DEPARTMENT OF BOTANY
UNIVERSITY OF KERALA

POST-GRADUATE PROGRAMME
M. Sc GENETICS AND PLANT BREEDING

REVISED SYLLABUS

JANUARY, 2006

M.Sc Genetics and Plant Breeding Course Details

Course code	Name of paper	No. of credits	Evaluation
I SEMESTER			
BOT. 511	Mendelian Genetics	4	
BOT. 512	Techniques in Cell Biology	4	
BOT. 513	Cytology	4	
II SEMESTER			
BOT. 521	Molecular Genetics	4	
BOT. 522	Cytogenetics	4	
BOT. 523	Plant Breeding	4	
BOT. 524	Plant Biochemistry	4	
III SEMESTER			
BOT. 531	Genetic Engineering	4	
BOT. 532	Plant Biotechnology	4	
BOT. 533	Environmental Genetics	4	
BOT. 534	Modern Methods in Crop Breeding	4	
IV SEMESTER			
BOT. 541	Population Genetics	4	
BOT. 542	Developmental Genetics	4	
BOT. 543	Biosystematics	4	
ELECTIVE PAPERS			
BOT. 501	Biophysics	2	
BOT.505	Applied Palynology	2	
BOT.51A	Plant tissue culture	1	
BOT.507	Transgenic plants	1	
BOT.508	Biotechnology	1	
BOT.53A	Phytochemicals	1	
BOT. 52A	Plant Cell Culture Technology	1	

BOT 511. MENDELIAN GENETICS

Unit 1. Gregor Mendel's Discoveries

(i) Mendel's Experimental approach to study the pattern of inheritance, Monohybrid cross, Dihybrid cross, Trihybrid cross, Mendel's analytical approach, Punnet square, Forkline method, Relations among pairs of independent alleles, Test cross.

(ii) Laws of probability, Binomial Theorem, Chi-Square analysis, Pedigree analysis. Human disorders follow Mendelian patterns of inheritance

Extending Mendelian Genetics

(i) Codominance, Multiple alleles. Lethal alleles. Epistasis, Complementation analysis, X linkage in *Drosophila*, X-linkage in humans, Sex limited and sex influenced inheritance, Hollandric genes, penetrance and expressivity, pleiotropy, position effects, temperature and nutrition effects, genomic imprinting.

(ii) Quantitative traits, Additive alleles, Statistical analysis of polygenic traits, mapping of quantitative trait loci.

Unit 2. Linkage maps and sex determination mechanisms

Relating Mendelism to Chromosomes

(i) Chromosome theory of heredity, coupling and repulsion theory, Morgan and crossing over, Sturtvant and mapping, single cross overs, linkage ratio.

(ii) Three point Mapping in *Drosophila*, crossing over involves physical exchange between chromatids. Works of Stern, Creighton and McClintock, determination of gene sequences, interference.

Sex determination and Sex Chromosomes

(i) Sex determination in *Drosophila*, humans and plants, Klinefelter and Turner's syndrome, Barr bodies, Lyon's hypothesis. The mechanism of inactivation, dosage compensation in *Drosophila*.

Unit 3. Errors and Exceptions to Chromosomal Inheritance

(i) Extranuclear inheritance, Chloroplast variation in Four O'clock plant, Mitochondrial mutations, Mutations in mitochondrial DNA cause human disorders. kappa in *Paramoecium*, maternal effect.

Practicals

1. Problems related to Mendel's laws, Probability, Pedigree analysis

2. Problems related to codominance, multiple alleles, lethal alleles, epistasis, complementation analysis, X linkage, sex-limited and sex influenced inheritance.

3. Statistical analysis of polygenic traits. Mapping of quantitative trait loci.

4. Problems related to two-point test cross, three point mapping in *Drosophila*, Determination of gene sequences, Interference

5. Sex determination in *Drosophila* humans, and plants

6. Chloroplast variation in Four O'clock plant, Mitochondrial mutations, Inheritance of Kappa in paramecium, Inheritance of Maternal effect.

References

Atherly, A.G., Girton, J.R. and Mc Donald, J.F. 1999. The Science of Genetics. Saunders College Publishing, Harcourt Brace College Publishers, New York

Benjamin A. Pierce. 2003. Genetics: A Conceptual Approach. W.H, Freeman and Company, New York, NY.

Gardner E.J., Simmons, M.J., and Snustad, D.P. 1991. Principles of Genetics, (8th edition) John Wiley & Sons Inc., New York.

Griffith A.F. J., Miller, J.H, Suzuki, D.T., Lewontin, R.C., Geibart., W.M, 1993. An Introduction to Genetic analysis (7th edition). W.H Freeman & Company, New York.

HartI D. L., Jones E.W. 2001. Genetics an analysis of Genes and Genomes (5th edition). Jones & Bartlett Publishers, Boston

Klung, W. and Cummings, M. R 2003. Concepts of Genetics. (7thedition) Pearson Education, Singapore.

Russell, P.J. 2005. Genetics A Molecular Approach (2nd edition). Pearson/Benjamin Cummings, San Francisco.

Stansfield 1991. Genetics (3rd edition), Schaum's outline series, McGraw Hill, New York.

Weaver, R.F and Hedrick P.W. 1997. Genetics (3rd edition), Wm. C Brown Publishers. Toronto.

BOT 512. TECHNIQUES IN CELL BIOLOGY

Unit 1. Microscopy

(i) Principles, Light, Phase contrast, Interference , Fluorescent, Electron Scanning, Transmission, Scanning, EDX, Scanning, Voltage

Unit 2. Processing of tissues

(i) Killing and fixing: Principles and Techniques, Properties of chemical reagents used, Constituents and properties of killing and fixing fluids-different types, Flemming's fluid, FAA, Carnoy's fluid, Nawaschins fluid, Zircles fluid, Killing and fixing methods for electron microscopy.

(ii) Dehydration: Principles, Important dehydrating and clearing agents, their properties and uses, Alcohol, xylol, glycerol, chloroform, dioxan, Types of micro-slide preparation, temporary-semi-permanent and permanent – smears and squashes, Methods of dehydration preparation of serial section Tertiary- Butyl Alcohol method (TBA), Ethyl alcohol method, Method of embedding of dehydrated material in paraffin wax.

(iii) Sectioning: Free hand sections, significance and problems. Types of Microtome: Rotary, Sledge, Sliding microtome, Freezing microtome (Cryotome, cryostat), Sectioning by Rotary microtome, Sledge microtome.

(iv) Stains and Staining: Principles of staining, classification of stains, Protocol for preparation of the following stains:-

a. Natural Stains: Haematoxylin, carmine, orcein.

b. Synthetic Dyes*:* Fast green, Orange G, Safranin, Crystal Violet, Basic fuchsin, Eosin, Cotton blue.

c. Technique of staining**:** Single staining, Double staining, Triple staining, Significance.

d. Mounting media: Properties and techniques. Common mounting media used, Principles and techniques of maceration.

(v) Histochemistry.

a. Cytochemical Localization of Cell Components.

Carbohydrates (Periodic acid –Schiff's [PAS] method), Fats, Oils, Suberin, Cutin, Sudan Dyes, Lignin- Phlroglucinol, Mucopolysaccharides- Alcian Blue, Nucleic acids -Fuelgen Reaction, Pectin-Ruthenium red method, Hydroxylamine, Phospholipids -Orange G and Aniline Blue, Proteins- Coomassie brilliant blue stain, Lipids Sudan Blue method, Starch iodine – Potassium iodide (IKI).

b. Cytochemical localization of enzymes: Acid phosphatases, Alkaline phosphatase, Cytochrome oxidase, Dehydrogenase, Esterases, Lipases, Pectinase.

Unit 3. Chromosome Banding Techniques

(i) Quinacrine banding, Giemsa banding (G-banding), Reverse fluorescent banding, C- banding, Fuelgen banding, Silver banding (AG- NOR banding), N- banding, Orcein banding.

Practicals

1. Preparation of double stained freehand sections of plant tissue.

2. Freehand sections showing localization of primary metabolites- Proteins, Carbohydrates and Lipids.
3. Dehydration of plant tissue using TBA method, embedding and Preparation of Paraffin blocks and preparation of serial sections.
4. Histochemical localization of starch, protein, nucleic acid and fat
5. Histochemical localization of estrase, acid phoshatase and pectinase
6. Sectioning by using cryotome (demonstration only)
7. Photo-documentation of micro-preparation by using image analyzer
8. Chromosome banding techniques.

References

Baker, J.R. 1958. Principles of Biological Microtechnique. Methuen & Co Ltd.,

Clark, M.S. & Wall, W.J. Chromosome: The Complex Code. Chapman & Hall, London.

Conn H.J., Danow, M.A. & Emmel, V.M. 1965. Staining procedures used by the biological stain commission. Biological stain commission. University of Rochester, Medical Center, Rochester NY & The Williams & Wilkins Co., Baltimore.

Galigher, A.E. & Kozloff, E.N. 1964. Essentials of Practical Microtechnique. Lea & Febiger, Philadelphia.

Gurr, E. 1965. The Rational Use of Dyes in Biology and General Staining Methods. Leonard Hill, London.

Jensen. W.A. 1962. Botanical Histochemistry. W.H. Freeman & Co., San Franscico & London.

Johanson, D.A. 1940. Plant Microtechnique: Manual of Histological and Special Staining Techniques. The Blakiston Division. Mc Graw-Hill Co. Inc. New York.

Jones A.W. & Carpenter, J.M. 1960. Microtechnique- A Student's guide to slide – making. Burgess Publishing Company.

Ruzin, S.E. 1999. Plant Microtechnique and Microscopy. Oxford University Press, New York.

Sharma, A.K. & Sharma, A 1999. Plant Chromosomes- Analysis, manipulation and Engineering. Hardwood Academic Publishers, Australia.

Sharma, A & Sen, S. 2002. Chromosome Botany. Oxford & IBH publ. Co. Pvt. Ltd., Calcutta.

BOT-513. CYTOLOGY

Unit 1. Cell Structure & Function

Ultrastructure, chemistry, functions, interrelationships and origin of cell organelles:

(i) Cell-wall

(ii) Cytoplasm: Plasma membrane, endoplasmic reticulum, ribosomes, golgi-bodies, plastids, mitochondria, centrioles, cytoskeletal structures- microtubules, microfilaments, intermediate filaments, lysosomes, peroxisomes, spherosomes, ribozymes

(iii) Nucleus: Nuclear envelope**,** Nucleoplasm, Nucleolus and Chromatin reticulum

Unit 2. Chromosomes:

(i) Structure & Chemistry*:* DNA, histones, non-histones and other associated proteins.

(ii) Molecular structure and functions of centromeres: Nucleolar organizing region, telomere, euchromatin and heterochromatin, unique and repetitive sequences.

Unit 3. Cell division:

(i) Mitosis.

a. Interphase stages;-G0, G1,S,G2. Discovery of regulatory proteins and their role, checkpoints. Concepts of DNA replication in prokaryotes and eukaryotes during S-phase, chromosome replication in eukaryotes, structure and function of centrioles.

b. Prometaphase, metaphase, anaphase, telophase. Nuclear and cytoplasmic changes,spindle structure and mechanism, microtubule organizing centers, motor proteins and other regulatory proteins.
c. Cytokinesis: Mechanism of cytokinesis and proteins involved, variations in plants, animals and bacteria.
d. Significance of mitosis: A brief review of cell division and life cycle of bacteria, fungi, algae, bryophytes and pteridophytes.
e. Variations from the normal mitotic plan-endoreduplication and endomitosis, C-mitosis, somatic reduction and genetic consequences of the above variations.

(ii) Meiosis:

a. Details of the prophase, metaphase, anaphase telophase. Role of spindle and regulatory proteins.
b. Molecular structure of the synaptonemal complex and its functions in pairing and synapsis. Variations in the pairing mechanism such as –asynapsis, desynapsis, exchange pairing, non-homologous pairing, distributive pairing, secondary pairing and somatic pairing.
c. Chiasma formation and genetic recombination. Models to explain molecular mechanism of genetic recombination.
d. Proteins (cohesins, securins, separase) involved in sister chromatid separation and terminalization.
e. Genetic significance of meiosis.

