Ph.D COURSE WORK SYLLABUS
SUBJECT- BIOTECHNOLOGY
COMMON PAPER
PAPER I – RESEARCH METHODOLOGY (BIOTECHNOLOGY)

Unit I: Tools and techniques in Research
1.1. Centrifugation techniques- Principle, types & applications
1.2. Spectrophotometric techniques- Principle, types & applications
1.3. Chromatographic techniques-Principle, types & applications
1.4. Electrophoretic techniques- Principle, types & applications
1.5. Microscopy- Principle, types & applications
1.6. Types of PCR and applications
1.7 Real time PCR and applications

Unit II: Recombinant DNA technology
2.1. Restriction enzymes and types; Modifying enzymes- Methylases, Polymerases, Ligases, Kinases, Phosphatases, Nucleases
2.2. Vectors for cloning, expression (gateway cloning vectors) and library preparation (Lambda phage vectors, Cosmids, BAC, YAC), prokaryotic (*E. coli*) and eukaryotic (Yeast) hosts
2.3. Strategies for construction of genomic (Chromosome walking and jumping for positional cloning of genes) and cDNA libraries (Subtractive and Normalized libraries)
2.4. Selection of recombinant clones - Insertional Inactivation, Alpha-Complementation, PCR screening, immunological screening for expressed genes, Screening using blotting techniques (Southern, Northern, Western blotting)
2.5. Protein expression and purification - expression vectors; Recombinant protein expression in bacteria, yeast, plant cells & mammalian cells; Post-translational modification of proteins
2.6. Advanced techniques in r-DNA technology- site directed mutagenesis, RNA interference, Knock-in and knock-out technology, Genome editing technologies- CRISPR-CAS system, TALENs & Zinc finger Nucleases

Unit III: Bioinformatics
3.1. Introduction to Bioinformatics, Application of Bioinformatics, Role of internet, Forms of biological information
3.2. Bioinformatics Resources: Sequence databases: Nucleic acid sequence databases: GenBank, EMBL, DDBJ; Protein sequence databases: UniProt (SCOP, CATH): Swiss-Prot, HapMap; RAP-db databases, Plant genome data bases
3.3. Nucleic acid & Amino acid properties: Various tools at the Expasy server, Sequence Analysis: Basic concepts of sequence similarity, identity and homology
3.4. Sequence alignment: Pairwise sequence alignment: Basic concepts of sequence alignment, Dot plots, Needleman and Wunsch, Smith and Waterman algorithms for pairwise alignments, BLAST and FASTA algorithms, Multiple sequence alignment and Phylogenetic analysis Tree construction methods (NJ and ML)

3.5. Genomics: Gene annotation in prokaryotes and eukaryotes, Proteomics- Protein identification, structural classification, structure prediction.

3.6. Medical application of Bioinformatics: Identification of disease genes, drug targets, overview of drug discovery, pharmacogenomics.

Unit IV: Statistics and Research concepts

4.1. Introduction to Biostatistics

4.2. Sample size- Basic data required for sample size determination; Collection of data, power of the sample, measures of dispersion, measures of central tendency

4.3. Tests of significance- Z-test, paired & unpaired t-test, F-test, Chi-square test and ANOVA; Correlation and Regression analysis; SPSS, tools for statistical analysis

4.4. Introduction to research concepts
a) Philosophy & Meaning of Research, Basic research, applied research and need based research; Identification and defining of the problem
b) Literature survey: the search for facts; the verification of facts; the analysis of evidence; truth & causation; Sources of prejudice and bias
c) Library reference schemes; Note making, Lab record, Internet.

