

**REVISED CURRICULUM
OF
GENETICS**

Curriculum Development Project

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Islamabad**



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CURRICULUM DIVISION, UGC

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PREFACE

Curriculum of a subject is said to be the throbbing pulse of a nation. By looking at the curriculum of a subject, one can judge the state of intellectual development and the state of progress of a nation. The world has turned into a global village, new ideas and information are pouring in a constant stream. It is, therefore, imperative to update our curricula by introducing the recent developments in the relevant fields of knowledge.

In exercise of the powers conferred by Sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide Notification No.D773/76-JEA (Cur.), dated December 4, 1976, appointed University Grants Commission as the Competent Authority to look after the Curriculum Revision Work beyond Class XII at Bachelor level and onwards to all Degrees, Certificates and Diplomas awarded by Degree Colleges, Universities and other Institutions of higher education.

In pursuance of the above decisions and directives, the Commission is continually performing curriculum revision in collaboration with the Universities. According to the decision of the 44th Vice-Chancellors' Committee, curriculum of a subject must be reviewed after every 3 years. For the purpose, various Committees are constituted at the national level comprising senior teachers nominated by the Universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these Committees.

The National Curriculum Revision Committee on Genetics in its meeting held in April at the U.G.C. Regional Centre, Karachi revised the curriculum after due consideration of the comments and suggestions received from the Universities and Colleges where the subject under consideration is taught.

The Final draft prepared by the Curriculum Revision Committee duly approved by competent authority is being circulated for implementation by the Universities.

(PROF. DR. ALTAF ALI G. SHAIKH)
ADVISER (C&T)

June, 2002

INTRODUCTION

Genetics is an important branch of biological sciences which deals with the laws of inheritance which were discovered at the beginning of 20th century and importance of genetics was realized back in 1950s when DNA, the genetic material was discovered and now it has reached to its culmination. This discipline of science has emerged from hybridization experiments, which gave birth to laws of inheritance and then emerged, cyto-genetics, quantitative and population genetics, fungal genetics, bacterial genetics, molecular genetics, recombinant DNA techniques, plant and animal molecular genetics which led to modern biotechnology. Nevertheless, the molecular genetics and the recombinant DNA techniques had profound impact on the understanding of biological systems, which are the foundation of modern biotechnology. In fact no subject area has had a more sustained impact on shaping our knowledge of living systems than genetics.

The 21st century is the era of biotechnology, which encompasses environment, food, industry, medicine and agriculture, hence addressing all aspects of our life. Advances in genetic technology are now having a profound impact on our knowledge of human genetics. More than any other event, the launching of the Human Genome Project in 1990 symbolizes our commitment to the pursuit of such knowledge. As we entered the twenty-first century, the application of genetics to the betterment of the human condition will be commonly realized. While this era will be filled with the excitement of scientific discoveries, many accompanying problems and controversies will also be faced. Among these, utilization of our knowledge of the nucleotide sequence of the human genome will be the greatest challenge in the future. This growing body of information has already generated many legal and ethical issues. Currently, the implications of genetic testing and gene therapy are becoming important societal concerns.

In view of the importance of genetics, UGC deems that independent Department of Genetics should be launched in every University and the discipline of Genetics be started at graduate level. Hence the Curriculum of Genetics in B.Sc, B.Sc(Hons-three years as well as four year program) and M.Sc have been designed to meet the requirements of this century.

The first meeting of National Curriculum Revision Committee (NCRC) on the subject of Genetics was held in UGC, Regional Centre, Karachi from November 13-15, 2001. The first draft Curriculum in Genetics was circulated by UGC, Islamabad for comments on December 7, 2001. Final meeting of NCRC in Genetics was held on April 23-25, 2002 at UGC Regional Centre, Karachi to prepare the final draft curriculum of Genetics. Followings attended the meeting:

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|----|---|----------|
| 1. | Dr. Nuzhat Ahmed
Director, Centre for Molecular Genetics,
University of Karachi
Karachi. | Convener |
| 2. | Prof Dr. Shahida Hasnain
Deptt. of Botany, University of the Punjab
Lahore | Member |
| 3. | Prof. Dr. Rehmatullah Arain
Deptt. of Botany, University of Sindh
Jamshoro | Member |
| 4. | Dr. Afsari S. Qureshi
Professor, Deptt. of Biological Sciences
Quaid-i-Azam University,
Islamabad | Member |
| 5. | Dr. Asghar Ali
Chairman, Deptt. of Zoology
Govt. College,
Sahiwal | Member |
| 6. | Prof. Shafiq-ur-Rehman
Assistant Professor, Deptt. of Botany
University of Azad Jammu & Kashmir
Muzaffarabad | Member |

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|-----|---|---|
| 7. | Dr. Ulfat-un-Nabi Khan
Director General
Tropical Agriculture Research Centre
Karachi | Member |
| 8. | Ms. Talat Haider
Chairperson, Deptt. of Genetics
University of Karachi
Karachi. | Member |
| 9. | Dr. Ghulam Sarwar Markhand
Associate Professor, Department of Botany
Shah Abdul Latif University,
Khairpur | Member |
| 10 | Mr. Muhammad Moin-ud-Din
Lecturer, Deptt. of Botany
Govt. Superior Science College
Karachi | Member |
| 11. | Ms. Nusrat M. Baig
PECHS College,
Karachi | Member |
| 12. | Mrs. Zarina Patel
Sir Syed College for Women
Karachi | Member
(Attended first meeting only) |
| 13. | Dr. Yusuf Zafar
Head, Plant Biotechnology Division
National Institute of Biotechnology
And Genetics Engineering (NIBGE),
Faisalabad | Secretary |

The meeting started with a brief introduction by Dr. Iqbal A. Panhwar, Director General UGC, Regional Centre, Karachi. He welcomed the participants and informed that draft curriculum on genetics was already circulated by UGC. Thus, the work of committee is now relatively easy. He assured all possible help and assistance to make this programme a success.

The existing set up for teaching the subject of Genetics was reviewed. It was noted with great satisfaction that University of Punjab, Lahore recently opened a new department of Microbiology & Molecular Genetics and started B.S. (Professional-4 years) programme. Earlier, M.Sc. (Genetics) degree has only been awarded by University of Karachi.

The committee then took up the agenda of the meeting and started discussion on the course contents of under graduate (B.Sc. General). After this, the undergraduate courses of B.Sc.(Hons) Genetics were discussed. Finally, M.Sc. (Genetics) courses were taken up. Recommendations were formulated towards the end of the meeting. The course contents for each category are given below.

It is expected that implementation of this Curriculum of Genetics will open up a new era in teaching and popularization of this subject in the country.

Dr. Yusuf Zafar
Head, Plant Biotechnology Division
Genetics National Institute of Biotechnology
and Genetics Engineering (NIBGE)
Faisalabad
(Secretary)

Dr. Nuzhat Ahmed
Director, Centre for Molecular
University of Karachi
Karachi
(Convener)

B. Sc. (General)

B.Sc. (General) Degree Programme

Genetics as a separate subject should be introduced like Botany, Zoology and Chemistry etc. There will be following four papers in the B.Sc. (Pass) for qualifying the subject of Genetics: 1) Principles of Genetics, 2) Biometry and Quantitative Genetics, 3) Microbial and Molecular Genetics, 4) Genetics of Eukaryotes.

B.Sc. Part-I

Paper 1. Principles of Genetics

Introduction of Genetics:	Heredity and variations.
Cell division:	Morphology and structure of Eukaryotic chromosomes, Mitosis & Meiosis.
Mendelism:	Monohybrid, Dihybrid, Trihybrid Crosses, Mendelian parameters and their locations.
Gene interaction:	Gene interaction and lethality, Modifications of Mendelian ratios, Modifying gene and Lethal genes.
Gene & environment:	Penetrance, Expressivity's, Pleiotropism & Phenocopies, Twin studies, Nature and Nurture.
Linkage & Crossing over:	Chromosome mapping, Crossing over, Methodology of mapping, Interference, Coefficient of Coincidence.
Multiple alleles:	Blood groups
Sex linkage:	Sex chromosomes, Sex linked inheritance and Sex determination.

Practicals:

1. Problems related to Mendelian inheritance, Gene interaction, Gene mapping.
2. Blood Groups-ABO blood groups and Rh factors
3. Drosophila culture techniques
4. Study of Mitosis & Meiosis, using Onion root tips and flower buds.