Unit 4. Karyotype & Pachytene analysis:

(i) Karyotype.

a. Standard parameters for karyotype analysis.Morphological classification and categorization of chromosomes. Natural karyotype. Current modifications in the system. Karyogram and Idiogram.

b. Karyotype differentiation and evolution. Factors affecting karyotype variations such as changes in chromosome number, structural alterations, centromere position, degree and distribution of heterochromatin. Unimodal and Bimodal karyotype. Banding techniques.

(ii) Pachytene analysis.

a. Chromosomal parameters utilized for analysis, Idiogram.

b. Chromosomal behaviour such as pairing and synapsis in pachytene and factors affecting the pairing. Cytogenetic significance.

Practicals

The given list of plants may be used to study the mitosis and meiosis in cells. Observations should be recorded for all the division stages in the materials provided.
Ten permanent slides of the countable metaphase spreads to be prepared and submitted at the end of semester I.

Plant material	**Gametic chr. number**	**Somatic chr. number**
Chlorophytum heynei	7	14
C. ignoratum	7	14
C. laxum	8	16
C. elatum	14	28
C. comosum	14	28
C.malabaricum	21	42
C. orchidastrum	21	42
Allium cepa	8	16

Zea mays	10	20
Aloe sp.	7	14
Capsicum annum	12	24
Trigonella foenum graceum	8	16
Crotalaria sp.	8	16

Endomitosis study by using *Cocos nucifera* endosperm.

References

Becker, W.M, Kleinsmith L.J. & Hardin J. 2005. The World of the Cell (6th edition). Benjamin/Cummings Pub. Co.

David R. Clark 2001. Molecular Biology. Elsevier Publishers, New York.

de Robertis E.D.F & de Robertis, E.M.F. 1988. Cell and Molecular Biology 8th edition. Lea and Febiger, Hong Kong.

Karp,G. 2004. Cell and Molecular Biology: Concepts and Experiments (4th edition). John Wiley and Sons Inc. U.S.A.

Kleinsmith, L.J & Kish, V.M. 1988. Principles of Cell Biology. Harper and Row publishers. New York.

Lewin, B. 2004. Genes VIII. Pearson Education, Prentice – Hall, New York

Lodish, H, Berk, A., Zipursky, S.L., Matsudaina, P., Baltimore, D & Darnell, J. 2000. Molecular Cell Biology (4th edition). W.H. Freeman & Co., New York.

Pollard, T.J & Earnshaw, W.C. 2004. Cell Biology. Elsevier Science. Health Science Division, Amsterdam.

Sen, S. & Kar, D.K. 2005. Cytology and Genetics B. M. Johri (Ed.) Narosa Publishing House. New Delhi.

Sharma, A. & Sharma, A. 1999. Plant Chromosomes. Hardwood Academic Publishers. Australia.

Sharma, A. & Sen, S. 2002. Chromosome Botany. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Singh, R. J.1993. Plant Cytogenetics. CRC Press Inc. BOCa raton Ann. Arbor. London, Tokyo.

Swanson, C.P, Merg, T. & Yarng, W.J. 1988. Cytogenetics (2^{nd} edition), Prentice Hall, .New York

BOT- 521. MOLECULAR GENETICS

Unit 1. Genetic organization:

(i) Genetics of Viruses, Bacteria, Neurospora and Yeast: - Types, Fine structure of genomes, life-cycle, genetic recombination and gene mapping.

(ii) DNA structure: Chemistry of nucleotides , organization of the poly nucleotide strand, double helical structure of DNA as proposed by Watson and Crick, Importance of Watson-Crick model, exception to Watson Crick organization of DNA, X-ray diffraction studies, Conformational changes in DNA structure, Single stranded DNA, Organization of the Eukaryotic DNA, Repetitive DNA, DNA variation in organisms.

(iii) DNA replication*:* Watson- Crick concept, electron microscopic autoradiograhy in *E. coli* DNA and in eukaryotic DNA, semi-discontinuous replication DNA polymerase I, II, III DNA gyrases, topoisomerases, ligases, initiation of replication, roles of RNA polymerase (primase) and replisome complex, current concept of DNA replication in prokaryotes and eukaryotes.

Unit 2. Gene expression:

(i) Evolution of the Gene Concept, Functional definition: One gene-one metabolic block, one gene-one enzyme, one gene-one polypeptide. Structural definition: Mutations and Recombinations within a gene. Operational definition: Intergenic and intragenic complementation

(ii) Molecular Biology of gene expression: Brief overview of the Central Dogma and Teminism. Transcription in prokaryotes and eukaryotes. Types and structure of RNA polymerase, Different types of RNA : mRNA, tRNA, rRNA, snRNA, snoRNA, miRNA, Xist, RNA, siRNA, shRNA, antisense RNA. Regulatory sequences and transcription factors involved. Mechanism: Initiation, elongation and termination. Split genes and RNA splicing in eukaryotes. Translation in prokaryotes and eukaryotes. Basic structure of proteins, ribosomes, tRNA. Genetic code Experiments conducted to decipher the genetic code, salient features, exceptions, Wobble-hypothesis, tRNA-suppressor mutations. Mechanism of translation: Chain initiation, elongation and termination, proteins involved, factors affecting translation accuracy

Unit 3. Molecular mechanism of Gene Regulation:

(i) Regulation in prokaryotes: Constitutive, Inducible and Repressible expression, positive and negative control. Induction and catebolite repression in *lac* operon, repression and attenuation in *trp* operon, lysogenic and lytic switches in lambda phage, Translational and post translational regulation.

(ii) Regulation in Eukaryotes: Transcriptional activator proteins, enhancers, silencers, eukaryotic transcription complex, chromatin remodeling during gene expression, alternative promoters, Epigenetic mechanisms: methylation and transcriptional inactivation, cosuppression through transcriptional silencing,

genome imprinting. RNA processing->alternative splicing, RNA stability, RNA interference. Translational regulation: Gene amplification, mating type interconversion.

(iii) Transposons: Historical background, works of Rhoades and McClintock. Structure of typical transposons and types of transposons. Transposons in bacteria (IS elements, Composite elements), Transposons in maize (Ac/ Ds elements, Spm / Ex elements), Transposons in *Drosophila* (P elements), Types of transposition, Genetic and evolutionary significance. Retro transposons Life cycle of retroviruses, Reverse transcription, LTRs. Retroposons in yeast (Ty elements), Retroposons in *Drosophila* (Copia elements), Retroposons in mammals (LINES, SINES), Application of transposons and retroposons in breeding programmes.

Unit 4. Genomics and Bioinformatics:

(i) Genomics: Structural genomics, Genetic and physical mapping (RFLP), microsatellite maps, cyotogenetic maps, physical maps, positional cloning, chromosome walks and jumps, Genome sequencing, genome databases, human genome sequencing project. Functional genomics. transcriptome, proteome and metabolome, Microarrays and gene-chips. Comparative genomics. Functional and evolutionary relationships prokaryotes, organelles and eukaryotes, orthologues and paralogues. Metabolomics: Identification and quantification of cellular metabolites in biological samples. Pharmacogenomics and drug designing.

(ii) Bioinformatics: Detecting open reading frames, gene prediction, programs for finding genes, secondary databases of functional domains, molecular phylogenetic programmes, comparing nucleotide and amino acid sequences using BLAST. Programmes for determination of protein structure

Practicals

1. Raising pure cultures of specific strains of bacteria by plate streaking method.
2. Plasmid DNA isolation using the alkaline lysis method
3. Genomic DNA isolation from plant tissues by CTAB method.
4. Electrophoresis: Separation of DNA and proteins.
5. DNA quantification and Southern blotting.
6. Problems relevant to concerned units

References

Anthony J . F. G .2000. An Introduction to Genetic Analysis. W. H. Freeman &Co. New York.

Anthony J . F. G. *et al.* 1999. Modern Genetic Analysis . W. H. Freeman & Co. New York.

Becker, W.M., Kleinsmith L.J. & Hardin J. 2005. The World of the Cell (6th edition). Benjamin/Cummings Pub. Co. New York.

Brooker, R. J. 1999. Genetics Analysis and Principles. Addison Wesley Longman Inc., New York.

Bruce, A. *et. al*. 2002. Molecular Biology of the Cell. Garland Publishing. New York.

Hartl, .D.L & Jones E. W. 2000.Genetic analysis of Genes and Genomes Jones and Bartlett Pub, Boston.

Klug .S.W. & Cummings, M.R. 2003. Concepts of Genetics . Pearson Education Pvt. Ltd., Singapore.

Kreezer *et al* . 2001. Recombinant DNA and Biotechnology. American Society for Cell Biology, New York.

Lodish Harvey *et al*. 1999. Molecular Cell Biology. W.H. Freeman &Co. New York.

Russell, P.J. 2005. Genetics: A Molecular Approach (2nd edition). Pearson/Benjamin Cumming, San Francisco.

Snustad, D. P. & Simmons M.J. 2003. Principles of Genetics. John Hailey & Sons Inc. U. S. A.

Websites

Human Genome Project;; http:// www.ornl.gov.
Hugo: http:// ash. gene. ncl. ac .nk..
DNA learning center: http://tor. cshl. org.
Genome Databases : http:www. gdb. org.
National Centre for Genome Resources. http: //www. neg r. org.
Washington Univ. Dept. of Genetics. http: // www. genetics. wustl. edu.
Genome Sequencing Center. http: // genome. imb- jena. dc.

BOT- 522. CYTOGENETICS

Unit 1. Chromosomal aberrations-numerical

(i) Haploidy*:* Types of haploids: Euhaploids, monohaploids, polyhaploids, amphihaploids, pseudohaploids, aneuhaploids, disomic haploids, addition haploids.

(ii) Polyploidy: Types of euploids, autopolyploids, allo-polyploids– segmental allopolyploids – autopolyploids – agmatoploids – origin of different types of polyploids – meiosis in polyploids, morphological, physiological and genetical characters of polyploids.

(iii) Aneuploidy: Hyperploids – trisomics, tetrasomics, double tetrasomics – Trisomics, types of trisomics, primary trisomics, secondary trisomics, tertiary trisomic, acrocentric trisomics, fragment trisomics, compensating trisomics – meiosis in trisomics, Hypoploids: monosomic, nullisomics. Meiosis in aneuploids, Role of aneuploids in the evolution.

(iv) Genetics of Polyploids: Genetic consequences of autopolyploids, tetrasomy. Allopolyploids – genetic regulation of chromosome pairing, allopolyploidization of autopolyploids, genome analysis – genetic consequences – deviation segregation, aneuploids in allo-polyploids-identification of homologous chromosomes. Segmental allopolyploids, fertility – Higher polyploids, diplodization, Agmatoploids. Complications with polyploids – primary trisomics, transmission and genetic consequences – Teritary trisomics, transmission and genetic consequences – transmission of

the extra chromosome through the female and male – morphology, physiology, anatomy and biochemistry of trisomics, Hypoploids. Aneuploidy of sex chromosome.

Unit 2. Chromosomal aberrations-structural

(i) Structural aberrations: Deficiency – origin, cytological behaviour, genetic effects, pseudodominance: Duplication – origin, types of duplications – tandem, reverse tandem, displaced, cytological behaviour, position effect. Inversion origin, types of inversion: paracentric, pericentric, meiotic behaviour: Translocations, types of translocations – shift, simple reciprocal, aneucentric and pseudo-isochromosome, meiotic behaviour, Translocation complex in *Rhoeo, Oenothera*, Renner effect.

(ii) Identification of chromosome segments and their alterations – Chromosome banding - Q band, G-band, R-band, C-band, E-bands, CT- bands, N-band and Q-bands – Physical localization of DNA sequences on chromosomes using *in situ* hybridization – GISH, FISH, Fiber FISH, Molecular maps etc.

