SHIV NADAR
INSTITUTION OF EMINENCE DEEMED TO BE UNIVERSITY
DELHI NCR

SCHOOL OF NATURAL SCIENCES

Prospectus

B.Sc. (Research) Biotechnology

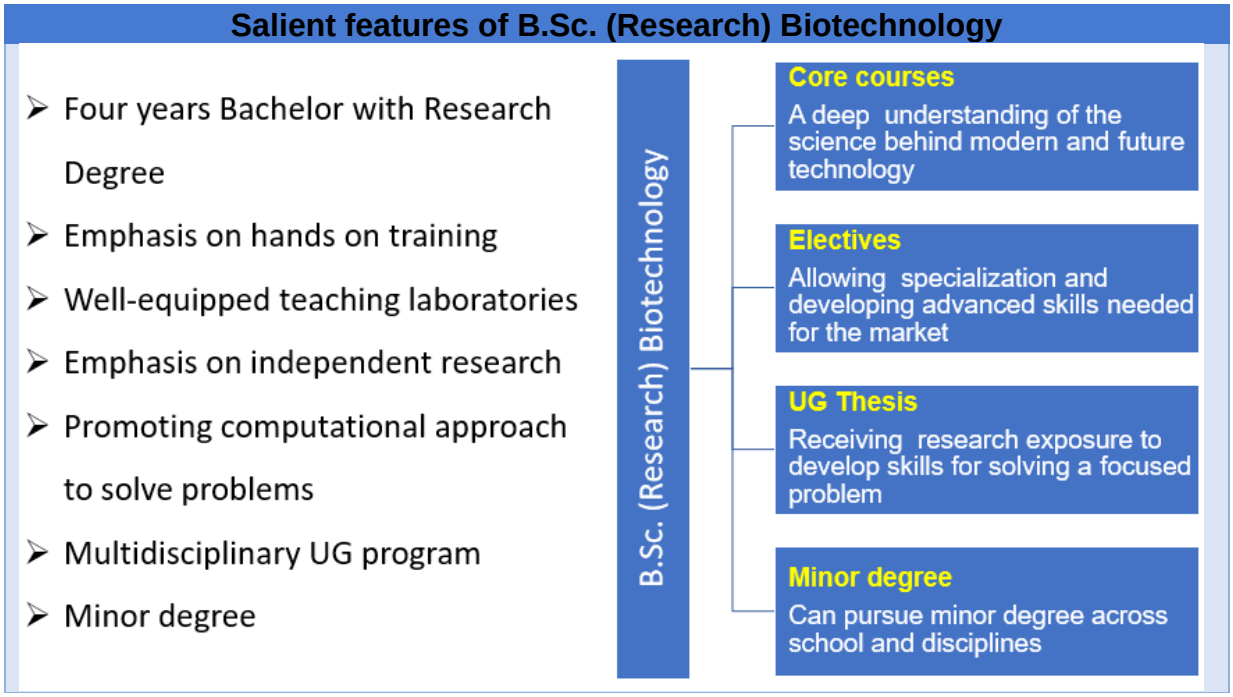
2024

Department of Life Sciences
School of Natural Sciences
Shiv Nadar Institution of Eminence, Delhi-NCR

B.Sc. (Research) Biotechnology

Overview

The Department of Life Sciences (DLS) at Shiv Nadar Institution of Eminence (SNIoE) imparts teaching and research that expands knowledge of biology and biotechnology. By introducing undergraduate students through the B.Sc. (Research) Biotechnology program to the fundamentals and advances of biology, the Department prepares students with in-depth and comprehensive knowledge related to biology and applications, as well as the next generation of scholars and teachers. The departments' various teaching and research areas include Biochemistry, Microbiology, Cell Biology, Cancer Biology, Molecular biology, Genetics, Neuroscience, Parasitology, Plant Science, Virology, Epigenetics, Developmental biology, Bioinformatics, Ecology and Evolutionary biology. The curriculum includes interdisciplinary courses in Chemistry, Physics, and Mathematics. The Biotechnology Major program aims to effectively engage students in learning, enhance their problem-solving to get a deeper understanding of the discipline and interact positively with others in a global community.



Program aims

The overall aim of the Biotechnology Major program is to effectively engage students in learning, enhance their problem-solving skills, to get deeper understanding of the discipline, and to interact positively with others in a global community.

Program outcomes

- An ability to apply knowledge of biology fundamentals and biotechnology specialization to solve complex biology questions.
- Skills to design and conduct appropriate experimentation, analyze and interpret data, and use rational judgment to draw conclusions.
- An ability to apply biotechnology to produce solutions for public health and welfare.

Laboratory Experience

The program is designed for hands on experience for students. The research in the Department of Life Sciences is multifaceted and interdisciplinary which includes Virology, Oncology, Protein Biology, Developmental Biology, Bacteriology, Neurobiology, Epigenetics, Computational biology, Plant biology, Bioinformatics and Drug discovery. The Department of Life Sciences has state-of-the-art laboratories equipped with advanced instruments like Cell sorter (FACS Aria), Fluorescence and Confocal Microscopes, Mass spectrometer, Genome Sequencers, Ultracentrifuges, FPLC and HPLC machines, Capillary electrophoresis (Tapestation), Real-time PCR machines and 2D gel electrophoresis. In addition to these, there are Biosafety two-level culture laboratories and animal and bacterial cell culture facilities equipped with Biosafety hoods, incubators, Circulating water baths, liquid nitrogen storage systems and deep Freezers.

New interdisciplinary research centers in Epigenetics and Drug discovery have been set up. A state-of-the-art Center for Integrative and Translational Research is also being established. This center will house a modern animal facility with multiple animal models and include a genome editing facility.

CITRES: Centre for Integrative & Translational Research
and
Experimental Animal House with Transgenic Core Facility

Research Focus

B.Sc. (Research) Biotechnology program is research-driven and equips students with research experience in an academic setup. The program requires each student to engage in a research project in their chosen topic for six months to one year. Students learn to formulate hypotheses, design and perform experiments, analyze data and write scientific reports. Students also have a choice to perform a semester of research in another university/ industry.

Research Infrastructure & Research Grants

Specialised equipment
- Flow cytometer and sorter (Multi-spectral 40 parameter sorter)
- Confocal Laser Scanning Microscope
- Advanced Fluorescence Microscopes
- Genome sequencers

Central instrumentation facility
LC-MS, CD, XRD, AFM, MST, Raman spectrometer, Luminometer, HPLC, FPLC, etc.

Culture facilities
- BSL-2 for Mammalian cells, Parasites, and Viruses
- BSL-3 laboratory

Animal facility
- A state-of-the-art SPF animal facility housing multiple model systems
- Animal BSL-3 Facility, In vivo imaging

Computational facilities
- High-performance IBM cluster ("Magus"): 63 nodes (1008 cores); 30 Tetraflops
- New cluster: 8064 cores, 320 Tetraflops
- Servers and workstations, Bioinformatics & Cheminformatics platforms

External Research Grants	
Total Accepted Projects	44
Industry Project	1
Total Funding in INR (Cr)	~18
(FIST, DST, CSR, DAE, ICAR, SERB, etc)	
Total Publications (2018-22)	136
Average Publication/faculty	2.66

Research opportunities for undergraduate students

The program provides various opportunities for research experience at undergraduate level as summarised below.

- ***Extracurricular research with faculty***
  Students can discuss their interest with the faculty and pursue research and training in the research labs.
- ***Opportunity for Undergraduate Research (OUR)***
  OUR is a flagship program run by the Office of Research, SNIoE. It is a one-year project that students can take up under the guidance of a faculty advisor during their second and third years. The Office of Research floats the call for OUR projects and students submit a project proposal through their faculty advisors. Students have to submit a midterm and a final report. Project work is evaluated in an OUR conference and students are provided certificates of project competition.
- ***Internships***
  Students are encouraged to seek internship opportunities outside SNIoE during their summer breaks.
- ***Minor and major project in the fourth year***
  In the fourth-year students work on a minor project and a major project as apart of their degree program.

Faculty & Research Interests

Sanjeev Galande
Dean, School of Natural Sciences,
Senior Professor, Department of Life Sciences,
Ph.D., Indian Institute of Science, India

Research Interests: Chromosome Biology and Epigenetic Regulation

Prasun Kumar Roy
Distinguished Professor

Research Interests: Neurobiology, Computational Neuroscience, Normal & Impaired Brain, Neurodegenerative disease, Neuro-oncology, Bioinformatics.

Ashish Gupta
Associate Professor, Ph.D., Jawaharlal Nehru University, India

Research Interests: Epigenetics and human diseases, Anti-malarial chemotherapy

Richa Priyadarshini
Associate Professor, Ph.D., University of North Dakota, USA

Research Interests: Bacterial Cell Biology, Environmental Microbiology

Anindita Chakrabarty
Associate Professor, Ph.D., University of Missouri-Columbia, Missouri, USA

Research Interests: Cancer Biology & cell signaling

Rohini Garg
Associate Professor, Ph.D., National Institute of Immunology, India

Research Interests: Epigenomics of Abiotic Stress Responses In Plants, Plant epigenomics

Sachin Deshmukh
Associate Professor, Ph.D., National Center for Biological Sciences, Bengaluru

Research Interests: Hippocampus, Spatial Navigation, Entorhinal Cortex, Electrophysiology, Sensory Systems, Behavioural and Systems Neuroscience.

Rajan Vyas
Assistant Professor, Ph.D., Panjab University, Chandigarh

Research Interests: Structure-Based Drug designing using Protein X-ray Crystallography

Puli Chandramouli Reddy
Assistant Professor, Ph.D., University of Pune

Research Interests: Evolutionary Developmental Biology, Regeneration Biology, Epigenetics and Genomics

Anil Kumar Challa
Senior Scientist, Ph.D., The Ohio State University

Research Interests: Molecular Genetics, Cell & Developmental Biology, Neurobiology

Jugal Kishore Das
Ramalingaswami Fellow, Ph.D., Kalinga Institute of Industrial Technology, Bhubaneswar

Research Interests: Immunology, Immunotherapy, Metabolic disorders.

Colin Jamora
Senior Professor and Head,
Department of Life Sciences,
Ph.D., University of California San Diego, USA

Research Interests: Tissue regeneration and repair.

Deepak Sehgal
Professor, Ph.D., Indian Agricultural Research Institute, India

Research Interests: Virology & Protein Biochemistry, Drug Development (HEV): Protein Expression Systems

Ashutosh Singh
Associate Professor, Ph.D., Banasthali University, India

Research Interests: Bioinformatics, Genomics and structure-based drug designing

Koyeli Mapa
Associate Professor, Ph.D., Ludwig Maximilian University, Germany

Research Interests: Protein Folding, Cell and Molecular Stress

Naga Suresh Veerapu
Associate Professor, Ph.D., All India Institute of Medical Sciences, India

Research Interests: Virology, Virus–Host Interactions, Biology of HEV & HCV

Sri Krishna Jayadev M.
Associate Professor, Ph.D., University of Delhi, India

Research Interests: Cancer Biology & cell signaling

Geetanjali Chawla
Associate Professor, Ph.D., Indian Institute of Science, Bengaluru

Research Interests: Age-related Diseases, RNA Biology, model organism genetics, RNA therapeutics development

Neelesh Naresh Dahanukar
Assistant Professor, Ph.D., University of Pune

Research Interests: Molecular ecology, Molecular phylogeny, biogeography and evolution, Evolutionary game theory and mathematical biology

Rudra Nayan Das
Assistant Professor, Ph.D., National Center for Biological Sciences, Bengaluru

Research Interests: Regeneration biology, Vascular development, Lymphatic transdifferentiation

Tanvi Deora
Fellow, Ph.D., National Centre for Biological Sciences, Bengaluru

Research Interests: Neurobiology and Biomechanics of Insect Pollination, Tactile sensing, Multisensory integration, Flight control, Sensory ecology

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Student outcome

Students who have pursued B.Sc. (Research) in Biotechnology from the department have secured positions in higher studies in India and abroad.