Recommended Books:

1. Strickberger M.W., Genetics, Third Edition. Macmillan Publishing, N.Y. London, 1985
2. Klug, W.S. and M.R .Cummings, Concepts of Genetics. Prentice Hall Inc. 1997
3. Rothwell N.V., Understanding Genetics. Second Edition. Oxford Univ. Press Inc. 1997

4. Tamarin R., Principles of Genetics, Sixth Edition. McGraw-Hill Book Co. Boston. USA. 1999
5. Brooker R.J. Genetics : Analysis and Principles Benjamin/Cummings; 1998
6. Snustad D. P., M. J. Simmons, Principles of Genetics, Second Edition, John Wiley & Sons; 1999
7. Lewin B. , Genes VII, 7th edition, Oxford University Press; 2000
8. Hartl D.L. and E.W. Jones, Essentials of Genetics, third edition. Jones and Bartlett Publishers, Sudbury, USA. 2002.
9. Weaver, R.F. and P.W. Hedrick. Genetics. Analysis and Principles. Benjamin / Addison, Wesley Longman Inc. 1997.
10. Gardner, A. Principles of Genetics. John Wiley and Sons. 1998.
11. Jones, R.N. and A. Karp Introducing Genetics, John Murray Publishers, London 1994

Paper 2.

Biometry and Quantitative Genetics

Introduction:	Biological variations & Statistics, Population & samples
Frequency distribution:	Presentation of data in frequency tables, histograms, frequency curve.
Measures of Central Tendencies.	Mean, Median and Mode
Measures of Dispersion (Spread)	Range, Mean deviation, Variance, Standard deviation & Standard error, Coefficient of variation.
Probabilities:	Mutually exclusive events and independent events, rules of combining probabilities.
Chi-square test:	Goodness of fit and Test of associations.
Quantitative Genetics:	Polygenic inheritance, Gene & genotypic frequencies, Hardy-Weinberg law, Factors affecting gene frequencies.

Practicals:

1. Collection of Data
2. Acquisition of random samples, graphical/tabular representation of data
3. Problems related to combining probabilities, central tendencies and dispersion
4. Problems related to chi-square
5. Problems of goodness of fit and independent events
6. Verification of genetic ratios and test of association
7. Problems of gene and genotype frequencies
8. Problems related to polygenic inheritance

Recommended Books:

1. Bendat J. S. , A. G. Piersol, Random Data: Analysis & Measurement Procedures third Edition, Wiley-Interscience; 2000
2. Steel R. G. D., J.H.Torrie, D. A. Dickey Principles and Procedures of Statistics: A Biometrical Approach, 3rd Edition, McGraw-Hill Higher Education; 1996
3. Sokal R. R. , F. J. Rohlf Biometry : The Principles and Practice of Statistics in Biological Research, 3rd edition, W H Freeman & Co.;1994
4. Zar J. H., Biostatistical Analysis, Fourth edition, Prentice Hall Co. 1998
5. Stephens K. S., The Handbook of Applied Acceptance Sampling: Plans, Procedures & Principles, 1st edition, American Society for Quality; 2001
6. Steel, R.G.D. and J.H. Torrie, Principles and Procedures of Statistics: A Biometrical Approach, McGraw Hill International Book Co. 1981

B.Sc. Part II

Paper 3.

Molecular and Microbial Genetics

Prokaryotes & Eukaryotes:	Differences and uniformity.
Life Cycles:	Bacteria, virus, yeast & <i>Neurospora</i>
Tetrad Analysis:	Yeast (unordered) and <i>Neurospora</i> (ordered)
Nucleic acid as Genetic Material:	Griffith's experiment, Macleod & Macarty, Hershey, Chase & Franklin & Conrat's experiments
Structure of nucleic acids:	DNA & RNA. DNA replication and its kinds
Mutations:	Types, Mutagens, Molecular basis of mutation
Genetic Code:	Genetic Code and its properties
Transcription & Translation:	Stages and processes
Recombination in bacteria:	Transformation, Conjugation and Transduction
DNA techniques:	Introduction to Recombinant DNA technology.

Practicals:

1. Precautionary measures
2. Sterilization techniques
3. Bacterial culture techniques, solid & liquid media
4. Gram's staining of bacterial culture
5. Study of colonial & cellular morphology of bacteria
6. Counting of cells in culture
7. Yeast culture techniques
8. Staining of yeast

Recommended Books:

1. Lewin B. ,Gene VII. Oxford University Press, Oxford, UK, 2000.
2. Adolph K. W. , Microbial Gene Techniques (Methods in Molecular Genetics, Vol 6) Academic Pr; 1995
3. Bainbridge B.W. , Genetics of Microbes (Tertiary Level Biology Series), 2nd edition Chapman & Hall; 1986
4. Wagner R. , Transcription Regulation in Prokaryotes, Oxford University Press; 2000
5. Summers D. K. , The Biology of Plasmids, Blackwell Science Inc, 1996

6. Streips U. N. , R. E. Yasbin, Modern Microbial Genetics 2nd edition, John Wiley & Sons;2002

Paper 4.

Genetics of Eukaryotes

Human Genetics:	Human genome, Pedigree analysis, Genetic diseases & disorders, Genetic Counseling, Methods of studying human genome.
Plant Breeding and Genetics	Principles and methods,. Outbreeding and Inbreeding, Methods of crop improvement; Selection, Hybridization, Introduction and Acclimatization and Mutation Breeding. Transgenic plants. <i>Arabidopsis</i> genome
Animal Breeding and Genetics:	Methods of animal breeding, Selection (methods and types), Inbreeding and Outbreeding, Transgenic animals, Use of recombinant DNA techniques, Artificial insemination, Embryo Transplantation, Heterosis.

Practicals:

1. Visit of live stock/poultry farms and report writing
2. Visit to agricultural research institutions.
3. Candling of eggs
4. Human Karyotyping from photographs and prepared slides
5. Problems relating to human pedigree analysis.
6. Emasculation and crossing techniques

Recommended Books:

1. Khan, M.A, E.Bashir and R.Bantel.. Plant Breeding. National Book Foundation, Islamabad, 1994.
2. Lewis, R. Human Genetics. McGraw Hill Co. Inc. N.Y,USA, 1999
3. Tamarin, R. Principles of Genetics. 6th Ed..McGraw Hill Book Co. Boston,USA, 1999
4. Bourdon, R.W. Understanding Animal Breeding. Prentice Hall Inc. New Jersey, USA, 2000
5. Ning L., and C.Yongfu, Animal Biotechnology, Intl Academic Pub House, 1997

B.Sc.(Hons)-Genetics

3-year Programme

B.Sc (Hons) in Genetics will be a new addition to the existing list of subjects (Biochemistry, Microbiology, Botany etc.) in which degree of B.Sc.(Hons) have routinely been awarded in various universities of Pakistan.

It is strongly suggested that Computer, Mathematics and Biochemistry should be taught as compulsory subjects. The other optional subjects are Microbiology, Botany, Zoology, Physiology and Chemistry.

The courses like English, Islamiat, Pakistan Studies will be taught as compulsory subjects as per existing system in the country.

A total of 14 core courses are suggested, however, the credit hours and the course allocations in a given semester will be decided by the relevant Board of Studies to fit in their existing system.

1. Fundamental of Genetics
2. Cell Biology
3. Biochemistry
4. Molecular Genetics
5. Principles of Breeding
6. Cytogenetics
7. Microbial Genetics
8. Biometry
9. Quantitative and Population Genetics
10. Human Genetics
11. Developmental and Behavioral Genetics
12. Mutation and Environmental Genetics
13. Evolution and Biodiversity
14. Genetic Engineering and Biotechnology

1. Fundamentals of Genetics

Laws of inheritance, chromosome theory of inheritance. Various types of alleles and their relationship. Linkage, crossing over and gene mapping in higher eukaryotes. Epistasis and non-epistatic interactions, pleiotropism. Genes and environment: penetrance, expressivity and phenocopies. Sex linkage and sex linked inheritance, sex influence, sex limited and holandric genes. Extra nuclear factors: maternal effects and maternal inheritance through mitochondrial and plastid genes. Hetro alleles, complementation and Recombination's.

Practicals:

1. Preparation of culture medium and maintenance of *Drosophila* cultures in lab.
2. Study of morphological characters and setting crosses of *Drosophila*.
3. Verification of Monohybrid and dihybrid F2 ratios.
4. Identification of first and second division segregations in *Neurospora* or *Sordaria* asci.
5. Problems involving various type of alleles, gene interaction, linkage, crossing over, gene mapping sex linked inheritance, extra nuclear inheritance and complementation.