(iii) Transposable elements and their molecular properties: Transposons, Retrotransposons – S-SAP (Sequence Specific – Amplified Polymorphism, IRAP (Inter-retrotransposon – Amplified polymorphism), REMAP (Retrotransposon – Microsatellite Ampli) RBIP (Retrotransposon – Based insertional polymorphism) – Retroelements and C-value paradox. Evolutionary implications of Transposable Elements – Regulation of Transposon and Retrotransposon activity.

Unit 3. Sex determination mechanisms and Human Cytogenetics

(i) Cytogenetics of sex determination: (a) Sex chromosomes; types of sex chromosomes – undifferentiated, structurally heteromorphic and multiple sex chromosomes, sex chromosomes in plants and animals, Evolution of sex chromosomes, origin of the sex chromosome mechanisms; (b) Sex chromatin: morphology and types: late replicating X chromosome and single X, origin of sex chromatin, Lyon's hypothesis and dosage compensation; chromosomal and genetic mechanisms of sex determination in dioecious plants and animals, role of 'sry' and 'tim' genes in mammalian sex determination, inter sexes, gynandromorphic, sex reversal, environmental influence in sexual dimorphism, evolution of dioecism.

(ii) Special types of chromosomes – polytene, lampbrush and B-chromosomes.

(iii) Human cytogenetics: Human chromosome culture technique, Normal karyotype in man; chromosome aberrations associated with congenital defects in man. Sex chromosomal: Turner's syndrome, Klinefelter's syndrome, triple X syndrome, hermaphroditism Autosomal: Down's syndrome, trisomy D1 and trisomy 18 syndromes. Chromosomes in malignant diseases in man. Molecular Tools for screening and diagnosis of human diseases – Prenatal Diagnosis of Genetic Disorders and Congenital Defects.

Practicals

1. Haploid – Anther Culture
2. Polyploid :Cytology of polyploid series of *Chlorophytum - Allamanda* Cytology of allopolyploid – wheat
3. Aneuploidy eg. *Datura*
4. Structural aberrations: Deletion, Duplication, Inversion – *Eleuthrine bulbosa,* Translocation - *Rhoeo*
5. Sex chromosomes in plants
6. Human cytogenetics
   (a) Human chromosome culture technique
   (b) Normal human karyotype
   (c) Chromosomal aberrations.

References

Chandrasekaran, S.N. & Parthasarathy. S.V. 1975. Cytogenetics and plant breeding (Revised Edition) Eds. Krishnaswamy. P. Varadachary & Co., Madras.

Elliott. J. 1958. Plant Breeding and Cytogenetics. McGrawHill Publications, London.

Goodenough, U. 1984. Genetics. Holt – Sauders International, London

Jain, K & Kharkwal, M.C. 2004. Plant Breeding – Mendelian to Molecular Approaches. Narosa Publishing House, New Delhi.

Jorde, B.L., Carey, J.C. Bamshed, M.J. & White, R.L. 2003. Medical Genetics (3rd edition), Elsevier Scientific Publ. Amsterdam.

Sen, S. Kar, D.K. 2005. Cytology and Genetics – Narosa Publishing House, New Delhi.

Sharma. A.K. & Sharma. A. (Eds.). 1985. Advances in Chromosomes and Cell Genetics, India Book House, New Delhi.

Stebbins, G.L. 1950. Variation and Evolution in Higher Plants. Columbia Univ. Press, New York.

Stebbins, G.L. 1971. Chromosomal Evolution in Higher Plants. Addison Wesley Publishing Co. London.

Swaminathan, M.S., Gupta, P.K. & Sinha, U. 1983. Cytogenetics of Crop plants. Macmillan India Ltd., New Delhi.

Sybenga, J. 1972. General Cytogenetics. North-Holland/American Elsevier. New York.

Theodore, T.P. & Kao, F. 1982. Somatic cell genetics and its application to medicine. Annual Review of Genetics. Col. 16. pp. 225-271.

Walter. V. Brown, 1972. Text Book of Cytogenetics. The C.V. Mosly Company, Saint Louis.

BOT-523. PLANT BREEDING

Unit 1. Introduction, objectives, activities of plant breeding and Centers of origin

(i) Introduction : History of Plant Breeding, the disciplines to be known by a breeder – Botany of the crop, cytogenetics – agronomy – physiology – pathology – entomology – biochemistry – bacteriology – statistics – plant biotechnology.

(ii) Objectives of plant breeding : High yield, improved quality, disease and pest resistance, early maturity, photosensitivity, varieties for new seasons, resistant varieties

(iii) Activities in plant breeding : Creation of new varieties, selection, evaluation, multiplication and distribution

(iv) Centres of origin: Different centres and their significance. Germplasm conservation- *in situ* seed banks, plant banks, shoot tip banks, cell and organ banks, DNA banks, germplasm evaluation- cataloguing- multiplication and distribution

Unit 2. Plant introduction, reproduction, incompatibility, sterility and selection

(i) Plant introduction: History of plant introduction- primary and secondary, plant introduction agencies. Procedure of plant introduction –quarantine- cataloguing- evaluation – multiplication- distribution – acclimatization, purpose of plant introduction , achievements, merits and demerits

(ii) Mode of reproduction: Vegetative reproduction – different methods- grafting, layering, apomixis- classification with examples

(iii) Incompatibility : different types – self incompatibility- homomorphic and heteromorphic incompatibility – gametophytic and sporophytic incompatibility, mechanism of self incompatibility, pollen- stigma interaction, pollen tube -style interaction, pollen tube -ovary interaction –significance of self incompatibility, methods to overcome self incompatibility- bud pollination, surgical methods and off season pollination, high temperature, irradiation

(iv) Sterility : male sterility – genetic male sterility - cytoplasmic male sterility – cytoplasmic genetic male sterility, application in crop improvement

Unit 3. Selection, back cross method of selection, hybridization:

(i) Selection : History of selection, pureline selection , mass selection, pedigree selection, bulk method of selection, merits and demerits, achievements of each type

(ii) Backcross method of selection : Introduction, requirements, applications of back cross methods, genetic consequences of repeated back crossing, procedure of back cross method - transfer of a dominant gene, transfer of a recessive gene, number of plants necessary in backcross generation, selection of the characters being transferred, transfer of quantitative characters, modification of back cross method, production of F2 and F3, use of different recurrent parents, application of back cross method in cross pollinated crops, merits and demerits, achievements

(iii) Hybridization: History , techniques and consequences, objectives , types of hybridization –interspecific, intergeneric, distant

hybridization, procedure of hybridization, choice of parents, evaluation of parents, emasculation – different methods, bagging, tagging, pollination , harvesting and storing of the F1 seeds and selfing, consequences of hybridization

Practicals

I Germplasm collection
1. Cereals - Paddy
2. Vegetables - *Capsicum*
3. Pulses - Green gram, Black gram, Red gram

II Plant propagation
1.Vegetative
a. Layering: (1). Air layering (2). Mound layering
b. Grafting
c. Budding – T – budding (wild rose and H*ibiscus*)
2.Apomixis
a. Polyembryony – Mango seedlings
b. Vivipary - *Alpinia* and grass

III Hybridization
Emasculation – different types
Solitary flower
1. 'V' cut method
2. Slit method
3. Round cut method
4. Bagging

IV Incompatibility – Pollen viability test

In vitro a. Brewbaker's medium preparation

b. Staining test in acetocarmine

In vivo – Pollen Germination on stigma

,, through style

,, through ovule

References

Allard, R.W.1960. Principles of Plant Breeding. John Wiley & Sons. Inc. New York.

Backcock., E.B. 2001 Genetics and Plant breeding. Agrobios (India), Jodhpur

Basra, A. S.2000. Heterosis and hybrid seed production In Agronomic Crops (Basra, A.S. Ed.). M.S. Swaminathan Research Foundation, Taraman Industrial Area, Chennai.

Bose, T.K., Mitra S.K. & Sadhu, M.K.1986. Propagation of Tropical and Subtropical Horticultural Crops. Naya Prakash, Calcutta.

Briggs,F.N & Knowles, P.F 1967. Introduction to Plant Breeding. Reinhold Publ. Co., New York/ Amsterdam/ London.

Chopra,V. L. 2000. Plant Breeding. Theory and Practicals (2^{nd} edition),Oxford & IBH Publ. Co. Pvt.. Ltd., New Delhi.

Frankel, R & Galum, E.1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer-Verlag, Berlin/ Heidelberg/ NewYork.

Jain H.K. & Kharkwal, M.C..(Eds.) 2004. Plant Breeding: Mendelian to Molecular Approaches.-. Narosa Publishing. House, New Delhi, Chennai, Mumbai, Calcutta.

Poehlman, J.M & David.A.S.1995. Field Crops (4^{th} edition). Panima Publ. Co., New Delhi/ Bangalore.

Poehlman, J.M. & Borthakur, D. 1959. Breeding Asian Field Crops with Special Reference to Crops of India. Oxford & IBH Publishing Co. New Delhi, Bombay, Calcutta.

Russel, G.E. 1985. Progress in Plant Breeding In Russel G E (Ed.) Butter Worth & Co. Publ. Ltd., Calcutta.

Sharma, J R. 1994 Principles and Practice of Plant Breeding, Tata-McGraw-Hill Publ. Co. Ltd, New Delhi.

Simmond, N.W.1976. Evolution of Crop Plants. N.W Simmond (Ed.) Edinburgh School of Agriculture & Longman Group Ltd.

BOT-524. PLANT BIOCHEMISTRY

1. Unit 1: Chemistry of Biological Molecules

(i) Carbohydrates: General composition and properties: solubility, reducing and non-reducing optical isomerism, stereoisomerisms, mutarotation, Classification.

a. Monosaccharides, their structure, occurrence, role, their derivatives by oxidation, reduction and substitution.

b. Oligosaccharides: Disaccharides, tetrasaccharides their structure, occurrence and role in glycosidic bond formation.

c. Polysaccharides: Homo and heterosaccharides, structural and storage polysaccharides – starch, glycogen, cellulose, hemicellulose, pectic substances, chitin, agar, gum tc synthesis and breakdown of glycosidic bonds, Amylase, invertase and phosphorylase action.

d. Synthesis and degradation of Carbohydrates – Starch and Sucrose synthesis, Metabolism of Carbohydrates: Glycolysis, Fermentation, pentose phosphate pathway and gluconeogenesis.

(ii) Aminoacids and Proteins: Classification of Amino acids, structure of common amino acids, physio-chemical properties of amino acids, Synthesis and breakdown of peptide bonds, oxidation, reductive amination, transamination, deamination and deamination.

a. Proteins: Classification, General accounts, Functions of protein, Classification of protein according to solubility characteristics and chemical nature. Structure – primary, secondary, quarternary structure, Ramachandran plot, Protein sequencing, proteotype enzymes.

b. Nitrogen availability to plants, Nitrogen – compounds in soil – biological nitrogen fixation – non-synthetic and symbiotic nitrogen fixation. Structure of nodule, mechanism of nitrogen fixation, Regulation of N_2 fixation.

(iii) Nucleic acids: Structure and forms: Types of DNA, Types of RNA their structure and functions, The structure of important purine and pyrimidine bases. General account of biosynthesis of purines and pyrimidines.

Unit 2: Lipids and lipid like substances

(i) Lipids: Classification and structure, Functions: Lipids in biological system, fatty acids, essential fatty acids, try-glycerides, fats and oils.

(ii) Lipid metabolism: Synthesis of fatty acids, oxidation of fatty acids α and β oxidation. Chemistry, structure and occurrence and physioliogical role of terpenes, (eg. hemi-mono, sequin, delta and poly-terpenes) alkaloids (eg. pyridine, pyrolidine, quinoline, iso quinoline, indole and purine derivatives) and phenols.

(iii) Secondary Metabolism in plants : A general account of the types of secondary metabolites in plants (eg phenolics, phenolic acids, alkaloids, steroids, terpenoids etc), Function of secondary metabolites to the producer plant. Importance of study of secondary metabolites.