Highlights of academic year 2023–2024

Student name	Achievement
Muthumeena Ramanathan	Fully funded PhD program in Biomedical sciences at the University of Maine, USA
Pranav Prabhu	Fully funded Ph.D. in Biology at the University of Rochester, USA (+ Ernst Caspari Fellowship) Other Ph.D. Offers: Purdue University (Biological Sciences), University of Georgia (Integrated Life Sciences)
Ananaya Jain	Queen Mary University of London, MSc. Genomic Medicine
Chaheti Goyal	University College Birmingham in the UK for Masters in Public Health
Amaan Tariq	Johns Hopkins University, MS in Biotechnology Other offers: King's College London, MSc in Biomedical and Molecular Sciences Research
Jyotika Singh	Erasmus Mundus scholarship to pursue the Leading International Vaccinology Education (LIVE) joint master's program Jointly hosted by Universitat Autònoma de Barcelona (UAB, Spain), Universitat de Barcelona (UB, Spain), Universiteit Antwerpen (UAntwerpen, Belgium and Lyon and Saint-Etienne (France).
Spandan Patra	University of Liverpool, UK, master's degree program in Cancer Research and Therapy
Lalit Athithyan	Master of Research (MRes) in Neuroscience at the University of Sussex Other offers: MRes Animal Behaviour at Newcastle University; MSc Artificial Intelligence and Adaptive systems at University of Sussex.
Bishwesh Verma	MSc in Biomedical Science, National University of Ireland, Galway
Archana Cherukat	Fully funded PhD position in Wake Forest Univeristy, USA
Tarani Jindal	University of Melbourne, Australia, M.Sc. in Biosciences
Abhisekh Patel	MSc program in Medical Biotechnology, Sanjay Gandhi Institute of Postgraduate Medical Sciences (SGPGI), Lucknow
Vasundhara Verma	Research Associate in the Center of Excellence in Epigenetics, Shiv Nadar IoE, Delhi NCR

Overall Program Structure

B.Sc. (Research) Biotechnology program is an amalgamation of four basic units: **fundamental (core) courses** that provide students with essential knowledge in areas of cell biology, biochemistry, genetics, molecular biology; **technical (skill enhancing) courses** such as recombinant DNA technology, animal, plant, and industrial biotechnology, IPR and Bio-ethics **and specialized courses** in the areas of developmental biology, neuroscience and cognition, epigenetics along with **research experience**.

Credit Requirements for Major in Biotechnology

Courses		Credits
Major		111
Core	84	
Elective	06	
Project	21	
University wide electives (UWE)		18
Core Common Curriculum (CCC)		18
Floating (UWE/CCC)		6
Total		153

Major Courses: Within the duration of the UG program, a student must complete **111** credits of major courses, including core courses, major electives and project.

Core courses and projects

Semester I	
BIO101	Fundamentals of Computers
BIO104	Ecology and Environmental Sciences
BIO108	Animal Sciences
CHY111	Chemical Principles
MAT020	Elementary Calculus

Semester II	
BIO105	Plant Sciences
BIO114	Basic Probability and Statistics
CHY122	Basic Organic Chemistry I
PHY108	Physics of Living Systems

Semester III	
BIO202	Microbiology
BIO204	Biochemistry
BIO209	Biophysics
BIO210	Cell Biology
BIO211	Genetics

Semester IV	
BIO205	Bio-Analytical Techniques
BIO206	Fundamentals of Molecular Biology
BIO207	Immunology
BIO208	Bioinformatics

Semester V	
BIO301	Animal Biotechnology
BIO302	Plant Biotechnology
BIO303	Recombinant DNA Technology
BIO304	Industrial Biotechnology

Semester VI	
BIO305	Genomics and Proteomics
BIO307	IPR, Bio-regulatory affairs, & Bioethics
BIO326	Developmental Biology

Semester VII	
BIO401	Research Methodology
BIO402	Project

Semester VIII	
BIO403	Project

Major Electives

Course code	Course name
BIO309	Cancer Biology
BIO322	Neuroscience and Cognition
BIO323	Epigenetics
BIO324	Hippocampus, spatial navigation, learning & memory
BIO325	The Functional Basis of the Human System
BIO327	Host-Pathogen Interactions & Cell Signaling
BIO328	Medical Microbiology
BIO329	Systems Biology in Drug Discovery and Development

UWE: Within the duration of the UG program, a student must complete a minimum of **18** credits of UWE offered by other departments of science, engineering, management and humanities. Students can pursue credits required for a minor degree of another department (for example, complete the credits for minor requirements in Chemistry) and earn a minor degree in the subject.

CCC: Within the duration of the UG program, a student must complete a minimum of **18** credits of CCC courses offered by all the departments of science, engineering, and humanities. A total of **42** combined CCC and UWE credits must be completed for the UG program. CCC704 (Environmental Studies) is a compulsory course for all undergraduate students.

At least 18 credits must be earned from CCC courses. Each student must earn at least 1.5 credits each from any six of eight topic areas listed below:

1. Indian History and Society (IHS)(CCC1XY)
2. World History and Society (WHS)(CCC2XY)
3. Culture and Communication (CAS)(CCC3XY)
4. Physical and Living Systems (PLS)(CCC4XY)
5. Cognition and Intelligence (CAI)(CCC5XY)
6. Technology and Society (TAS)(CCC6XY)
7. Environment and Ecology (EAE)(CCC7XY)
8. Reasoning and Analysis (RAA)(CCC8XY)

A list of CCC courses offered by faculty of Life Sciences is provided below.

Code	Course title
CCC402	Genetic Engineering - The Journey of Life
CCC416	Science of Drug Addiction and Awareness
CCC419	Cancer, a Deadly Disease: Myths and facts
CCC409	Advances in applied biotechnology
CCC512	Brain Sciences and Cognition
CCC696	A Journey Through Landmark Discoveries in Medicine
CCC444	Biology of Aging
CCC524	Brain and Mind in Science, Fiction, and Philosophy
CCC729	Climate Change 101
CCC844	Evolution of cooperation and the theory of games

Roadmap to the B.Sc. (Research) Biotechnology degree

Compulsory and optional courses for each semester are explained. Students should not exceed 25 credits in a semester. It is advisable to take no more than 20 to 22 credits.

Semester I
In the first semester students should only take following major courses.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO101	Fundamentals of Computers	2:0:1
BIO104	Ecology and Environmental Sciences	2:0:1
BIO108	Animal Sciences	2:0:1
CHY111	Chemical Principles	3:1:1
MAT020	Elementary Calculus	3:1:0
	Total	**18**

L:T:P = Lecture credits : Tutorial credits : Practical credits

Semester II
Following courses are compulsory for the second semester.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO105	Plant Sciences	3:0:1
BIO114	Basic Probability and Statistics	2:1:0
CHY122	Basic Organic Chemistry I	2:1:1
PHY108	Physics of Living Systems	3:0:1
CCC704	Environmental Studies	3:0:1
	Total	**19**

In addition, students can opt for one or at the most two half semester 1.5 credit CCC courses. It is advisable not to exceed total 22 credits.

Semester III
Following courses are compulsory for the third semester.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO202	Microbiology	2:0:1
BIO204	Biochemistry	2:0:1
BIO209	Biophysics	2:0:1
BIO210	Cell Biology	2:0:1
BIO211	Genetics	3:0:0
	Total	**15**

In addition, students can opt for CCC and UWE courses worth 5 to 7 credits with the total credit load not exceeding 22.

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Semester IV
Following courses are compulsory for the fourth semester.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO205	Bio-Analytical Techniques	2:0:1
BIO206	Fundamentals of Molecular Biology	2:0:1
BIO207	Immunology	2:0:1
BIO208	Bioinformatics	2:0:1
	Total	**12**

In addition, students can opt for CCC and UWE courses worth 8 to 10 credits with the total credit load not exceeding 22.

Semester V
Following courses are compulsory for the fifth semester.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO301	Animal Biotechnology	2:0:1
BIO302	Plant Biotechnology	2:0:1
BIO303	Recombinant DNA Technology	2:0:1
BIO304	Industrial Biotechnology	2:0:1
	Total	**12**

In addition, students can opt for one Major Elective (3 credits) and CCC and UWE courses worth 5 to 10 credits (depending on whether you have taken major elective) with the total credit load not exceeding 22.

Semester VI
Following courses are compulsory for the sixth semester.

Course Code	Name of the Course	Credits (L:T:P)[#]
BIO305	Genomics and Proteomics	2:0:1
BIO307	IPR, Bio-regulatory affairs, & Bioethics	3:0:0
BIO326	Developmental Biology	2:0:1
	Total	**9**

In addition, students can opt for one or two Major Elective (3 credits each) depending on whether major elective was taken in the fifth semester. Further, CCC and UWE courses worth 5 to 10 credits (depending on whether you have taken one or two major electives) can be opted with the total credit load not exceeding 22.

Semester VII
Following courses are compulsory for the seventh semester.

Course Code	Name of the Course		Credits (L:T:P)[#]
BIO401	Research Methodology		3:0:0
BIO402	Internal Project Dissertation		0:0:9
		Total	**12**

In addition, if the students have not completed two Major Electives, then they can do so by opting for Major Elective course(s). Further, any pending credits for CCC and UWE courses can be can be completed with the total credit load not exceeding 22.

Semester VIII
Following course is compulsory for the eight semester.

Course Code	Name of the Course		Credits (L:T:P)[#]
BIO403	Project Dissertation		0:0:12
		Total	**12**

If any credits for Major Elective, CCC or UWE are pending, students can complete these in the final semester. If all other credit requirements are complete, then students can choose to do the final semester project outside the campus.

B.Sc. (Research) Biotechnology major and major elective course catalog

Course Code	Name of the Course	Credits L:T:P [#]
Semester I		
BIO101	Fundamentals of Computers	2:0:1
BIO104	Ecology and Environmental Sciences	2:0:1
BIO108	Animal Sciences	2:0:1
CHY111	Chemical Principles	3:1:1
MAT020	Elementary Calculus	3:1:0
	Total Credits	**18**
Semester II		
BIO105	Plant Sciences	3:0:1
BIO114	Basic Probability and Statistics	2:1:0
CHY122	Basic Organic Chemistry I	2:1:1
PHY108	Physics of Living Systems	3:0:1
	Total Credits	**15**
Semester III		
BIO202	Microbiology	2:0:1
BIO204	Biochemistry	2:0:1
BIO209	Biophysics	2:0:1
BIO210	Cell Biology	2:0:1
BIO211	Genetics	3:0:0
	Total Credits	**15**
Semester IV		
BIO205	Bio-Analytical Techniques	2:0:1
BIO206	Fundamentals of Molecular Biology	2:0:1
BIO207	Immunology	2:0:1
BIO208	Bioinformatics	2:0:1
	Total Credits	**12**

[#] L:T:P = Lecture credits : Tutorial credits : Practical credits

Semester V		
BIO301	Animal Biotechnology	2:0:1
BIO302	Plant Biotechnology	2:0:1
BIO303	Recombinant DNA Technology	2:0:1
BIO304	Industrial Biotechnology	2:0:1
	Total Credits	**12**
Semester VI		
BIO305	Genomics and Proteomics	2:0:1
BIO307	IPR, Bio-regulatory affairs, and Bioethics	3:0:0
BIO326	Developmental Biology	2:0:1
Elective 1 (BIO309)	Cancer Biology *	3:0:0
Elective 2 (BIO322)	Neuroscience and Cognition*	3:0:0
Elective 3 (BIO323)	Epigenetics*	3:0:0
Elective 4 (BIO324)	Hippocampus, spatial navigation, learning & memory*	3:0:0
Elective 5 (BIO325)	The Functional Basis of the Human System*	3:0:0
Elective 6 (BIO327)	Host-Pathogen Interactions & Cell Signaling *	3:0:0
Elective 7 (BIO328)	Medical Microbiology*	3:0:0
Elective 8 (BIO329)	Systems Biology in Drug Discovery and Development *	3:0:0
	* Any two of the electives from the above can be selected. Some electives may be offered in monsoon semester.	
	Total Credits	**15**
Semester VII		
BIO401	Research Methodology	3:0:0
BIO402	Internal Project Dissertation	9
	Total Credits	**12**
Semester VIII		
BIO403	Project Dissertation	12
	Total Credits	**12**
Total course major credits		**111**
CCC (18 credits minimum) + UWE (18 credits minimum) + CCC/UWE		**42**
Total Credit for B.Sc. (Research) Biotechnology		**153**

BIO101: Fundamentals of Computers

Learning Goals and Outcomes

1. This course will introduce you to Linux, the operating system commonly used to access and analyze biological data.
2. The course will teach you the fundamentals of the R programming language and the RStudio software environment.
3. The course will train students in algorithms and software for sequence alignment, get acquainted with Bioinformatics major resources and applications in solving complex biological problems.

