Annexure II

Programme: PhD in Genomics

Programme outcome:

Genomics, an era of modern science, has been designed to produce a new generation of young minds by doing research at the genome level. The scholars studied under the programme reach research independence and become a scholar in the chosen research area. The research outcome by the scholars has placed the department on the global map.

Programme specific outcome:

The students on completion of the programme will be able to

1. Do independent research in their chosen area of specialization
2. Demonstrate the ability to work with diverse team and execute team spirit
3. Acquire critical thinking and problem solving skills
4. Identify networking and initiate collaborative research with reputed institutions
5. Improve their communication, scientific writing and presentation skills

COURSES:

Research Methodology (GEN-7001) Credit -4

Course Objective:
To impart comprehensive knowledge on conduct of research

Course Learning Outcomes :

After successful completion of the course, the student should be able to

1. Gain broad understanding on definition of research problem and steps to pursue research
2. Recognize the significance of data collection, statistical analysis and interpretation
3. Understand the principle and working of major laboratory instruments used in metabolomics, genomics and proteomics

I. Introduction to Research Methodology

- Scope, identification and selection of research problem
- Definition and objectives of Research; Types of research, various steps in research process, Formulation of research objectives; Significance of research
- Format of thesis and research article. History and Philosophy of Science, Publishing. How to write a Scientific Paper, Reviewing a paper. Scientific ethics (norms). Collaborative work/research. Presentation skills, Oral presentation, Poster etc.

II. Quantitative Data Analyses

- Data collection, methods and tools of data collection Hypothesis testing, normal and binomial distributions
- Tests of significance, Student *t*-test, *F*-test, *Chi-square* test Correlation and regression;

ANOVA – One-way and two-way

- Uses of SPSS, Excel and statistical tools in analysis of biological data

III. Advanced tools and Techniques

Principle, protocol and application of GC & HPLC, MALDI-TOF, ITRQ, SILAC Electrophoresis, PCR, Real time PCR, DNA microarray and DNA sequencing, Next generation DNA Sequences (NGS),ChIP-CHIP and ChIP-Seq. Hybridization techniques-southern, western and northern blotting. Proteomics methods and its applications.

Texts/References

- J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
- Biostatistical Analysis, 5/E Jerrold H. Zar, 2009.
- C.R. Kothari, IInd edition (2004) Research methodology, Methods and techniques, New Age International (P) Ltd, Publishers, New Delhi
- Khandpur R.S. Handbook of biomedical instrumentation, Tata McGraw Hill.

Research and publication ethics (7002) Credit - 2

Course Objective :

To cover all essentials required to understand research integrity and publication ethics

Course Learning Outcomes:

The students should be able to

1. Elaborate the concept of philosophy and ethics
2. Understand the need for research integrity and honesty
3. Apply their knowledge to identify scientific misconduct and publication ethics
4. Appreciate citation index, impact factor , open access publication
5. How to make plagiarism check using latest software

Unit I: Philosophy and ethics

Introduction to philosophy; definition, nature and scope, concept, branches
Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit II: Scientific conduct

Ethics with respect to science and research
Intellectual honesty and research integrity
Scientific misconducts: Falsification, fabrication and plagiarism (FFP)
Redundant publications; duplicate and overlapping publications, salami slicing
Selective reporting and misrepresentation of data

Unit III: Publication ethics

Publication ethics: definition, introduction and importance
Best practices / standards setting initiatives and guidelines: COPE, WAME, etc
Conflicts of interest
Publication misconduct: definition, concept, problems that lead to unethical behavior and vice

versa, types
Violation of publication ethics, authorship and contributor ship
Identification of publication misconduct, complaints and appeals
Predatory publishers and journals

Unit IV: Open access publishing
Open access publications and initiatives
SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
Software tool to identify predatory publications developed by SPPU
Journal finder/journal suggestion tools viz., JANE, Elservier journal finder, springer journal suggester, etc.

