LIFE-SCIENCES

Programme Code: LIFE04

Programme Outcome:

- At the end of the course work pursued, the Ph. D. student will be well versed in the recent advances in crucial areas of Life Sciences such as Biochemistry, Immunology, Cell and Molecular Biology, Plant Sciences, Microbiology and Cancer biology.
- The students will receive hands on experience in several techniques related to the above fields as well as those Structural Biology, Bioinformatics and Instrumentation.
- The course work will help the students to have a broader outlook of their research work and be able to judge and use techniques for a superior outcome and higher impact publications.

DETAILED COURSE STRUCTURE

Core Courses (Mandatory)				
S. No.	**Course Code**	**Subject Title**	**Hours (T)**	**Credits**
1	LIFE-JRF-CC01	Biochemistry, Molecular Biology, Plant Sciences and Genetics	**31**	**2**
2	LIFE-JRF-CC02	Animal Cell Biology, Immunology and Radiation Biology	**31**	**2**
3	PHYS04.8	Health Physics	**15**	**1**
4	LIFE-JRF-CC03	Safety in Life Science Research	**15**	**1**
5		Research Methodology	**15**	**1**
6		Research & Publication Ethics	**30**	**2**
Hours and Credits			**137**	**9**

Elective Courses (5/8)				
S. No.	**Course Code**	**Subject Title**	**Hours (T)**	**Credits**
1	LIFE-JRF-EC01	Advanced Course in Genetic Engineering	**20 L + 25 P**	**2**
2	LIFE-JRF-EC02	Advanced Course in Plant Breeding	**20 L + 25 P**	**2**
3	LIFE-JRF-EC03	Advanced Course in Stem Cell Research and Therapy	**20 L + 22 P**	**2**
4	LIFE-JRF-EC04	Applications of Radioisotopes and Molecular Methods in Diagnosis and Therapy	**20 L + 25 P**	**2**
5	LIFE-JRF-EC05	Advanced Course in Instrumentation	**20 L + 25 P**	**2**
6	LIFE-JRF-EC06	Structural Biology: Methods and Applications	**20 L + 25 P**	**2**
7	LIFE-JRF-EC07	Advances in Genome Biology	**20 L + 22 P**	**2**
8	LIFE-JRF-EC08	Biostatistics, Bioinformatics and Laboratory Techniques	**15 L + 30 P**	**2**
Hours and Credits			**95-100 L+ 119-130 P**	**10**

SUMMARY				
	Course	**Quantity**	**Hours**	**Credits**
1	Core Courses	6 Nos.	**137**	**9**
2	Elective Courses	5 Nos.	**95-100 L+ 119-130 P**	**10**
Total Hours and Credits			**~232-237 L+119-130 P**	**19**

COORDINATORS

Program coordinators:

Dr. Kuber Bhainsa (Chief-coordinator) (NA&BTD Extn.: 22763, kuber@barc.gov.in)
Dr. Rachna Agarwal (Co-coordinator) (HBNI, Extn.: 27624, rachna@hbni.ac.in)

Core courses coordinators:

Course	Coordinators	E-mail
Biochemistry, Molecular Biology, Plant Sciences and Genetics	Dr. Archana Joshi Saha Dr. Sumit Gupta	archanaj@barc.gov.in sumitg@barc.gov.in
AnimalCell Biology, Immunology and Radiation Biology	Dr. Himanshi N. H.	narangh@barc.gov.in
Health Physics	Dr. Ranjan Mittal	rmittal@barc.gov.in
Safety in Life Science Research	Dr. Kuber C. Bhainsa	kuber@barc.gov.in
Research Methodology	Dr. Kallola Swain	kallola@barc.gov.in
Research Publication and Ethics	Dr. Kallola Swain	kallola@barc.gov.in

Elective courses coordinators:

Course	Coordinators	E-mail
Advanced Course in Genetic Engineering	Dr. Chitra Mishra	chitras@barc.gov.in
Advanced Course in Plant Breeding	Dr. J. G. Manjaya	manjaya@barc.gov.in
Advanced Course in Stem Cell Research and Therapy	Dr. Deepak Sharma	dsharma@barc.gov.in
Applications of radioisotopes and molecular methods in diagnosis and therapy	Shri M. K. Ray	mkray@barc.gov.in
Advanced Course in Instrumentation	Dr. Kuber C. Bhainsa	kuber@barc.gov.in
Structural Biology: Methods and Applications	Dr. Mukesh Kumar, Dr. Gagan D Gupta	mukeshk@barc.gov.in
Advances in Genome Biology	Dr. Y. S. Rajpurohit	ysraj@barc.gov.in
Biostatistics, Bioinformatics and Laboratory Techniques	Dr. R. Shashidhar	shashi@barc.gov.in

CORE COURSES

LIFE-JRF-CC01: Biochemistry, Microbiology, Molecular Biology and Plant Science (31 Lecture Hrs)

Coordinators: Dr. Archana Joshi Saha,

Dr. Sumit Gupta
(archanaj@barc.gov.in,
sumitg@barc.gov.in)

Course Details:

1.1 Biochemistry

Food Biochemistry

Definition and scope of food chemistry, Major food constituents (carbohydrates, fats and proteins) and their functional properties with respect to food processing, Physical and chemical properties (water activity, pH, thermal conductivity, viscosity, color), Chemical changes in food farm to fork.

Food Processing: Standards and regulations, FSSAI regulations regarding food irradiation, Radiation processing of food products, applications, chemical changes and wholesomeness, Basic process of food irradiation, Isotopes and technologies used for food irradiation, Low medium and high dose applications of food irradiation, Effect of radiation on macro and micro nutrients in food products, Newer methods of food processing (high pressure processing, pulsed white light, ohmic heating, ultrasonic treatment, pulsed electric field) and their applications

1.2 Microbiology

Introduction to Basic Microbiology

Overview of food-borne pathogens, spoilage and fermentative organisms. Industrially relevant spoilage and fermentation process, Microbial death kinetics during processing, Concept of D10 value (during thermal and irradiation processing), Calculation of D10 value and its application during food processing.