Bioinformatics for biologists: Efficient hardware in modern computers, Introduction to operating systems, Biological Databases concept: Nucleotide Sequence databases (EMBL, GenBank, DDBJ) Protein Databases – (UNIPROT, PIR, TREMBL), Protein family/domain databases, Metabolic & Pathway databases (KEGG), Structural databases (PDB). Sequences and File Formats, Archives and Information Retrieval (Biological databases). Linux operating system. R language for Bioinformatics applications.

Introductory Bioinformatics: Concept of 'Omics', Gene and genomics, Sequence similarity and homology concept, Sequence Alignment concept, Algorithms in sequence alignment, Heuristic methods of alignment, Multiple Sequence Alignment.

Recommended Books

1. Bioinformatics -David Mount
2. Introduction to Bioinformatics- Attwood
3. Developing Bioinformatics Computer Skills- Cynthia Gibas
4. Introduction to Bioinformatics- Arthur M Lesk
5. Fundamentals of Computers, -V Rajaraman, PHI.
6. Introduction to computers - Peter Norton
7. Computer Fundamentals – P.K. Sinha
8. Operating system concepts, Silberschatz, A., Galvin, P. B., Gane, G., Pub: John Wiley & Sons.
9. Various web resources for R, PERL and Bioinformatics

BIO104: Ecology and Environmental Sciences

Learning Goals and Outcomes

1. To provide students with comprehensive understanding of fundamental concepts in ecology, environmental sciences and conservation related issues.
2. To develop students' skills in multidisciplinary thinking.
3. To develop students' practical skills in ecological data collection, analyses and interpretation

Introduction to Ecology, Community and Ecosystem (Inter-relationships between living world and environment, Biosphere, ecosystem and its components (abiotic and biotic).

Population and Community Ecology**:** Population attributes, density, natality, mortality, age ratio, sex ratio, dispersal and dispersion of population, exponential and logistic growth, life history strategies, population interactions, predation-types, predator-prey system, functional and numerical response, host-parasite interactions, social parasitism, symbiosis.

Global ecology and biogeography**:** Biogeography, Phytogeography, Phytogeographic realms, major plant communities of the world, Vegetation of India, Zoogeography, Zoogeographic realms.

Environmental ecology**:** Environment related concepts and laws (theory of tolerance, laws of limiting factors). Community characteristics- organization and concept of habitats and niche. Bioenergetics. Biogeochemical cycles, Hydrologic cycle. Concept of habitat and niche.

Conservation ecology**:** Threatened species of animals. Principles of wildlife management, wildlife sanctuaries, parks and biosphere reserves in India, endangered and threatened species of plants and animals in India, germplasm banks. Environmental Issues, Policies and Regulation. Impact of urbanization and industrialization, EIA-Environmental Impact Assessment (Global, National and Local), restoration of degraded ecosystems, bioremediation, environmental pollution, global climatic change.

Recommended Books

1. Allaby M (1996) Basics of Environmental Science. 2nd Edition. Routledge, London.
2. Frankham R, Ballou JD, Briscoe DA (2002) Introduction to Conservation Genetics. Cambridge University Press.
3. Kot M (2001) Elements of Mathematical Ecology. Cambridge University Press.
4. Magurran AE (2013) Measuring Biological Diversity. Wiley-Blackwell.
5. Miller GT Jr, Spoolman SE (2010) Environmental Science. 13th Edition. Brooks/Cole, Cengage Learning.
6. Smith TM, Smith RL (2015) Elements of Ecology. 9th Edition. Pearson.

BIO108: Animal Sciences

Learning Goals and Outcomes

1. This course aims at enhancing the basic understanding of invertebrate and vertebrate animal physiology. It familiarizes the students with popular experimental animal models used in studying basic and translational biology. This course intends to serve as the groundwork for studying advanced topics like development and regeneration biology.
2. On successful completion of the course, students will be able to:
   a) Understand and explain basic physiology of invertebrates and vertebrates.
   b) Understand and explain functions of different tissue/organ systems in higher organisms.
   c) Understand and explain the use of model organisms in biological studies.
   d) Understand and explain the basic concepts of fertilization and early development using invertebrates and vertebrates as model systems.
   e) Understand and explain basic concepts of scientific ethics in animal cloning and making designer babies.

This course is intended to teach freshman students about life forms. It is divided into two broad units as follows:

Unit I: Classification and Model systems to study biological processes

Classifications: theories and perspectives, protozoans, and model organisms: plasmodium, leishmania, etc (phylum-protozoa), invertebrates: basis of division and phylum, study of invertebrate model organisms: hydra (phylum- coelenterata), planaria (phylum- platyhelminthes), C. Elegans (phylum- nematoda), drosophila & anopheles (phylum- arthropoda)

Unit II: Comparative perspectives of animal physiology

1) Gas Exchange in organisms:
   - Respiration in air and water, respiratory organs in aquatic and terrestrial systems; gills (in water), lungs (vertebrate lungs - birds and mammals), trachea (insects), countercurrent flow,
   - Blood, oxygen transport, respiratory pigments across animal kingdom, CO_2 & O_2 dissociation curves (Hemoglobin, myoglobin), effect of temperature, pH & CO_2, altitude, body size etc.
   - Cardiovascular system: closed and open circulatory systems; pumps, channels and flow in tubes, Vertebrate pumps: Structure and function, invertebrate circulation.

2) Food & Energy: feeding mechanisms and stomachs, metabolic rate, effect of body size & scaling, effect of locomotion and gaits

3) Temperature: physics of heat transfer; convection & radiation, Homeostasis: behavioral, circulatory, metabolism, effect of high temperatures, cold hardiness and freeze tolerance.

4) Water: osmotic regulation in aquatic and terrestrial animals, transport epithelia - ion channels and gradients, excretion of water and solute in vertebrates and invertebrates, mammalian kidney and hormonal regulation.

5) Information, movement and integration: overview of neuronal structure and function; nerve cells, introduction to ion channels and graded and action potential, synaptic transmission, neurotransmitters, nervous system organization in vertebrates and invertebrates.

Recommended Books

1. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002)
2. the Invertebrates: A New Synthesis. III Edition. Blackwell Science.
3. Modern Text Book of Zoology: Invertebrates by Prof. R.L. Kotpal
4. Moore: An Introduction to the Invertebrates, Cambridge University Press, 2001
5. Jordan, E.L. and P.S. Verma, 2010, Invertebrate Zoology, S. Chand & Co Ltd., Ram Nagar, New Delhi.
6. Animal Physiology: Adaptation and Environment (5th edition) by Knut Schmidt-Neilson, Cambridge University Press.
7. Campbell Biology (12th edition) by Neil A. Campbell, Lisa A. Urry, Michael L.Cain, Steven A. Wasserman, Peter V. Minorsky, & Peter V. Reece, Pearson.

CHY111: Chemical Principles

Learning Goals and Outcomes:

1. To refresh students' basic knowledge in chemistry and advance their understanding of the fundamentals and applied chemistry.
2. To develop students' experimental skills, especially their ability to perform meaningful experiments, analyse data, and interpret observations.
3. understand the fundamentals behind the formation of atomic and molecular structures, the equilibrium and thermodynamics involved in a chemical system, various organic reactions and the basic analytical techniques to characterize chemical compounds and diagnose which mathematical elements can be used for particular analysis of data,

Organic Chemistry

Introduction to organic chemistry: Examples of various organic chemicals of natural and industrial importance, Bulk vs fine chemicals

Functional group: Types and nature

Physical properties of organic compounds: A general view on physical properties of organic compounds with a variation of functional groups: melting point and boiling point, solubility, acidity and basicity, dipole moment, colour (resonance, phenolphthalein, nature pigments), alkanes vs polyethylene, fun facts (proteins, natural acid, fats)

Substitution reactions: SN1 and SN2, Elimination reactions: Hoffmann and Saytzeff elimination, Name reactions: Markownikoff and Anti-Markownikoff reaction (ionic vs. free radical addition)

Stereochemistry: definition, classification in isomerism

Physical Chemistry (Thermodynamics, Equilibrium, Kinetics and Electrochemistry, Thermodynamic System & Surroundings)

- Laws of Thermodynamics: Zeroth Law; First Law: Heat & Work; State and Path Functions; Different Thermodynamic
- Processes; Thermal Process using an ideal gas; Specific Heat capacities; Enthalpy;
- Thermochemistry (Hess's law)
- Second Law: Entropy; Heat Engines; Carnot's Principle and the Carnot Engine;
- Refrigerators and Air Conditioners
- Third Law: Variation of Entropy with Temperature, Pressure and Volume;
- Absolute Entropy; Standard Molar Entropy; Calculation of Entropy; Probability and Entropy
- Energy: Gibbs and Helmholtz; Maxwell Relations
- Phase Equilibrium: Phase Diagram; Gibbs Phase Rule; Degrees of Freedom; Phases

Chemical Equilibrium: Equilibrium Law
Chemical Kinetics: Rate of a reaction, rate law and specific rate constant, integrated rate equations and half-life (zero, first and second order reactions), Time constant, Activation energy, Arrhenius equation.

Catalysis: Homogeneous and Heterogeneous - Basics, Characteristics and Features
Atomic structure, Periodic table, VSEPR, Molecular Orbital Theory and Spectroscopy:

Introduction atomic structure**,** concept of atom, molecules, Rutherford's atomic model, Bohr's model of an atom, wave model, classical and quantum mechanics, wave particle duality of electrons, Heisenberg's uncertainty principle, Quantum-Mechanical model of atom, Bohr's theory of the hydrogen atom and spectra.

Concept of Atomic Orbitals, representation of electrons move in three-dimensional space, wave function, Radial and angular part of wave function, radial and angular nodes, Shape of orbitals, the principal (n), angular (l), and magnetic (m) quantum numbers, Pauli exclusion principle.

Orbital Angular Momentum (l), Spin Angular Momentum (s), HUND's Rule, The aufbau principle. Shielding Effect, Effective Nuclear Charge, Slater's rule, Periodic properties elements, Lewis structures, Valence shell electron pair repulsion (VSEPR) Valence-Bond theory (VB), Orbital Overlap, Hybridization, Molecular Orbital Theory (MO) of homo-nuclear diatomic molecules. Molecular Orbital Theory of hetero-nuclear diatomic molecules.

Spectroscopy**:** Basic of atomic and molecular spectroscopy, Basic principles of different types of spectroscopy and regions of the spectrum: NMR/EPR spectroscopy, (radiofrequency), (Rotational Spectroscopy (microwave), (Vibrational spectroscopy (infrared), (Electronic spectroscopy (UV-Vis) Bond energies of various single and double bond and their vibrational frequency values in IR. Vibrational Spectroscopy of simple Harmonic oscillators like H_2, O_2, N_2, HCl, CO, NO, and CO_2, degree of freedom, stretching and bending vibrational modes.
IR spectra of different functional groups such as -OH, -NH_2, -CO_2H etc.
UV-Vis Spectroscopy of organic molecules, Electronic Transitions, Beer-Lambert Law, Chromophores

Recommended Books

1. Chemical Principles - Richard E. Dickerson, Harry B. Gray, Jr. Gilbert P. Haight
2. Valence - Charles A. Coulson [ELBS /Oxford Univ. Press]
3. Valence Theory - J. N. Murrell, S. F. A. Kettle, J. M. Tedder [ELBS/Wiley]
4. Physical Chemistry - P. W. Atkins [3rd Ed. ELBS]
5. Physical Chemistry - Gilbert W. Castellan [Addison Wesley, 1983]
6. Physical Chemistry: A Molecular Approach - Donald A. McQuarrie, J.D . Simon
7. INORGANIC CHEMISTRY: Duward Shriver and Peter Atkins.
8. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey,
9. Ellen A. Keiter and Richard L. Keiter.
10. Inorganic Chemistry: Catherine Housecroft, Alan G. Sharpe.

MAT020: Elementary Calculus

Learning Goals and Outcomes

1. Understand the concepts of real functions and be able to compute limits and evaluate continuity.
2. Visualize derivatives as rates of change or slopes of tangents, be able to compute them, and apply them to curve sketching and optimization problems.
3. Understand definite integration as capturing the notion of area, and be able to calculate or estimate integrals
4. Set up and solve separable first order differential equations.

Functions: Real line and its subsets, real functions, graphs, polynomials, rational functions, real powers, trigonometric functions, roots, boundedness, monotonicity, composition of functions, inverse functions.

Limits and Continuity: Algebra of limits, left and right limits, limits involving infinity, continuity, left and right continuity, types of discontinuity.