Unit V:

A. Group Discussion
Subject specific ethical issues, FFP, authorship
Conflicts of interest
Complaints and appeals: examples and fraud from India and abroad

B. Software Tools
Use of plagiarism software like Turnitin, URkund and other open source software tools

Unit VI: Database and research metrics

A. Databases
Indexing databases
Citation databases: web of science, scopus etc

B. Research Matrices
Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score
Matrices : h-index, g-index, i10 index, altmetircs

References
Bird A (2006). Philosophy of science. Routledge
MacIntyre, Alasdair (1967) A short history Ethics. London
P. Chaddah (2018) Ethics in competitive research: Do not get scooped; do not get plagiarized, ISBN; 978-9387480865
National Academy of Sciences, National Academy of Engineering and Institute of Medicine (2009). On being a scientist: A guide to responsible conduct in research : third edition, National Academies press
Resnik . D.B (2011). What is ethics in research and why it is important. National institute of environmental health sciences, 1-10. Retrived from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index/cfm
Beall, J.(2012). Predatory publishers are corrupting open access. Nature, 489 (7415), 179-179. https://doi.org/10.1038/489179a
Indian National Science Academy (INSA), Ethics in science Education, Research and Governance (2019). ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics Book.pdf.

Genomics (GEN-7003) Credit -4

Course Objective :

To provide the essentials of sequence analysis using bioinformatics tools

Course Learning Outcomes: On completion of this course, the students should be able to

1. Understand the basics of genetics
2. Demonstrate structure and organization of genomes
3. Apply the various bioinformatics tools to sequence analysis and interpretation
4. Gain broad understanding on cancer genomics and metagenomics

UNIT- I: Principles of genetics

Introduction to genetics, basic mechanisms of inheritance; Mendelian genetics - Mendel's laws of inheritance; gene interaction, mutations, linkage & crossing over.

UNIT- II: Genomics

Organization and structure of genomes - size, complexity, gene-complexity, virus and bacterial genomes. Mapping genomes - physical maps, EST, SNPs as physical markers, sequencing genomes: high-throughput sequencing, strategies of sequencing, recognition of coding and non- coding regions and annotation of genes, quality of genome-sequence data, base calling and sequence accuracy. Assembly of genomes, Programs used for assembly.

UNIT- III: Bioinformatics

Detailed study of GenBank of NCBI orthologous and paralogous sequence, BLAST, F ASTA file formats.Sequence alignments: The concepts and need for sequence alignments, dot plots; sequence alignment methods- local and global. Pair wise and multiple sequence alignments, sequence similarity and distances. Similarity scores, match, mismatch and gap scores. PAM and BLOSUM matrices, the Needleman-Wunch algorithm for global alignment, Smith-Waterman algorithm for local alignment, Statistical significance of alignments- e values ; Using and interpreting BLAST results. Multiple sequence alignments, datasets, sequence analysis based on alignment, de novo identification of genes, *in silico* methods. Molecular Phylogenetics: Concept of phylogenetics -Application of Phylogenetic trees- Molecular clock hypothesis, Distance based methods- NJ algorithm, Character based methods-Maximum parsimony method, Maximum likelihood methods.Transcriptome analysis.

Unite- IV: Cancer Genomics

Tumor suppressor genes and oncogenes. Mutational process in tumors. Instability of tumor genome. P53 as guardian of genome, Programmed cell death. Cancer- associated polymorphisms – Epigenetics. A review of the cancer gene cloning strategies in pre-genomic and post-genomic eras.

Unite-IV: Metagenomics

Isolation and functional characterization of genes from unculturable organisms in the environment, and its relevance and potential applications including in biotechnology, green chemistry, and bioenergy. 16S rRNA based survey, 16S rRNA – microarray (phylochip), sequence base analysis, functional based analysis, heterologous expression, identifying active clones - clone screens, selection and functional anchors, identifying habitats and collecting metadata, gene expression system, single cell analysis; data management and bioinformatics

challenges of metagenomics - genomics data, metagenomics data, the importance of metadata, databases for metagenomics data, software, analysis of metagenomics sequence data.