(iv) Vitamins: Water soluble and lipid soluble structure and role of vitamin A, D_2, Tocopherol , thiamin, riboflavin, nicotinic acid, panthothenic acid, folic acid, Ascorbic acid, lipoic acid, PABA.

(v) Plant hormones: Chemical structure and synthesis of hormones in plants, transport, mode of action and physiological effects of Auxin, Gibberellin, Cytokinins and Ethylene in plants.

(vi) Plant Pigments: Chemistry of photosynthesis and plant product, chemistry, structure and role of chlorophyll, carotenoids and anthocyanin, light absorption and energy transfer, light and dark reaction, Hill reaction O_2 evolution, photosynthetic unit and reaction centre. Emerson enhancement effect, photosystems, electron transport system, mechanism of photophosphorylation, quantum requirements of quantum yield, CO_2 fixation, Calvin cycle, Hatch and Slack pathway, CAM pathway, Bacterial photosynthesis, photorespiration.

Unit 3. Enzymes and their function

(i) Enzymes: General account: Importance of enzymes in biological sciences, the classification and nomenclature of enzymes with examples, Mechanism of enzyme action role of enzyme in chemical action, various factors affecting the enzyme activity, Properties of enzymes, Competitive and non-competitive enzyme inhibition and types.

(ii) Biochemical oxidation: Substrate of respiration, respiratory quotient, aerobic and anaerobic oxidation and mechanism of ATP synthesis in mitochondria after oxidative phosphorylations.

Practicals

I. Quantitative tests for Carbohydrates

1. Molisch's Test

2. Benedict's Test
3. Fehling's Test
4. Seliwanoff's Test
5. Iodine Test for starch

II. Acid hydrolysis of starch

III. Qualitative and quantitative tests for proteins

1. Million's Reaction
2. Xanthoproteic Reaction
3. Ninhydrin Test
4. Biuret Test
5. Precipitation Test
6. Estimation of protein using Lowry's method.

IV. Qualitative Test for fats

1. Sudan IV Test
2. Formation of Acrolein from fat

V. Qualitative Tests for Biological Compounds

1. Test for biological compounds in plant tissues
2. Tests for the chemical nature of milk.

VI. Calorimetric estimation of carbohydrates and proteins.

VII. Enzymes

1. Demonstration of polyphenoloxidase in plant tissue.
2. Action of invertase on sucrose.
3. Effect of temperature on enzyme activity.
4. Action of salivary enzyme on starch.

VIII. Photosynthesis Pigments

1. Separation of the green and yellow pigments.

References

Barber,J. (Ed.) 1987. Topics in Photosynthesis: The Lights Reaction (Vol.8), Elsevier Scientific Publ., Amsterdam.

Chesworth, J.M., Stuchbury. T. & Scaife, J.R. 1998. An Introduction to Agricultural Biochemistry, Chapman & Hall, New York.

Deb, A.C. 2000. Concept of Biochemistry, Books and Allied (P) Ltd.New Delhi.

Govindjee, 1982. Photosynthesis, Vol. I. Energy Conversion by Plants and Bacteria, Academic Press, New York.

Hans-Waiter H.2005. Plant Biochemistry, Elsevier, Amsterdam.

Karp, G. 1985 Cell biology (2^{nd} edition), International Student Education.

Kleinsmith, L.J. & Kish, V.M. 1988. Principles of Cell biology, Happer & Row Publ., New York.

Lawlor, D.M.1987. Photosynthesis: Metabolism, Control and Physiology, Longman Scientific and Technical, John Weily and Sons, New York.

Lehinger, A.L.(1987) Principles of Biochemistry, Worth Publications, Inc. USA.

Noggle,G.R. &.Fritz, G.J 1986. Introductory Plant Physiology, Prentice Hall of India Ltd., New Delhi.

Sinha, R.K 2004. Modern Plant Physiology, Narosa Publishing House, New Delhi.

Taiz , L. & Zeiger, R. 2003. Plant Physiology, Panima Publishing Co. Pvt. Ltd., New York.

BOT- 531. GENETIC ENGINEERING

Unit 1. Gene Cloning -Tools and Techniques

(i) Purification and Separation of Nucleic acids:

a. Extraction and Purification of Nucleic acids: Isolation of plasmid DNA, chromosomal DNA and plant cell DNA, total cellular RNA.

b. Separation and Purification of DNA using gel electrophoresis: Agarose, Polyacrylamide, DISC electrophoresis, Analytical and Preparative Gel Electrophoresis.

c. Elution of DNA from gels, Density and Ultra centrifugation.

(ii) Vectors:

a. Plasmids, phages, cosmids, animal viruses such as SV40, Adenoviruses, retroviruses.

b. Special vectors such as shuttle vectors, expression vectors, dominant selectable vectors, amplifiable vectors, integrating vectors, single-stranded plasmid vectors, artificial mini chromosomes, broad host range vectors, P-elements, Retrotransposons.

(iii) Recombinant DNA technology:

a. Cutting and joining DNA: Restriction enzymes, nomenclature, specificity, sticky and blunt ends.

b. Ligation: Enzymes involved and optimization conditions.

c. Modification of restriction fragments: Linkers, Adaptors.

(iv) Gene transfer technology:

a. Introducing genes into prokaryotes: Transformation, transduction, conjugation transposition, cell transformation with plasmids, transfection with phage vectors.

b. Introducing genes into eukaryotes: Recombinant viral technique, DNA mediated gene transfer method, protoplast fusion, microcell fusion technique, metaphase chromosome transfer, liposomes, microinjection technique, electrophoration.

(v) Identifying the right clone:

a. Direct screening: Insertional inactivation of marker genes, visual screening methods, plaque phenotype.

b. Direct selection: Complementation or suppression of a mutation, selection of recombinant deficient phages, Spi-phenotype recombinant efficiency, TK/HAT system, dhfr as a selectable marker, CAT system, *Alu* markers for human genes.

c. Indirect screening techniques: Immunological techniques, Hybrid-arrested translation, Hybrid-selected translation, Rescue techniques, nucleic acid hybridization, colony and dot-blot hybridization.

d. Probes and Tests: RNA, cDNA DNA, nick-translated probes, antigen and antibody probes. Hybridisation and blotting techniques, immunological tests such as precipitin test, immuno-diffusion technique, immuno-electrophoretic technique, radioimmunoassay, enzyme linked immuno-absorbent assay, immuno-affinity chromatography.

(vi) DNA Engineering techniques and applications:

a. Isolation of important crop genes: Plasmid and marker rescue techniques, transposon tagging.
b. Genomic and cDNA libraries.
c. Site directed mutagenesis: oligonucleotide directed, insertional mutagenesis, directed single base mutations.
d. Mapping of DNA: restriction mapping, DNA foot-printing, chromosome walking and jumping, DNA fingerprinting, RAPD, RFLP, AFLP, SSR, ISSR
e. DNA sequencing: Maxam-Gilbert method, Sanger-Caulson method, Messey's shot gun method, DNA sequencer.
f. Applications: Agriculture, Biotechnology, Protein engineering, clinical, Environmental pollution, biosensors and biochips.

Unit 2. Genetically modified organisms

(i) Methods of gene transfer to plants:

a. Protoplast fusion, organelle engineering. Recombinant vector techniques: Non-integrative DNA transfer- Caulimoviruses, Geminiviruses, plant RNA viruses, Cornybacterial plasmids. Integrative DNA transfer- *Agrobacterium* Ti and Ri plasmids, Agroinfection, homologous DNA and transposons as vector. Genetic transformation of Monocotyledonous plants: Factors and problems involved.
b. Procedure and protocols of producing transgenic plants., first commercial transgenic plants- transgenic tomatoes, control of ripening by antisense technology, insect resistance (Bt. protein), golden rice, herbicide resistance, commercializing insect resistant cotton, next generation commercial transgenic

plants, designer oils and biodiesel, plant secondary products, designer flowers, plants as bioreactors, vaccines, plantibodies, and bioplastics. Using molecular biology to probe plant physiological processes- prospects of engineering RUBISCO and nitrogen fixation. Production of male sterile lines.

(ii) Gene transfer to animals:

a. Methods-DNA microinjection, stem cell mediated gene transfer, retroviral-mediated gene transfer .

b. Applications in medical research to identify the functions of specific factors in complex homeostatic systems through over- or under-expression of a modified gene (the inserted transgene); in toxicology: as responsive test animals (detection of toxicants); in mammalian developmental genetics; in molecular biology, the analysis of the regulation of gene expression makes use of the evaluation of a specific genetic change at the level of the whole animal; in the pharmaceutical industry, targeted production of pharmaceutical proteins, drug production and product efficacy testing; in biotechnology: as producers of specific proteins; genetically engineered hormones to increase milk yield, meat production; genetic engineering of livestock and in aquaculture affecting modification of animal physiology and/or anatomy; cloning procedures to reproduce specific blood lines; and developing animals specially created for use in xenografting.

c. Animal welfare and ethics.

(iii) Transgenic microbes:

a. Genetic manipulation of microorganisms: Natural genetic engineering-forced evolution and adaptive mutations; specific

environmental stresses used to force microorganism to mutate and adapt creating microorganism with new biological capabilities. Preservation of microorganisms-strain stability methods that provide this stability are lyophilization (freeze-drying) and storage in liquid nitrogen. Site- directed mutagenesis, Protoplast fusion, Transfer of genetic information between different organisms, Modification of gene expression.

b. Major Products of Industrial Microbiology: Antibiotics, Amino acids, Organic acids, Specialty compounds for use in medicine and health-include sex hormones, ionophores, and compounds that influence bacteria, fungi, amoebae, insects, and plants, Biopolymers-microbially produced polymers, Biosurfactants, Bioconversion processes-microbial transformations or biotransformations, biodegradation, bioremediation, bioleaching. Biotechnological Applications: Biosensors, Microarrays, Biopesticides.
c. Impacts of Microbial Biotechnology

Unit 3. Hazards and Impact of GMOs.

a. Biosafety Considerations: Biological risks, ethical issues, economic issues, legal issues.

Practicals

1. Raising pure cultures of specific strains of bacteria by plate streaking method.
2. Plasmid DNA isolation using the alkaline lysis method
3. Genomic DNA isolation from plant tissues by CTAB method.
4. Electrophoresis: Separation of DNA and proteins.

5. Demonstration of Plant transformation techniques, DNA quantification and Southern blotting
6. Problems related to above topics.

References

Apasani, K.(Ed.). 2005. RNA Interference Technology-From Basic Science to Drug designing.

Bourgaize, D., Jewell, T.R & Buiser, R.G. 2003. Biotechnology-Demystifying the Concepts, Pearson Education, India.

Cappucino, J.G. & Sherman, N. 2004. Microbiology-A Laboratory Manual. Pearson Education, India.

Chirikjian, J.G. 1995. Genetic Engineering, Mutagenesis, Separation Technology. Biotechnology-Theory and Techniques II. Jones and Bartlott Publishers, London.

Clark M.S.(Ed.). 1997. Plant Molecular Biology-A Laboratory Manual. Springer-Verlag, Heidelberg, Germany.

Cowell, G.I & Austin, C.A. 1997. cDNA library protocols: Methods in Molecular Biology 69. Humana Press, New Jersey.

Cullis, A.C. 2004. Plant Genomics and Proteomics. Wiley-Liss, John-Wiley and sons Inc. New Jersey.

Dale, J.W. & von Schautz, M. 2002. From Genes to Genomes: Concepts and Applications of DNA technology. John Wiley and Sons Ltd. U.S.A.

Hammond, J., McGarvey & Yusibov, V. (Eds.). 2000. Plant Biotechnology-New Products and Applications. Springer-Verlag, Heidelberg, Germany.

Joyner, A.L.2000. Gene Targeting - A Practical Approach. Oxford University Press, Oxford.

Kruezer, H & Massey, A. 2001. Recombinant DNA and Biotechnology- A Guide for students. ASM Press, Washington.