Differentiation: Rates of change, tangents to graphs, first and higher derivatives, algebra of differentiation, chain rule, exponentials and logarithms.

Applications of differentiation: Exponential growth and decay, intervals of increase and decrease, first and second derivative tests, curve sketching.

Integration: Definite and indefinite integrals, Fundamental Theorem of Calculus, substitution, integration by parts, trigonometric integrals, improper integrals.

First-Order Differential Equations: Separable differential equations, logistic growth.

Recommended Books

1. *Short Calculus,* by Serge Lang, Springer.
2. *Essential Calculus – Early Transcendentals*, by James Stewart. Cengage, India Edition.
3. *The Calculus Lifesaver*, by Adrian Banner, Princeton University Press, 2007.

Online Courses

1. Videos of lectures by Prof Adrian Banner, Princeton University. http://press.princeton.edu/video/banner/

BIO105: Plant Sciences

Learning Goals and Outcomes

1. To provide students with an understanding of the general principles of classification, cell differentiation, and developmental regulation and outcomes in plants, plant physiology and biochemistry to understand the plant system as a whole.
2. To develop skills in analyzing and creating strategies to understand basic principles of tissue organization and functions
3. Demonstrate ability to design strategies for genetic improvement of crops and non-crop plant species.
4. Demonstrate ability to think analytically by analyzing different experimental conditions and creating set of conditions to validate the outcomes.

Plant Systematics: Plant identification, Classification, Nomenclature; Biosystematics**:** General principles of plant taxonomy. General characteristics of different plant life forms including lower plants and higher plants. Outlines and relative studies on classification of angiosperms.

Phycology and Introduction to Fungi**:** General characteristics of cyanobacteria, algae, ecology and distribution; Role of algae in the environment, agriculture, biotechnology and industry. General characteristics of fungi; Affinities with plants and animals; Nature of associations of algal and fungal partners; establishment of Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance, Role of fungi in biotechnology.

Plant Tissue and cell types**:** Leaves, stems, and roots; Xylem and Phloem, cell wall components; cellulose, and lignin, simple and complex tissues.

Water and nutrient transport in plants: Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation, ascent of sap–cohesion-tension theory, transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Plant nutrition**:** macro and micronutrients, mineral deficiency symptoms, roles of essential elements, chelating agents. Nitrate and ammonium assimilation; amino acid biosynthesis, mechanisms of loading and unloading of photoassimilates; Source–sink relationship.

Photosynthesis**:** Light and dark phases of photosynthesis. Role of ATP and NADPH in carbon dioxide assimilation, factors influencing photosynthesis, photosynthesis of CAM plants. Role of plants in converting radiant energy into chemical energy. - photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, CO_2 fixation-C3, C4 and CAM pathways, photorespiration, Factors affecting CO_2 reduction. Starch and Sucrose accumulation.

Respiration and photorespiration**:** Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.

Secondary Metabolites in plants**:** Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.

Developmental processes in angiosperms**:** Life cycle of an angiosperm plant, Plant growth and development, Embryonic and post-embryonic development, Characteristics of plant development, Generation and characterization of developmental mutants, studying temporal and spatial expression pattern of developmental regulators, Morphogenesis and organogenesis in plants: Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in Arabidopsis and Antirrhinum.

Sensory photobiology**:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks, effect of the circadian clock on plant development.

Plant hormones**:** Introduction to the plant hormones (auxin, cytokinin, gibberellins, brassinosteroids, ethylene, abscisic acid, jasmonates, and salicylates) through their roles during the plant's life. The biosynthesis, transport, perception, signal transduction and downstream effects of the hormones and cross-talk in hormone signaling are introduced in this course.

Recommended Books

1. Plant taxonomy and biosystematics, Stace, C. A., Pub: Cambridge University Press.
2. Plant systematics: a phylogenetic approach, Judd, W. S., Pub: Sinauer Associates.
3. Howell, S.H. Molecular genetics of plant development. Pub. Cambridge University Press. 1998.
4. Raven, P.H. Evert, R.F. and Eichhorn, S.E. Biology of plants. Pub: Macmillan. 2005 8th Eds.
5. Plant Physiology And Development. By Taiz And Zeiger. Pub: Sinauer Associates.
6. Mechanisms in Plant Development. Ottoline Leyser, Stephen Day. Pub: John Wiley & Sons.
7. Principles of Development. Lewis Wolpert, Cheryll Tickle, and Alfonso Martinez Arias. Pub: Oxford University Press
8. The Arabidopsis Book vol 14, 2016 by American Society of Plant Biologists

BIO114: Basic Probability and Statistics

Learning Goals and Outcomes

1. To provide students with a comprehensive understanding of fundamental concepts in probability theory and statistics and their importance in studying biological systems.
2. To develop students' skills to decipher patterns and processes from quantitative biology.
3. To develop students' practical skills in biological data processing, graphing, analyses and interpretation.

Probability and statistics in biological context**:** Biological variability is inevitable. Making sense of biological variation using probability and statistics. Biological patterns, randomness and uncertainties. Chance versus reality.

Probability**:** Understanding uncertainties with basic concepts in probability theory. Conditional probability or how reliable are our intuitions. Predicting randomness using probability distributions. Discrete probability distributions (Binomial, Poisson, Geometric) and continuous probability distributions (Normal, Z distribution) and their biological relevance.

Statistics**:** Summarizing variations in biological systems. Basic concepts of variability and statistics; population and samples; types of data; descriptive statistics (measures of central tendencies, dispersion, variation); degree of freedom. Sample to population estimates; standard errors; confidence intervals; accuracy and precision. Presenting data graphically. Foundations of statistical hypothesis testing, null and alternative hypothesis, types of errors, thresholds for α (critical value), one and two tailed tests. Road map for hypothesis testing: one group, two groups, and multi-group analysis. Relating two variables through correlation and regression. Finding associations between variables using the chi-square test. Dos and don'ts of statistical analysis.

Recommended Books

1. Rumsey D (2006) Probability for dummies. Wiley Publications Inc.
2. van Emden HF (2019) Statistics for terrified biologists. 2nd Edition. John Wiley & Sons: England, UK.
3. Zar JH (2010) Biostatistical analysis. 5th edition. Pearson Education: New Jersey, USA.

CHY122: Basic Organic Chemistry I

Learning Goals and Outcomes:

1. To provide students an understanding of the structure of an organic compound in guiding various physical and chemical properties.
2. The importance of structure in dictating the properties and their relevance in designing experiments.
3. To provide students with a working knowledge on correlation of theoretical and experimental aspects of organic reactions
4. To enable skills in writing the structures with an efficient critical analysis and communication with an appropriate terminology.

Intermolecular forces of attraction: Detailed view of van der Waals forces, ion-dipole, dipole-dipole and hydrogen bonding with several examples

Bond fission: Homolytic and heterolytic bond fission, Curly arrow rules

Hybridization: Bonding, Shapes of molecules

Electron displacements: Inductive, electromeric, resonance, hyperconjugation effect

Shape and stability: carbocations, carbanions, free radicals, carbenes, benzynes

Energy diagrams: various types of reactions

Solvents: Types, classification, roles

Acidity and basicity of organic molecules: Alkanes/Alkenes, Alcohols/Phenols/ Carboxylic acids, Amines, amides, pKa, pKb. Effect of solvents. Electrophiles and nucleophiles. Nucleophilicity and Basicity

Aromaticity: aromatic, nonaromatic, antiaromatic, rules, Tautomerism: Thermodynamic, solvent effect, Molecular chirality and Isomerism

Cycloalkanes (C3 to C8): Relative stability, Baeyer strain theory and Sachse Mohr theory. Conformations and Conformational analysis: Ethane, n-butane, ethane derivatives, cyclohexane, monosubstituted and disubstituted cyclohexanes and their relative stabilities.
Stereochemistry (Structural- and Stereo-isomerism)

Molecular representations: Newman, Sawhorse, Wedge and amp; Dash, Fischer projections and their inter conversions.

Geometrical isomerism in unsaturated and cyclic systems: cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules (revisit). Geometrical isomerism in dienes-Isolated and conjugated systems, determination of configurations.

Chirality and optical isomerism: Configurational isomers. Molecules with two or more chiral centres- constitutionally symmetrical and unsymmetrical molecules; Enantiomers

and diastereomers. meso structures, Racemic mixture and their resolution. Measurement of optical activity: specific rotation, molar rotation; dissymmetry, meso compounds, racemic modifications and methods of their resolution; stereochemical nomenclature: erythro/threo, D/L and R/S nomenclature in acyclic systems. Atropisomerism

Recommended Books

1. Morrison, Robert Thornton & Boyd, Robert Neilson Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Seventh Edition, 2005.
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Sixth Edition, 2003.
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of
4. Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Fifth Edition, 1975.
5. Graham Solomons, T.W., Craig B. Fryhle Organic Chemistry, Ninth edition.
6. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; First Edition, Wiley: London, 1994.
7. Clayden, Greeves Warren and Wothers, Organic Chemistry, Oxford University Press.

PHY108: Physics of Living Systems

Learning Goals and Outcomes

1. The course will introduce Newtonian mechanics, Fluids, Electricity and Magnetism, Wave Optics.
2. To provide students with a comprehensive understanding of fundamental concepts in physics and their relation to biological systems.

Introduction**:** Relation of Physics with other sciences, Estimation and Units, Dimensional analysis, Vector and scalar.

Mechanics**:** Newton's laws of motion in one dimension, work & energy in one dimension, Motion in two dimensions, Momentum, Rotational motion.

Fluids**:** Ideal fluid, Viscous fluid, Surface Tension.

Electricity & Magnetism**:** Electric force & field, Energy & potential, Magnetic force & field, Electromagnetic induction

Wave optics**:** Interference, diffraction, Diffraction gratings, Polarization

Recommended Books

1. Physics of the Life Sciences, Jay Newman (Springer)
2. Physics for Scientists and Engineers with Modern Physics, John W. Jewett, Raymond A. Serway
3. The Feynman Lectures on Physics: Volume - 1 (Addison-Wesley)

BIO202: Microbiology

Learning Goals and Outcomes

1. To provide students with an understanding of the nature and practice of Microbiology
2. To provide students with a deeper understanding on the key concepts in microbiology
3. Acquired skills for basic microbiology experiments
4. Development of scientific competency that would have enduring and lasting value beyond the classroom and laboratory.

History, Evolution and Development of Microbiology**:** Diversity of microorganisms- scope and importance. Characterization and identification of bacteria based on morphology, physiology, biochemistry, ecology, chemotaxonomy and molecular systematics. Bergey's manual – classification of bacteria, fungi, algae and archaea. Economic importance of algae and fungi. Clinically important bacteria. Distribution of microbes in nature.

Introduction to Bacteriology**:** Bacterial physiology, growth, bacterial cell, cell wall, cell envelope, transport mechanism, motility and bacterial flagella, chemotaxis, biofilms, quorum sensing, antibiotics and resistance. Archaebacteria.

Bacterial Genetics**:** Gene transfer in bacteria. Bacterial recombination, transformation, conjugation and transduction. Mapping of the prokaryotic genome. Gene regulation in bacteria. Operons- Inducible operon and repressible operon.

History and Development of viruses**:** Nature, origin and evolution of viruses. Nomenclature, recent classification, structure and characteristics of viruses. Biological and chemical properties of viruses. Animal, and bacterial viruses and their interactions with hosts. Virus replication and genome expression. Transmission of viruses (direct and indirect) persistence of viruses and their mechanism.

Recommended Books

1. Microbiology: Concepts and Applications, Pelczar, M. J., Chan, E. C. S., Krieg, N. R., Pub: Mcgraw hill International Book Company.
2. Brock Biology of Microorganisms (16th edition, global), Madigan, M. T. et al. Pub: Pearson, ISBN-13 : 978-1292404790
3. Prescot's Microbiology, Willey, J. et.al.. Pub: MacGraw Hill. ISBN-13 : 978-1265123031
4. Microbiology: An Introduction, Toratora, et al., Pub: Pearson Benjamin Cummings. ISBN-13 : 978-0134605180

BIO204: Biochemistry

Learning Goals and Outcomes

1. Advanced understanding of the principles of Biochemistry and chemical nature of biomolecules.
2. Advanced understanding of the metabolic pathways of biomolecules.
3. Structural insights on biomolecules along with the basis for their function.
4. Expected learning outcomes include: Students will be able to define the role of biological molecules. Students can describe the major concepts of Biochemistry.
5. Students develop skills to perform and demonstrate biochemical assays.