Texts/References

- J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
- Strickberger, Genetics, 3rd edition, McMillan, 1985.
- Snustad & Simmons, Principles of Genetics, 4th Edition, Wiley, 2005.
- C. David Allis, Epigenetics, CSHL, 2007.
- Principle of Genome Analysis and Genomics, Primrose, S. B. and Twyman R. M., (7th Ed., 2006), Blackwell Publishing Company, Malden, USA
- Bioinformatics: Sequence and Genome Analysis, Mount, D. W., Cold Spring Harbor Laboratory Press, New York, USA
- Genomes 2nd Ed.- Bown .T.A, John Wiley & Sons, 2002
- Introduction to bioinformatics: theoretical and practical approaches- S.A. Krawetzt, D.D. Womble, Human Press.
- Book: "The New Science of Metagenomics: Revealing the Secrets of Our Microbial Planet" National Reserach Council of The National Academics, 2007 ISBN-10: 0-309-10676-1, ISBN-13: 978-0-309-10676-4
- C. de la Taille A, Chen MW, Burchardt M, Chopin DK, Buttyan R Apoptotic conversion: evidence for exchange of genetic information between prostate cancer cells mediated by apoptosis. Cancer Res. 1999 Nov 1; 59(21):5461-3.
- Yan B, Wang H, Li F, Li CY. Regulation of mammalian horizontal gene transfer by apoptotic DNA fragmentation. Br J Cancer. 2006 Dec 18;95(12):1696-700.
- Gudkov AV. Converting p53 from a killer into a healer. Nat Med. 2002;8(11):1196-8.
- Robson ME, Storm CD, Weitzel J, Wollins DS, Offit K. American Society of Clinical Oncology Policy Statement Update: Genetic and Genomic Testing for Cancer Susceptibility. J Clin Oncol2010;28(5):893-901

Genetics of Populations (GEN -7004**) Credit -6**

Course Objective :

This course is proposed to familiarize with the branch of evolutionary biology concerned with the genetic structure of populations and how it changes through time.

Course Learning Outcomes:

- Solve biological problems with the help of population genetics principles
- Explain the principles of population genetics
- Identify relevant question formulations in population genetics and propose strategies to solve the problems
- Use previously acquired knowledge (mathematics, statistics and programming) to solve

genetic problems

This course is proposed to familiarize with the branch of evolutionary biology concerned with the genetic structure of populations and how it changes through time.

- **Introduction to Basic Genetics:** Genetic variation, Introduction to Population Genetics, Elements of Population Genetics Phenotypic & Genetic Variation in Natural Populations, Population Genomics
- **Structure of Populations:** Hardy Weinberg, Systems of Mating, Genetic Drift, Neutrality and Molecular Evolution, Coalescence, Gene Flow & Subdivision, Population substructure, F Statistics. Migration Effective Population Size
- **Selection:** Fitness, modes of selection, one-locus selection models , Mean Population Fitness, Measures of Fitness & Constant Fitness Models, Interactions of selection with other evolutionary forces
- **Units and Targets of Selection:** The Unit of Selection, Meiotic and Molecular Drive, Sexual & Density Dependent Selection, Kin Selection
- **Ecological Genetics:** Environmental Heterogeneity, Coevolution, Life History Evolution
- **Speciation:** Species and the process of speciation. Allopatric vs. Sympatric speciation. Forces that bring about evolutionary change.

References

- Phillip W Hendricks. Genetics of Populations (2009). Jones & Bartlett Learning. 700 pages
- Daniel L. Hartl and Andrew G. Clark (2007) Principles of Population Genetics, Fourth Edition. Sinauer Associates 545 pages.
- Masatoshi Nei and Sudhir Kumar (2000) Molecular Evolution and Phylogenetics. Oxford University Press, USA 333 pages
- Jean-Baptiste De Panafieu, Patrick Gries and Linda Asher. Evolution (2011). Seven Stories Press. 448 pages.