Potrykus, I. & Spangenberg, G. (Eds.). Gene transfer to plants. Springer Lab Manual. Springer-Verlag, Heidelberg, Germany.

Primrose, S.B & Twyman, R.M. 2003. Principles of Genome Analysis and Genomics. Blackwell Publishing Company, Berlin, Germany.

Primrose, S.B., Twyman, R. & Old, R.W. 2001. Principles of Gene Manipulation. Blackwell Science, Oxford, U.K.

Purohit, S.S. 2004. Plant Biotechnology. A Laboratory Manual. Agrobios, Jodhpur, India.

Sambrook, J. & Russell, D.W. 2001. Molecular Cloning-A Laboratory Manual. ColdSpring Harbor Laboratory Press, U.K.

Winnacker, E.L. 2003. From Genes to Clones- Introduction to gene technology. Panima Publishing Co., New Delhi, India.

BOT. 532 PLANT BIOTECHNOLOGY

Unit 1. Plant Tissue Culture Techniques

(i) Historical aspects and significance: Plant cell and tissue culture- Introduction, history, and scope. Development of organ, tissue and cell culture, exploitation of totipotency.

(ii) Laboratory requirements for plant tissue culture: Designing of plant tissue culture laboratory. Lab maintenance and fumigation.

(iii) Basic aspects of plant tissue culture: Sterilization techniques, different culture media components, growth regulators, undefined supplements, surface sterilization of explants, inoculation, subculturing etc.

(iv) Types of Cultures: Cyto differentiation, organogenic differentiation, callus culture, callus mediated organogenisis, cell suspension culture- different types, measurements of growth pattern of cells in suspension, culture methods of single cells, testing viability of cells. Application of cell suspension and callus culture with special reference to medicinal and aromatic plants

(v) In vitro Techniques for Micropropagation: Axillary bud proliferation approach, meristem and shoot tip culture. Production of virus free plants, phases of micropropagation, Micropropagation of tree species, medicinal and aromatic plants. Organogenesis via callus formation.

Unit 2. Plant Tissue Culture - Applications

(i) Somaclonal variation: Somoclonal and gametoclonal variations and importance. Technique for detection and isolation of

somaclonal variants. Factors controlling somoclonal variation and its application in plant breeding.

(ii) Cell Suspension Culture: Types of suspension culture Batch culture, Continuous culture, Open continuous, Closed continuous, Semi continuous, Growth measurements, Techniques for single cell culture Production of Secondary metabolites, Secondary products found in plants, Method of production – factors affecting yield. Immobilized cell systems, Bioreactors. Secondary metabolites detected in plant tissue culture. Root and hairy root culture. Methods of enhancement of secondary metabolite production in culture. Problem associated with secondary metabolite production.

(iii) Somatic Embryogenesis: Principle and concept, Ontogeny and development of somatic embryos. Factors affecting embryo formation. Application of somatic embryogenesis.

(iv) Artificial- Synthetic Seeds: Introduction to synseed, Production of synthetic seed encapsulation, Steps of commercial artificial seed production, Artificial seed propagation, Application.

(v) In vitro Production of Haploids: *In vitro* production of haploids and uses of haploids, Androgenic methods, anther culture, microspore (pollen) culture, factors governing the success of androgenesis, Genotype, Physiological status of the donor plants, Stages of pollen, Pretreatment of anthers, Culture media, Process of androgenesis. The ploidy level and chromosome doubling, Diplodisation, Uses of haploids in plant breeding, Gynogenic haploids, Factors affecting gynogenesis. Embryo rescue techniques, Ovary, ovule, endosperm and embryo culture *In vitro*

pollination and test tube fertilization, methodology, factors affecting seed set application. Green pod culture of orchids. Application.

Unit 3. Protoplast Isolation and Culture

(i) Protoplast Isolation: Isolation- different methods-Mechanical method, Enzymatic method, Production of protoplasts, osmoticum, Protoplast viability and density, Protoplast purification,

(ii) Culture of Protoplast: Culture techniques, Culture medium and environmental factors, Protoplast culture, cell wall formation, Growth, division and regeneration of plants, Protoplast fusion, somatic hybridization, different types, fusion methods, Spontaneous fusion, Induced fusion, Different types of Fusagen, Mechanism of fusion, Identification and selection of hybrid cells, Verification and characterization of somatic hybrids, Chromosome status of fused protoplasts, Cybrids, achievements and limitations, Significance of protoplast culture and somatic hybridization, Somatic hybridization for crop improvement, Problems and limitations of somatic hybridization, Genetic modification of protoplasts, Direct genetic transformation of DNA into protoplasts, Particle bombardment, transformation of protoplast by electroporation, microinjection and microprojectiles.

(iii) Secondary metabolites*:* Secondary products found in plants, method of production – factors affecting yield. Bioreactors. Secondary metabolites detected in plant tissue culture. Root and hairy root culture, Methods of enhancement of secondary

metabolite production in culture, Problem associated with secondary metabolite production.

Unit 4. Transgenic Plants

(i) Transgenic plants for crop improvement (dicots and monocots), Insect resistance, insecticide, Resistance to virus, Resistance to other diseases, Recombinant DNA techniques for the production of transgenic plants, Procedure and protocols of producing transgenic plants. Transgenics for quality, Transgenics for improved storage, Transgenics for male sterility, Transgenics for flower color and shape, Transgenics for terminator seed, Transgenics plants as bioreactors, Transgenics plants to study regulated gene expression, Commercial transgenics crops,

(ii) Uses and applications of transgenic plants, new products, pharmaceuticals. Bioremediation, edible vaccines, antiviral proteins

Unit 5. Germplasm Storage and Cryopreservation

(i) Conservation of germplasm, *In vitro* strategies, Short, medium and long term (cryopreservation) preservation application, Techniques of cryopreservation, Determination of survival and viability, Plant growth and regeneration, Application of cryopreservation.

Practicals

1. Preparation of culture media (MS)
2. Stock solution preparation
3. Sterilization of culture media

4. Techniques of isolation, surface sterilization and inoculation of different explants.
5. Direct and indirect organogenesis (Medicinal plant)
6. Preparation of artificial seeds
7. Green pod (embryo culture) culture of orchid (*Spathoglotis plicata*).
8. Protoplast isolation by enzymatic method
9. Submit a record on the above work done.

References

Bajaj, Y.P.S. 1986. Biotechnology in Agriculture and Forestry. Volume I-16. Springer- Verlag, Berlin.

Benson, E.E. (Ed.) 1999. Plant Conservation Biotechnology. Tayor and Francis, .

Kumar, U.1999. Studies in Biotechnology Series No. 3. Synthetic Seeds for Commercial Crop production. Agro Botanica Publ. Jodhpur.

Loyok-Vargs, V.M. & Vazquez-Flota, F. 2005. Plant Cell Culture Protocol. Humana Press, New Jersey.

Mental S.H. & Smith S. 1983. Plant Biotechnology. Cambridge University Press, Cambridge UK.

Morris, P., Scragg, A.H., Stafford, A. & Fowller, M. 1986. Secondary Metabolism in Plant Cell Cultures, Cambridge University press, Cambridge, UK.

Prasad, S. 2004. Impact of Plant Biotechnology on Horticulture. (3rd edition) Agrobios, Jodhpur, India.

Purohit, S.S. 2004. A Laboratory Manual of Plant Biotechnology (2nd edition). Agro Botanica Publ. Jodhpur.

Reinert, J. & Bajaj Y.P.S. 1977. Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture . Springer- Verlag, Berlin.

Slater, A. Scolt, N. & Flower, M. 2003. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford University Press, Oxford.

Thrope, T.A. 1981. Plant Tissue Culture. Academic Press, New York.

Veeresham, C. 2004. Medicinal Plant Biotechnology. CBS Publishers, New Delhi.

BOT- 533. ENVIRONMENTAL GENETICS

Unit 1. Environmental factors affecting genes and their expression

(i) Heritable changes*:* Spontaneous and induced mutations Luria Delbruck fluctuation Test, Somatic mutation and germinal mutation, genetic mosaics.

(ii) Environmental Mutagens:

a. Physical- Corpuscular radiations-Alpha particles, Beta particles, and Neutrons.

b. Electromagnetic radiations - Gamma rays, X rays and ultra violet radiations, Interaction of radiations with matter-ionization and excitation, Photoelectric effect, Compton effect, Pair production, Properties of radio nucleotides, Radiation units.

c. Chemical- Alkylating agents, Base analogues, Acridines, deaminating agents and miscellaneous.

d. Environmental impact on genetic organization of organisms.

(iii) Chromosomal mutations:

a. Variation in chromosome number -Monosomy, Cri-du-Chat syndrome, Trisomy, Down syndrome, Patau Syndrome, Edward syndrome.

b. Chromosome structure mutations- Deletion, Duplication- Bar eye in *Dropsophila,* Inversion-Consequences of inversions, Translocation- Familial Down syndrome, Fragile sites in Humans

Unit 2. Molecular basis of mutations

(i) Molecular Mutations : Tautomeric shifts, transitions and trasversions, back mutations, suppression mutations, Silent mutations, Neutral mutation, Missense mutations, Nonsense mutations and Frame shift mutations

(ii) Mutation detection systems: Specific locus test, Ames test, CIB method, Muller-5 method, Attached X-Chromosomes, mutation detection in humans, mutation frequency, SuperMutagens

(iii) DNA repair mechanisms: Photoreactivation, Excision repair, Post replication recombination, Mismatch repair, SOS repair.

Unit 3. Human mutations

(i) Understanding of mutations in Humans, ABO blood types, Muscular Dystrophy, Fragile X syndrome, Huntigton's disease, Xeroderma pigmentosum, Site-directed Mutagenesis, Knock out mutations and transgenes, Transposable genetic elements in maize, in *Drosophila* and in humans.

Practicals:

1. Problems related to radiation dose and mutation frequency.

2. Problems related to chromosome variations in number and structure.

3. Problems related to variation in genetic code and protein synthesis

4. Problems related with point mutations and frame shift mutations

5. Problems with mutation detection systems in plants, Drosophila and humans.

6. Problems related with DNA repair mechanisms.

7. Problems with mutations in humans

8. Chromosomal aberrations due to the effects of mutagens eg. EMS, 2,4-D or acridine orange in *Allium cepa* or *Vicia faba*

References

Brooker, J.B 1999 Genetics Analysis and Principles Addison-Wesley California

Gardner, E.J., Simmons, M.J. & Snustad, D.P. 1991 Principles of Genetics, (8th edition) John Wiley & Sons New York

Hartl, D. L.& Jones E.W. 2002. Genetics an analysis of Genes and Genomes (5th edition), Jones & Bartlett Publishers, Boston

Klung W & Cummings M. R2003 Concepts of Genetics (seventh edition) Peason Education, Singapore.

Russell, P. J. Essential of Genetics. 2003 Genetics: A Conceptual Approach. Benjamin A. Pierce. W.H. Freeman & Company, New York

Russell, P.J. 2005. Genetics A Molecular Approach (2nd edition). Pearson/Benjamin Cumin g, San Francisco.

Stansfield F. 1991 Genetics. (3rd edition), Schaum's outline series, McGraw Hill, New York.

Suzuki, J.H., Lewontin, D.T. & Gelbart, R.C. 1999 An Introduction to Genetic analysis (7th edition) W.H Freeman & Co., New York

Weaver, R.F & Hedrick P.W. Genetics, WmC Brown Publishers, Toronto.

BOT- 534. MODERN METHODS IN CROP BREEDING

Unit 1. Heterosis and Inbreeding, Hybrids and synthetic varieties:

(i) Heterosis and Inbreeding: Definitions. Inbreeding depression – effect of inbreeding – degree of inbreeding depression – homozygous and heterozygous balance. Heterosis and luxuriance – manifestation of heterosis. Genetic basis – dominance hypothesis- overdominance hypothesis – similarities and differences. Physiological basis of heterosis- mitochondrial complementation – fixation of heterosis. Recurrent selection- types- simple- recurrent selection for general combining ability – for specific combining ability – reciprocal recurrent selection.