Recommended Books:

1. Dunlap J. C. and C-Ting Wu, Advances in Genetics: Homology Effects, Academic Press, Incorporated, 2002
2. Griffiths L. G., Modern Genetic Analysis, W. H. Freeman Company, 2001
3. Hartl D.L. and E.W. Jones. Genetic Analysis of Gene and Genomes. Jones and Bartlett Publishers, Sudbury, USA. 2000.
4. Hartl D.L. and E.W. Jones, Essentials of Genetics, third edition. Jones and Bartlett Publishers, Sudbury, USA. 2002.
5. Strickberger M.W., Genetics, Third Edition. Macmillan Publishing, N.Y. London, 1985
6. Klug, W.S. and M.R.Cummings,. Concepts of Genetics. Prentice Hall Inc. 1997
7. Rothwell N.V., Understanding Genetics. Second Edition. Oxford Univ. Press Inc. 1997
8. Tamarin R., Principles of Genetics, Sixth Edition. McGraw-Hill Book Co. Boston. USA. 1999
9. Brooker R.J. Genetics : Analysis and Principles Benjamin/Cummings; 1998
10. Snustad D. P. , M. J. Simmons, Principles of Genetics, Second Edition, John Wiley & Sons; 1999.
11. Lewin B. , Genes VII, 7th edition, Oxford University Press; 1999
12. Weaver, R.F. and P.W. Hedrick. Genetics. Analysis and Principles. Benjamin / Addison, Wesley Longman Inc. 1997.
13. Gardner, A. Principles of Genetics. John Wiley and Sons. 1998.
14. Jones, R.N. and Karp A. Introducing Genetics, John Murray Publishers, London 1994

2. Cell Biology

Introduction	History, development, progress
Prokaryotes & Eukaryotes cell	Differences, uniformity
Structure of plant Cell	Examples from plant, animal, bacteria and viruses
Cell wall:	Physio-chemical structure, ultrastructure
Cell membrane:	Plasma membrane and permeability; membrane transport, receptor proteins and cell to cell interaction
Ultra structure and function of cell organelles	cytoskeleton (Microtubules and microflamants), Endoplasmic reticulum, Golgi complex, Mitochondria, Lysosomes, Ribosomes (80s, 70s, 55s) Plastids, Chloroplast, ultra structure of Nucleous and Nucleolus.
Chromosomes:	Morphology and molecular structure of prokaryotic and eukaryotic chromosome, significance of histones and high mobility proteins in packing of chromosome and gene expression.
Cell Cycle:	synchronizing, Analysis of the control and Models of control of cell cycle.
Mitosis:	General description of mitosis, molecular organization and functional role of apparatus (spindle, kinetochore and anaphasic movement), Cytokinesis and significance of mitosis.
Meiosis:	types of meiosis, the first meiotic division, genetic consequences of meiosis, comparison of mitosis and meiosis.

Practicals:

1. Demonstration of cell structure through photograph of electron microscope
2. Cell structure in the staminal hair of Tradescantia
3. Quantitative determination of following in the cell: proteins, carbohydrates, cellulose and nucleic acids.
4. Mitosis: smear preparation of onion roots
5. Meiosis: smear preparation from anthers of plants such as onion, wheat, maize etc.

Recommended Books:

1. De. Robertis, E.P. and De. Robertis, E.M.F. Cell and Molecular Biology, 8th Edition, , Holt Lea and Fbiger, New York. 2001
2. Darnell, Jr. J. H. Lodisch, and D. Balimore, Molecular Biology of the Cells, Scientific American Inc. N.Y. 1990
3. Alberts, B., D. Bray, J. Lewis, M. Raff, K . Roberts, and J.D. Watson, Molecular Biology of the Cell, Garland Publishing Inc. New York. 1994
4. Lodish, H. D. Baltimore, A. Berk, S.L. Zipursky, P. Matsudaira, J. Darnell, Molecular Biology of the Cell. Scientific American Books, W.H. Freeman and Company, New York. 2001

3. Biochemistry

Carbohydrates: Occurrence, classification, optical activity, structure and molecular configuration, mutarotation and important reactions. A general account of ribose, dexyribose, xylulose, xylose, D-glucose, D-galactose, D-mannose, cellobiose, sucrose, maltose, pentosans, strach, cellulose, hemicellulose, amino sugars, derived acids and alcohols, glycosides, mucilages, pectins and lignins.

Lipids: Occurrence, classification, structure and chemical properties of fatty acids, triglycerides, phospholipids, glycolipids, sulpholipids, waxes, sterols.

Proteins: amino acids and their structure, Electro-chemical properties and reactions of amino acids, classification of proteins, primary, secondary, tertiary and quarternary structure of proteins, Biological role.

Nucleic Acids: General introduction, Purine and Pyrimidine bases, nucleosides, nucleotides, structure and properties of DNA and RNA, types and functions of RNA, chemical synthesis of oligonucleotides and DNA sequencing.

Enzymes: Nature and functions, I.U.E classification with examples of typical groups. Specificity, factors affecting enzyme activity, co-factors, Kinetics, Nature of active site and mode of action, Isozymes, allosteric enzymes and feedback mechanism.

Vitamins: General properties and role in metabolism.

Practicals:

1. Solutions, acids and bases, Electrolytes, non-electrolytes, buffers, pH chemical bonds.
2. To determine the RF value of monosaccharides on a paper Chromatogram.
3. To estimate the amount of vitamin C in a plant organ (orange, apple juice)
4. Analysis of various lipids by TLC methods.
5. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
6. To estimate the amount of propein by Kjeldhl's method
7. To determine the RF value of amino acids on a paper chromatogram
8. Extraction of Nucleic acids from plant or animal materials and their estimation by UV absorption or colour reactions
9. To estimate the catalytic property of enzyme catalase or peroxidase from a plant or animal source.

Recommended Books:

1. Lehninger A.L., Principles of Biochemistry. Worth Publishers Inc. 1998.
2. Lehninger A. L., D. L. Nelson, M. M. Cox, Principles of Biochemistry 3rd edition Worth Publishing; 2000
3. Conn E. E. and P.K. Stumpf, Outlines of Biochemistry, John Wiely and Sons Inc. Publishing Co. New York. , 2002.
4. Boet D., J.G. Voet and C.W. Pratt, Fundamentals of Biochemistry, John Wiley and Sons, New York, 1998
5. Mathews C. K. , K. E. Van Holde, K. G. Ahern, Biochemistry, Third Edition, Benjamin/Cummings; 2000,
6. Robert K. D. K., P. A. M. Granner, V. Rodwell, Harper's Biochemistry, 25th edition McGraw-Hill Professional Publishing; 1999

4. Molecular Genetics

Nucleic acids as hereditary material: structure and types of nucleic acids (DNA & RNA). Watson and Crick's model DNA and RNA replication: models, mechanism and enzymes of replication. Mutation kinds and mutagenic agents. Genetic code. Properties and evidences, deviation from universalities. Gene expression in pro and eukaryotes: Promotors and various consensus sequences, types of RNA polymerase initiation and termination of transcription. Mechanism of splicing and its control, translation of the message. Gene regulation in pro and eukaryotes: Operon concept, *lac* operon and his operon, model for eukaryotic

gene regulation. Gene recombination and DNA repair: Molecular mechanisms of DNA recombination, gene conversion, DNA damage and its repair processes.

Practicals:

1. Bacteriological culture media preparation, autoclave handling, inoculation and handling of bacterial cultures.
2. Simple and differential staining of bacteria and yeasts
3. Detection of Bio chemicals mutants in bacteria and yeasts
4. Induction of mutations in bacteria.
5. Problems relating to theory.

Recommended Books:

1. Weinzierl R. O. J. , Mechanisms of Gene Expression : Structure, Function and Evolution of the Basal Transcriptional Machinery, World Scientific Pub Co; 1999
2. Sarah C. R. Elgin, J. L. Workman, Chromatin Structure and Gene Expression (Frontiers in Molecular Biology, 2nd edition, Oxford University Press, 2001.
3. Hardin C.C., C. C. Harbin, Cloning, Gene Expression and Protein Purification : Experimental Procedures and Process Rationale, Oxford University Press, 2001.
4. Vaillancourt P. E. , E. coli Gene Expression Protocols (Methods in Molecular Biology, Vol 205, Humana Press, 2002.

5. Principle of Breeding

Goals and scope of breeding: Reproductive systems and population control in plants and animals. Incompatibility systems: Male sterility systems. Selection procedures. Role of genotype and environment, continuous variation and heritability, Genetic consequences of hybridization. Genetic basis of inbreeding depression and heterosis. Breeding plans for self and open pollinated populations. Pure line breeding and Mass selection, Pedigree method, Bulk population method in plants, Back cross breeding, Hybrid varieties, Recurrent selection and Synthetic varieties. Breeding for disease and insect resistance in plants. Mutation. breeding, Characters of wild and domestic species, Animal breeding for economic traits.

Practicals:

1. Study of floral biology of economically important plants of the season.
2. Controlled pollination techniques: Emasculation and pollination by different methods.
3. Problems involving self and cross-incompatibility systems. Gametophytic and sporophytic.

4. Study of Phenotypic, genotypic and environmental variations.
5. Estimation of heritability and genetic advance under selection in plants and animals.
6. Experiments with pollen morphology and germination.
7. Estimation of inbreeding depression and heterosis in plants and animals.