1.3 Molecular Biology

Gene Expression and Genetic Engineering

Gene expression, epigenetics and regulation: An overview. Plasmids, different types of vectors, cloning, Genetic manipulation techniques: Mutagenesis, Overexpression, genomic integration, Experimental approaches to understanding DNA-protein and protein-protein interactions

DNA Repair Mechanisms
Different DNA repair pathways (Homologous, NHEJ, UV repair), Regulation, A comparative

study in prokaryotes and eukaryotes

RNA Biology

Different types of RNA, role of RNAs. Structure-function aspects of tRNA. Regulatory roles of siRNA, snRNA, interference RNA

1.4 Genetics

Basic and quantitative genetics

Mendelian genetics, deviation from Mendel's findings: allelic variation and gene function, gene interactions and epistasis [multiple alleles, allelic series, testing gene mutations for allelism, incomplete dominance and co-dominance, pleiotrophy, Quantitative genetics [Theory of allele frequencies, the Hardy- Weinberg (H-W) principle, application of H-W principle, natural selection, random genetic drift, factors affecting H-W equilibrium]

Linkage and mapping

Concepts of linkage and crossing over, chromosomal mapping in eukaryotes [linkage, genetic test for linkage, chiasmata and crossing over, twopoint test cross, three point test cross, mapping functions, genetic mapping in plants], complementation test
Molecular markers

Concept of markers, development of genome based markers, application of markers in plant breeding. Map position-based cloning of genes, marker assisted selection (MAS) in plant breeding, examples in specific crops, outcome of MAS breeding

1.5 Genetic improvement of

Plant host-pathogen interactions

Gene for gene concept, molecular basis of pathogenesis, mechanisms of host defence, approaches to developing disease resistant plants and gene pyramiding
Mutagenesis in plants

Molecular basis of mutagenesis [tautomerism, mode of action of different mutagen (physical and chemical mutagen), mutation induced by transposable elements, phenotypic effects of mutations], induced mutation breeding in crop plants: principles and methods, outcome: examples and impact of plant mutant varieties

1.6 Plant developmental biology

Plant developmental biology

Floral induction and development, photoperiodism and its significance, vernalization and hormonal control, inflorescence and floral determination
Plant tissue culture – fundamentals and applications

Plant tissue culture and differentiation: totipotency, micropropagation, direct and indirect

regeneration pathways, zygotic & somatic embryogenesis, organogenesis, embryo and anther culture, somaclonal and gametoclonal variation, industrial application of plant tissue culture, hairy root cultures, large scale propagation of plants, bioreactors, secondary metabolite production

Course Outcomes:

• The student will get to learn the basics followed by recent advances on biochemical pathways, food biochemistry, different fields of microbiology, DNA repair and both prokaryotic and eukaryotic molecular biology and genetic engineering. This would render them versatile to work in any of the three systems i.e. with microbes, plants or animals.

References:

1. Principles of Biochemistry Global Edition -- by Donald Voet, Judith G. Voet, Charlotte W. Pratt
2. Principles of Biochemistry: International Edition -- by David L. Nelson, Michael Cox
3. Enzymology (HB 2016) by Krintel C.
4. Basic Concepts in Enzymology by Dr. P. Palanivelu.
5. Posttranslational Modification of Proteins: Tools for Functional Proteomics edited by Christoph Kannicht
6. Prescott's Microbiology – 10th Edition
7. By Joanne Willey, Linda Sherwood and Christopher J. Woolverton, McGraw-Hill Education
8. Microbiology by Tortora, Funke and Case, Pearson Education India, 11th edition
9. The Biofilm Mode of Life – Mechanisms and Adaptations, by Staffan Kjelleberg and Micahel Givskov
10. Horizon Bioscience, 2007
11. Quorum Sensing and its Biotechnological Applications, Edited by: Vipin Chandra Kalia, Springer Nature
12. Molecular Biology of the Cell (6th edition),2014, Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Robertsand Peter Walter, Garland Science:New York;
13. Molecular Biology of the Gene (7th edition),2017, James Watson., Pearsons Education, India.
14. Molecular Cell Biology (4th edition), 2000, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. W. H. Freeman: New York;
15. Principles of Genetics. EJ Gardners, MJ Simmons and DP Snustad. John Wiley & Sons
16. Genetics. MW Strickberger. Pearson, IN
17. Fundamentals of Genetics. PJ Russell. Benjamin Cummings
18. Plant Breeding principle and methods. B.D. Singh, Kalyani Publishers.
19. Plant Physiology. L Taiz and E Zeiger. Sunderland: Sinauer Associates.
20. Plant Tissue culture: Theory and practice, a revised edition. SS Bhojwani and MK Rajdan. Elsevier, Netherland.
21. Plant Propagation by Tissue Culture-Handbook and Directory of Commercial Laboratories. EF George and PD Sherrington, Exegetics limited, Eversley, Basingstoke, Hants, England.

LIFE-JRF-CC01: Animal Cell Biology, Immunology and Radiation Biology (31 Lecture Hrs)

Coordinators: Dr. Himanshi N. H. (narangh@barc.gov.in)

Course Details:

2.1 Animal Cell Biology

Basic Animal Cell Biology

Fundamentals of cell structure and organization in plants and animals, Origin of cell, Cell Structure, Cell Membrane/Cell Wall, Cellular Components and their function, ECM

Cell communication, cell cycle and differentiation

Cell to cell communication, Types of signaling - Surface and intracellular receptors, Amplification of signal etc; Cell cycle, Cell cycle regulation, Phases, Check points, Latest techniques to detect cell cycle phases; Cell death – Apoptosis, Necrosis, Autophagy.
Differentiation and Development - Basic processes of development, Signals guiding development, Differentiation, Determination and Stem cells, Experimental approaches.