4.5. Research proposal design & formulation; Hypothesis- Direct & alternate methods; Research methodology; Data collection& validation

4.6. Statistical approach, Validation of findings, Plagiarism, Research communications and Impact factor of journals

4.7. The structure of a thesis; Language, style & format in the thesis, References & styles

REFERENCE BOOKS

1. Biophysical Chemistry by Upadhyay, Upadhyay and Nath 4th edition, Himalaya publishing House, Mumbai.
2. Practical Biochemistry by Keith Wilson and John Walker, 5th edition, Cambridge University press, U.K.
3. Molecular Biology of the gene by J. Watson
4. Genes Vol VI, VII and VIII by Benjamin Lewi
5. Molecular Biotechnology Principles and application of recombinant DNA
6. Principles of Gene manipulation by R.W. Old and S.B. Primrose
7. Recombinant DNA: A short course by J. Watson, Tooze and Kurtz
8. Bioinformatics: Sequence and Genome Analysis by David W. Mount, ColdSpringHarbor Laboratory Press
9. Biological Sequence Analysis : Probabilistic Models of Proteins and Nucleic Acids by Richard Durbin, Sean R. Eddy, Anders Krogh, Graeme Mitchison, Cambridge University Press.
10. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Second Edition by Andreas D. Baxevanis, B. F. Francis Ouellette, Wiley-Interscience.
11. Introduction to Biostatistics by Robert Sokal and James Rohlf, Dover publications

Ph.D COURSE WORK SYLLABUS
SUBJECT- BIOTECHNOLOGY
PAPER II- MEDICAL BIOTECHNOLOGY
(RESEARCH SPECIALIZATION)

Unit I: Molecular basis of Human disease

1.1. SNPs and disease susceptibility, Human genome project, 1000 genome project, Hapmap data
1.2. NGS; Exome sequencing and GWAS- significance
1.3. Epigenetic programming underlying diseases
1.4. Inherited diseases- Single gene/Mendelian/Complex/Mitochondrial diseases
1.5. Molecular basis of cancer
1.6. Molecular basis of infectious diseases- Role of genes; MHC and disease susceptibility

Unit II: Diagnostic approaches for human diseases

2.1. Invasive & Non-invasive techniques- Aminocentesis, Fetoscopy, Chorionic villi sampling (CVS), ECHO, ECG, 2D Doppler
2.2. DNA based disease diagnosis- Thalassemia, Sickle cell anaemia, CML, infectious diseases
2.3. RNA based disease diagnosis- Infectious Diseases, Cancer
2.4. Microarray technology- genomic and cDNA arrays, application to disease diagnosis
2.5. Non-coding miRNA for diagnosis
2.6. Diagnosis using protein and enzyme markers (PKU, Creatinine kinase, Troponin)
2.7. Diagnosis using monoclonal antibodies

Unit III: Therapeutics

3.1 Gene therapy : *ex-vivo* and *in-vivo;* Strategies of gene therapy- loss of function
3.2 (GAT, prodrug therapy), gain of function (TFOs); Gene therapy trials for familial hypercholesterolaemia, cystic fibrosis and cancer.
3.3 Genome editing for human diseases (ZFN, TALENS, CRISPR-Cas9).
3.4 DNA based vaccines: subunit vaccines, attenuated vaccines, r-DNA vaccines.
      RNAi, ribozymes, antisense therapy-principles and applications.
3.5 Production of proteins and enzymes as therapeutics: Enzyme therapy-Gaucher disease; hormone replacement therapy- diabetes, growth hormone deficiency; cytokine therapy, recombinant interferons- monoclonal antibodies, aptamers, intrabodies
3.6 Pharmacogenomics: Origin, status and future prospects - G6PD, CYP and Cardiovascular diseases.

Unit IV: Regenerative and Nanomedicine

4.1. Tissue engineering Triad (cells, biomaterial scaffolds and cell signalling factors)
4.2. Structure and function of the engineering tissues --Bone/Joint replacements (Cartilage, tendons, ligaments); Soft tissue replacements (skin); Internal organs (liver & Pancreas)
4.3. Regulatory &ethical issues of tissue engineering

4.4. Nanomedicine; Nanomaterials- Types of nanomaterials and their classifications (1D, 2D and 3D etc.); Properties of nanomaterials –electronic, thermal and magnetic properties; Biosensors