Recommended Books:

1. Allard R.W. , Principles of Plant Breeding, 2nd Edition, John Wiley & Sons; 2 edition 1999.
2. Chahal G. S. , S. S. Gosal , Principles and Procedures of Plant Breeding : Biotechnological and Conventional Approaches, CRC Press;2002.
3. Nettancourt D.De, Incompatibility and Incongruity in Wild and Cultivated Plants, Springer Verlag; 2nd edition 2000
4. Richards A. J. , Plant Breeding Systems, Stanley Thornes Pub Ltd; 1997
5. Acram T. P. P. Kumar, Prakash Lakshmanan , In Vitro Plant Breeding Food Products Press 2001
6. Bourdon, R.W..Understanding Animal Breeding. Prentice Hall Inc. Upper Saddle River New Jersey, USA, 2000
7. Ning L., and C.Yongfu, Animal Biotechnology, Intl Academic Pub House, 1997

6. Cytogenetics

Generalized Cell: Cell organelles. Morphology of chromosomes. Ultrastructure of chromosomes. Cell cycle and division. Mitosis and meiosis. Life cycles: fungi, Yeasts, Protozoa, higher plants and animals. Linkage. Crossing over, its mechanism and cytological evidences. Chromosome function: Lyon hypothesis, special types of chromosomes: polytene, lampbrush and B-chromosomes. Position effects. Chromosomal aberrations: Variations in chromosome number and structure. Chromosome systems, (parthenogenesis and aposimis). Induced chromosome doubling and behaviour of chromosomes in interspecific and intergeneric crosses, Molecular cytogenetic techniques.

Practicals:

1. Microscopy; simple , compound, phase contrast, dark field, fluorescent and scanning, transmission electron microscopy
2. Study of mitosis and meiosis in plants and animals.
3. Preparation of permanent slides.
4. Study of special types of chromosomes.
5. Problems on gametogenesis and chromosomal aberrations.
6. Staining techniques.

Recommended Books:

1. Robertis De., E.P. and De. Roberts, E.M.F. Cell and Molecular Biology, 8th Edition, , Holt Lea and Fbiger, New York. 2001
2. Darnell, Jr. J. Lodisch, H. and Balimore, D. Molecular Biology of the Cells, Scientific American Inc. N.Y. 1990
3. Albert's, B., Bray, D. Lewis, J.; Raff, M., Roberts, K and Watson, J.D., Molecular Biology of the Cell, Garland Publishing Inc. New York. 1994
4. Lodish, H. D. Baltimore, A. Berk, S.L. Zipursky, P. Matsudaira, J. Darnell, Molecular Biology of the Cell. Scientific American Books, W.H. Freeman and Company, New York. 2001
5. Swanson, C.P., Merz, T. and Young, W.J. (second edition) Cytogenetics: The chromosome in division, inheritance and evolution. Prentice – Hall Inc. 1990

7. Microbial Genetics

Morphology and life cycles of bacteria and viruses. Recombination in bacteria, transformation, transduction and conjugation, their types, mechanisms and significance. Gene mapping in bacteria: Mode of action of antibiotics and development of resistance Extra chromosomal elements: Plasmids classification with emphasis on R-factors, bacteriocins biodegradative and yeast plasmids. Transposable elements: IS elements (types & function), Muphage-structure, life cycle integration and significance. Transposition, Integrans, Recombination in bacteriophages, virulent and avirulent phages.

Practicals:

1. Growth curve of bacteria
2. Induction of lytic cycle by U.V.
3. Oligodynamic action of metals on bacteria and yeast.
4. Detection of R-plasmids in bacterial strains.
5. Detection of transposons in bacterial strains
6. Curing of bacterial plasmids
7. Detection of mutants using replica plating techniques
8. Transfer of genetic markers through conjugation
9. Gene mapping by interrupted mating in bacteria
10. Detection of mutagenic activity by Ames test/yeast system.

Recommended Books:

1. Maloy S. R. , J. Jr Cronan, D. Freifelder, J. E. Cronan, Microbial Genetics, Second Edition, Jones & Bartlett Pub; 1994
2. Dale J. , Molecular Genetics of Bacteria, 3rd edition, John Wiley & Son Ltd; 1998
3. Streips U. N. , R. E. Yasbin, Modern Microbial Genetics 2nd edition, John Wiley & Sons;2002

4. Adolph K. W., Microbial Gene Techniques (Methods in Molecular Genetics, Vol 6) Academic Press; 1995

8. Biometry

Presentation of data: Bar graph, Pie chart, Frequency polygon, Histogram. Measures of central value; mean median mode. Measures of spread: Range, variance, standard deviation, standard error, co-efficient of variation. Probability: mutually exclusive events, population and samples, random samples, discrete and continuous variables.

Distributions: Binomial, normal and poisson distributions. Introduction to inference: general statistical problem: Estimation and hypothesis testing: t-distribution: hypothesis testing on population mean, comparing two means: pooled t-test and paired t-test. Chi-squared tests: Goodness of fit, test for Association. F-test, analysis of variance (one-way and two way), correlation coefficient, linear regression. Experimental designs: Completely Randomized Design, Randomized Complete block design, Latin Square, Factorial design.

Practicals:

1. Acquisition of random sample from a population, recording data about a continuous variable, and to plot bar graphs, array graphs histogram and frequency polygons.
2. Calculations of the following statistics by different methods (hand method, coding method, by calculator and large sample methods): Mean, standard deviation, variance, standard error, coefficient of variability.
3. Solving problems on probability: simple and two three rules of comparing probabilities.
4. Estimation of population mean
5. Comparison of two population means through unpaired & Paired t-tests.
6. Testing various genetic ratios through chisquared test of goodness of fit and heterogeneity.
7. Problems on Chi-Squared test for independence.
8. Analysis of independence.
9. One and two factor ANOVA in CRD, RCB and Latin Square designs and sub sampling, co-efficients of linear regression and correlation, LSD and Duncan's Multiple Range test, estimation of LD values.

Recommended Books:

1. Benda t.J. S. , A. G. Piersol, Random Data: Analysis & Measurement Procedures third Edition, Wiley-Interscience; 2000
2. Steel R. G. D. , J. H. Torrie, D. A. Dickey, Principles and Procedures of Statistics: A Biometrical Approach, 3rd Edition, McGraw-Hill Higher Education; 1996
3. Sokal R. R. , F. J. Rohlf Biometry : The Principles and Practice of Statistics in Biological Research, 3rd edition, W H Freeman & Co.;1994
4. Zar J. H. , Biostatistical Analysis, Fourth edition, Prentice Hall Co. 1998
5. Stephens K. S. , The Handbook of Applied Acceptance Sampling: Plans, Procedures & Principles, 1st edition, American Society for Quality; 2001
6. Steel, R.G.D. and J.H. Torrie, Principles and Procedures of Statistics: A Biometrical Approach, McGraw Hill International Book Co. 1981
7. Norman G. R. , Streiner, D. L. Streiner, Biostatistics: The Bare Essentials, 2nd edition, B C Decker; 2000

9. Population and Quantitative Genetics

Genetic constitution of a population: Hardy-Weingberg (HW) equilibrium. Changes in gene frequency: Migration, mutation, selection and genetic drift. Inbreeding and heterosis. Variance: components, Genetic and environmental variances. Repeatability. Covariance: Genetic and environmental; offspring and one parent, offspring mild parent, half sibs, full sibs, twins. Estimations of heritability. Selection : response and its prediction. Changes of mean and variance in inbred and crossbred populations. Correlation: Genetic and environmental.

Practicals:

1. Problems on HW law and changes in gene frequencies under migration, mutation, selection and genetic drift.
2. Estimation of phenotypic, genotypic and environmental variances.
3. Partitioning of genetic variance into additive, dominance and epistatic components, and estimation of heritability in board and narrow sense.
4. Calculation of co-efficient of Inbreeding through pedigrees.
5. Estimations of genetic covariance through pedigrees.
6. Problems on Genetic and environmental correlation.

Recommended Books:

1. Lynch M., B. Walsh, Evolution and Selection of Quantitative Traits, Sinauer Associates, Incorporated, 2002
2. Kang M.S. , Quantitative Genetics, Genomics, and Plant Breeding, CABI Publishing, CAB International; 2002
3. Falconer D. S. , F. C.Trudy MacKay, Introduction to Quantitative Genetics Addison-Wesley Pub Co; 4th edition 1996
4. Kearsy M.J., H. S. Pooni, Genetical Analysis of Quantitative Traits, Stanley Thornes Pub Ltd; 1996
5. Weir B. , Genetic Data Analysis III, Sinauer Assoc; 2002
6. Hartl D.L., Andrew G. Clark, Principles of Population Genetics Sinauer Assoc; 1997
7. Hedrick P.W. , Genetics of Populations, Jones & Bartlett Pub; 2000

10. Human Genetics

Patterns of transmission of single gene traits: Pedigree analysis with criteria for identification of various modes of inheritance. Genetic defects in prenatal development; Genetical basis of cancer, Normal chromosomes, congenital malformations, Metabolic variation and diseases: In-born errors in Amino acid, carbohydrate, Lipids and Nucleic acid metabolism, Errors in transport system, Inherited variations, Genetic linkage: Family method, Somatic cell hybridization, deletion mapping and duplication mapping. Eugenics. Twin studies.

Practicals:

1. Study of different qualitative and quantitative traits.
2. Pedigree analysis.
3. Analysis of sex chromosomes in Inter-phase nuclei.
4. Karyotyping of normal and abnormal human chromosomes.
5. Screening of metabolic and other disorders.
6. Dermatology of normal and mentally retarded individuals.
7. Problems solving on genetic counseling.