Cancer Biology

Cancer cell biology, Causes (genetic and environmental), Tumor suppressors, Oncogenes, Hallmarks and enabling characteristics of a tumor, Metastasis, Targets for therapeutic interventions, Tumor microenvironment, Latest developments in diagnosis and treatment

Genetic manipulation techniques for animal cells and animals

Methods for genetic manipulation of mammalian cells and animals, Recent advances in transgenic, congenic and conditional knockout mice, Ethical issues related to genetic manipulation and research in experimental rodents and stem cells.

2.2 Immunology

Immune System

Introduction to immune system: Cells and Organs of the Immune system and systemic functions of immune system, Innate immunity, Non-specific host immunity, Cells of the innate immune system, Complement system, Pattern recognition by innate immune system, Antigen presentation, Major Histocompatibility complex, Antigen presenting cells, Endogenous and Exogenous antigen presenting pathways, Humoral immunity, Antibody structure and diversity, Antibody mediated effector functions, Antibody classes and biological activity.

Cell Mediated immunity

T-cell receptor, alloreactivity, T-cell maturation, and Thymic selection, T-cell activation and differentiation, dynamics of adaptive immunity, Properties of effector T-cells and T-cell mediated cytotoxicity

Advances in applied and clinical immunology

Immunotherapy for treatment of cancer- using inhibitors or antibodies; Vaccines and personalized therapy for immune disorders, Chimeric antigen receptor T cells for treatment of lymphoma

2.3 Radiation Biology

Basics in radiation biology

Physics and Chemistry of radiation absorption, Radiation types, units, doses and measurements, Interaction of radiation with matter, Free radical biology, Radiation biology – Cell survival curves, Radiosensitivity and its factors, Oxygen effect, Radiomodulation, Linear Energy transfer and Radiobiological Effectiveness (LET and RBE)

Biological effects of radiation

Biological effects of radiation (Deterministic, stochastic), Radiation safety and protection: Personal Protective Equipment, regulatory guidelines and exposure limits, Adaptive response, Radiation hormesis, Application of different types of radiation in diagnosis and therapy, Concepts of 5Rs' of radiotherapy (Repair, Repopulation, Redistribution, Reoxygenation, and Radiosensitivity). High LET radiation (charged and neutral particles), Bragg's peak in relation to cancer therapy. High natural radiation areas and their significance,
International bodies related to radiation safety.

Genetic effects of radiation

Genetic effects of radiation, Causal association of radiation with cancer, Biological and clinical dosimetry, Cytogenetics and molecular biomarkers

Course Outcomes:

• The course deals with animal cell biology and cancer biology including recent advances, therapeutics and genetic manipulation of animal cells. Basic and advanced immunology with advances in applied and clinical immunology is included as part of this course work. Radiation biology is a new concept which is introduced to the students and they get insights in to the effect of different radiation doses on cellular matter and how the cells deal with it, with inputs from information available from regions which have high background radiation.

References:

1. Molecular Biology of the Cell by Bruce Alberts, Dennis Bray, James Watson, Julian Lewis, Keith Roberts, and Martin Raff
2. Gerald Karp Cell and Molecular Biology
3. Developmental Biology by Gilbert Hallmarks of Cancer: The Next Generation- Cell Review| Volume 144, ISSUE 5, P646-674, March 04, 2011
4. Programmed cell death pathways in cancer: a review of apoptosis, autophagy and programmed necrosis. Cell Proliferation. 2012 Dec;45(6):487-98.
5. Basic Clinical Radiobiology; Michael Joiner and Albert van der Kogel -Fourth Edition

PHYS04.8: Health Physics (31 Lecture Hrs)

Coordinators: Dr. Ranjan Mittal
(rmittal@barc.gov.in)

Course Details:

Introduction

Radiation sources, Uses of radiation sources, quantities and units, Natural and Induced radioactive sources, Units of radioactivity, Half-Life and Decay constant, Specific activity, Uranium-238 series and associated radioactivity; Definition of various dosimetric terms (exposure, absorbed/equivalent/effective dose, concept of radiation/tissue weighting factors and their importance (with stress to use only SI units however old and new units relation can be given), Exposure dose relationship.

Radiation detection and measurement

Brief introduction on Charged particle interaction, ionization and excitation, Interaction of gamma radiation with matter: Photoelectric, Compton and pair production (not detailed); Neutron interaction and dose; Ionization chamber, proportional counter and GM counter working principle; HP instruments Alpha, Beta, Gamma and Neutrons; Buildup concept, shielding for alpha, beta, gamma and neutron sources, Shielding for mixed sources.
Luminescence (theory & materials): Radiation dose measurement (Basics of dose measurements, different methods of radiation dose measurements, Importance and requirement of radiation dose measurements).

Radiation protection program

Types of exposure (occupational, medical and public), Exposure situations (Planned, Existing and Emergency, National and International regulatory bodies, their role and responsibilities. Latest Dose limits stipulated by these bodies, Dose limits observed in India, Radiation protection philosophy, Principles of radiation protection, Justification, Optimization and Dose Limits.

