Programme: PhD in Genomics

Programme outcome:

Genomics, an era of modern science, has been designed to produce a new generation of young minds by researching 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:

Since the inception of the PhD programme, 35 PhD scholars have enrolled in the programme, and 10 of them has successfully defended the thesis and graduated. The scholars have published their research work in high impact factor journals and received appreciation from the scientific community. Out of 10 who graduated, five of them went abroad for Post-Doc, one working as Postdoc at National institute, two working in R & D.

COURSES:

Research Methodology (GEN-7001)

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.

Genomics (GEN-7002)

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 -7003)

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 -7004)

- 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-7005)

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-7006)

- 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.