Recommended Books:

1. Tomn S. A. P. Read, Human Molecular Genetics, 2nd edition, Wiley-Liss 1999.
2. Ehrlich P.R. , Human Natures: Genes, Cultures, and the Human Prospect, 1st edition, Penguin USA Paper, 2002.
3. Relethford J. H. , Genetics and the Search for Modern Human Origins, Wiley-Liss 2001.
4. Annual Review of Genomics and Human Genetics (Annual Review of Genomics and Human Genetics, Vol 2, Annual Reviews, 2001.

5. Dennis C. , R. Gallagher, J. Watson, The Human Genome, 1st edition, Palgrave 2002.

11. Developmental and Behavioral Genetics

Developmental Genetics

Differentiation: The constancy of genome, Differential gene expression at various stages of development: Variation and regulation in RNA, Amino acid and Protein synthesis, Gene activity in Polytene and Lampbrush chromosomes. Role of heterochromatin. Cytoplasmic regulation of gene expression during development: Nuclear Cytoplasmic interactions. Metamorphosis and Regeneration: Sexual differentiation in Mammals.

Behavioural Genetics

Heredity and behavior in Human; Effect of hormone, Behavior due to abnormal chromosome constitution, gene mutation, Psychoses and Socially event behavior, Heredity and I. Q . Scores. Social ethical and legal problems associated with advances in genetics; Paternity Identification, Social and ethical and legal aspects of genetic counseling and screening, Problems resulting from sex selection, Restriction on consanguineous marriages, artificial insemination, legal rights of children. Aging: Memory, Intellectual development.

Recommended Books:

1. Nordgren A. , Responsible Genetics: The Moral Responsibility of Geneticists for the Consequences of Human Genetics Research, Kluwer Academic Publishers, 2001
2. Glannon W. , Genes and Future People: Philosophical Issues in Human Genetics, Westview Press, 2002
3. Laurie G. , Law and Ethics of Genetic Privacy, Cambridge University Press, 2002
4. Plomin R. , John C. Defries, Gerald E. McClearn, McGuffin, Behavioral Genetics W H Freeman & Co.; 4th edition 2000
5. Christine R. B. B., Quantitative Genetic Studies of Behavioral Evolution University of Chicago Press; 1994
6. Plomin R. , Nature and Nurture : An Introduction to Human Behavioral Genetics, Wadsworth Pub Co; 1990
7. Plomin R. , John C. Defries, Gerald E. McClearn, M. Rutter, Behavioral Genetics W H Freeman & Co.; 1997

12. Mutation and Environmental Genetics

Mutations

Spontaneous and induced mutations, types of mutations, mutagenic agents- physical agent, chemical agents, molecular basis of mutations, practical applications of mutations.

Environment

Environmental Science- an interdisciplinary field, ecosystem and natural resources, environmental pollution- air, water, soil, agrochemicals and pesticides, effects of environmental hazards on genetic material- bacteria, plants, animals and humans, biodegradation and bioremediation, chemical and biological warfare

Practicals:

1. Mutation induction by physical and chemical mutagens industrial wastes, Agrochemicals in Bacteria, Yeast, Germinating seeds, *Drosophila*
2. Bioremediation using bacteria, fungi or plant material

Recommended Books:

1. Nga B. H. , H. M. Tan, K. Suzuki, B. Nga, Microbial Diversity in Asia : Technology and Prospects, World Scientific Pub Co; 2001
2. Staley J. T. , A. Reysenbach, Biodiversity of Microbial Life : Foundations of Earth's Biosphere (Wiley Series in Ecological and Applied Microbiology), Wiley-Liss; 2001
3. Moore J. A., J. A. Moore, From Genesis to Genetics The Case of Evolution and Creationism University of California Press ,2002
4. William M. S., Evolutionary Algorithms : The Role of Mutation and Recombination (Natural Computing Series), Springer Verlag; 2000
5. Cook R., Mutation, Berkley Pub Group; Reissue edition 1991
6. Landegren U. , Laboratory Protocols for Mutation Detection, Oxford Univ Press, 1996
7. Cotton R.G.H., E. Edkins, S. Forrester, C.E. Forrester , S. Forrester, Mutation Detection : A Practical Approach (Practical Approach Series (Paper), 1998
8. Burger Reinhard , The Mathematical Theory of Selection, Recombination, and Mutation (Wiley Series in Mathematical and Computational Biology), John Wiley & Sons; 2000
9. Van Harten A. M. , Mutation Breeding : Theory and Practical Applications Cambridge University Press; 1998
10. Woodruff R.C. and John N. Thompson, Mutation and Evolution (Contemporary Issues in Genetics and Evolution, V. 7), Kluwer Academic Publishers;1998

11. Taylor G. R. , Laboratory Methods for the Detection of Mutations and Polymorphisms in DNA, CRC Press; 1997
12. Maier R. M. , I. L. Pepper and C. P. Gerba , Environmental Microbiology, Academic Press 2000
13. Burlage R. S. , R. Atlas, and D. Stahl, Techniques in Microbial Ecology, Academic Press 2000

13. Evolution & Biodiversity

Evolution

The process and concepts of evolution, theories of origin in life, historic idea of evolution, sources of variability, organization of genetic variability in population, synthetic theory of evolution and its development, evolution of genetic systems, genetics of species formation, systems of reproductive isolation and their role in evolution and molecular evolution

Biodiversity

Evaluation, criteria and values, inventory, measuring of biodiversity, *in-situ* and *ex-situ* conservation of living organisms, characteristics of wild and domestic organisms, wild population and some breeds, environmental pollution and biodiversity, genetic conservation.

Practicals:

1. Study of biodiversity of bacteria / plant/ animals
 - a. Morphological characters
 - b. Biochemical characters
 - c. Isozyme patterns on gels
2. Use of database on computers

Recommended Books:

1. Nga B. H. , H. M. Tan, K. Suzuki, B. Nga, Microbial Diversity in Asia : Technology and Prospects, World Scientific Pub Co; 2001
2. Staley J. T. , A. Reysenbach, Biodiversity of Microbial Life : Foundations of Earth's Biosphere (Wiley Series in Ecological and Applied Microbiology), Wiley-Liss; 2001
3. Moore J. A., J. A. Moore From Genesis to Genetics: The case Evolution and Creationism, University of California Press ,2002
4. Spears W.M. , Evolutionary Algorithms : The Role of Mutation and Recombination (Natural Computing Series), Springer Verlag; 2000

14. Genetic Engineering and Biotechnology

Restriction and modification system: types, enzymes, classification, nomenclature, genetics and applications. Cloning vectors: plasmids (Bacterial and yeasts), viruses (Ca, MV, SV40, BPV) phages (lambda, Mu, M13) Cosmids and phasmids. Cutting and joining of DNA molecules: isolation and purification of DNA, cutting of DNA molecules, ligation of DNA molecules, blunt ends and cohesive termini, homopolymer tailing. Cloning strategies; selection and characterization of recombinant molecules, verification and amplification of desired genes, Gene Banks. PCR, RFLP, DNA sequencing techniques. Techniques developed for cloning eukaryotic genes in prokaryotes, host systems available (bacteria, yeast, plant cell, animal cells). Applications of genetic engineering in medicine, agriculture, environmental & molecular biology.

Practicals:

1. Isolation of plasmid and chromosomal DNA from bacteria and yeast.
2. Screening of bacteria for plasmid by electrophoresis of total cell lysate.
3. Gel electrophoresis of plasmid DNA chromosomal DNA & RNA.
4. Plasmid transformation in *E. coli*.
5. Comparing plasmids of different molecular weights using molecular weight markers.

Recommended Books:

1. Old R.W. and S.B. Primrose. Principles of Gene Manipulation, an Introduction to Genetic Engineering (4th edition). Blackwell Scientific Publications. 1994
2. Setlow J.K. , Genetic Engineering: Principles and Methods. Kluwer Academic Publishers. 2000
3. Nicholl D. S. T. , An Introduction to Genetic Engineering, Cambridge University Press, 2002
4. Yount L. , Genetic Engineering, Gale Group, 2002
5. Sambrook J. , D. W. Russell, J. Sambrook, Molecular Cloning: A Laboratory Manual (3-Volume Set), Cold Spring Harbor Laboratory Press, 2001
6. Brown T. A., Gene Cloning and DNA Analysis: An Introduction 4th edition, Blackwell Science Inc 2001

M.Sc.

There will be 12 core courses, which will be taught in M.Sc. Part-I and partially in Part-II. In Part-II special papers/special paper and research will be taken. Following core courses are recommended:

1. Fundamentals of Genetics.
2. Cytogenetics
3. Cell Physiology and Biochemistry
4. Biometry
5. Molecular Genetics
6. Microbial Genetics
7. Principles of Breeding
8. Human Genetics
9. Developmental, Behavioural and Environmental Genetics
10. Quantitative and Population Genetics
11. Genetic Engineering and Biotechnology
12. Mutation, Evolution and Biodiversity

Special papers will be according to the specialization and available expertise of the University.