Occupational Radiation Protection

Radiation Safety Officer (RSO); Nature of duties and responsibilities of RSO/Health Physicist, Protection against internal and external exposure; Time, Distance and Shielding; Concept of ALI & DAC (with suitable problems); Modes of entry of radionuclides into the human body leading to internal exposure; Personnel monitoring, workplace monitoring, environmental monitoring. Surface contamination and air activity monitoring, and Criticality Safety; Dosimeters, TLDs, DRD (pocket dosimeters), alarm dosimeters CR-39 etc.; Bioassay, whole body counting and Liquid Scintillation Spectrometry (LSS) techniques (not in detail); Role of ESL in environmental monitoring; Radiotoxicity and classification of laboratories, design of laboratory for radioactive work

Radiation Protection procedures

Procedures followed in radiation work places, work permits, zoning concept, contamination

control methods, and rubber areas, spill pack (contains gloves + absorbing paper), Decontamination techniques, Precautions during radioactive source storage and handling, Safety during transportation of radioactive sources, Transport index, TREM card, Radioactive waste classification and management.

Emergency Preparedness

Types of emergencies, emergency preparedness; Nuclear and radiological emergencies, RDD, IED, International Nuclear Events Scale (INES), Examples of nuclear and radiological accidents, and Iodine Prophylaxis.

Industrial Safety (Conventional): Basic Principles of industrial safety and industrial hygiene;

Course outcome:

- Understanding the fundamentals of radioactivity, the interaction of radiation with matter, and the principles of radiation detection.
- Understanding the basic principles of operational radiation protection.
- Understanding the genetic effects of radiation

References:

1. Introduction to Health Physics, Herman Cember, 4th Edition (McGRAW-HILL, 2009).
2. Physics for Radiation Protection, James E. Martin, 2nd Edition (Wiley -VCH Verlag GmbH, 2006).
3. IAEA Regional Basic Professional Training Course on Radiation Protection (Course jointly organized by BARC and IAEA), October 26-December 18, 1998.
4. Radiobiology for radiologists, Eric J. Hall, 7th Edition, (Lippincott Williams & Lippincott, 2012).
5. Accident Prevention Manual for Industrial Operation, Vol. 2, National Safety Council, 11th Edition, (National Safety Council, USA, 1997).

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LIFE-JRF-CC03: Safety In Life Science Research (15 Lecture Hrs)

Coordinators: Dr. Kuber C. Bhainsa
(kuber@barc.gov.in)

Course Details:

Cyber safety and security

Cyber safety and security: Introduction to cyber safety, sources of threat and ways to prevent them: Web browsing, Email, Malware, Identity theft, Social networking, Phones, Passwords etc., online transaction frauds, cyber hacking, mobile hacking, cyber frauds, cyber terrorism, digital foot prints, National Cyber Safety & Security Standards (NCSSS)

References

- National Cyber Crime Reference Hand Book published by National Cyber Crime Reference Hand Book (third edition)
- https://www.udemy.com/course/cyber-security-and-internet-safety/
- https://ncdrc.res.in/organization-profile.php
- https://rcsindia.co.in/KVFILES/CyberSafety.pdf

Fire Safety

Introduction, the fire triangle, major causes of fire, classification, prevention, protection and control of fire, use of fire extinguishers, fire hazards, fire emergency and preparedness

Radiation Safety

Radiation hazards, Introduction, types of radiation and its effect, general principles and techniques of monitoring, assessment and control of radiation hazards, Environmental release, management of solid, liquid and gaseous wastes Radiation Emergency Preparedness
Discussion of type of incidents/accidents likely to be encountered, procedures for handling such events

Chemical safety

Introduction, routes of entry and its effect, types of hazardous chemicals, labelling and storage, incompatible chemicals, hazard control-fume hood, local exhaust, personal equipment, chemical spill, emergency measures, precaution in handling hazardous chemicals

References:

1. Indian Standard (IS) 4209-1987 Code of Safety in Chemical Laboratories. Manufacture, Storage and Import of Hazardous Chemicals Rules -1989. Chemical Risk Analysis- Bernard Martel
2. Hazards in Chemical Laboratory- G. D. Muir

Biosafety and animal ethics

Introduction to biosafety, Institutional Bio-Safety Committee (IBSC)-scope and objectives, pathogenic organism, Genetically Modified Organisms (GMOs) - recombinant DNA technology, micororganisms, plants and animals, release to the environments, role of Genetic Engineering Approval Committee (GEAC), Indian act for animal welfare and Prevention of Cruelty to Animal act (PCA, 1960), use of animals in research and animal care, Animal Ethics

Committee (AEC).

Course Outcome:

This course gives an understanding of various safety aspects in life science research while dealing with realistic life science problem performing the task in day-to-day research work. Basic safety aspects including cyber safety, fire safety, radiation and chemical safety along with biosafety and ethics is meant to equip the researchers on all front to be able to address safety issues if encountered and succeed through it. Both protection of self and of the life and property of the institution is high lighted while working towards one's objective is emphasized

Research Methodology (15 Lecture Hrs)

Course Details:

Objectives and types of research: Motivation and objectives - Research methods vs. Methodology. Types of research – Descriptive vs. Analytical; Applied vs. Fundamental; Quantitative vs. Qualitative; Conceptual vs. Empirical.

Research Formulation – Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem - Literature review – Primary and secondary sources - reviews, treatise, monographs-patents - web as a source - searching the web - Critical literature review - Identifying gap areas from literature review - Development of working hypothesis.

Research design and methods - Research design – Basic Principles - Need of research design - Features of good design – Important concepts relating to research design - Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis. Experimentation: Proper approach - Importance of recording observation, maintaining the records, sample history, transparency in data recording. Determining experimental and sample designs.

Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.

Value of Statistics; Errors and Statistics - Limitation of analytical methods; Accuracy; Precision; Classification of errors; Minimisation of errors; Significant figures and computations; Standard Deviation; Normal Distribution; Comparison of results - students's t test; F-test; Chi Square test; propagation of errors.