(ii) Hybrids and synthetic varieties: Prcocedure – development of inbreds – evaluation of inbreds – phenotypic and top cross test, single cross evaluation, production of hybrid seeds- double cross and polycross hybrids. Role of cytoplasmic genetic male sterility and self incompatibility in hybrid seed production. Improvement of inbred lines- pedigree selection- backcross method – convergent improvement – gametic selection – merits and demerits – achievements

Unit 2. Mutation Breeding and Ploypoidy Breeding:

(i) Mutation Breeding: Introduction – spontaneous and induced mutation- mutation effects- molecular basis- base substitution- addition and deletion. Mutagens- physical – chemical and radiation dose effects of non ionizing radiation on biological targets. Factors

affecting radiation effects- biological, environmental – water content, temperature, chemical factors, mechanism of action of radiations, mechanism of action of chemical mutagens, procedure of mutation breeding, recurrent irradiation, gamma garden, directed mutagenesis, application of mutation breeding, limitations and achievements.

(ii) Polyploidy breeding: Definitions, types of changes in chromosome number – euploids and aneuploids – auto and allopolyploids. Aneuploids- nullisomics, monosomics, double monosomics and trisomics. Autopolyploids, autotriploids, autotetraploids, autohexaploids and autooctoploids. Allopolyploids, allotetraploids, allohexaploids, allooctoploids, morphological and cytological features. Production of autopolyploids: materials and agents used-method of treatment-merits and demerits-achievements

Unit 3. Distant hybridization, quality breeding, Ideotype breeding, Resistance Breeding, Breeding for stress resistance:

(i) Distant hybridization: History, barriers in production of distant hybrids-failure of zygote formation-failure of zygote development-lethal genes-phenotypic disharmony between two parental genomes- chromosome elimination- incompatible cytoplasm-endosperm abortion-failure of hybrid seedling development. Techniques of production of distant hybrids- sterility in distant hybrids- cytogenetic basis- genetic basis and cytoplasmic basis-application of distant hybridization in crop improvement- alien

chromosome addition and substitution lines–transfer of small chromosome segment–achievements and limitations

(ii) Quality breeding: Introduction. Quality traits – morphological-nutritional – geological –hulling and milling recovery- cooking quality- nutritional quality of rice, wheat, fiber colour, length and strength in cotton, elimination of toxic substances-lathyrism-protein and mineral content and quality. Laboratory evaluation for protein quality and quantity, problems and prospects of quality breeding.

(iii) Ideotype breeding: Ideotype concepts, types, development of ideotypes, steps in development. Characters of a crop ideotype, selected crops' ideotype; Barley, Rice, Cotton, *Brassica* – ideotype breeding- limitations

(iv) Resistance breeding: Historical account, loss due to disease, variability in pathogen. Physiological races and pathotypes. Genetics of pathogenicity- disease development-disease escape-disease resistance, susceptible reaction- immune reaction, resistance-tolerance. Vertical and Horizontal resistance-Mechanism of disease resistance–mechanical, hypersensitivity and nutritional. Genetics of disease resistance – oligogenic inheritance, gene for gene relationship–molecular basis for gene for gene relationship – polygenic inheritance.

(v) Methods of breeding for disease resistance: Testing for disease resistance – Disease epidemics, Insect resistance, mechanism of resistance, breeding methods, screening techniques, problems in insect , resistance breeding.

(vi) Breeding for stress resistance:

a. Drought resistance; introduction – types of abiotic stresses – minimizing drought resistance – breeding methods – Genetics of drought resistance –Problems.
b. Mineral stresses: Salt affected soil- alkali soil, breeding for salinity resistance – effect of salinity stress, water stress, salt toxicity – salinity resistance, sources of salinity resistance breeding approach- Problems

Unit 4. Breeding of Crop plants:

Origin, taxonomy, cytogenetics and evolution of the following crops

1. Cereals	-Rice, Wheat, Maize
2. Tuber Crops	-Tapioca, Potato
3. Fibre yielding	-Cotton, Jute
4. Plantation Crops	-Rubber
5. Sugar yielding	-Sugar cane
6. Narcotics	-*Nicotiana*
7. Vegetables	-*Allium*, Tomato
8. Oil yielding	-*Brassica*, *Arachis*
9. Pulses	-V*igna*
10. Beverages	-Coffee, Tea

Practicals

1. Heterosis Breeding

i. Pepper

Uthirankotta X Cheriakaniakkaden

Panniyur

ii). Maize cob

iii). Sorghum

2. Mutation breeding

i). *Capsicum* seed treated with chemicals. Drawings of control & treated seedlings showing morphological variations

ii). Figures of mutants – sunflower, tapioca

3. Polyploidy breeding

a. Autopolyploids- colchicines treatment –i.*Capsicum* seed and seedling
b. Polyploids – Evolutionary chart of the following;
   i). Wheat – *Triticum aestivum* and *Triticale*
   ii). Cotton, *Nicotiana, Brassica*

4. Ideotype: - Super rice 2000

5. Resistance Breeding

6. Crops: Description on taxonomy, cytogenetics & evolution of all the above mentioned crops.

References

Allard, R.W.1960.Principles of Plant breeding. John Wiley & Sons. Inc., New York.

Backcock, E. B. 2001. Genetics and Plant breeding. Agrobios (India) Jodhpur.

Basra, A.S. 2000. Heterosis and Hybrid Seed Production in Agronomic

Crops. In Basra, A.S.(Ed.). M.S. Swaminathan Research Foundation, Taraman Industrial Area Chennai.

Bose,T.K., Mitra S.K. & Sadhu, M.K.1986.Propagation of Tropical and Subtropical Horticultural Crops. Naya Prakash, Calcutta.

Briggs, F.N & Knowles, P.F.1967. Introduction to Plant breeding. Reinhold Publ. Co. Ltd., New York.

Chopra,V. L. 2000. Plant Breeding. Theory and Practicals (2nd edition) Oxford & IBH Publ. Co. Pvt. .Ltd. New Delhi.

Frankel, R & Galum, E.1977. Pollination Mechanisms, Reproduction and Plant Breeding. Springer Verlag, Berlin, Heidelberg &. New York.

Jain H.K. & Kharkwal, M.C. .(Eds.) 2004. Plant Breeding. Mendelian to Molecular Approaches, Narosa Publishing House, New Delhi.

Poehlman, J.M. & Borthakur, D. 1959. Breeding Asian field crops with special reference to Crops of India. Oxford & IBH Publ. Co. New Delhi.

Poehlman, J.M. & David, A.S.1995. Field Crops (4th edition), Panima Publ. Co. Ltd., NewDelhi.

Russel. G.E. 1985. Progress in Plant Breeding I In Russel G E (Ed.) Butter Worth & Co. Publ. Ltd. Calcutta.

Sharma, J. R. 1994. Principles and Practice of Plant Breeding, Tata-McGraw-Hill. Publ. Co. Ltd New York, NewDelhi.

Simmond, N.W.1976 Evolution of Crop Plants. In Simmond N.W (Ed.) Edinburgh School of Agriculture/ Longman Group Ltd., London.

BOT- 542. DEVELOPMENTAL GENETICS

Unit 1. Cell differentiation and growth

(i) Cell Differentiation and Development: General characteristics of cell differentiation, effects of mutations in developmental processes, antennapaedia complex, the bithorax complex, segmental genes, Gap genes and pair rule genes in *Drosophila*, Effects of nuclear and cytoplasmic factors in development, environmental effects, maternal effects, nuclear cytoplasmic interactions with particular reference to *Acetabularia*

(ii) Genes in development: Gene expression and regulation, chromatin and DNA methylation, signal transduction in development, the cell division cycle, cytoskeleton, cell adhesion and the extra-cellular matrix.

(iii) Molecular mechanism of cell differentiation: Control at the level of transcription, translational control, amplification, gene rearrangements.

(iv) Growth and Development in Plants: Patterns of growth and differentiation; Gene expression and mutations regulating meristem function, embryogenesis, seedling, root, leaf and flower development. Homeotic genes, ABCD model in *Arabidopsis* flower, hormonal control of plant tissue development, effect of auxins on root and root formation, gibberellin promoted growth of plants, ethylene and triple response mutants, brassinosteroids and photomorphogenesis.

Unit 2. Developmental mechanisms

(i) Special cases of differentiation: Sex as a developmental phenotype, factors influencing sex differentiations - environmental effects, hormonal effects, effects of ploidy, sex determination – monoecious and dioecious plants

(ii) Biological Rhythms: Circadian rhythms, rhythm responses to environment, clock mechanism.

(iii) Photoperiodism *:* General principles , florigen concept.

(iv) Photomorphogenesis*:* Phytochrome genes and their expression, control of photo-morphogenic responses. Dose-response relations in photo-morphogenesis, light induced chloroplast differentiation, effect of photoreceptors.

(v) Ageing *:* Cellular and molecular changes in ageing, mechanism of senescence, extra cellular ageing. Theories of ageing -theories involving induced damage, genetically programmed ageing and cell death, evidence from tissue culture. Difference between necrosis and apoptosis. Processes, pathways and proteins involved in apoptosis regulation. Factors and signals inducing cell death. Cell-types affected.

Unit 3. Regulation of Cancer

(i) Tumourigenesis in plants: Characteristics of CGT cells, crown gall and plant transformation, Interaction between wound cell and bacteria, plasmids as tumour inducing principle.

(ii) Carcinogenesis: Characteristics of cancer cells, cytological changes, Theories of carcinogenesis - Chromosomal somatic mutation, environmental carcinogenesis.

(iii) Viruses that cause cell transformation*:* DNA tumour virus - papova virus, adenoviruses, RNA tumour virus, oncogenic retrovirus

(iv) Oncogenes and cancer: Molecular basis, cell division signals and oncogenes, activation carcinogens - Chemical carcinogens, radiation as carcinogens tumour suppressor genes, teratomas, teratocarcinomas, teratogenesis.

Practicals

1. Study of various developmental stages and polytene chromosomes of *Drosophila*
2. Preparation of sex chromatin from cheek cells
3. Angiosperm embryo development using bean seeds
4. Early plant development – Pollen tube formation
5. Study of plant tumours – galls, club root of cabbage
6. Study of human cancers (blood cancer, breast cancer, uterine cervix cancer etc.) using permanent slides
7. Problems

References

Avery A. S. 1980. Chromosomes in Human Cancer and Leukemia, Elsevier, New York.

Bernard L Strehler 1964. Advances in Gerontological Research, Academic Press, New York, London.

De Robertis & De Robertis 1988. Cell and Molecular Biology. 8th edition. Lea and Febiger, Hong Kong.

Donald E. F. 1994. Plant Growth and Development- A molecular approach. Academic Press.

James G. 1974. Chromosomes and Cancer. John Wiley and Sons, New York, London.

Nover, L.M. Luckner & B Parthier (Eds) 1982 Cell Differentiation. Springer –Verlag, Berlin.

Raghavan. V. 1999. Developmental Biology of Flowering Plants. Springer Verlag, New York.

Rose M. R., Finch C. E. (Ed) 1993. Genetics and Evolution of aging. Kluwer Academic Publishers, London.

Salisbury, F.B. & Ross. W. 1991. Plant Physiology Wadsworth Publ. Co., California, USA.

Schneider E.L. 1978. The Genetics of Ageing. Pleneum Press, New York, Loadoa.

Stephen E. H. 1998. Molecular Genetics of Plant Development Cambridge University Press, Cambridge.

Swoeney, B.M. 1969. Rhythmic Phenomena in Plants, Academic Press, London, New York.

Wolpert, L. 2002. Principles of Development, Oxford University Press, Oxford.

BOT- 541. POPULATION GENETICS

Unit 1. Genetic Composition and Mendelian Population

(i) History: Gene frequencies and Genotype frequencies, Gene pool.

