, methods in single molecule detection.

**References:**

1. Principles of Light Microscopy: From Basic to Advanced
2. Light- B. Ghosh & K. G. Mazumdar

## 05-LIFE04-611-E: Macromolecular Structure Determination using Cryo-EM (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Light and electron microscopes, Transmission and scanning electron microscopes, Components of a TEM, Direct Electron detectors (DED), Historical developments in TEM and cryo-EM of biological macromolecules.

- Sample preparation for room temperature TEM and cryo-EM, Principles of image formation in TEM, Motion-correction and Contrast transfer function (CTF), 3D reconstruction and refinement, Data processing strategy for cryo-EM, Model building in cryo-EM maps, Map and model validation for cryo-EM, Fourier Shell correlation (FSC), Plastic embedding in TEM, Immunoelectron microscopy. Cryo-electron tomography sample preparation, Cryo-electron tomography imaging and image processing, Case studies on various macromolecular structures determined by cryo-EM.

***Course Outcomes:***

- Advanced understanding of macromolecular structure determination using cryo-EM.

**References:**

1. Single-particle Cryo-EM of Biological Macromolecules, Biophysical Society-IOP publishing 2021, Edited by Glaeser, Nogales, Chiu
2. CryoEM: Methods and Protocols, Humana Press, Edited by Gonen and Nannenga
3. The Resolution Revolution: Recent Advances In cryoEM (Methods in Enzymology Volume 579), Edited by R.A. Crowther
4. Cryo-Electron Microscopy in Structural Biology: From Structural Insights to Tomography and Drug Discovery, CRC Press 2025, Edited by Krishnarao Appasani

## 05-LIFE04-613-E: Mechanobiology (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Cytoskeleton and nucleoskeleton, mechanics of cell-cell adhesion and migration, gross cell mechanics, experimental set-up to study biomechanics, disease models.

***Course Outcomes:***

- Knowledge on role of mechanical forces in cell biology.

**References:**

1. Topical research papers on mechanobiology

## 05-LIFE04-614-E: Chromatin and Epigenetics (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Methods to study chromatin structure, Epigenetics and gene regulation, DNA repair mechanisms in chromatin context, Chromatin dynamics in Stem cell differentiation and cancer, Chromatin as drug target.

***Course Outcomes:***

- Understanding the intricate details of chromatin and epigenetics in cellular functions.

**References:**

1. Topical research papers on implications of Epigenetics (readers, writers and erasers) in cancer.

## 05-LIFE04-615-E: Intracellular Trafficking (15 Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Protein translocation, protein trafficking (endocytosis, exocytosis, transcytosis), de novo organelle biogenesis, protein quality control (role of internal vesicles), lysosomal biogenesis and degradation.

***Course Outcomes:***

- In-depth understanding of various aspects intracellular trafficking.

**References:**

1. The Cell by Cooper
2. Cell Biology by Pollard and Earnshaw
3. Molecular cell Biology by Darnell
4. Molecular Biology of the Cell by Bruce Alberts , Rebecca Heald , Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter , John Wilson, Tim Hunt
5. Topical research papers

## 05-LIFE04-617-E: Nanomaterials (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Principles of nanoscience/nanotechnology, Structural and functional nanomaterial synthesis. Advanced techniques in nanoscience (NSET, HRS, SERS, electron & force imaging).

- Concept of antigen and antibody, Antigen-specific aptamers.

- Functional nanomaterials for specific targeting and sensitive biomarker detection and quantification for early stage diagnosis, different therapeutic methods: photon, photodynamic, micro pH and photo thermal therapy and their advantages over chemo and radiation therapy. PET scan, Magnetic

  separation, complete blood count (CBC), blood protein testing, tumor marker testing along with spectroscopic (UV-vis, Fluorescence, and Raman techniques) and imaging techniques (TEM and AFM).

- Bi-metallic nanomaterials with programmable crystal defects for bacterial cytoskeleton targeting.

***Course Outcomes:***

- Advanced knowledge on structural and functional nanomaterials and their synthesis and applications in biology.

**References:**

1. Topical research papers on methods to generate nanomaterials and their applications

## 05-LIFE04-618-E: An Introduction to Artificial Intelligence (AI) for Biologists (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in), Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- **Fundamental concepts**
  What is AI, its relation to neuroscience, Intelligent agent, Machine learning, Artificial neural network, Deep learning, Re-enforcement learning, Natural language processing, Concept of bias in training data.

- **AI in action**
  Application of machine learning in biology, Application of AI tools to solve biological problems, A few hands-on problems solving, Brain-computer interface, AI and bioRobots, Philosophical foundation, Future of AI.

***Course Outcomes:***

- Understanding the fundamental concepts, applications and future of AI in biology.