Properties and importance of water. Chemical bonds in biochemistry: covalent and non-covalent interactions -electrostatic, hydrogen bond, van der Waals forces, hydrophobic and hydrophilic interactions, disulphide bridges. pH, pK, acid base reactions and buffers.

Carbohydrates**:** Structure of monosaccharides, disaccharides and polysaccharides. Carbohydrate metabolism and regulation: glycolysis, Krebs cycle, oxidative phosphorylation, gluconeogenesis, pentose phosphate pathway, glyoxylate cycle.

Proteins**:** Classification and properties of amino acids, structure and organization, structural organization of proteins (primary, secondary, tertiary, and quaternary structures). Enzymes classification, lock and key, and induced fit hypothesis, enzyme kinetics -Michaelis-Menten equation, significance of Km, Vmax and Kcat, Lineweaver – Burk plot. Catabolism of amino acids, inborn errors of amino acid metabolism.

Nucleic acids**:** Structure and properties of nitrogenous bases and nucleic acids. Different forms of DNA -A, B, Z. Different types of RNA: mRNA, and non-coding RNA– tRNA, rRNA, snRNA, miRNA and siRNA, biosynthesis and regulation of purine nucleotides and pyrimidine nucleotides, formation of deoxyribonucleotides and their regulation.

Lipids**:** Classification, structure, properties and functions of fatty acids, triglycerides, phospholipids, sphingolipids, cholesterol and eicosanoids- prostaglandins, saturated and unsaturated fatty acid synthesis, β-oxidation and regulation, ketone bodies, biosynthesis of triacylglycerides, phospholipids, and cholesterol.

Vitamins**:** Source, structure, biological role and deficiency disorders of vitamins.

Recommended Books

1. Lehninger Principles of Biochemistry (5th ed.), Nelson, D., Cox, D., Pub: Macmillan.
2. Biochemistry (6th ed.), Stryer, L., Pub: Freeman-Tappan.
3. Text Book of Biochemistry by West, E.S., Todd, W.R., Bruggen, J.T.V., Pub: Mac Milan.
4. Principles of Biochemistry by White, A., Handler, P., Smith, E.L., Pub:McGraw Hill.
5. Harper's Biochemistry, Murray, R. K., et al., 27 ed., Pub: Langeman
6. Biochemistry (3rd ed.), Voet, D., Voet, J. G., Pub: John Wiley.

BIO209: Biophysics

Learning Goals and Outcomes

1. To be able to apply key principles of physics to biological problems
2. Understand physics underlying functionality of living systems
3. Be able to apply physics to understand the structure and function of biological molecules

Introduction**:** Definition of biophysics, why to study, examples.

Thermodynamics: Entropy, Enthalpy, The free energy of a system, Chemical potential, Redox potential, Bioenergetics.

Biophysical properties: Surface tension, Diffusion & Brownian motion, Osmosis, Dialysis, Colloids.

Application of Radiation to Biological systems**:** Introduction, particles and radiations of significance, physical and biological half-lives, macroscopic absorption of radiation, activity and measurements, units of dose, relative biological effectiveness and action of radiation at molecular level.

Experimental methods in biophysics:

a) Microscope**:** Light characteristics, microscopes- compound, phase contrast, polarization, fluorescent and electron microscopes – Transmission Electron Microscope, Scanning Electron Microscope, and Scanning tunneling electron microscope, Atomic Force Microscopy.
b) Spectroscopy**:** Interaction of EM radiation with matter Ultraviolet & Visible spectroscopy-Beer Lamberts law- spectrophotometer. Infrared spectroscopy, Raman spectra, Circular Dichroism, Fluorescence spectroscopy, NMR spectroscopy.

Recommended Books

1. Intermolecular and surface forces by J. Israelachvilli (Elsevier, 2011)
2. Molecular & Cellular Biophysics by M. B. Jackson
3. Biophysics, V. Pattabhi & N. Gautham (Narosa Publishing House)
4. Biophysics by R. Glaser (Springer, 2004)

BIO210: Cell Biology

Learning Goals and Outcomes:

1. Comprehensive learning and developing problem-solving skills related to various basic and advanced topics in Cell Biology.
2. On successful completion of the course, students will be able to comfortably discuss and attempt solving problems in Cell Biology.
3. Students will also learn to design and conduct some basic experiments focusing on techniques that are used to study the structure and functions of cells.

- Origin of life
- Cells and its evolution from uni- to multicellularity
- Cellular organelles, their functions and association with diseases: nucleus (genetic information storage), ribosome and rough endoplasmic reticulum (protein synthesis), smooth endoplasmic reticulum (lipid synthesis), golgi (protein modification and trafficking), peroxisome (lipid degradation), lysosome (protein degradation), mitochondria (energy biogenesis), cytoskeleton (structural support, mobility and cell division), chloroplast (photosynthesis), vacuole (water balance in plants).
- Cell membrane, its general structure, pumps, transporter and channels
- Extracellular matrix
- Cell growth: cell cycle, mitosis, and meiosis
- Cell death: apoptosis, necrosis, autophagy and ferroptosis.
- Cellular senescence and its impact on aging and old-age syndromes and diseases.
- Stem cells and differentiation: concept of regeneration and induced pluripotency
- Cloning: concepts of reproductive and therapeutic cloning
- Cancer: as a model disease of aberrant cell growth and death
- Epithelial mesenchymal transition and cell migration: relationship with physiology and pathology
- Basics of cell signaling/cell-cell communication: Receptors, ligands, effectors, and introduction to common signaling pathways.

Recommended Books

1. An Introduction to the Molecular Biology of the Cell, Alberts, B., Bray, D., Johnson, A., Lewis, J., Roff, M., Robert, K., Walter, P., Roberts, K., Pub: Garland Publishing Company.
2. Cell and Molecular Biology, Sheelar, P., Bianchi, D. E., Pub: John Wiley.
3. Molecular Cell Biology, Lodish, H., Berk, A., Zipursky, S.L., Matsudaura, P., Baltimore, D., Danell, J., pub; W.H. Preeman and Company.

BIO211: Genetics

Learning Goals and outcomes

1. To introduce the concepts of Mendelian genetics, Genetic Linkage, Linked genes
2. To discuss the basis of non-Mendelian inheritances
3. To discuss about basis of common genetic disorders
4. Familiarize students with concepts of different types of inheritance, basis of common genetic disorders.

Introduction to Genetics:

Laws of inheritance**:** Mendel's Laws, concept of dominance, segregation, independent assortment; Chromosome theory of inheritance.

Genetic Linkage**:** Concepts, recombination, gene mapping in prokaryotes and eukaryotes, fine structure mapping.

Sex-linked inheritance**:** Conceptual basis, sex influenced traits, mechanism of sex determination.

Quantitative inheritance**:** Concept, Genes and Environment - heritability, penetrance and expressivity.

Genetic Interactions: epistasis and its different types of epistasis.

Cytoplasmic inheritance: Basis and mechanism, role of organellar genes.

Mutation: Classification, mechanism, repair, role in genetic analysis and evolution.

Changes in Chromosome number and structure**:** Polyploidy, aneuploidy, chromosomal rearrangements - deletion, duplication, inversion, and translocation. Meiotic consequences in structural heterozygotes, role in speciation and evolution.

Different model systems in Genetics**:** Bacteriophage, E. coli, Neurospora crassa, yeast, Arabidopsis, maize, Drosophila, C. elegans, Zebra fish, Homo sapiens - General outline of life cycle, importance in Genetic analysis.

Recommended Books

1. Concepts of Genetics Klug W. S. and
2. Cummings M. R, (Prentice-Hall)
3. Genetics-a Conceptual Approach Pierce B. A. (Freeman)
4. Genetics- Analysis of Genes and Genomes Hartle D. L. and Jones E. W. (Jones & Bartlett)
5. An Introduction to Genetic Analysis Griffith A. F. et al (Freeman)
6. Principles of Genetics Snustad D. P. and Simmons M. J.John (Wiley &Sons.)
7. Genetics Strickberger M. W. (Prentice-Hall)

BIO205: Bio-Analytical Techniques

Learning Goals and Outcomes

1. Students will be able to learn bioanalytical techniques and principles
2. Students can understand and operate various Life Science instruments
3. Students develop skills to perform and demonstrate biochemical assays

Introduction**:** Standard operating procedures, dealing with research instruments, analytical method validation, basic principles and usage of pH meter.

Molecular techniques**:** PCR and its variations, real-time PCR, Southern and Northern hybridization, Western blotting, Sanger sequencing.

Electrophoresis**:** Agarose gel electrophoresis, native polyacrylamide gel electrophoresis and denaturing polyacrylamide gel electrophoresis, immunoelectrophoresis, 2D electrophoresis, isoelectric focusing.

Spectroscopy**:** Principle and law of absorption, absorption and emission spectroscopy, fluorimetry, colorimetry, spectrophotometry, UV, visible and IR spectroscopy, polarography, mass spectrometry, circular dichroism.

Chromatography techniques**:** Partition, adsorption, ion exchange chromatography, molecular exclusion, affinity chromatographies, HPLC and FPLC.

Microscopy**:** Resolution, numerical aperture, light microscopy -bright field, dark field, phase contrast. Fluorescence and confocal microscopy. Electron microscopy -scanning and transmission electron microscopy.

Centrifugation**:** sedimentation theory, centrifugal force, Svedberg equation, pelleting, differential pelleting, density gradient centrifugation -rate zonal and isopycnic, analytical centrifugation.

Recommended Books

1. Principles and Techniques of Biochemistry and Molecular Biology Ed. Wilson KM, Valker, JM Pub: Cambridge University Press
2. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, Impe., J. F. V., Vanrolleghem, P. A., Iserentant, D. M., Pub: Kluwer Academic.
3. Modern Spectroscopy, Hollas, J. M., Pub: John Wiley and Son Ltd.
4. Principles of Physical Biochemistry, Holde, K. E. V., Johnson, W. C., Ho, P. S., Pub: Prentice Hall.
5. Microscopic Techniques in Biotechnology, Hoppert M., Pub: Wiley VCH.

BIO206: Fundamentals of Molecular Biology

Learning Goals and Outcomes

1. Students will be able to understand molecular mechanisms of cellular process
2. Gain knowledge Fundamental concepts in regulation of gene expression and its relation to various biological processes
3. Solve analytical problems related to molecular biology.

Nature of genetic material**:** organization of genetic material in prokaryotes and eukaryotes. Structure of chromatin, fine structure of the gene. Different kinds of genes- split genes, overlapping, assembled, polyprotein & nested genes.

DNA replication: Types of DNA polymerases. Mechanism of DNA replication. Enzymes and accessory proteins involved in DNA replication. Replication of telomeres and its significance. Differences in prokaryotic and eukaryotic DNA replication and regulation. DNA damage and repair.

Transcription in prokaryotes and eukaryotes**:** Mechanism of transcription, Types of RNA polymerases, and promoter-polymerase interactions. Transcriptional factors. Processing of mRNA, tRNA, and rRNA. RNA editing and transport.

Translation in prokaryotes and eukaryotes**:** Genetic code, translational machinery, mechanism of initiation, elongation and termination. Regulation of translation, and post-translational modification. Protein folding and degradation

Regulation of gene expression in prokaryotes and eukaryotes: the operon concept, negative & positive control and attenuation. Role of enhancers, cis-trans elements, DNA methylation and chromatin remodeling in gene expression. Environmental regulation of gene expression. RNA degradation and control, RNAi and gene silencing.

Recommended Books

1. Genes X11, Lewin, B., Pub: Oxford. ISBN-13 : 978-1284104493
2. Molecular Biology of the cell, Bruce Alberts, ISBN-13 : 978-0393884852
3. Molecular Biology, Frefielder, D., ISBN-13 : 978-9384323059
4. Molecular Biology of the Gene, Watson, J. D., *et. al*., Pub: Benjamin. ISBN-13 : 978-0321762436

BIO207: Immunology

Learning Goals and Outcomes

1. Understand the importance and application of the immune system of the body in health and diseases.
2. Basics and hands-on learning about different immunological experiments.

Concepts of immune response. Innate immunity – barriers and role of toll like receptors in innate immunity. Cells of the immune system, Adaptive immunity – organization and structure of lymphoid organs. Antigens –immunogenicity, antigenicity, factors influencing the immunogenicity, haptens, adjuvants and mitogens. Super antigens, B & T cell epitopes.