Course Outcomes:

Understand the concept of research methodology
Importance of statistics in research
Knowledge of various statistical tools used during research

References:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research
Methodology, RBSA Publishers.
2. Kothari, C.R., 2000, Research Methodology: Methods and Techniques. New Age International.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Publications (2 volumes)
4. R. Paneer Selvam - Research Methodology Prentice Hall India Learning Private Limited; Second edition
(2013)
5. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn
and Bacon.
6. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
7. Vogel's Text Book of Quantitative Inorganic Analysis, ELBS.

Research And Publication Ethics (30 Lecture Hrs)

Course Details:

- *Research Formulation and Design*

Defining and formulating the research problem; Selecting the problem; Necessity of defining the problem; Importance of literature review in defining a problem; Literature review; Primary and secondary sources; reviews, treatise, monographs, patents, web as a source, searching the web; Critical literature review; Identifying gap areas from literature review; Development of working hypothesis, Research design; Basic Principles; Need of research design; Features of good design; Important concepts relating to research design; Observation and Facts; Laws and Theories, Prediction and explanation, Induction, Deduction; Development of Models; Collection of data through questionnaire and schedules; Collection of secondary data; Selection of appropriate method for collection, Guidelines for developing questionnaire; Successful interview; Survey v/s experiment; Developing a research plan - Exploration, Description, Diagnosis; Experimentation: Proper approach, Importance of recording observation, Maintaining the records, Sample history, Transparency in data recording.

- *Research Ethics*

Philosophy and ethics, Ethics with respect to Science and research, Intellectual honesty and research integrity, Application of results and ethics - Environmental impacts - Ethical issues - ethical committees - Commercialization - Scientific misconducts- fabrication, falsification, duplicate and overlapping publications, selective reporting and misrepresentation of data, Artificial Intelligence in Research Ethics.

- *Publication Ethics*

Definition, introduction and importance, best practices, standards setting initiatives and guidelines, Conflict of interest, Publication misconduct, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, predatory journals and publishers. Plagiarism - Citation and acknowledgement - Reproduction of published material & and accountability.
Open Access Publications, Indexing Databases, Citation Databases: Web of Science, Scopus, Google Scholar etc. Impact Factor of Journals, CiteScore, h-index, i10 index etc.

- *Intellectual Property Rights (IPR)*

Intellectual property rights and patent law, Copy right - Royalty -Trade Related aspects of IPRs. Patent procedures in DAE.

- *Reporting and Thesis and Writing*

Structure and components of scientific reports - Types of report - Technical reports and thesis Significance - Different steps in the preparation - Layout, structure and Language of typical reports - Illustrations and tables - Bibliography, referencing and footnotes - Oral Presentation Planning - Preparation - Practice - Making presentation - Use of visual aids - Importance of effective communication -Computers in Chemistry, Usage of packages such as, Excel, AIM2000, ChemDraw, etc. Manuscript drafting based on ‘Experimental data and Literature Survey’.

Course Outcomes:

- Familiarity with concepts of research formulations and design
- Understanding of ethical concepts during research and publications
- Better presentation of research outputs

References:

1. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
3. David Resnick, 2005, The Ethics of Science, An Introduction, Taylor and Francis.
4. P. Chaddah, 2018, Ethics in competitive research: Do not get scooped; do not get plagiarized, ISBN: 978-9387480865.

ELECTIVES COURSES

LIFE-JRF-EC01: Advanced Genetic Engineering (45 Lecture Hrs)

Coordinators: Dr. Chitra Mishra
(chitras@barc.gov.in)

Course Details:

1. Plant Genetic Engineering

- Ethics of Genetic Engineering: What is right and what is wrong?
  What is GMO and what is not? Approvals required for their release
- Selectable marker and reporter genes: Antibiotic resistant marker genes, Herbicide marker genes, Reporter genes, removal of marker genes, alternate selectable marker systems

- Methods of plant genetic transformation: Direct gene transfer methods, particle bombardment, electroporation, sonication, electrophoresis, liposome delivery, microinjection, whisker mediated transfer; Agrobacterium-mediated, strains, virulence genes, mechanism of T -DNA transfer and integration, different methods of Agro-transformation, vectors used in Agro transformation; Genome editing in plants

- Enhancing and stabilizing transgene expression: Transgene silencing and activation – mechanism and results

- Metabolic engineering of plants

2. Practical aspects of animal cell manipulation

- Types of vectors for mammalian transfection
- Methods of transfection / transduction
- Generation of antibiotic kill curve in mammalian cells
- Practical demonstration of transfection in mammalian cells
- Visualization, identification and selection of transfected cells

3. Microbial genetic engineering

- Essence of plasmid incompatibility, copy numbers, selectable markers, origin of replication: Its influence on designing of cloning strategies.
- A practical guide for cloning: Choice of vectors, different ligation strategies and bacterial strains used for cloning and expression
- Ways to get DNA inside cells - choosing the right method.
- The CRISPR toolkit and how it can advance your research.
- Lambda Red Recombineering system – what it can and cannot do.
- Protein expression and purification – getting the fold right
- Notable genetically engineered microbial strains: Applications for biotechnology

Course Outcomes:

• Recent methodologies in genetic manipulation of microbes, plants and animal cells along with hands on experience. While imparting knowledge on these aspects the students are also given a brief on the ethics to be followed for genetic manipulation, which is an important aspect.

References:

1. Molecular Cloning: A Laboratory Manual. Edward F. Fritsch, Joseph Sambrook, and Tom Maniatis (Fourth Edition, 2012). Cold Spring Harbor Laboratory Press.
2. Brief guide to gene cloning. Woojin Hong, Seokjun G Ha, Hyunwoo C Kwon, Seung-Jae V Lee. Mol Cells. 2025 May 29;48(8):100234. doi: 10.1016/j.mocell.2025.100234.
3. Plant Tissue Culture: Theory and Practice. S. S. Bhojwani and M. K. Razdan. Elsevier; First Edition (15 November 2003).