Cancer Biology (GEN -7005) Credit -6

Course Objectives: The program is designed to provide a grounding in the molecular and cellular biochemistry that underpins cancer biology. Here we practice an in depth understanding of the cancer treatment by measuring the cancer cell state on treatment with novel metabolites and exploring the new treatment options using the drug repurposing method. The module focuses on regulating genes and associated proteins implicated in tumorigenic signaling pathways and the analysis of data retrieved from genomic studies of cancer.

Course Learning Outcomes: On successful completion of the course, an individual shall have a high level of understanding of cellular regulation, cancer genome, in-vitro drug response, and its applicability

- Can delineate the molecular and cellular processes underlying cancerous cell state and differentiate it from normal cell growth.
- Indicate the principles of tumorigenicity and heterogeneity and measure the impact on treatment through applied research methods such as gene and protein quantification techniques.
- Interpret complex genomic rearrangement and their impact on cancer causes.

- This course offers students broad research skills training and the development of research hypotheses and critically evaluating cancer therapeutics.

  - Biology and Genomic integrity of Cancers.
  - Detection of cancers, prediction of aggressiveness of cancer, advances in cancer detection.
  - The impact of the cell cycle (proliferation), gene mutations receptors and cell signaling.
  - Programmed cell death, caspases, cell death receptor and apoptosis, pro and anti apoptotic pathways and cell survival, proteosomes.
  - Cancer-development and causes of cancer, transformation of cells in culture, role of oncogenes and tumor suppressor genes.
  - Molecules for cancer therapy: Different forms of therapy, chemotherapy, radiation therapy, and Immuno therapy: advantages and limitations.
  - Drug design and treatment: novel targeted therapeutic agents in the treatment of cancer.

Molecular Genetics and Genomics (GEN-7006) Credit -6

Course objective: The course is designed to offer basics of molecular genetics and genomics with various examples including plants, animals and human beings.

Course Learning Outcome: Upon successful completion of this course student would be able to

- Learn and understand the basic concepts of central dogma of molecular genetics.
- Demonstrate the concept of prokaryotic and eukaryotic gene and regulatory mechanism of gene.
- Understand structure and applications of different genetic markers.
- Understand about phylogenetic analysis.
- Knowledge about genetic diversity in natural populations and its significance.
- Knowledge about the implications of genetics in conservation of endangered species.
- Knowledge about different types of genomic techniques and its application.

UNIT I: Gene and genome structure and organization; gene concept; gene regulation; DNA replication and transcription.

UNIT II: Chromatin-structure and organization; histone tail modifications; DNA methylation; epigenetics and disease.

UNIT III: Principles of population genetics; Hardy-Weinberg equilibrium; factors affecting Hardy-Weinberg equilibrium; genetic diversity and measures of diversity; linkage and linkage disequilibrium.

UNIT IV: Introduction to phylogenetics; molecular markers; phylogenetic tree construction methods and programs.

UNIT V: Polymerase chain reaction; recombinant DNA technology; microarray; Real Time PCR; DNA sequencing principle and methods-Sanger and Next generation sequencing techniques.

Texts/References

1. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
2. Strickberger, Genetics, 3rd edition, McMillan, 1985.
3. Snustad & Simmons, Principles of Genetics, 4th Edition, Wiley, 2005.
4. Lewin, Genes IX, 9th Edition , Jones & Bartlett, 2007.
5. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.
6. P W Hedrick, Genetics of Populations, 2nd Edition, Jones & Bartlett 2000.
7. Hartl & Clark, Principles of Population Genetics, Third Edition, Sinauer Associates, Inc. 1997.
8. Alberts et al, Molecular Biology of The Cell, 2nd. Edition, Garland, 2007.
9. C. David Allis, Epigenetics, CSHL, 2007.