Types of B cells, BCR, developmental stages of B cells, regulation of immune response. Classification, fine structure and functions of antibodies. Antigenic determinants on immunoglobulins – isotypes, allotypes and idiotypes. The generation of antibody diversity. Effector cell mechanism of humoral response. T cell ontogeny – Types of T cells, T cell development. T-cell maturation and activation. Structure of TCR. T-cell differentiation, Effector cell mechanism. Cell death and T-cell populations, Types of cell mediated immunity.

Cytokines – classes and their biological activities. Therapeutic uses of cytokines and their receptors. Complement system– mode of activation, classical, alternate and mannose binding pathway, biological functions and regulation. Major histocompatibility complex (MHC). Human leukocyte antigens (HLA), MHC restriction. MHC and disease susceptibility, regulation of MHC expression. APC's and antigen processing and presentation.

Recommended Books

1. Kuby Immunology (6th ed.), Kindt, T. J., Goldsby, R. A., Osborne, B. A., Pub: W. H. Freeman and Company.
2. Roitt's Essential Immunology (12th ed.), Delves, P. J., Martin, S. J., Burton, D. R., Roitt, I. M., Pub: Wiley- Blackwell.
3. Janeway's Immunobiology (8th ed.), Murphy, K., Pub: Garland Science.
4. Fundamental Immunology (6th ed.), Paul, W. E., Pub: Lippincott Williams &Wilkins publishers.

BIO208: Bioinformatics

Learning Goals and Outcomes
The course is designed to give understanding in Bioinformatics skills and it covers sequence analysis, structural bioinformatics, concept of Drug Discovery, Phylogenetic tree construction, Protein structure prediction methods and basic gene expression data analysis.

Structural Bioinformatics**:** Classification of protein structures, Primary, Secondary and Tertiary structures, Quaternary structure, Protein folding concept, Potential energy map and Ramachandran plot. Secondary structure prediction methods, Classification of Three-Dimensional Structures of Proteins, Motifs, Folds and Domains, Classification of Three-Dimensional Structures in PDB (HSSP, SCOP, FSSP, CATH). Structural Alignment Methods, Homology Modeling, fold recognition and ab initio methods. Computer aided drug design (CADD): Structure based drug designing and Ligand based drug design, Molecular Docking, Virtual Screening.

Genomics**:** The Human Genome, Advanced Comparative Genomics (Comparative genomics of Model organisms), gene identification methods, Phylogenetic Analysis, concept of SNP and snip analysis, Advanced R and primary gene expression analysis.

Recommended Books

1. Bioinformatics–Sequence, Structure and Databanks, Higgins, D., Taylor, W., Pub: Oxford University Press, Incorporated.
2. Bioinformatics: A practical guide to the analysis of genes and proteins, Baxevanis, A. D., Ouellette, B.F.F., Pub: John Wiley and Sons Inc.
3. Bioinformatics: Sequence and Genome Analysis, Mount, D.W., Pub: Cold Spring Harbor Laboratory Press.
4. Structural Bioinformatics, Ed: Bourne, P. E., Weissig, H., Pub: Wiley-Blackwell.

BIO301: Animal Biotechnology

Learning Goals and Outcomes

1. Understand the application of all the molecular approaches in the animal system.
2. Basics and hands on learning about in-vitro Cell and tissue culture.

Basic techniques of cell, tissue and organ culture: Primary culture and subculture of cells. kinetics of cell growth. Properties of normal and transformed cells. Role of carbon dioxide, serum and other supplements in cell culture. Different types of culture media- natural media, BSS, MEM, serum free media. Different methods for the estimation of cell viability and cytotoxicity. Applications of cell culture. Stem cells – Embryonic and adult stem cells. Isolation and culture of stem cells. Induced pluripotency of stem cells. Stem cell markers. Stem cell plasticity and differentiation. Application of stem cells in medicine. Apoptosis- mechanism and significance with reference to degenerative diseases – Parkinson's disease, stroke and diabetes.

Organ culture and tissue engineering**:** Organ cultures, histolytic cultures, three dimensional cultures, organotypic cultures. Production of bio-artificial skin, liver and pancreas. Tissue engineering- cell source and culture, culture of cells, design engineering of tissues, tissue modeling. Embryonic stem cell engineering.

Production of monoclonal antibodies**:** Production of Transgenic Animals -Mouse, sheep, cattle and fish by microinjection, retroviral vector method and embryonic stem cell method. Animal cloning-Somatic cell nuclear transfer and embryonic stem cell nuclear transfer methods. Bio pharming and gene knockout.

Recommended Books

1. Culture of Animal cells; A manual of Basic techniques (6th ed.), Freshney, R. I., Pub: Wiley-Blackwell.
2. Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick, B. R., Pasternak, J. J., Pub: ASM Press.
3. Elements of Biotechnology, Gupta, P. K., Pub: Rastogi & Co.
4. Concepts of Biotechnology, Balasubrahmanian, et al., Pub: University press.

BIO302: Plant Biotechnology

Learning Goals and Outcomes

1. To provide students with an understanding of the nature and practice of plant tissue culture, methods for genetic improvement in agriculture
2. To develop skills in analyzing and creating biotechnological methods and strategies for crop improvement
3. To enable students to work in groups, to make presentations in front of peers and experts, and to think and converse about biological systems.
4. Demonstrate ability to design and use the available molecular tools to design strategies for genetic improvement of crops and non-crop plant species.

Plant tissue culture media preparation and optimization, phytohormones, in vitro cultures- initiation and maintenance of callus, suspension cultures and single cell clones- organogenesis, somatic embryogenesis, cite differentiation and morphogenesis. Embryo, endosperm and organ culture production of triploids and haploids. Introduction to the processes of embryogenesis and organogenesis and their practical applications. Micropropagation, axillary bud, shoot-tip and meristem culture. Somaclonal variations and applications.

Introduction to protoplast isolation and applications. Introduction of somatic hybridization. Various methods for fusing protoplasts, chemical and electrical. Cybrids- definition and application. Use of plant cell, protoplasts and tissue culture for genetic manipulation of plants and to study basic cellular processes.

Introduction to *A. tumefaciens*. Tumor formation on plants using *A. tumefaciens* (Monocots vs. Dicots). Practical application of genetic transformation and genetic engineering. Development of plant transformation vectors, identification of transgenic plants, reporter and selectable markers, constitutive and tissue specific gene expression of desired transgene. Methods of gene transfer in plants- direct and indirect (Agrobacterium and viral mediated) gene transformation. Stable vs transient transformation.

Basic introduction to Plant genetics and breeding, molecular markers, genome-wide association studies, marker assisted selection and their applications with the help of some examples. Methods for marker identification RFLP, AFLP, simple sequence repeats, RAPD for molecular mapping and their use in crop improvement for biotic and abiotic stress tolerant variety development.

Plant biotechnology: Development of transgenic plants- herbicide tolerance, disease resistance, insect resistance, stress tolerance, biofortification, regulation of fruit ripening, edible vaccines. Genetic manipulation of photosynthetic traits for improvement of crop yield.

Recommended Books

1. Experiments in Plant Tissue Culture, Dodds, J. H., Roberts, L. K., Pub: Cambridge University Press.
2. Plant Tissue Culture: An Introductory Text. Sant Saran Bhojwani, Prem Kumar Dantu.

3. Principles of Plant Genetics and Breeding by George Acquaah. Pub: John Wiley and Sons Limited
4. Principles of Genetics. D. Peter Snustad and Michael J. Simmons. Pub: John Wiley and Sons Limited
5. Plant Biotechnology, Slater, A., Scott, N. W., Fowler, M. R., Pub: Oxford University press.
6. Biotechnology in Agriculture, Swaminathan, M. S., Pub: Mc. Millian India Ltd.
7. Biotechnology and its applications to Agriculture, Copping, L. G., Rodgers, P., Pub: British Crop Projection.
8. Plant Biotechnology, Kung, S., Arntzen, C. J., Pub: Butterworths.
9. Plant Biotechnology: Experience And Future Prospects, Agnes Ricroch, Surinder Chopra, Shelby Fleischer, Pub: Springer International Publishing, 2016,
10. Gene Cloning And DNA Analysis: An Introduction, T. A. Brown. ISBN: 978-1-119-07256-0
11. The Arabidopsis Book Vol 14, 2016, Pub: American Society Of Plant Biologists

BIO303: Recombinant DNA Technology

Learning Goals and outcomes

1. To provide students with an understanding of usage and application of recombinant DNA technology.
2. To develop students' skills in all basic techniques of recombinant DNA technology.
3. To motivate students to make new recombinant DNA to answer challenging biological problems.
4. Design the strategy of making a recombinant DNA and Make genetically modified organisms.

Introduction to recombinant DNA technology**:** Isolation of DNA, and introduction of DNA into living cells. Introduction to gene cloning and its uses, tools and techniques: plasmids and other vectors, DNA, RNA, cDNA. Polymerase Chain Reaction, PCR variations and their applications.

Enzymes used in genetic engineering**:** Restriction endonucleases and restriction mapping, DNA ligase, DNA polymerase-I, reverse transcriptase, Sl nuclease, terminal nucleotide transferase, alkaline phosphatase, polynucleotide kinase, polynucleotide phosphorylase.

Cloning vectors: salient features, plasmid vectors, phage vectors, cosmids, phagemids (Lambda and M13 phages), viral vectors (SV40, Baculo-virus and CMV), artificial chromosomes BAC, YAC and MAC.

Ligation of DNA to vectors: cohesive end, blunt end, - homopolymer tailing, linkers, and adaptors.

Gene transfer techniques**:** transformation, transfection, microinjection, electroporation, lipofection and biolistics.

DNA sequencing**:** Chemical, enzymatic and NGS methods. Modern methods of genome editing and its applications. Introduction to synthetic biology.

Production of proteins from cloned genes**:** Different types of expression vectors and expression systems. Uses of gene cloning in medicine (Pharmaceutical agents such as insulin, growth hormones, recombinant vaccines), gene therapy for genetic diseases.

Reporter gene assay: selection and expression of r-DNA clones. Salient features of the human genome project. Applications of genetic engineering in agriculture, animal husbandry, medicine and industry.

Recommended Books

1. Recombinant DNA Technology, Watson, J. D., Pub: W. H. Freeman.
2. Gene cloning and DNA analysis, Brown, T. A., Pub: Wiley Blackwell, Ltd.
3. Principles of Gene manipulation: an introduction to Genetic Engineering, Primrose, Old R. W., Primrose, S.B., Pub: Blackwell Science Ltd.

BIO304: Industrial Biotechnology

Learning Goals and Outcomes

1. Understand the role of microbes and other microbial products in Industrial biotechnology.
2. Fundamental understanding to exploit microbes/proteins/enzymes and other metabolites for manufacturing products of industrial significance.
3. Apply practical biotechnology skills for entrepreneurial development.

Introduction to fermentation, the fermentation industry, Production process batch and Continuous system of cultivation, Solid-state fermentation. Selection of industrial microorganisms, media for fermentation, aeration, pH, temperature and other requirements during fermentation, downstream processing and product recovery, food industry waste as fermentation substrate.

Primary and secondary metabolites and their applications; preservation of food. Biogas; bio-fertilizers and bio-pesticides. Use of microbes in mining: leaching of ores by microorganisms; microorganisms and pollution control-bioremediation; biosensors.

Industrial application of microbes for the production of - Wine, Beer, amino acids, organic acids, enzymes, antibiotics, alcohol, and SCP. Enzyme technology - production and recovery of enzymes, enzyme immobilization - application of enzyme in industries. Biosensors. Biological waste treatment and in-plant sanitation.

Recommended Books

1. Industrial Microbiology, Casida, L. E., Pub: Wiley.
2. Principles of fermentation Technology, Stanbury, P. F., Whitaker, A., Hall, S. J., Pub: Pergamon.
3. Industrial Biotechnology, Sustainable Growth, and Economic Success. *Wim Soetaert and Erick J. Vandamme.*
4. Modern Industrial Microbiology and Biotechnology, *Nduka Okafor.*
5. Essentials in Fermentation Technology, *Aydin Berenjian*

BIO305: Genomics and Proteomics

Learning Goals and Outcomes

1. Understand the basic concepts of genome organization
2. Gain basic knowledge on genome regulation
3. Learn functional output of genome
4. Know the advanced methodologies used in genomics
5. An overview on the application of genomics in disease, development of organisms, ecology and evolution.
6. To investigate protein-protein interaction
7. Protein expression analysis
8. Protein structure and its relevance to the disease
9. Application of proteomics in biotechnology

Genomics: An introduction to the genome biology and its applications. Here, concepts on genome organization, dynamics of genome regulation and their functional products will be introduced. Students will be introduced to advanced methodologies used in sequencing technologies to study the genomes and other methodologies to dissect the genome organization and function.