LIFE-JRF-EC02: Advanced Course In Plant Breeding (45 Lecture Hrs)

Coordinators: Dr. J. G. Manjaya
(manjaya@barc.gov.in)

Course Details:

1. Principles of Plant Breeding

History of Plant Breeding; Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance. Plant introduction and role of plant genetic resources in plant breeding. germplasm collection, exchange and quarantine

Breeding for self-pollinated crops-Pure line theory, pure line selection and mass selection methods; line breeding, pedigree, bulk, backcross, single seed descent method.

Breeding methods in cross pollinated crops- Population breeding-mass selection, progeny testing, progeny selection schemes, recurrent selection and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds. Breeding methods in asexually/clonally propagated crops.

Malesterility in crop plants and their commercial exploitation; Concept of designer crop - plant ideotype and its role in crop improvement; Transgressive breeding.

Practicals:

- Floral biology in self and cross pollinated species, selfing and crossing techniques.
- Selection methods in segregating populations and evaluation of breeding material
- Analysis of variance (ANOVA); Estimation of heritability and genetic advance;
- Maintenance of experimental records

2. Mutation breeding

Mutation and its history - Nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations, mutagenic agents, Molecular basis of mutagenesis [automerism, mode of action of different mutagen (physical and chemical mutagen), mutation induced by transposable elements, phenotypic effects of mutations], Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras etc., - Observing mutagen effects in M2 generation - Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations -– Mutations in traits with continuous variation. Mutation breeding in cereals, pulses and oilseeds – Achievements made

Principles of quantitative genetics: Genetic basis of breeding self- and cross - pollinated crops including mating systems and response to selection - nature of variability, components of variation; Heritability and genetic advance, genotype- environment interaction; General and specific combining ability; Types of gene actions and implications in plant breeding; Principles of Analysis of Variance (ANOVA) - Expected variance components, Comparison of means

and variances for significance, Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance.

Practicals

- Learning the precautions on handling of mutagens;
- Treating the plant propagules at different doses of physical and chemical mutagens - Learning combined mutagenic treatments;
- Raising the crop for observation - Mutagenic effectiveness and efficiency
- Study of M1 generation – Parameters to be observed
- Study of M2 generation – Parameters to be observed
- Procedure for detection of mutations for polygenic traits in M2 and M3generations.

3. Breeding for abiotic and biotic stresses

Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops - Concepts in insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host- pathogen interaction, gene-for-gene hypothesis. Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants. Classification of abiotic stresses - Stress inducing factors –moisture stress/drought and water logging & submergence; Acidity, salinity/alkalinity/sodicity; High/low temperature, wind, etc. Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies. Genetics of abiotic stress resistance.

Practicals:

- Screening methods for diseases resistance.
- Screening crops for drought and flood resistance

4. Breeding for quality trait

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement. Molecular basis of quality traits and their manipulation. Breeding for quality improvement in cereals, pulses and oilseeds.

Practicals:

- Grain quality evaluation in cereals, oilseeds and pulses
- Estimation of antinutritional factors

5. Biotechnology for crop improvement

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding.
Tissue culture- History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation.
QTL mapping; Strategies for QTL mapping - desired populations for QTL mapping - statistical methods in QTL mapping - QTL mapping in Genetic analysis; Marker assisted selection (MAS) - Approaches to apply MAS in Plant breeding - selection based on marker - simultaneous selection based on marker and phenotype - factors influencing MAS. Use of mutagens in genomics, allele mining, TILLING
Maintenance breeding and concepts of variety release and seed production Cultivar development- testing, release and notification, maintenance breeding, Classes of seed, Participatory Plant Breeding, Plant breeders' rights and regulations for plant variety protection and farmers rights.

Practicals:

Requirements for plant tissue culture laboratory- Techniques in plant tissue culture - Media components and media preparation -Aseptic manipulation of various explants; observations on the contaminants occurring in media –interpretations - Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants; Establishing a greenhouse and hardening procedures - Visit to commercial micropropagation unit. Isolation, DNA purity and quantification tests, gel electrophoresis of proteins and isozymes, PCR-based DNA markers, gel scoring and data analysis for tagging and phylogenetic relationship, construction of genetic linkage maps using computer software.

Course Outcomes:

• Hands on experience with theoretical knowledge on the different plant breeding methods practiced and statistical evaluation of the results. The students gain experience on the importance of evaluation of field trials before release of different varieties.

References*:*

1. Plant Breeding principle and methods. B.D. Singh, Kalyani Publishers.
2. Plant Physiology. L Taiz and E Zeiger. Sunderland: Sinauer Associates.
3. Plant Tissue culture: Theory and practice, a revised edition. SS Bhojwani and MK Rajdan. Elsevier, Netherland.
4. Plant Propagation by Tissue Culture-Handbook and Directory of Commercial Laboratories. EF George and PD Sherrington, Exegetics limited, Eversley, Basingstoke, Hants, England.