**References:**

1. Artificial Intelligence by Russel and Norvig, Third Edition, Pub: Pearson.
2. Various Review articles and research papers

## 05-LIFE04-619-E: Drug Discovery: A Modern Day Approach (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in), Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Pre 20th century drug discovery. Drug discovery pipeline, drug targets and target validation. Methods of lead identification and optimization.
- Early prediction of ADMET (Absorption, Distribution, Metabolism Excretion and Toxicity). QSAR (Quantitative Structure Activity Relationship) predictions. Lipinski rule of 5. Polar surface area. Blood brain barrier crossing model. Predicting toxicity.
- Introduction to drug docking and pharmacophore modeling.
- Application of biophysical methods in protein-based drug discovery and development.

***Course Outcomes:***

- Understanding the fundamental concepts, applications and future of AI in biology.

**References:**

1. Topical research papers on latest developments in generating biosimilars, biobetters and developments in immunotherapy

## 05-LIFE04-620-E: RNA Biology (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in),**
**Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Structure, function, flexibility of RNAs - the dark matter of the genome, structural versatility of non-coding RNAs, Cellular super-regulation, Tools and techniques, Construction of lncRNA- RPBs- gene regulatory networks using available online databases, Understanding miRNA-lncRNA association which may affect a target gene, To predict RNA secondary structure using online tools.

***Course Outcomes:***

- Advanced knowledge on roles of RNA in cellular regulation.

**References:**

1. RNA, the Epicenter of Genetic Information: A New Understanding of Molecular Biology - by John Mattick & Paulo Amaral (CRC Press)
2. The Catalyst: RNA and the Quest to Unlock Life's Deepest Secrets, byThomas R. Cech (W W Norton & Co Inc)

## 05-LIFE04-622-E: Multiscale Modelling and Simulations of Biological Systems (15L Hours)

**Coordinators: Prof Sangram Bagh(sangram.bagh@saha.ac.in), Prof. Padmaja Prasad Mishra(padmaja.mishra@saha.ac.in)**

***Course Details:***

- Foundations of molecular mechanics and classical description of molecules, Newton's law, Trajectory generations, Conformational search, Statistical mechanics application to macroscopic ensembles.

- Advanced simulation techniques, Enhanced sampling techniques, Coarse-grained methods, Electronic structure calculation methods, Hybrid Quantum Mechanics/Molecular Mechanics (QM/MM) methods. Practical aspects of computer simulations, Illustrative examples.

***Course Outcomes:***

- Advanced knowledge on various computer simulation methods and its application in understanding biological systems.

**References:**

1. Molecular Modelling: Principles and Applications (2nd Edition) By AndrewLeach

## 05-LIFE04-624-E Genomic Regulation of the Immune System (15L Hours)

***Course Details:***

- Introduction to the Immune System, Master Transcription factors in Immune Cell development, Epigenetic Regulation and 3D Genome Architecture in the Immune System, Immunogenomics in Health and Disease, Genomic tools to study Immune System

***Course Outcomes:***

- Knowledge of genomic, epigenetic, and transcriptional control of the immune system dynamics

**References:**

1. Kuby's Immunology (Primary) — Jenni Punt, Sharon A. Stranford, Patricia P. Jones, Judy A. OwenW. H. Freeman and Company / Macmillan Learning, 8th Edition, 2022/2023
2. Janeway's Immunobiology (Primary) — Kenneth Murphy, Casey WeaverGarland Science (Taylor & Francis Group), 10th Edition, 2021
3. Robbins & Cotran Pathologic Basis of Disease (Primary) — Vinay Kumar, Abul K. Abbas, Jon C. Aster, Matthew P. Nicol Elsevier Saunders, 10th Edition, 2020
4. Principles of Genetics and Genomics (Supplementary) — Daniel L. Hartl, Elizabeth W. JonesJones & Bartlett Learning, 7th Edition, 2018
5. Translational Omics: Concepts and Clinical Applications (Reference) — Mauro Ferrari, Joe Gray, Lance Liotta (eds.)Springer, 1st Edition, 2017

## 05-LIFE04-625-E Molecular spectroscopy (15L Hours)

***Course Details:***

- Frequency domain spectroscopy - UV-visible absorption spectroscopy, Principles of fluorescence spectroscopy, Instrumentation of absorption spectrophotometer, Instrumentation of fluorimeter, Time domain spectroscopy, Frequency modulation of time domain spectroscopy, Two level systems, Laser

***Course Outcomes:***

- Knowledge of spectroscopic theory and applications

**References:**

1. Fundamentals of Molecular Spectroscopy By C. N. BANWELL

# PROJECT

## 05-LIFE04-05-623-PR: Project (180 Hours)

***Course Details:***

- Each student chooses one topic from an offered list and carries out experiments with specific scientific aims under the supervision of a faculty member. The student submits a dissertation describing the background of the study and reporting the experimental findings which will be evaluated by two faculty members. Finally, the student presents and defends the work in an open forum.

***Course Outcomes:***

- Preparedness to do independent doctoral research