Contents of 12 core courses are as follows:

1. Fundamentals of Genetics

Laws of inheritance, chromosome theory of inheritance. Various types of alleles and their relationship. Linkage, crossing over and gene mapping in higher eukaryotes. Epistasis and non-epistatic interactions, pleiotropism. Genes and environment: penetrance, expressivity and photocopies. Sex linkage and sex linked inheritance, sex influence, sex limited and holandric genes. Extra nuclear factors: maternal effects and maternal inheritance through mitochondrial and plastid genes. Hetro alleles, complementation and Recombination's.

Practicals:

1. Preparation of culture medium and maintenance of *Drosophila* cultures in lab.
2. Study of morphological characters and setting crosses of *Drosophila*.
3. Verification of Monohybrid and dihybrid F2 ratios.
4. Identification of first and second division segregations in *Neurespora* or *Sordria* asci.
5. Problems involving various type of alleles, gene interaction, linkage, crossing over, gene mapping sex linked inheritance, extra nuclear inheritance and complementation.

Recommended Books:

1. Dunlap J. C. and C-Ting Wu, *Advances in Genetics: Homology Effects*, Academic Press, Incorporated, 2002
2. Griffiths L. G., *Modern Genetic Analysis*, W. H. Freeman Company, 2001
3. Gardner E.J., *Principles of Genetics*, John Wiley and Sons, New York. 1984.
4. Hartl D.L. and E.W. Jones. *Genetic Analysis of Gene and Genomes*. Jones and Bartlett Publishers, Sudbury, USA. 2000.
5. Hartl D.L. and E.W. Jones, *Essentials of Genetics*, third edition. Jones and Bartlett Publishers, Sudbury, USA. 2002.
6. Strickberger M.W., *Genetics*, Third Edition. Macmillan Publishing, N.Y. London, 1985
7. Klug, W.S. and M.R.Cummings,. *Concepts of Genetics*. Prentice Hall Inc. 1997
8. Rothwell N.V., *Understanding Genetics*. Second Edition. Oxford Univ. Press Inc. 1997
9. Tamarin R., *Principles of Genetics*, Sixth Edition. McGraw-Hill Book Co. Boston. USA. 1999
10. Brooker R.J. *Genetics : Analysis and Principles Benjamin/Cummings*; 1998
11. Snustad D. P. , M. J. Simmons, *Principles of Genetics*, Second Edition, John Wiley & Sons; 1999
12. Lewin B. , *Genes VII*, 7th edition, Oxford University Press; 1999
13. Weaver, R.F. and P.W. Hedrick. *Genetics. Analysis and Principles*. Benjamin / Addison,Wesley Longman Inc. 1997.
14. Gardner, A. *Principles of Genetics*. John Wiley and Sons. 1998.
15. Jones, R.N. and A Karp. *Introducing Genetics*, John Murray Publishers, London 1994

2. Cytogenetics.

Generalized Cell: Cell organelles. Morphology of chromosomes. Ultrastructure of chromosomes. Cell cycle and division. Mitosis and meiosis. Life cycles: fungi, Yeasts, Protozoa, higher plants and animals. Linkage. Crossing over, its mechanism and cytological evidences. Chromosome function: Lyon hypothesis, special types of chromosomes: polytene, lampbrush and B-chromosomes. Position effects. Chromosomal aberrations: Variations in chromosome number and structure. Chromosome systems, (parthenogenesis and aposimisis). Induced chromosome doubling and behaviour of chromosomes in interspecific and intergeneric crosses, Molecular cytogenetic techniques.

Practicals:

1. Microscopy; simple , compound, phase contrast, dark field, fluorescent and scanning, transmission electron microscopy

2. Study of mitosis and meiosis in plants and animals.
3. Preparation of permanent slides.
4. Study of special types of chromosomes.
5. Problems on gametogenesis and chromosomal aberrations.
6. Staining techniques.

Recommended Books:

1. Roberts De., E.P. and De. Roberts, E.M.F. Cell and Molecular Biology, 8th Edition, , Holt Lea and Fbiger, New York. 2001
2. Darnell, Jr. J. H Lodisch,. and D. Balimore, Molecular Biology of the Cells, Scientific American Inc. N.Y. 1990
3. Albert's, B., D Bray,. J. Lewis,; Raff, M., Roberts, K and J.D. Watson, , Molecular Biology of the Cell, Garland Publishing Inc. New York. 1994
4. Lodish, H. D. Baltimor, A. Berk, S.L. Zipursky, P. Matsudaira, J. Darnell,.Molecular Biology of the Cell. Scientific American Books, W.H. Freeman and Company, New York. 2001
5. Swanson, C.P., T. Merz, and W.J. Young, (second edition) Cytogenetics: The chromosome in division, inheritance and evolution. Prentice – Hall Inc. 1990

3. Cell Physiology and Biochemistry

Ultra structure function of cell organelles in plants and animals: Metabolism of cellular macromolecules, proteins, carbohydrates, nucleic acids and lipids. Structural and functional changes in malignant cells. Biochemical aspects of hormonal action and its regulation.

Practicals:

1. Microscopical examination of animal and plant cells.
2. Isolation and quantitative estimation of proteins, carbohydrates and nucleic acids.
3. Chromatographic separation of amino acids, carbohydrates and lipids.
4. Response of plant and animal cell to different solute concentrations.

Recommended Books:

1. De. Robert's, E.P. and De. Robertis, E.M.F. Cell and Molecular Biology, 8th Edition, , Holt Lea and Fbiger, New York. 2001
2. Darnell, Jr. J. H. Lodisch, and D. Balimore, Molecular Biology of the Cells, Scientific American Inc. N.Y. 1990
3. Albert's, B., Bray, D. Lewis, J.; Raff, M., Roberts, K and Watson, J.D., Molecular Biology of the Cell, Garland Publishing Inc. New York. 1994
4. Lodish, H. Baltimor, D. Berk, A. Zipursky, S.L. Matsudaira, P. Darnell, J..Molecular Biology of the Cell. Scientific American Books, W.H. Freeman and Company, New York. 2001

5. Lehninger A.L., Principles of Biochemistry. Worth Publishers Inc. 1998.
6. Lehninger A. L., D. L. Nelson, M. M. Cox, Principles of Biochemistry 3rd edition Worth Publishing; 2000
7. Conn E. E. and P.K. Stumpf, Outlines of Biochemistry, John Wiley and Sons Inc. Publishing Co. New York. , 2002.
8. Boet D., J.G Voet AND C.W. Pratt, Fundamentals Of Biochemistry, John Wiley and Sons, New York, 1998
Mathews C. K., K. E. Van Holde, K. G. Ahern, Biochemistry, Third Edition, Benjamin/Cummings; 2000,
9. Robert K. D. K. Granner, P. A. Mayes, V. Rodwell, Harper's Biochemistry, 25th edition McGraw-Hill Professional Publishing; 1999

4. Molecular Genetics

Nucleic acids as hereditary material: structure and types of nucleic acids (DNA & RNA). Watson and Crick's model DNA and RNA replication: models, mechanism and enzymes of replication. Mutation kinds and mutagenic agents. Genetic code. Properties and evidences, deviation from universality. Gene expression in pro and eukaryotes: Promoters and various consensus sequences, types of RNA polymerase transcriptional factors and their sequences involved in transcription initiation and termination of transcription. Mechanism of splicing and its control, translation of the message. Gene regulation in pro and eukaryotes: Operon concept, *lac* operon and his operon, model for eukaryotic gene regulation. Gene recombination and DNA repair: Molecular mechanisms of DNA recombination, gene conversion, DNA damage and its repair processes.

Practicals:

1. Bacteriological culture media preparation, autoclave handling, inoculation and handling of bacterial cultures.
2. Simple and differential staining of bacteria and yeasts
3. Detection of Bio chemicals mutants in bacteria and yeasts
4. Induction of mutations in bacteria.
5. Problems relating to theory.

Recommended Books:

1. Weinzierl R. O. J. , Mechanisms of Gene Expression : Structure, Function and Evolution of the Basal Transcriptional Machinery, World Scientific Pub Co; 1999

2. Sarah C. R. Elgin, J. L. Workman, Chromatin Structure and Gene Expression (Frontiers in Molecular Biology, 2nd edition, Oxford University Press, 2001).
3. Hardin C.C , and C.C. Harbin, Cloning, Gene Expression and Protein Purification : Experimental Procedures and Process Rationale, Oxford University Press, 2001.
4. Vaillancourt P. E. , E. Coli Gene Expression Protocols (Methods in Molecular Biology, Vol 205, Humana Press, 2002).

5. Biometry

Presentation of data: Bar graph, Pie chart, Frequency polygon, Histogram. Measures of central value; mean median mode. Measures of spread: Range, variance, standard deviation, standard error, co-efficient of variation. Probability: mutually exclusive events, population and samples, random samples, discrete and continuous variables.