LIFE-JRF-EC03: Advances In Stem Cell Research And Therapy (44)

Coordinators: Dr. Deepak Sharma
(dsharma@barc.gov.in)

Course Details:

1. Stem Cells: Introduction and estimation

- General concepts in stem cell biology and their role in research and therapy
- Surface marker analysis
- Dye efflux and aldehyde dehydrogenase-based assays
- In vitro differentiation and culture-based characterization

2. Embryonic, umbilical cord and adult stem cells

- Embryonic stem cells
- Umbilical cord blood stem cells
- Wharton's Jelly Mesenchymal stem cells
- Adult tissue stem cells: intestinal stem cells, hematopoietic stem cells, neural stem cells, skeletal muscle stem cells, skin epithelial and hair follicle stem cells and heart stem cells
- Isolation, identification and enumeration of hematopoietic stem cells
- Isolation, identification and enumeration of skin epithelial and hair follicle stem cells
- Enumeration of stem cells in human blood

3. Stem cells for tissue regeneration and therapy

- In vitro expansion of stem cells
- Human induced pluripotent stem cell derivation, mouse and human embryonic stem cell derivation, and the mechanisms underlying ICM cells differentiation
- Adoptive transfer and in vivo manipulation of stem cell differentiation
- Mammalian gene transfer and genome engineering
- In vivo manipulation of hematopoietic stem cells in mice

4. Gene expression pattern and genetic manipulation of stem cells

- Stemness associated genes
- Dedifferentiation and re-differentiation of stem cells
- Genetic manipulation of stem cells for therapy
- Use of stem cells for mitigation of radiation injury
- Isolation, identification, enumeration and cryopreservation of Human Wharton's Jelly Mesenchymal Stem cells
- In vitro culture, real time monitoring of cell growth, induced differentiation and genetic manipulation of stem cells

5.

- Organoids
- Stem cell characteristics in T lymphocytes
- Cancer stem cells
- Enumeration of breast cancer stem cells by surface phenotyping and side population

based high content screening

6.
- Stem cell applications
- Ethics in stem cell research
- Biofilm formation in bacteria, Similarities with malignant tumours
- Plant stem cells, vitality and bioprocess engineering
- Identification and characterization of plant stem cell

Course Outcomes:

• The students are introduced into a new and upcoming area of research of stem cells with insight into its generation and uses in animals, plants and bacteria

References:

1. Stem cell research and therapeutics :1 (Advances in Biomedical Research) by ShaiY. (2008)
2. Stem Cell Therapy: A Rising Tide: How Stem Cells Are Disrupting Medicine and Transforming Lives by Neil H Riordan (2017)
3. Stem Cells: From Biology to Therapy, 2 Volumes edited by Robert A. Meyers (2013)

LIFE-JRF-EC04: Applications of Radioisotopes and Molecular Methods in Diagnosis and Therapy (45 Lecture Hrs)

Coordinators: Shri M. K. Ray
(mkray@barc.gov.in)

Course Details:

1. Molecular Biology methods in tuberculosis diagnosis and prevention

- Introduction to TB, its evolution and comparison with other infectious diseases
- Molecular biology techniques in diagnosis of tuberculosis
- Understanding of molecular epidemiology in tuberculosis
- Drug used in tuberculosis and molecular mechanisms of drug resistance in TB
- Use of immune-modulators in TB treatment
- Prevention of TB: new vaccines

2. Molecular Biology methods in thyroid cancer diagnosis and prevention

- Introduction to thyroid cancer (TC)
- Molecular Pathways in TC & their diagnostic importance, molecular mechanisms of resistance to treatment in thyroid cancers
- Genetics & Transcriptomics & their relevance in TC
- Post translational modifications & their role in TC prognosis
- Metabolomics in cancer diagnosis
- Molecular Mechanisms of Resistance to treatment &newer treatment options

3. Use of RIA and other immunological methods in detection of analytes in biological fluids

- Introduction of Immunological methods: Ag-Ab interactions (RIA, IRMA, ELISA)
- Production of polyclonal and monoclonal antibodies
- Affinity calculation, titre estimation of antibodies
- Immobilization of antibodies and their uses
- SCFV antibodies, Abzymes and phage display libraries
- Nanobody production

4. Radiopharmaceuticals in diagnosis and therapy of cancer and other metabolic diseases

- Introduction to radiopharmaceuticals (sourcing of radioisotopes, types of radioisotopes, methods of radiolabeling, BFCA concept)
- Quality control of radiopharmaceuticals, targeted use of radiopharmaceuticals.
- BIO QC of Radiopharmaceuticals.

- Diagnostic applications of radiopharmaceuticals (SPECT, PET)
- Therapeutic applications of radiopharmaceuticals (use of β- emitting radioisotope-based therapy, α radionuclide therapy)
- Types of therapy (Radio-immunotherapy, Receptor-based therapy, etc.) in various cancers
- Radiological Safety regulations related to preparation, transport, storage, use and disposal of Radiopharmaceuticals and Radioisotopes used in Radionuclide therapy.

Course Outcomes:

• In this course students are exposed to techniques used for detection of several important and highly prevalent disease such as tuberculosis and thyroid cancer with emphasis on easier, sensitive and reliable immunological techniques.

References:

1. Tuberculosis: Laboratory Diagnosis and Treatment Strategies (Advances in Molecular and Cellular Microbiology Book 21) by Timothy D. McHugh (2013)
2. Thyroid Cancer: Diagnosis and Treatment, Orlo H. Clark and Shiro Noguchi (2001)
3. Handbook of Radiopharmaceuticals: Methodology and Applications edited by Michael R. Kilbourn and Peter J. H. Scott (2021)

LIFE-JRF-EC05: Advanced Course in Instrumentation (45 Lecture Hrs)

Coordinators: Dr. Kuber C. Bhainsa (kuber@barc.gov.in)

Course Details:

Overview of advanced Instrumentation

1. Inductively Coupled Plasma Spectrophotometer (ICP), Fluorescence Microscopy
2. Liquid Chromatography Mass Spectrometry (LCMS)
3. Electrochemical Biosensors
4. Scanning Electron Microscopy (SEM)-EDS
5. X-ray Diffraction (Powder)
6. Rheometer
7. Atomic Force Microscopy (AFM)
8. Transmission Electron Microscopy (TEM)
9. Surface Plasmon Resonance (SPR)

Course Outcomes:

• In this course the students are exposed to several modern-day instruments used for studying cell surfaces, DNA-protein interactions and protein-protein interactions. The students are also exposed to several analytical instruments.