Proteomics: Introduction and scope of proteomics; Protein separation techniques: ion exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels; Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing; Protein modifications and proteomics; Applications of proteome analysis to drug; Protein-protein interaction (Two hybrid interaction screening); Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics in industry.

Recommended Books

1. Lesk, A. M. *Introduction to genomics*. Oxford University Press. (Second edition 2012/Third edition 2017)
2. Primrose, S. B., & Twyman, R. M. Principles of genome analysis and genomics.
3. Liebler, D. C. *Introduction to proteomics: tools for the new biology*. Springer Science & Business Media.
4. *Proteins: Structure and Molecular Properties'* by Thomas Creighton, W.H. Freeman & Company
5. *Principles of Proteomics '* by R.M.Twyman; Taylor and Francis.
6. *Principles of Protein Structure'* by G.E.Schulz and R.H.Shirmer, Springer-Verlag Press, New York
7. Handbook of Proteomic Method, P. M. Conn, Pub: Humana Press.

BIO307: IPR, Bio-regulatory affairs & Bioethics

Learning Goals and Outcomes

1. The students are expected to understand concepts pertaining to Intellectual property rights and its application
2. Students shall be exposed to basic bioethics concepts in relation to both research and clinical setup.
3. Learn about the regulatory processes involved in Drug/Vaccine development.

IPR: Introduction to various Intellectual Property Rights with a special focus on Patent laws, role of IP in research and development, International framework for the protection of IP (TRIPS, PCT, Paris Convention etc.), application of patent law in the domain of biotechnology, patentability: requirements and non-patentable subject matter, statute and rules for the administration of Patent law in India, legal requirements and administrative steps for getting a patent for a biotechnological invention, process flow of grant of a patent, use of databases of (patent and non-patent) for retrieving information to conduct research before filing a patent, understanding the published patent document, interpreting and constructed a patent claim, challenging and revoking a granted patent , Enforcing a patent: remedies available.

Bio-Ethics: General Bio-Ethical Considerations, Moral theories of Ethics, Clinical and Medical Ethics, Research ethics- Basic and Clinical research.

Bio-Regulatory Affairs: Definition**,** History and Need**,** New Drug Development Process**,** Drug Regulatory Agencies: US, Europe and India**,** Regulatory Filing Process for New Drug and Marketing**,** Good Laboratory Practices (GLP)**,** Good Manufacturing Practices (GMP)**,** Good Clinical Practices (GCP)

Recommended Books

1. Beier, F.K., Crespi, R.S. and Straus, T. *Biotechnology and Patent protection*- Oxford and IBH Publishing Co. New Delhi.
2. Singh K, *Intellectual Property rights on Biotechnology*, BCIL, New Delhi
3. Indian Patent Act, 1970
4. Manual of Patent Practice and Procedure, Indian patent Office
5. Patents for Chemicals, Pharmaceuticals and Biotechnology- Fundamentals of Global Law, Practice and Strategy by Philip W. Grubb, Oxford University Press
6. Fundamentals of US Regulatory Affairs. ISBN:978-1-947493-33-9.
7. Bioethics: The Basics, Alastair V. Campbell ISBN 978-0-415-79031-4

BIO326: Developmental Biology

Learning Goals and Outcomes

1. Cells communication during the development of the organisms and molecular interplay in spatiotemporal manner give rise to different outcomes
2. Body axes are patterns and different germ layers and development of specialized tissue types and organs.
3. Effect of environment on the development of organisms.

Introduction to developmental biology**:** Historical perspective on the transition of embryology to developmental biology and integration of different biology streams such as molecular biology, cell biology and genetics.
Evolutionary developmental biology**:** Introduction to popular and unconventional model organisms used in developmental biology. Provide the advantages and limitations of these model systems to address the various questions pertinent to organismal development.
Early embryonic development**:** Overview of Fertilization, Cleavage, Zygotic genome activation/Mid blastula transition, Gastrulation, Body axes patterning, Germ layer specification. A comparative perspective on these events in the selected organism will be provided from the evolutionary developmental biology perspective.
Cell-cell communication in development**:** Introduction to the concepts such as cell induction, competition, Cell-cell and cell-ECM interactions with cell surface receptors. Introduction to the developmental signaling pathways such as Wnt, Hedgehog, TGF-beta, JAK-STAT, Notch, RTK, Hippo and nuclear hormone-mediated signaling
Organogenesis**:** Overview of development of different organs from different germ layers. A detailed account of brain development and limb development using appropriate examples.
Germ cell development and sex determination**:** A comparative note on germ cell specification and development. Conserved and lineage-specific sex determination process in selected animal models.
Regeneration and Aging**:** An overview of the regeneration process occurring animal kingdom will be discussed. An overview of cellular and molecular changes reported during the aging process will be provided.
Environment and animal development**:** A brief overview of the role of various environmental factors such as biotic and abiotic stress conditions on the development of animals in different ecological niches and the possible consequences will be discussed.

Recommended Books

1. Gilbert, Scott F. *Developmental biology*. sinauer associates, Inc, 7th edition and 10th edition.
2. Wolpert, Lewis, Cheryll Tickle, and Alfonso Martinez Arias. *Principles of development*. Oxford University Press, USA, 2015.
3. Additionally, relevant review/research articles will be suggested in the class.

Major Elective

BIO309: Cancer Biology

Learning Goals and Outcomes

1. This course aims to teach students history, biology, evolution and therapies of cancer, its biomarkers, nature's anticancer strategies, preventative measures, clinical trials, drug repurposing, drug resistance and its remedies, application of functional genomics and synthetic lethality in understanding and treating cancer.
2. On successful completion of the course, students will be able to understand the history and nature of one of the deadliest of all non-communicable diseases, its prevention and treatment.

This course covers basic and advanced topics of biology of cancer and its treatment modalities.

- Definition, classification and hallmarks of cancer; history, lifestyle and prevention of cancer
- Peto's paradox: nature's own cancer prevention strategies
- Tumor viruses, oncogenes, tumor suppressors, oncogene addiction and loss of heterozygosity
- Multistep evolution of cancer: clonal and stem cell theories
- Darwinian evolution and tumor heterogeneity
- Angiogenesis and metastasis
- Cancer metabolism
- Microbial dysbiosis and carcinogenesis
- Five pillars of cancer therapies, nanoKnife and its application in cancer treatment
- Evolution and mechanisms of anticancer drug resistance
- Evolutionary therapeutics, cancer biomarkers, clinical trials;
- Drug repurposing
- Application of functional genomics and synthetic lethality in understanding and treating cancer.

Recommended Book

1. The Biology of Cancer by Robert A Weinberg. Publisher: Garland Science. Second edition

Major Elective

BIO322: Neuroscience and Cognition

Learning Goals and Outcomes

1. To understand the brain/mind system as a frontier of science, technology and humanities.
2. To comprehend the basis of neuroscience, cognition and behavior from the perspectives of both basic and translational research.
3. To have knowledge of techniques in diagnosis, prevention and treatment from the perspective of neurological disorders and mental health.

Introduction to brain**,** mind, and behaviour (History of neuroscience/understanding of the brain; scales of understanding the brain and its function: molecules, synapses, neurons, circuits, networks, systems, mind, behaviour, intelligence and intellectual functioning)
Channels, resting membrane potential and action potentials
Synaptic transmission, neurotransmitters, excitatory and inhibitory signals
Sensory systems and sensory processing [Audition, Vision, Chemosensation (Smell and Taste) Touch and Pain].
Motor control and pattern generators (including basal ganglia, cerebellum, and invertebrate CPGs)
Spatial Navigation, Learning and memory, Emotion and valence

Neuronal development and adult neurogenesis

Development and Ageing

Brain disorders and Mental Health**:** Theories of mind, Animal Behaviour

Techniques:
Electroencephalography, extracellular single neuron recordings, patch clamp, Calcium Imaging, Optogenetics,Brain imaging including functional neuroimaging techniques like Positron Emission Tomography, Functional Magnetic Resonance Imaging, deep brain stimulation, neural gait analysis, neurostimulation, neuroprotection etc. will be introduced and elaborated upon during lectures about systems that were understood or manipulated using these techniques.
Psychological Testing and Personality Evaluation.

Recommended Books

1. Neuroscience: Exploring the Brain, Bear, Connors, and Paradiso. Wolters Kluwer
2. Neuroscience, Purves et al. Sinauer Associates
3. Guyton and Hall. Textbook of medical physiology, Hall and Hall. Elsevier

Major Elective

BIO323: Epigenetics

Learning Goals and Outcomes

1. To introduce students to basic concepts in gene regulation, chromatin biology, genome-environment interaction, epigenetics and its applications in genomics and disease biology.
2. The course would be useful for students who are interested in learning about the organization of genes and their organization at the molecular level and using a systems approach.
3. The discussions will encompass genetics, biochemistry, bioinformatics, genomics, proteomics, computational biology and systems biology.

Fundamental principles of epigenetics**:** Why is epigenetics a new frontier in biology, from genetics to epigenetics: why do we need epigenetics to fully explain heritability (non-Mendelian propagation, dynamic organization of the genome and its impact on gene regulation)

Mechanism and molecules that regulate epigenetic processes**:** Epigenetic chromatin modifications: how multiple varieties of chemical modifications decorate the epigenome and its activity, DNA methylation, histone modification, chromatin remodelling and various epigenetic factors, regulation of epigenetic processes by non-coding RNAs, epigenetics of alternative splicing, crosstalk between DNA modifications and histone modifications

Epigenetic phenomenon in different model organisms**:** What we can learn from them X chromosome inactivation in mammals, var gene regulation and immune evasion in plasmodium, epigenetic inheritance in plants, epigenetic processes in fungi

How epigenetics influences life of an organism**:** Inheritance of chromatin modifications at the beginning of life, epigenetic reprogramming and genomic imprinting, role of epigenetic mechanisms during DNA replication, cell division and cell differentiation, epigenetic variations in human populations (DNA sequence and chromatin organization, regulatory elements such as boundary elements and insulators)

Epigenetics and diseases**:** Epigenetics and aging, epigenetic mechanisms in metabolic diseases, epigenetics and neurological disorders, role of DNA methylation and epigenetic histone modifications in cancer, therapeutic epigenetic approaches to cancer

How environment and aging influence hereditability**:** How nutrition and life style drive heritable epigenetic changes, recent developments underlying epigenetic regulation of complex traits such as behavior

Future perspectives**:** What will be the new frontiers of epigenetics research, implication of epigenetics discoveries for human society.

Recommended Books

1. Histone variants – ancient wrap artists of the epigenome. Talbert P. B. and Henikoff, S. Nat. Rev. Mol. Cell Biol., 2010 doi:10.1038/nrm2861
2. Divide and (epigenetic) rule: Chromatin domains as functional and structural units of genomes. Mishra RK and Galande S. Journal of Indian Academy of Sciences, Platinum
3. Jubilee issue, 2009, pp 211-224.
4. The mammalian epigenome. Berstein et al., Cell 2007, 128: 669-681.
5. Linking DNA methylation and histone modification: patterns and paradigms. Cedar H, Bergman Y. Nat Rev Genet. 2009, 10(5):295-304.
6. Boundaries. Boundaries...Boundaries??? Lunyak VV. Curr Opin Cell Biol. 2008, 20(3):281-7.
7. Transgenerational Epigenetic Inheritance: Myths and Mechanisms. Heard E and Martienssen R, Cell 2014, 157(1):95–109.

Major Elective

BIO324: Hippocampus, spatial navigation, learning & memory

Learning Goals and Outcomes

1. The hippocampus is involved in critical functions such as navigation and memory. It has also historically been used as the model system to understand brain function at molecular, synaptic and systems levels. Discoveries made in the hippocampus have been instrumental in understanding the brain. In this course, students will learn about hippocampus at molecular, neuronal, networks and systems levels and its role in spatial navigation, learning and memory.
2. This course aims to introduce students to the hippocampus as the model system to understand brain structure and function.

Hippocampus as the model system to understand brain function at molecular, synaptic and systems levels.

Types of memory. Memory systems. Hippocampus dependent and independent memory.

Synaptic plasticity and its relationship to learning and memory.

Hippocampus neuroanatomy, input/output circuitry. Space and cognitive map. Navigation.