Distributions: Binomial, normal and poisson distributions. Introduction to inference: general statistical problem: Estimation and hypothesis testing: t-distribution: hypothesis testing on population mean, comparing two means: pooled t-test and paired t-test. Chi-squared tests: Goodness of fit, test for Association. F-test, analysis of variance (one-way and two way), correlation coefficient, linear regression. Experimental designs: Completely Randomized Design, Randomized Complete block design, Latin Square, Factorial design.

Practicals:

1. Acquisition of random sample from a population, recording data about a continuous variable, and to plot bar graphs, array graphs histogram and frequency polygons.
2. Calculations of the following statistics by different methods (hand method, coding method, by calculator and large sample methods): Mean, standard deviation, variance, standard error, coefficient of variability.
3. Solving problems on probability: simple and through three rules of compining probabilities.
4. Estimation of population mean
5. Comparisons of two population means through unpaired & Paired t-tests.
6. Testing various genetic ratios through chisquared test of goodness of fit and heterogeneity.
7. Problems on Chi-Squared test for independence.
8. Analysis of independence.
9. One and two factor ANOVA in CRD, RCB and Latin Square designs and sub sampling, co-efficients of linear regression and correlation, LSD and Duncan's Multiple Range test, estimation of LD values.

Recommended Books:

1. Benda tJ. S. , A. G. Piersol, Random Data: Analysis & Measurement Procedures third Edition, Wiley-Interscience; 2000
2. Steel R. G. D. , J. H. Torrie, D. A. Dickey, Principles and Procedures of Statistics: A Biometrical Approach, 3rd Edition, McGraw-Hill Higher Education; 1996
3. SokalR. R. , F. J. Rohlf Biometry : The Principles and Practice of Statistics in Biological Research, 3rd edition, W H Freeman & Co.;1994
4. Zar J. H. , Biostatistical Analysis, Fourth edition, Prentice Hall Co. 1998
5. StephensK. S. , The Handbook of Applied Acceptance Sampling: Plans, Procedures & Principles, 1st edition, American Society for Quality; 2001
6. Steel, R.G.D. and J.H. Torrie, Principles and Procedures of Statistics: A Biometrical Approach, McGraw Hill International Book Co. 1981
7. Norman G. R. , Streiner, D. L. Streiner, Biostatistics: The Bare Essentials, 2nd edition, B C Decker; 2000

6. Microbial Genetics

Morphology and life cycles of bacteria and viruses. Recombination in bacteria, transformation, transduction and conjugation, their types, mechanisms and significance. Gene mapping in bacteria: Mode of action of antibiotics and development of resistance Extrachromosomal elements: Plasmids classification with emphasis on R-factors, functions bacteriocins biodegradative and yeast plasmids. Transposable elements: IS elements (types & function), Mu phage-structure, life cycle, integration and significance. Transposition, Integrons, Recombination in bacteriophages, virulent and avirulent phages.

Practicals:

1. Growth curve of bacteria
2. Induction of lytic cycle by U.V.
3. Oligodynamic action of metals on bacteria and yeast.
4. Detection of R-plasmids in bacterial strains.
5. Detection of transposons in bacterial strains
6. Curing of bacterial plasmids
7. Detection of mutants using replica plating techniques
8. Transfer of genetic markers through conjugation
9. Gene mapping by interrupted mating in bacteria
10. Detection of mutagenic activity by Ames test/yeast system.

Recommended Books:

1. Maloy S. R. , J. Jr Cronan, D. Freifelder, J. E. Cronan, Microbial Genetics, Second Edition, Jones & Bartlett Pub; 1994
2. Dale J. , Molecular Genetics of Bacteria, 3rd edition, John Wiley & Son Ltd;
3. Streips U. N. , R. E. Yasbin, Modern Microbial Genetics 2nd edition, John Wiley & Sons;2002
4. Adolph K. W. , Microbial Gene Techniques (Methods in Molecular Genetics, Vol 6)Academic Press; 1995

7. Principle of Breeding

Goals and scope of breeding: Reproductive systems and population control in plants and animals. Incompatibility systems: Male sterility systems. Selection procedures. Role of genotype and environment, continuous variation and heritability, Genetic consequences of hybridization. Genetic basis of inbreeding depression and heterosis. Breeding plans for self and open pollinated populations. Pure line breeding and Mass selection, Pedigree method, Bulk population method in plants, Back cross breeding, Hybrid varieties, Recurrent selection and Synthetic varieties. Breeding for disease and insect resistance in plants. Mutation. breeding, Characters of wild and domestic species, Animal breeding for economic traits.

Practicals:

1. Study of floral biology of economically important plants of the season.
2. Controlled pollination techniques: Emasculation and pollination by different methods.
3. Problems involving self and cross-incompatibility systems. Gametophytic and sporophytic.
4. Study of Phenotypic, genotypic and environmental variations.
5. Estimation of heritability and genetic advance under selection in plants and animals.
6. Experiments with pollen morphology and germination.
7. Estimation of inbreeding depression and heterosis in plants and animals.

Recommended Books:

1. Allard R.W. , Principles of Plant Breeding, 2nd Edition, John Wiley & Sons; 2 edition 1999
2. Chahal G. S. , S. S. Gosal , Principles and Procedures of Plant Breeding : Biotechnological and Conventional Approaches, CRC Press;2002
3. De Nettancourt D., Incompatibility and Incongruity in Wild and Cultivated Plants Springer Verlag; 2nd edition 2000
4. Richards A. J. , Plant Breeding Systems, Stanley Thornes Pub Ltd; 1997

5. Taji A., Prakash P. Kumar, Prakash Lakshmanan , In Vitro Plant Breeding Food Products Press 2001
6. Bourdon, R.W..Understanding Animal Breeding. Prentice Hall Inc. Upper Saddle River New Jersey, USA, 2000
7. Ning L., and C.Yongfu, Animal Biotechnology, Intl Academic Pub House, 1997

8. Human Genetics

Patterns of transmission of single gene traits: Pedigree analysis with criteria for identification of various modes of inheritance. Genetic defects in prenatal development; Genetical basis of cancer, Normal chromosomes, congenital malformations, Metabolic variation and diseases: In-born errors in Amino acid, carbohydrate, Lipids and Nucleic acid metabolism, Errors in transport system, Inherited variations, Genetic linkage: Family method Somatic cell hybridization, deletion mapping and duplication mapping. Eugenics. Twin studies.

Practicals:

1. Study of different qualitative and quantitative traits.
2. Pedigree analysis.
3. Analysis of sex chromosomes in Inter-phase nuclei.
4. Karyotyping of normal and abnormal human chromosomes.
5. Screening of metabolic and other disorders.
6. Dermatology of normal and mentally retarded individuals.
7. Problems solving on genetic counseling.

Recommended Books:

1. Tomn Strachan, Andrew P. Read, Human Molecular Genetics, 2nd edition, Wiley-Liss 1999.
2. Ehrlich P. R. , Human Natures: Genes, Cultures, and the Human Prospect, 1st edition, Penguin USA Paper, 2002.
3. Relethford J. H. , Genetics and the Search for Modern Human Origins, Wiley-Liss 2001.
4. Annual Review of Genomics and Human Genetics (Annual Review of Genomics and Human Genetics, Vol 2, Annual Reviews, 2001.
5. Dennis C. , R. Gallagher, J. Watson, The Human Genome, 1st edition, Palgrave 2002.

9. Developmental, Behavioural and Environmental Genetics

Developmental Genetics

Differentiation: The constancy of genome, Differential gene expression at various stages of development: Variation and regulation in RNA, Amino acid and Protein synthesis, Gene activity in Polytene and Lampbrush chromosomes. Role of heterochromatin. Cytoplasmic regulation of gene expression during development: Nuclear Cytoplasmic interactions. Metamorphosis and Regeneration: Sexual differentiation in Mammals.

Behavioural Genetics

Heredity and behavior in human and animals; Effect of hormone, Behavior due to abnormal chromosome constitution, gene mutation, Psychoses and socially event behavior, Heredity and I. Q . scores. Social ethical and legal problems associated with advances in genetics; Genetic counseling, Artificial insemination, Legal rights of children. Aging: Memory, Intellectual development.

Environmental Genetics

Environmental science as an interdisciplinary field, Ecosystem and natural resources, Environmental pollution air, water, soil, Agrochemicals and pesticides, Effects of environmental hazards on genetic material, Chemical and biological warfare.