(ii) Systems of Mating:

a. Random mating and Hardy-Weinberg Principle, Application of Hardy-Weinberg principles-Test for Random mating, Test for sex-linked trait, Test for carrier gene frequency, Test for mode of inheritance, Test for multiple gene.

b. Non – random mating-Positive non-random mating-Negative non random mating.

Unit 2. Factors affecting gene frequencies in natural populations

(i) Factors affecting random mating-Migration-Mutation and Selection, Mutation and Selection- balance, Selection against dominant genotype, Selection against recessive genotype, Selection for heterozygote .

(ii) Random drift, Genetic Load, Founder effect.

Unit 3. Consanguinity in natural populations

(i) Inbreeding/Consangunity: Definition-Inbreeding co-efficient, degrees of inbreeding, Types of inbreeding, Harmful effects of inbreeding, Genetic effects of Inbreeding.

Practicals 25 problems pertaining to the above chapters.

References

Chopra, V.L. 2000.Plant Breeding-Theory and Practicals (2nd edition), Oxford & IBH Publ. Co. Pvt.Ltd. New Delhi.

Genetics Problem solvers 1993. REA Research and Education Associates, New Jersey.

Jain H.K. & Kharkwal, M.C. 2004. Plant Breeding Mendelian to Molecular Approaches

Klug, W. S & Cummings, M.R. 2003. Concepts of Genetics. Pearson Education (Singapore), New Delhi.

Kowles, R. 2000 Solving Problems in Genetics. Springer –Verlag, New York, Berlin, London.

Russell, P.J. 1998 Genetics (5th edition), Addison Wesly & Longman Inc, California, New York, London & Amsterdam.

Singh, B.D. 2003. Plant Breeding, Kalyani Publ., Co. Pvt. Ltd., New Delhi.

Singh, B.D.2003. Genetics. Kalyani Publ., Co. Pvt. Ltd., New Delhi.

Snustad D.P & Simmons, M.D. 1999. Principles of Genetics. (2nd edition). John Wiley & Sons. Inc. New York, Singapore, Toronto.

Weaver, R F & .Hedrick P.W. 1997. Genetics (3rd edition), WCB Toronto, Seoul, Mexico City, Sydney, Tokyo.

BOT. 543 BIOSYSTEMATICS

Unit 1. Historical background, Herbarium Taxonomic relations:
(i) Historical background: Rise of experimentally based taxonomy, Review of biosystematics, The challenge of new approaches to systematic.

(ii) Herbarium: History and development of a herbarium, Functions of herbarium, different kinds of herbarium, important herbarium of the world. Method for preparing a herbarium.

(ii) Morphology in relation to taxonomy.
a. External morphology: Vegetative features, reproductive features

b. Micrscopic morphology (epidermal characters) or ultrastructural systematics: Trichomes, epidermal cells, seed surface pattern, pollen wall ornamentation, stomata, types of stomata

(iii) Anatomy in relation to taxonomy: Taxonomic applications of anatomical features. Vegetative and floral anatomy, Floral anatomy in relation to taxonomy and phylogeny Eg, Apocyanaceae, Caesalpiniaceae , Papilonaceae, Saxifragaceae, Ranunculaceae, Leaf anatomy in relation to taxonomy Eg. Myrtales

(iv) Embryology in relation to taxonomy: Basic embryological characters of taxonomic significance. Embryological characters, Taxonomic applications of embryological features. Eg. Scytopetalaceae, Loranthaceae. Cyperaceae. *Trapa. Paeonia*.

(v) Cytology in relation to taxonomy: Chromosome techniques, Chromosome banding as a tool in taxonomy, Chromosome number and size, Chromosome morphology- Chromosome morphology and relative size, Heterochromatin. Chromosome behaviour at meiosis. The genome, Natural karyotype. Genomic characters and classification. The importance of genomic characters for biosystematics.

The taxonomic value of cytological data: General, Family level and above Generic level, Specific level and below in angiosperm families -

Zingiberales, Liliaceae, Malvaceae. Cucurbitaceae, Araceae, Rubiaceae, Araliaceae

Polyploidy and taxonomy ; Frequency of polyploidy, Types of polyploidy, Auto and allopolyploidy, Cryptic structural polyploidy, Segmental allopolyploidy and other situations.

Unit 2. Phytochemistry, plant reproductive strategies:

(i) Phytochemistry in relation to taxonomy: Chemotaxonomy- Origin and nature of chemotaxonomy. Compounds useful in plant taxonomy. Value of chemotaxonomy . Secondary metabolites, Distribution and description of directly visible chemical substances, chemical test characters, Plant products, Alkaloids. Flavonoid profiles as biosystematical aids. Chemical identification of plant cultivars. Chemistry of plant hybrids. Chemistry in taxon*o*mic revisions. Eg. *Brassica* Leguminosae, Papaveraceae, Fumariaceae, Centrospermae.

(ii) Numerical taxonomy: Principles and status of numerical taxonomy, Historical account of the development of numerical taxonomy, Aims and objectives and nomenclature. Merits and demerits of numerical taxonomy. Applications of numerical taxonomy . Eg. *Polemonium pulcherrimum* and Chenopodiaceae.

(iii) Plant reproductive strategies: Apomixis and biosystematics , Modes of asexual reproduction, origin and fixation of apomixis. The evolutionary prospects of apomixis Eg. *Potentilla tabernaemontana and* Curculinoideae. Breeding systems and pollination mechanisms in plants and their use in biosystematics .

(iv) Palynology in relation to taxonomy: Pollen morphological characters, Pollen morphoforms, Exine sculpturing, Pollen size and shape, Evolution of pollen morphological characters, Role of palynology in rrlation to taxonomy. Eg. Acanthaceae, Rubiaceae, Scrophulariaceae, Rutaceae , Malvaceae.

Unit 3. Molecular systematics, serology, cytogeography in relation to taxonomy:

(i) Molecular systematics : Molecules and genomes in plant systematics- Techniques used in molecular taxonomy, Chloroplast DNA and the study of plant phylogeny,- present status and future prospects, Use of chloroplast DNA rearrangements in reconstructing plant phylogeny, Mitochondrial DNA in plant systematics, Applications and limitations, Ribosomal RNA as a phylogenetic tool in plant systematics. Eg. Saxifragaceae, Asteraceae, Onagraceae, *Brassica*, Nymphales. Molecular approaches to plant evolution, Intraspecific cp DNA variation in systematic and phylogenetic implications. Molecular evidence and plant introgression, molecular data and polyploid evolution in plants. Molecular systematics and crop evolution.

(ii) Serology in relation to taxonomy: Brief history of sero-taxonomy. Methods used in sero-taxonomy. Role of serology in taxonomy.

(iii) Cytogeography and biosystematics: Cytogeography and structure of a group of related taxa Eg. *Ranunculus plantagieus*, *Polycarpon polycarpoides, Erysimum grandiflorum*. Cytogeography and historical botanical geography, The occurrence of other biosystematic methods on cytogeography.

References

Davis, P.H. &Heywood. 1967. Principles of Angiosperm Taxonomy. Oliver and Bond Edinburgh, London.

Grant, W.F. (Ed.). 1984. Plant Biosystematics. Academic Press, New York

Hawkes, J.G. (Ed.) 1968. Chemotaxonomy and Serotaxonomy. The Systematics association special volume. No. 2. Acdemic Press London, New York.

Horborne, J.B.D., Boulter B.L. & Turner 1971. Chemotaxonomy of the Leguminosae. Academic Press, London and New York.

Judd.W.S. *et al.* 2002. Plant Systematic- A Phylogenetic Approach – 2nd Edition. Sinauer Associates Inc. Publishers Sunderland. Massachusetts, U.S.A.

Purohith, K.M. & Panigrahi, G. 1991. The family Rosaceae in India. (Reversionary studies in some genera). Dehradun.

Singh, G. 2004. Plant Systematics- Theory and Practice. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Sivarajan, V.V. 1991. Introduction to the Principles of Plant Taxonomy 2nd Edition. Oxford and IBH Pub Co. New Delhi.

Solitis. D. E. & Doyle, J.J. 1992. Molecular Systematics of plants. Chapman and Hall, New York, London.

Stebbins, G.L. 1960. Variation and Evolution in Plants. Columbia University Press. Newyork..

Subrahmanyan, N.S. 1995. Modern Plant Taxonomy. Vikas Publishing House Pvt. Ltd. New Delhi.

JOURNALS

Taxon

Plant Systematics and Evolution

ELECTIVES

501 – BIOPHYSICS

ELECTIVE: 2 CREDIT COURSE

Unit 1. Bioenergetics, Tools and Technique in Biology:

(i) Bioenergetics: Concepts of Entropy, free energy, enthalpy, redox potential.

Tools and Technique in Biology:

(i) Microscopy: Principles and applications of light, phase contrast fluorescence, Polarizing, Scanning and transmission electron microscopy: cytophotometry and flow cytometry, video-micrometry, camera lucida and photomicrography.

(ii) Centrifuges: Basic principles of sedimentation – Types of centrifuges and their uses – Preparative and Analytical centrifuge – Sedimentation equilibrium method, Sedimentation velocity method – Density Gradient Centrifugation – Isokinetic and isopycinic centrifugation – Differential centrifugation.

(iii) Chromatography: General principles – Adsorption and Partition Chromatography – Thin layer chromatography, paper chromatography, Gas-liquid chromatography (GLC), High performance liquid chromatography (HPLC), Ion-Exchange Chromatography and Affinity Chromatography.

(iv) Electrophoresis: General principles – apparatus, methods and applications – Moving boundary, electrophoresis and zone electrophoresis – Paper electrophoresis thin layer column chromatography – starch gel, agarose gel and polyacrylamide gel electrophoresis – SDS, Non-SDS, DIS

electrophoresis Isoelectric focusing, Istotachophoresis and immuno electrophoresis.

Separation of nucleic southern blotting – DNA sequencer, DNA synthesizer.

Unit 2. Spectroscopic techniques, X-ray diffraction Autoradiography:

(i) Spectroscopic techniques: General principles, Types of spectra and their biochemical usefulness, visible and UV spectrophotometry, Infra-red (IR) Circular Dichroism (CD), NMR, ESR and mass spectroscopy, Spectro-fluorimetry, Luminometry, Atomic/Flame spectrophotometry, Atomic absorption and plasma emission spectroscopy.

(ii) X-ray diffraction – Principles and Application: Radiation Biophysics: Types of radiation, interaction between radiation and matter – dosimetry,- radiation detectors.

(iii). Autoradiography – Light microscope auto radiography – fibre auto radiography, High resolution auto radiography.

Practicals

2. Different parts of microscope.
3. Separation of compounds using Paper and Thin layer Chromatography
4. Electrophoresis: Separation of protein using PAGE, immuno electrophoresis.
5. Centrifuge: Separation of compound/materials using desktop and High speed centrifuge
6. Spectrophotometry: Quantification of biological compounds using spectrophotometric method.

7. Micrometry: Determination of pollen diameter, stomatal length and breadth using micrometry.

8. Working of equipments like pH meter PCR machine etc.

References

Ackerman 1962. Biophysical Science Prentice Hall, Inc.

Daniel, M.1989. Basic Biophysics, Agro Botanical Publishers Bikner.

Das, D.J. 1987. Biophysics and Biophysical Chemistry. Academic Publishers. Calcutta.

Boyer, R. F. 1986. Modern Experimental Biochemistry. The Benjamin/Cummings Publishing Co. Inc. New York

Srivastava, P.K. 2005. Elementary Biophysics, Narosa Publishing House, New Delhi.

Piramal, V. 2005. Biophysics. Dominant Publishers and Distributors, New Delhi.

BOT 505. APPLIED PALYNOLOGY
ELECTIVE : 2 CREDIT COURSE

Unit 1. Area of study, Applied Palynology

i. Area of study : Based on pollen or spore morphology, Basic Palynology (pollen, spore morphology, pollen ecology) and Applied palynology

ii. Applied Palynology: Melittopalynology, aeropalynology, palaeopalynology, iatropalynology, pharmacopalynology, copropalynology and forensic palynology.