Implications of hippocampal connectivity patterns on information processing: pattern separation in DG, completion in CA3, who knows what in CA1? Comparator?

Coexisting maps in the hippocampal system.

Building a cognitive map: input/output transformations in the entorhinal-hippocampal circuitry.

BIO325: The Functional Basis of the Human System

Learning Goals and Outcomes

1. To obtain an integrated grasp on the function and structure of the human system, its subsystems and organ-systems in its totality
2. To understand the dynamics of the human system in terms of relevant electrical, mechanical, chemical, and biological activity.
3. To comprehend the normal and abnormal processes in subsystems and organ systems, for enabling translation to biotechnological, diagnostic, and innovation or discovery-led solutions.
4. To be aware of the impairment of the different subsystems and organ systems for application to bio-engineering, medical device design, health-tech, and formulation of treatment-oriented utilities.

Introduction to Human Functional Principles.

The Heart and the Circulatory processes: Anatomy of the heart and the blood vessels. Heart-position and function. Origin of the heart beat and electrical activity of the heart. Arteries, capillaries and veins- structure and function. Cardiac and peripheral circulation. Blood pressure and its regulation. Blood flow and its regulation. Circulatory shock. Lymph and dynamics of lymph flow.
Blood and the Immunity processes: Blood composition and function. Structure and function of red blood cells, white blood cells and platelets. Blood transfusion. Haemostasis. Immune mechanisms.
Respiratory processes: Anatomical parts of the system and function. Mechanics of respiration. Lung volumes and capacities. Gas transport between the lungs and tissues. Regulation of respiration. Respiratory adjustments in health and diseases.
Digestive processes: Different parts of the digestive system. Structure and function of these organs. Digestion of proteins, carbohydrates, fats. Basic mechanism of gastrointestinal absorption of nutrients.
Hormonal and Reproductive processes: Knowledge of structure and function of endocrine glands. Functions of male reproductive organs, female reproductive organs and contraception.
Musculo-skeletal and Movement processes: Different types of muscles and their characteristics. Neuro-muscular transmission. Structure of bone. General description of joints and structure. Disorders of neuro-muscular apparatus and joints.
Urinary and osmo-regulation processes: Various parts, structure and functions of the kidney and urinary tract. Physiology of urine formation and acid base balance. Diseases of the urinary system with reference to drugs used.
Peripheral automated neural processes: Physiology and functions of the autonomic nervous system. Mechanism of Neurohumoral transmission in this neural system.
Brain and central neural processes: Functions of different parts of brain and spinal card. Neurohumoral transmission in the central nervous system, reflex action, electroencephalogram, specialized functions of the brain, cranial nerves and their functions.

BIO327: Host-Pathogen Interactions and Cell Signaling

Learning Goals and Outcomes

1. Provide an in-depth understanding of different cellular responses to invading pathogens.
2. Help students to establish a foundation of knowledge involving molecular crosstalks that enable a host to become either susceptible or resistant to invasion by a foreign pathogen.

Host Pathogen Interactions: Introduction to human pathogens and diseases. Modes of pathogen attack and entry into the human body. Blood- and lymphatic routes of pathogen dissemination. Molecular machinery involved underlying host cell susceptibility and resistance. Molecular machinery recruited by pathogen for host-cell invasion. Experimental approaches and model systems of host-pathogen interactions.

Host cell responses and Cell Signaling: Pathogen-tissue microenvironment interactions. Parasitic strategies for tissue-specific infection – Overcoming Epithelial and Blood-brain barriers. Cell signaling and pathogenic modulation, subversion, and hijacking of cellular processes. Host-protective mechanisms include; damage sensing, Calcium and potassium-dependent cell signaling, membrane repair, endo-and exocytosis, cytoskeleton remodeling, stress mechanisms, signaling pathways for cell survival and autophagy. Barriers, Pattern Recognition Receptors & Signaling. Cellular innate sensing mechanisms using pattern recognition receptors. Molecular sensing by Inflammasomes for triggering innate immunity against pathogen associated molecular patterns (PAMPs) and damage associated molecular patterns (DAMPs). Inflammation and effector mechanisms for innate immunity. Innate immune control of adaptive immunity.

BIO328: Medical Microbiology

Learning Goals and Outcomes

1. Give students the knowledge and tools to explore the mechanisms by which pathogens cause infections
2. Learn the molecular basis of infection and expand into new concepts, key findings, and cutting-edge research in infection biology

Biology of infectious diseases. History of infectious diseases, basic concepts of disease dynamics, parasite diversity, evolution & ecology of infectious diseases Emergence of diseases: The basic reproductive number, critical community size, epidemic curve, zoonosis. Molecular basis for the rise in strains of multiple drug-resistant bacteria.

Bacterial Pathogenesis: Bacterial virulence mechanisms that contribute to pathogenicity. Characterization of microbe-host interactions, comparisons between pathogenic and non-pathogenic bacterial isolates, and demonstration of virulence properties and physiological processes of importance for a specific infection. Bacterial secretion systems and virulence, bacterial toxins, and different defense mechanisms of the host against pathogenic microorganisms. Importance of the human Microbiota.

Viral Pathogenesis: Sequential steps in viral infection with examples, including polio virus, rabies virus, smallpox, influenza virus, HCV, HIV: transmission, entry and spread within the host, incubation period. Acute and chronic viral infections. Molecular basis of tropism: virus factors and host factors. Virus virulence and disease mechanisms: damage caused by a virus and host immune system, host factors and host defense. Emerging viral diseases – Zika virus, the SARS- and MERS-coronaviruses. Antivirals and drug resistance. Host response to viral infection: Immune responses to viral infection. Virus-induced immunopathology - Immunopathological lesions caused by T-cells and B-cells and nitric oxide.

Recommended Books

1. The Biologic and Clinical Basis of Infectious Diseases, Shulman, S. T., Pub: Saunders.
2. A practical approach to infectious diseases. Reese, R. E., Betts, R. F., Pub: Little Brown and Company.Viral Pathogenesis and Immunity 2nd Edition, by Neal Nathanson, Rafi Ahmed, Margo A. Brinton, Johnson.
3. Fields Virology by Peter M. Howley, David M. Knipe, Sean Whelan. 6th Edition, Lippincott.
4. Bacterial Pathogenesis: A Molecular Approach, 4th Edition. Brenda A. Wilson, Malcolm Winkler, Brian T. Ho. ASM Press.
5. Ananthanarayan and Paniker's Textbook of Microbiology, Eleventh Edition. Pub-The Orient Blackswan

BIO329: Systems Biology in Drug Discovery and Development

Learning Goals and Outcomes

1. This course will make students appreciate the complexity of life
2. This course will provide students with an examples-based understanding that therapeutic success depends much more upon the coherent manipulation of a physiological system as a whole than upon the manipulation of a target in a molecular context.
2. The course will train students in the utilization of pluridisciplinary approaches;
3. The course will train students to think in terms of interplays between physiological mechanisms that can then be reconstructed upwards from the molecular level.
4. The course will train students to utilize the scientific literature to identify what is false to then identify what could be true.

Systems biology has for object the construction of biological models from which means of intervention/manipulation could be directly derived. However, this has many faces. It could be applied to very well-defined mechanisms in which case the primary approach will be mathematical. Or it could address the elucidation of poorly understood and/or very ill-defined pathological mechanisms to then identify possible means of treatment. In this case, mathematical approaches will fail and the problem has to be handled from a biological stand point. This, however, will entail the utilization of numerous biological disciplines, ranging from physiology, biochemistry, immunology, endocrinology, genetics, all the way to neurology, signal transduction and molecular biology.

Introduction to complexity in Biology

- Introduction to complex systems
- Emergent properties and evolution of biological complexity

Integration and organization in Cells

- Signal transduction - representing the outside and communication
- Gene regulation and gene regulatory networks
- Integration and organization in Organisms (5 lectures)
- Early development and pattern formation
- Differentiation and hierarchical gene expression
- Growth, Regeneration and Stem cells
- Cell death
- Aging

Integration and organization in Physiology

- The immune system
- The nervous system

Disease modelling and Drug Discovery: It will start with a detailed exposition of what the problems encountered in building a model addressing a poorly understood pathology will be and what would be the most effective means of resolving these problems. The subsequent lectures will correspond to modules, each starting with a concrete example followed by a demonstration on how that particular problem was solved and whether or not a defined treatment could be considered.

The modules presented will address

- Cancer,
- Neuropathies,
- Infectious diseases,
- Neurodegenerative diseases,
- Immunological disorders,
- Metabolic disorders, and
- Unknown pharmacological modes of action.

Recommended Books

1. Essentials of Endocrinology and Metabolism; Springer, 2020 (ISBN: 978-3-030-39572-8)
2. Berne & Levy Physiology, 7th Edition; Elsevier, 2018 (ISBN: 9780323393942)
3. Carpenter's Neurophysiology, 6th Edition; Routledge, 2021 (ISBN 9780367340605)
4. Basic Immunology (A. K. Abbas, A. H. Lichtman, and S. Pillai), 6th Edition; Elsevier, 2019 (ISBN: 9780323549431).

BIO401: Research Methodology

Learning Goals and Outcomes

1. The course is course is designed to enable the students to design research problems, strategic planning of experiments
2. This course aids the students to develop as researchers who can generate ideas, think out of box questions and try to solve unanswered research puzzles.

Safety in laboratories general safety measures**:** personal protection; chemical hazards; spillage and waste disposal; first aid. Research methodology: Meaning of research; objective of research; motivation in research; types of research; research approaches; significance of research.

Research and scientific methods**:** Importance of knowing how research is done; Research process; Criteria for good research.

Research problem design**:** Selecting research problem; necessity of defining a problem; techniques involved in defining the problem; basic principles of experimental design; important experimental designs. Statistical models and analyses that can be applied to different kinds of biological data, and statistical analyses.

Interpretation and report writing: significance of report writing; layout of research report; Presentation of research work- oral, poster and writing research paper; Precautions for writing research report.

Review of literature**:** Understanding the role of review; Writing research proposal, manuscript writing, research poster making and presentation, Characteristics of a proposal; content and organization of a proposal; weakness in proposal seeking funding. Writing of research proposal, report and Research paper. Ethical, legal, social and scientific issues in biological research. Plagiarism in science.

Undergraduate Thesis Work (BIO402 and BIO403)

Project work is divided into two semesters. BIO402 (7th Semester) is 9 credits and BIO403 (8th Semester) is 12 credits. Students can pursue same research project for one year as part of both the courses or they can do two separate projects for BIO402 and BIO403. Project under BIO402 is internal and must be pursued in the SNIoE. If all the other credit requirements are complete, then students can also do their project under BIO403 outside the campus in other institutes.

BIO402: Internal Project Dissertation

Students submit a project proposal and advisor selection form at the beginning of the seventh semester. They need to submit a mid-semester report during the mid-semester examinations of other courses. Final evaluation is based on final project report and poster presentation conducted at the end of the semester.

BIO403: Project Dissertation

Irrespective of whether the students are continuing BIO402 or are starting a fresh project, they have to submit a project proposal and advisor selection form at the beginning of the seventh semester. They need to submit a mid-semester report during the mid-semester examinations of other courses. Final evaluation is based on final project report and oral presentation conducted at the end of the semester.

Minor in Biotechnology

The Department of Life Sciences offers a minor degree to students pursuing various major degrees across the university. The department has 10 seats reserved for students opting for a minor degree. The criteria for selection of students for a minor will be based on the overall CGPA and/or followed by an interview by the departmental committee.

For getting a minor degree, the students have to complete a minimum of **21** credits in the Life Science department, which includes some compulsory coursework and some optional coursework. Four compulsory courses have to be completed by each student to receive the minor degree. Apart from these, each student is required to take a minimum of three optional courses.

*The minimal credit requirement for a minor in biotechnology is **21** credits, out of which **12** credits are compulsory

Credit Requirements for Minor in Biotechnology

Each student opting for a minor degree has to pass all the compulsory courses. The compulsory courses are as listed below:

CODE	COURSE NAME	CREDITS
BIO 210	Cell Biology	3
BIO 202	Microbiology	3
BIO 204	Biochemistry	3
BIO 206	Fundamentals of Molecular Biology	3

All courses offered to BSc Research in Biotechnology major students in the II, III, IV, V and VI semesters can be taken as optional courses for the minor degree. For details, please see BSc (Research) Biotechnology. Students not having Biology at 12th Grade level, have to do the **BIO113** (Essentials of Cell Biology) course and score a minimum of B-Grade to be eligible for a Minor.

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