Genomics-assisted breeding (GEN-7007) Credit -6

Course Objective:

The course aims to give the theory and research knowledge on how the genomics tools and techniques speeding the breeding with practical examples on plants and animals

Course Learning Outcome:

1. The importance of reference genome and genome-wide surveys to associate the allelic variation with phenotypes.
2. Understands the methods to evaluate the genetic worth of vast genetic resources in crop improvement programs.
3. The role of precise genome editing technologies in breeding program will be understood.

- Breeding science, Conventional breeding methods (Plants & Animal)
- Genetics and breeding, Marker- assisted selection, Genomics-assisted breeding – Crops &
- livestocks
- Genomic selection, Selection sweep and Genome-Wide Association Mapping
- Success research outcomes of Genomics-assisted breeding, Sequence based approach
- Future direction in sequencing era.

Metabolic pathway engineering in plants (GEN- 7008) Credit -6

Course Objective:
To impart basic knowledge on primary and secondary metabolism in plants

Course Learning Outcome: After the successful completion of the course, the student will be able to

1. Demonstrate the linkage between primary and secondary metabolism
2. Understand the convergence and divergence of various biosynthetic pathways
3. Learn the concept of enzyme kinetics
4. Conceptualize plant hormone synthesis and regulation

Unit I: Glycolysis, Citric acid cycle, Pentose phosphate pathway

Unit II: Secondary metabolic pathways in plants: Super pathway of phenylalanine, tyrosine and tryptophan biosynthesis, Polyketide pathway in plants: aromatic Polyketide biosynthesis, Mevlonate Pathway, Shikimate pathway, Terpenoids Biosynthesis: (diterpenes, triterpenes, sesquiterpenes).

Unit III: Enzyme kinetics: Enzyme specificity, catalytic activities, Reaction Eqilibria, Physico-chemical properties of enzymes, Enzyme acceleration and enzyme transition states. Enzyme substrate complex, Enzyme active sites, Michelis-Menten Model,Significance of Vmax and Km;Kcat/Km criterion, Enzyme inhibition, Allosteric Enzymes, Transition state analogs, Enzyme regulatory strategies,

-Feed back inhibition. Eg. Aspartate transcarbamoylase
- Cyclic AMP activation of protein kinase A
- Specific cleavage of single peptide bond
- Specific cleavage of single peptide Bond. Eg Chymotripsinogen

Unit IV: Plant Hormone Biosynthesis: Gibberellin biosynthesis, super pathway of gibberellin biosynthesis

Texts/References

1.Razdan M.K. (2003). Introduction to plant tissue culture Oxford – IBH publishing
Co. Pvt. Ltd.
2.Glick, B.R., Pasternak, JJ (1998) Molecular Biotechnology: Principles and applications of recombinant DNA, ASM Press.
3 Lewin, B (2004). Genes VIII. Pearson- Prentice Hall Press
4 Dubey, R.C.(2006). A textbook of Biotechnology-S. Chand & Company Ltd

Plant microbe interaction (GEN -7009) Credit -6

Course Objectives:

- Distinguish between the different types of plant-microbe interactions.
- Explain the physiological and biochemical processes underlying the best characterized plant-microbe interactions.
- Recognize conserved processes among plant-microbe interactions.
- Objectively analyze the design and content of current research studies from the scientific literature.
- Draw connections between the biology of plant-microbe relationships and the impacts of these relationships on the ecosystem and human society

Course Learning Outcomes:

- Show knowledge about the different forms of interactions that exist between plants and microbes and about the signaling systems behind these different interactions.
- Explain the importance of symbiosis from a nutritional perspective and how the nutritional exchange between organisms works and describe the balance between symbiosis and parasitism
- Describe the different molecular processes that underlie pathogenicity and how plants defend themselves
- Practically use the information stored in different organism databases in aim to elucidate protein interactions and identify genes that are involved in different processes
- Understand the importance of interactions between different organisms in the ecological context

Unit 1: Introduction to plant-microbe interactions: Beneficial associations: (eg: root nodulation, mycorrhizae), detrimental pathogenic associations: (eg: crown gall tumorigenesis, phytophthora infection)

Unit 2: Concept of Plant immunity: plant innate immune system, pathogen-associated molecular pattern, damage-associated molecular pattern, hyper sensitive responses, pathogen derived effectors and toxins, pattern recognition receptors in plant immunity, PAMP-triggered immunity, effector-triggered immunity, Plant Resistance genes, proteins and mechanisms, systemic acquired resistance, Role of plant secondary metabolites in host-pathogen interaction.