4.5. Applications of nanomaterials in medicine-Diagnostics/Drug delivery & therapeutics

4.6. Safety and ethical issues associated with Nanomedicine

REFERENCE BOOKS

1. Introduction to Human Molecular Genetics– J.J Pasternak, John Wiley Publishers.
2. Human Molecular Genetics–Tom Strachen and A P Read, Bios Scientific   Publishers
3. Human Genetics Molecular Evolution, Mc Conkey
4. Recombinant DNA Technology , AEH Emery
5. Principles and Practice of Medical Genetics, I, II, III Volumes by AEH Edts. Emery
6. Medical Biotechnology-PratibhaNallari, V.Venugopal Rao-Oxford Press
7. Nanomaterials Handbook- Yury Gogotsi
8. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens
9. Nanomaterials Handbook- Yury Gogotsi
10. Springer Handbook of Nanotechnology by Bharat Bhushan

Ph.D COURSE WORK SYLLABUS
SUBJECT- BIOTECHNOLOGY
PAPER II: PLANT BIOTECHNOLOGY
(RESEARCH SPECIALIZATION)

Unit I: Plant cell and tissue culture & its applications

1.1.   Callus and cell suspension cultures and plant regeneration
1.2.   Organogenesis and somatic embryogenesis – micro-propagation & its applications
1.3.   Anther culture, production of haploids, double haploids (isogenic lines)& applications in plant breeding
1.4.   Production of Somatic hybrids and Cybrids & their applications in crop improvement
1.5.   Cryopreservation of plant germplasm - Seed banks, Gene banks
1.6.   *Invitro* production of secondary metabolites, Biotransformation and production of novel compounds

Unit II: Gene transfer and Genome editing in plants

2.1.   Methods of direct gene transfer in plants – particle bombardment, electroporation, PEG mediated.
2.2.   *Agrobacterium* mediated transformation - Features of Ti and Ri Plasmids and their use as vectors for plant transformation (binary and co-integrate vectors)
2.3.   Selection (Reporter genes – scorable and selectable marker genes) and molecular characterization of transformants , Transgene stability and gene silencing
2.4.   Post transcriptional gene silencing - Antisense and RNAi technology
2.5.   Chloroplast transformation – Transplastomic plants; advantages & applications
2.6.   Genome editing techniques – CRISPR/CAS system; advantages & applications

Unit III: Transgenic plants for improvement of productivity and performance

3.1.   Genetic modification of plants for Insect/Pest resistance
3.2.   Production of transgenic plants for bacterial, fungal and viral resistance
3.3.   Development of genetically modified plants for abiotic stress (drought, salt, low and high temperature, flooding and heavy metal) tolerance
3.4.   Pathway engineering for production of secondary metabolites
3.5.   Molecular Farming for production of biopharmaceuticals (plantibodies, plantigens, therapeutic proteins and edible vaccines) and industrial products (industrial enzymes, lysozyme)
3.6.   Genetic modification of plants for improvement of shelf life of fruits, Oil quality and nutritional quality (amino acids, vitamins, micronutrients)

Unit IV: Molecular breeding for crop improvement

4.1.   Limitations of conventional breeding; Aspects of molecular breeding
4.2.   Development of sequence based molecular markers - SSRs and SNPs
4.3.   QTL mapping using structured populations, Map based gene/QTL isolation and development of gene based markers
4.4.   Allele mining by TILLING and Eco-TILLING
4.5.   Marker assisted selection (MAS) in backcross and heterosis breeding
4.6.   Marker assisted selection and gene pyramiding

REFERENCE BOOKS

1. Bhojwani SS. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.
2. Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons
3. Dixon RA. 2003. *Plant Cell Culture*. IRL Press.
4. Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.
5. Pena L. 2004. *Transgenic Plants: Methods and Protocols*. Humana Press.
6. Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.
7. Singh BD. 2007. *Biotechnology: Expanding Horiozon.* Kalyani
8. Buchanan B, Gruissen W & Jones R. 2000. *Biochemistry and Molecular*
9. *Biology of Plants*. American Society of Plant Physiologists, USA.
10. Chittaranjan K. 2006-07. *Genome Mapping and Molecular Breeding in Plants.* Vols. I-VII. Springer.16
11. Newbury HJ. 2003. *Plant Molecular Breeding*. Blackwell Publ.