Recommended Books:

1. Nordgren A. , Responsible Genetics: The Moral Responsibility of Geneticists for the Consequences of Human Genetics Research, Kluwer Academic Publishers, 2001
2. Glannon W. , Genes and Future People: Philosophical Issues in Human Genetics, West view Press, 2002
3. Laurie G. , Privacy, Cambridge University Press, 2002.
4. Plomin R. , C. Defries, Gerald E. McClearn, McGuffin, Behavioral Genetics W H Freeman & Co.; 4th edition 2000
5. Christine R. B. Boake, Quantitative Genetic Studies of Behavioral Evolution University of Chicago Press; 1994
6. Plomin R. , Nature and Nurture : An Introduction to Human Behavioral Genetics, Wadsworth Pub Co; 1990
7. Plomin R. , C. John. Defries, Gerald E. McClearn, M Rutter, Behavioral Genetics W H Freeman & Co.; 1997
8. Maier R. M. , I. L. Pepper and C. P. Gerba (Editor)Environmental Microbiology, Academic Press 2000
9. Burlage R. S. , R. Atlas, and D. Stahl, Techniques in Microbial Ecology, Academic Press 2000

10. Population and Quantitative Genetics

Genetic constitution of a population: Hardy-Weingberg (HW) equilibrium. Changes in gene frequency: Migration, mutation, selection and genetic drift. Inbreeding and heterosis. Variance: components, Genetic and environmental variances. Repeatability. Covariance: Genetic and environmental; offspring and one parent, offspring mild parent, half sibs, full sibs, twins. Estimation of heritability. Selection : response and its prediction. Changes of mean and variance in inbred and crossbred populations. Correlation: Genetic and environmental.

Practicals:

1. Problems on HW law and changes in gene frequencies under migration, mutation, selection and genetic drift.
2. Estimation of phenotypic, genotypic and environmental variances.
3. Partitioning of genetic variance into additive, dominance and epistatic components, and estimation of heritability in board and narrow sense.
4. Calculation of co-efficient of Inbreeding through pedigrees.
5. Estimations of genetic covariance through pedigrees.
6. Problems on Genetic and environmental correlation.

Recommended Books:

1. Lynch M. B. Walsh, Evolution and Selection of Quantitative Traits, Sinauer Associates, Incorporated, 2002
2. Kang M.S. , Quantitative Genetics, Genomics, and Plant Breeding, CABI Publishing, CAB International; 2002
3. Falconer D. S. , Trudy F. C. MacKay, Introduction to Quantitative Genetics Addison-Wesley Pub Co; 4th edition 1996
4. Kearsey M.J., H. S. Pooni, Genetical Analysis of Quantitative Traits, Stanley Thornes Pub Ltd; 1996
5. Bruce W. , Genetic Data Analysis III, Sinauer Assoc; 2002
6. Hartl D.L., Clark A.C., Principles of Population Genetics Sinauer Assoc; 1997
7. Hedrick P.W. , Genetics of Populations, Jones & Bartlett Pub; 2000

11. Genetic Engineering and Biotechnology

Restriction and modification system: types, enzymes, classification, nomenclature, genetics and applications. Cloning vectors: plasmids (Bacterial and yeasts), viruses (Ca, MV, SV40, BPV) phages (lambda, Mu, M13) Cosmids and phasmids. Cutting and joining of DNA molecules: isolation and purification of DNA, cutting of DNA molecules, ligation of DNA molecules, bluntends and cohesive termini, homopolymer tailing. Cloning strategies; selection and

characterization of recombinant molecules, verification and amplification of desired genes, Gene Banks. PCR, RFLP, DNA sequencing techniques. Techniques developed for cloning eukaryotic genes in prokaryotes, host systems available (bacteria, yeast, plant cell, animal cells). Applications of genetic engineering in medicine, agriculture, environmental & molecular biology.

Practicals:

1. Isolation of plasmid and chromosomal DNA from bacteria and yeast.
2. Screening of bacteria for plasmid by electrophoresis of total cell lysate.
3. Gel electrophoresis of plasmid DNA chromosomal DNA & RNA.
4. Plasmid transformation in *E. coli*.
5. Comparing plasmids of different molecular weights using molecular weight markers.

Recommended Books:

1. Old R.W. and S.B. Primrose. Principles of Gene Manipulation, an Introduction to Genetic Engineering (4th edition). Blackwell Scientific Publications. 1994
2. Setlow J.K. , Genetic Engineering: Principles and Methods. Kluwer Academic Publishers. 2000
3. Nicholl D. S. T. An Introduction to Genetic Engineering, Cambridge University Press, 2002
4. Yount L. , Genetic Engineering, Gale Group, 2002
5. Sambrook J. , D. W. Russell, J. Sambrook, Molecular Cloning: A Laboratory Manual (3-Volume Set), Cold Spring Harbor Laboratory Press, 2001
6. Brown T. A., Gene Cloning and DNA Analysis: An Introduction 4th edition, Blackwell Science Inc 2001

12. Mutation, Evolution & Biodiversity

Mutations

Spontaneous and induced mutations, types of mutations, mutagenic agents physical agent, chemical agents, molecular basis of mutations, practical applications of mutations.

Evolution

The process and concepts of evolution, theories of origin in life, historic idea of evolution, sources of variability, organization of genetic variability in population, synthetic theory of evolution and its development, evolution of genetic systems, genetics of species formation, systems of reproductive isolation and their role in evolution and molecular evolution.

Biodiversity

Evaluation, criteria and values, inventory, studying biodiversity, *in situ* and *ex-situ* conservation of living organisms, characteristics of wild and domestic organisms, wild population and some breeds, environmental pollution and biodiversity, genetic conservation

Practicals:

1. Mutation induction by physical and chemical mutagens industrial wastes, Agrochemicals in Bacteria, Yeast, Germinating Seeds, *Drosophila*
2. Study of biodiversity of bacteria / plant / animals
 - a. Morphological characters
 - b. Biochemical characters
 - c. Isozyme patterns on gels
3. Use of database on computers.

Recommended Books:

1. Nga B. H. , H. M. Tan, K. Suzuki, B. Nga, Microbial Diversity in Asia : Technology and Prospects, World Scientific Pub Co; 2001
2. Staley J. T. , A. Reysenbach, Biodiversity of Microbial Life : Foundations of Earth's Biosphere (Wiley Series in Ecological and Applied Microbiology), Wiley-Liss; 2001
3. Moore J. A., J. A. Moore From Genesis to Genetics: The case Evolution and Creationism, University of California Press ,2002
4. Spears W.M. , Evolutionary Algorithms : The Role of Mutation and Recombination (Natural Computing Series), Springer Verlag; 2000
5. Cook R. Mutation, Berkley Pub Group; Revised edition 1991
6. Landegren U. Laboratory Protocols for Mutation Detection, Oxford Univ Press, 1996
7. Richard G, H. Cotton, E. Edkins, S. Forrester. Mutation Detection : A Practical Approach (Practical Approach Series (Paper), 1998
8. Burger R. The Mathematical Theory of Selection, Recombination, and Mutation (Wiley Series in Mathematical and Computational Biology), John Wiley & Sons; 2000
9. Van Harten A. M. Mutation Breeding : Theory and Practical Applications Cambridge University Press; 1998
10. Woodruff R.C. and John N. Thompson, Mutation and Evolution (Contemporary Issues in Genetics and Evolution, V. 7), Kluwer Academic Publishers;1998
11. Taylor G. R. Laboratory Methods for the Detection of Mutations and Polymorphisms in DNA, CRC Press; 1997

B.Sc.(Hons)-Genetics 4-year Programme

B.Sc (Hons) in Genetics 4-year programme will be a new addition to the existing set up. It will be comparable with overseas degrees.

It is strongly suggested that Computer, Mathematics and Biochemistry should be taught as compulsory subjects. The other optional subjects are Microbiology, Botany, Zoology, Physiology and Chemistry.

The courses like English, Islamiat, Pakistan Studies will be taught as compulsory subjects as per existing system in the country. In the first three years 14 core courses are suggested while in 4-year either special papers (16 credit hours according to specialization and expertise available in the universities) or special paper (8 credit hours) and research (8 credit hours) is recommended.

The core courses are same as in the B. Sc (Hons) 3-year programme, however, the credit hours and the course allocations in a given semester will be decided by the relevant Board Studies to fit in their existing system.

RECOMMENDATIONS

1. Realizing the importance of Genetics the committee (NCRC-Genetics) strongly recommends that Master's programme (M.Sc.) in Genetics should be introduced in all the public universities with prerequisite of the subject.
2. The committee (NCRC-Genetics) recommends that Genetics in B.Sc PASS should be introduced as an optional subject. The basic requirements, trained personnel be arranged in respective colleges and refresher courses should be organized for college teachers at regular intervals.
3. As Genetics is a vital component of biomedical sciences, therefore the committee (NCRC Genetics) strongly feels that genetics should be taught as a compulsory subject at all medical and dental colleges. With the advancement in immunology, diagnostic, human genetic disorders, genetic counseling and gene therapy, teaching of genetics in medical sciences is direly needed.
4. The curriculum should be revised at regular intervals.
5. Recently computer science as an optional subject has been introduced at high school level as alternate subject to biology. This committee strongly feels that with this policy, biological sciences will be gradually eliminated in future, while the demand of the country is to strengthen biological sciences. Computer is a tool used in biological sciences. Hence the revision in this policy is imperative. This committee recommends that computer science should be made compulsory course like English etc. but not at the expense of biology.

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