Unit 2. Basic palynology, palynological features

i. Pollen –Spore morphology (Basic palynology):

a. Origin of exine, pollen wall structure and development, prime exine, sporopollenin (nature and composition), role of tapetum in pollen wall formation.
b. Pollen units: Monad, dyad, tetrad, polyad, pollinia, massula.
c. Polarity: Apolar, isopolar, hetropolar.
d. Shape: Pollen shape (tertiary): Radio symmetrical, bilateral, shape index in radio symmetrical grains (P/E X100). Shape types- oblate, suboblate, oblate-spheriod, spherical, prolate-spheriodal, subprolate, prolate, perprolate.
e. Symmetry: Symmetric, Asymmetric.
f. Size: Based on Walker and Doyle (1975).

ii. Palynological features:

a. Aperture (primary): NPC System.
b. Exine surface ornamentation (secondary): projection types- spinate, spinulate, verrucate, gemmate, bacculate, tuberculate. Depression types- reticulate, lophate, fossulate, scrobiculate, punctate, pilate, psilate.
c. Exine strata: intine, exine with endo exine (base layer), mid exine (columella layer) and extoexine (the tectum, tegillum and supra tegillum).

References

Devi. S. 1977. Spores of Indian Ferns. Today and Tomorrows Printers and Publishers, New Delhi.

Erdtman, G. 1952. Pollen morphology and Plant taxonomy. Amquist & Wiksell, Stockholm.

Harrison, J. 1971. Pollen development and physiology. Butterworths, London.

Harrison, J. H. 1975. The physiology of pollen grain surface. Proc. Roy. Soc. London Series-b 190: 275-299.

Johri, B.M.& Shivanna, K.R. 1985. The Angiosperm pollen structure and function. Wiley Eastern, New Delhi.

Nair, P.K.K. 1966. Essentials of Playnology. Today and Tomorrow's Printers and Publishers, New Delhi.

Nair, P.K.K. 1970. Pollen morphology of Angiosperms – A Historical and Phylogenetic Study. Vikas Publishing House, Delhi.

Saxena, M.R. 1993. Palynology-A treatise. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

Woodhouse, R.P. 1935. Pollen grains. McGraw Hill book. Co. NY.

BOT. 51A. PLANT TISSUE CULTURE
ELECTIVE : 1 CREDIT COURSE

1. Introduction

History of plant tissue culture and cell culture

2. Basic techniques& principles

a. General laboratory facilities and requirements
b. Media composition and preparation, sterilization techniques.
c. Different types of media (MS, B5, White, SH, WPM, VW, Wimber etc)

3. Growth and differentiation

a. Callus culture- characteristic features, cytodifferentiation, significance
b. Suspension culture-different types, growth patterns, significance
c. Organogenesis, chemical and physical factors, pathway of development
d. Embryogenesis. Chemical and physical factors, pathway of development, Artificial seeds

4. Application of culture technologies to plant improvement

a. Micropropagation protocol and application
b. Anther culture protocol and application
c. Protoplast culture and somatic hybridization protocols and application
d. Cryopreservation –procedure and applications.
e. Somoclonal variation-causes, merits and demerits.

References

Balasubramanian, D, 1993, Genes and Means, CSIR, New Delhi

Chawla, H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. New Delhi

Gupta, P.K. 1006. Elements of Biotechnology. Rastogi Publishers, Meerut

Kalyankumar D, 1992. An introduction to Plant Tissue Cultur, New Central Book agency, Calcutta.

BOT. 507 TRANSGENIC PLANTS

ELECTIVE : 1 CREDIT COURSE

1. Basic concept of genetic engineering

Genetic transformation of plants, Transgenic techniques, Steps for developing new crop verities

2. Gene transfer methods

Bacteria and gene transfer in plants, Vector mediated gene transfer Creating recombinant DNA.

3. *Agrobacterium* mediated gene transfer

Tumor inducing principle and the Ti plasmid, *Agrobacterium* mediated virus infection- agro infection.

4. Vectorless or direct DNA transfer

Physical gene transfer methods, ElectroporationParticle bombardment/ microprojectile/ biolistic, Macroinjection, Microinjection

5. Chemical gene transfer methods

6. Transgenic in crop improvement

Resistance to biotic stresses, Insect resistance, Virus resistance, Disease resistance, Resistance to abiotic stresses, Transgenic for quality

7. Ethics of transgenic plants

References

Balasubramanian, D, 1993, Genes and Means, CSIR, New Delhi

Brown, T. A. 1992. Genetics: A molecular Approach. Chapman & Hall, London.

Chawla, H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. New Delhi

Gupta, P.K. 1006. Elements of Biotechnology. Rastogi Publishers, Meerut

BOT. 508 BIOTECHNOLOGY

ELECTIVE : 1 CREDIT COURSE

1. Somatic embryogenesis

Ontogeny and development of somatic embryos. Factors affecting embryo formation application.

2. Artificial- synthetic seeds

Protocol and its significance.

3. *In vitro* production of haploids

In vitro production of haploids and uses of haploids, Androgenic methods, anther culture, microspore (pollen) culture, factors governing the success of androgenesis, uses of haploids in plant breeding, Gynogenic haploids, factors affecting gynogenesis.

Embryo rescue techniques, ovary, ovule, endosperm and embryo culture

In vitro pollination and test tube fertilization, methodology, factors affecting seed set application. Green pod culture of orchids. Application.

4. Protoplast culture

Protoplast isolation, different methods, production of protoplasts, protoplast culture, regeneration of plants, protoplast fusion, somatic hybridization, different types, fusion methods, identification and selection of hybrid cells.

Cybrids, achievements and limitations.

Significance of protoplast culture and somatic hybridization.

Somatic hybridization for crop improvement.

5. Secondary metabolites

Secondary products found in plants, method of production – factors affecting yield. Bioreactors. Secondary metabolites detected in plant tissue culture.

Root and hairy root culture.

Methods of enhancement of secondary metabolite production in culture.

Problem associated with secondary metabolite production .

6. Germplasm storage and cryopreservation

Conservation of germplasm *in vitro* strategiesShort, medium and long term (cryopreservation) preservation application.

7. Transgenic plants

Transgenic plants for crop improvement, Procedure and protocols of producing transgenic plants, Transgenic plants for molecular farming

Practical

Preparation of culture media (MS)

Stock solution preparation

Sterilization of culture media

Techniques of isolation, surface sterilization and inoculation of different explants.

Direct and indirect organogesis (Medicinal plant)

Preparation of artificial seeds

Green pod(embryo culture) of orchid (*Spathoglotis plicata*).

Protoplast isolation by enzymatic method

Submit a record on the above work done.

References

Balasubramanian, D, 1993, Genes and Means, CSIR, New Delhi

Brown, T. A. 1992. Genetics: A molecular Approach. Chapman & Hall, London.

Chawla, H.S. 2000. Introduction to Plant Biotechnology. Oxford & IBH Publishing Co. New Delhi

Gupta, P.K. 1006. Elements of Biotechnology. Rastogi Publishers, Meerut

BOT- 53A PHYTOCHEMICALS

ELECTIVE: 1 CREDIT COURSE

1. **Introduction:** Major classes of plant chemicals-terpenoids, alkaloids and other nitrogen containing metabolites, phenolic compounds.

2. **Phytochemical databases**: DR. Duke's Phytochemical and ethnobotanical databases, NAPRALERT, MEDFLOR, USDA Phytochemical and ethnobotanical databases.

3. **Phytochemicals as nutraceuticals**: With secial reference to vegetables and fruits from lant families such as Lilieaceae, CRUCIFERAE, solanaceae, Umbelliferae, Compositae and Rutaceae.

4. **Phytochemicals in cosmetics**: Brief description of properties and constituents of plants and plant arts used as Cosmetics and in Aromatherapy.

5. **Phytochemicals in disease prevention**: Utility in treatment of cancer, diabetes, cardiovascular diseases. Mode of action-antioxidants, hormonal action, stimulation of enzymes, interference with DNA replication, antibacterial and antifungal effects, blocking and suppressing agents, phytoestrogens, isoflavanoids and lignans. Toxins such as glycoalkaloids, fucocoumarins, miscellaneous toxicants. Drug discovery and development.

6. **Methods of isolation and analysis:** Extraction techniques. Separation and Purification techniques-chromatography TLC, HPLC and GC. Detection techniques-UV-Vis spectroscopy, Infrared spectroscopy (IR) and Mass spectroscopy (MS), NMR spectroscopy.

7. **Biotechnology and Phytochemical production**: Engineering the plant metabolism. Methods of expression of foreign proteins in plants, production of pharmaceuticals and industrial enzymes, expression of whole proteins and pharmaceutically active peptides. Isolation and purification from plants.

References

D'Amelio, F.S. 1999. Botanicals- A Phytocosmetic Desk Reference---

Harborne, J.B. 1998. Phytochemical Methods-A Guide to Modern techniques of Plant Analysis, Chapman and Hall, London.

Meskin, M.S., Bidlack, W.R., Davies, A.J. Lewin, D.S. & Randolph, K. (eds.) 2004. Phytochemicals - Mechanism of action. CRC Press, Washington.

Walton, N.J. & Brown, D.E. 1999. Chemicals from plants: Perspectives on plant secondary products. Imperial College Press and World Scientific Publishing Co. Pte. Ltd. London.

BOT. 52A. PLANT CELL CULTURE TECHNOLOGY
ELECTIVE: 1 CREDIT COURSE

Unit 1. Introduction: Plant metabolites and their importance

Cell culture techniques: suspension culture- bioreactors, cell line selection, *in vitro* mutagensis, protoplast hybridization: consequences and applications.

Unit 2. Secondary metabolite classes & groups

Alkaloids- morphines, codeine, quinine, nicotine, cocaine, hyoscyamine, lysergic acid, taxol

Terpenoids: Menthol, camphor, caroteniod, pigments

Polyterpenes: rubber

Phenyl propanoids: Anthocyanin, coumarins, favanoids, isoflavniods, stilbenes, tannins

Quinones: Anthraquinones, benzoquinones, naphthoquinones

Steroids: Diosegnin, sterols, ferruginol

Exploitation of secondary metabolites in culture. Role of cell line selection, *in vitro* mutagenesis for exploitation. Biochemicals from cultured plant cells, productivity enhancement- optimization of medium and culture conditions, development of high yielding cell lines, elicitors, use of organ culture and two-phase system.

Unit 3. Large scale exploitation of secondary metabolites

Hairy root culture- advantages, commercial production of shikokonin, berberine, diosegnin, taxol, vincristine, vinblastine, scopolamine, ajmaline

Biotransformation, Metabolic engineering - advantages and limitations.

References

Balasubramanian, D., Bryce, C.F.A., Dharmalingam, K., Green, J. & Jayaraman, K. 1996. Concepts in Biotechnology. COSTED-BIN, Universities Press (India) Ltd., Hyderabad.

Dodd, J.H. & Roberts, L.W. 1985. Experiments in Plant Tissue Culture. Cambridge University Press, Cambridge, U.K.

Green, C.E., Somers D.A., Hackett, W.P. & Biesboer, D.D. 1987. Plant Tissue and Cell Culture. Liss, New York.

Hall, R.D. 1999. Plant Cell Culture Protocol. Humana Press, New York.

Harbne, J.B. 1998. Phytochemical Methods- A guide to modern techniques of plant analysis (3rd edition), Chapmann & Hall, London.

Mantell, S.H., Mc Kee, R.A. & Mathew, J.A. 1985. Principles of Plant Biochemistry. Blackwell Scientific Publ., Oxford, England.

Parve, P., Faust, U, Sittig, W. & Sukatsch, D.A. 1987. Fundamentals of Biotechnology. VCH Publ. Wiesbaden, Germany.

Staba, E.J. 1980. Plant Tissue Clture as a Source of Biochemicals. CRC Press, Boca Raton FL.

Walton N.J. & Brown, D.E. 1999. Chemicals from plants: Perspectives on Plant Secondary Products. Imperial College Press, London.