References:

1. ICP Emission Spectrometry: A Practical Guide, 2nd Edition, Joachim Nölte, (2021).
2. Electron Microscopy: Methods and Protocols (2014), Springer Nature
3. Atomic Force Microscopy in Molecular and Cell Biology by J. Cai (2018) Springer Nature
4. X-Ray Diffraction: Structure, Principles and Applications, Edited by Kaimin Shih 2013)

LIFE-JRF-EC06: Structure Biology- Methods and Applications (45 Lecture Hrs)

Coordinators: Dr. Mukesh Kumar, Dr. Gagan D Gupta
(mukeshk@barc.gov.in)

Course Details:

- Overview of structural biology, Structural features of biomolecules in three-dimensional space, structure determination methods and recent developments, Troubleshooting the recombinant protein expression and purification

- Principles and methods of protein crystallization, Crystal symmetry, Theory of diffraction and Fourier synthesis, X-ray sources

- Diffraction data collection and processing, Diffraction data to structure: Solving the crystallographic phase problem

- Diffraction data to structure: Electron density map and model building, Diffraction data to structure: Refinement and validation

- Structure-based drug design - a rational approach, Principles of CD and fluorescence spectroscopy in protein structure analysis

Course Outcomes:

- In this course the students learn more about protein structure and different software available for predicting structures and protein-ligand interactions, which is very important in the field of drug discovery.

References:

1. Protein Crystallography by *T. L. Blundell* and *L. N. Johnson*; Academic Press
2. Outline of Crystallography for Biologists by *David Blow*; Oxford Univ Press
3. Crystallography Made Crystal Clear by *Gale Rhodes*; Academic Press
4. Principles of Protein X-Ray Crystallography by *Jan Drenth*, Springer

LIFE-JRF-EC07: Advances in Genome Biology (44 Lecture Hrs)

Coordinators: Dr. Y. S. Rajpurohit
(ysraj@barc.gov.in)

Course Details:

- Genome structure with certain examples
- Genome packaging in bacteria, plants and animals
- Genome maintenance and integrity
- Mechanisms of genome segregation
- Factors affecting genome dynamics
- Various approaches for creating genomic alteration in plant and bacterial systems, particularly ploidy
- Usefulness of genomic perturbation in quality and strain improvements and harmful implication in mammalian cells
- Pulsed field gel electrophoresis to analyse genome from plants, animals and multipartite genome harboring bacteria.
- Visualisation of real time dynamics of genome segregation in bacterial and mammalian cells during stressed growth by fluorescence microscopy (Time lapse).
- Isolation of protoplast of plants with different levels of ploidy and visualization of DNA organization in these crop plants by DNA staining and fluorescence microscopy.

Course Outcomes:

• The take home message of this course is deeper understanding about genome organization, integrity, maintenance, segregation and sorting in microbial, plant and animal cells.

References:

1. Molecular Biology of the Cell (6th edition),2014, Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Robertsand Peter Walter, Garland Science:New York
2. Molecular Biology of the Gene (7th edition),2017, James Watson., Pearsons Education, India.
3. Molecular Cell Biology (4th edition), 2000, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. W. H. Freeman: New York;
4. Molecular cloning, A laboratory Manual; Sambrook J and Russel DW, vol 1, 2, 3 (2001)

LIFE-JRF-EC08: Biostatistics, Bioinformatics and Laboratory Techniques (35 Lecture Hrs)

Coordinators: Dr. R. Shashidhar
(shashi@barc.gov.in)

Course Details:

Biostatistics

Standard statistical distribution (e.g., normal, binomial and Poisson) and their application in biology, Measure of central tendency; mean, median and mode, Measure of dispersion: range, variance, standard distribution, standard error, Correlation and regression

Graphical representation of data

Statistical test of significance: Design of experiments t-test, ANOVA, chi-square test

Software program for statistical analysis

Tutorials

Bioinformatics

Sequence Analysis/Alignment techniques: Pair wise sequence alignment: local and global alignment, consensus sequence (sequence logo), frequency matrices (PAM, BLOSUM), log odds score, penalty. Introduction to graphical, Dynamic programming and heuristic methods, database similarity, searches-BLAST/FASTA algorithms.

Multiple sequence alignment: Clustering, Dendrogram/tree construction,
Molecular phylogeny.

Introduction to the protein structural databases (PDB, CATH, SCOP etc.), structure prediction methods with particular focus on homology/comparative modeling Structural validation approaches, protein structures in biotechnology (drug design/protein engineering etc.)

Big data, data analytics, machine learning, deep learning

Course Outcomes:

- Biostatistics and bioinformatics are the backbone of most biology work. In this course the students are taught the different aspects and methods involved in biostatistics and bioinformatics along with a few insights into research tools and techniques.

References:

1. Introduction to Bio-Statistics, Banerjee Pranab Kumar, S. Chand
2. Biostatistics: Basic Concepts and Methodology for the Health Sciences, Wayne. Daniel, Wiley
3. Bioinformatics: A Practical Handbook of Next Generation Sequencing and Its Applications
4. Low and Tammi, World Scientific Publishing Co
5. Understanding Bioinformatics, Zvelebi and Baum, Garland Science
6. Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Wilson & Walker, Cambridge University Press
7. Introducing Proteomics: From Concepts to Sample Separation, Mass Spectrometry and Data Analysis, Lovric Josip, Wiley
8. Principles and Practice of Animal Tissue Culture, Sudha Gangal, Sudha Gangal