Unit 3: Plant-Bacterial interactions: Mechanism of bacterial virulence, TypeIII secreted helper proteins, role of type III secretion on plant hormones, Plant resistance response. **Plant-Fungal interactions:** Establishment of infection structures, pathogenicity and virulence of fungi, contribution of host to infection, controlling defense responses, mechanism of fungal disease resistance.

Unit 4: Plant-Oomycete interactions: Infection strategies, genome characteristics, resistance mechanisms of host. **Plant-Viral interactions:** unique challenges by viruses, virus infection and

propagation, resistance strategies towards viral diseases. **Induced resistance**: Induced resistance signaling, cross talk between defense signaling pathways, methods for enhancing defense.

Microbial Genetics and Genomics (GEN- 7010) Credit-6

Course Objectives: The course aims to deliver theoretical knowledge on microbial genome architecture and the regulation of genes through small molecules that eventually influences the mechanism for shaping the microbiome structure and functions. The course shall also discuss the latest cutting-edge approaches to mapping the microbiome composition. Furthermore, it shall also explore the techniques to harness the microbiome genetic diversity for discovering novel biomolecules from the environment.

Course Learning Outcome: Upon completing the course, the students shall have in-depth knowledge of microbiome genome structure, regulation, and manipulation.

- Interaction of the individual microbial cells and its influence on microbial community heterogeneity and plasticity.
- Practical techniques to map the overall microbiome and its application in microbial ecology studies in context to biological and medical implications.
- Approaches to preparing metagenomic library preparation and screening of novel industrial and pharmaceutical bioactive molecules from natural biosystems.
- Standard molecular techniques for genetic manipulation and expression of chimeric genes in microbial cells.
- Develop scientific communication and presentation skills suitable for international conferences, presentations, and public speaking.

I. **Genomics of Microbes and Microbiomes:** Genome architecture of microbes, dynamics of microbial diversity (Soil habitat, Un-culturable microorganisms, and Culturable microorganisms).
II. **Population Genetics and Micro heterogeneity**: Symbiosis, Competition, Communication role of small molecules, Sequence based screening for small molecules Antibiotics as signal molecules, Chemical ecology.
III. **Omics approaches to study microbial diversity**: Omics in diversity analysis (metagenomics; metaproteomics and metatrancriptomics).
IV. **Metagenomics:** culture independent insights and drug discovery platform, high through put sequence based analysis (NGS), function metagenomics, heterologous expression, identifying active clones-screen, selection, library construction, Sequencing of the cloned DNA, sequence analysis and phylogenetic tree construction, functional anchor search for potential novel compounds.
V. **Bioprospecting:** in (a) agriculture, (b) environmental remediation, (c) clinical science, (d) quorum sensing, (e) industry, (f) renewable energy.

References:

1. Metagenomics: Theory, Methods and Applications, Pub. Caister Academic Press, Ed. Diana Marco *Universidad Nacional de Cordoba, Argentina* Publication 2010**,** ISBN: 978-1-904455-54-7

2. Metagenomics: Current Innovations and Future Trends, Pub. Caister Academic Press Ed. Diana Marco *Microbiology Department, Estación Experimental del Zaidín (CSIC), Granada, Spain,* Publication 2011, ISBN: 978-1-904455-87-5
3. Metagenomics: Methods and Protocols, Eds. Streit, Wolfgang, Daniel, Rolf, Pub. 2010, ISBN 978-1-60761-823-2
4. Board on Life Sciences, The New Science of Metagenomics: Revealing the Secrets of Our Microbial Planet, The National Academies Press, Washington, DC.