CURRICULUM

OF

GENETICS

For

BS (Hons) & MS (Hons)

(Revised 2006)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

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

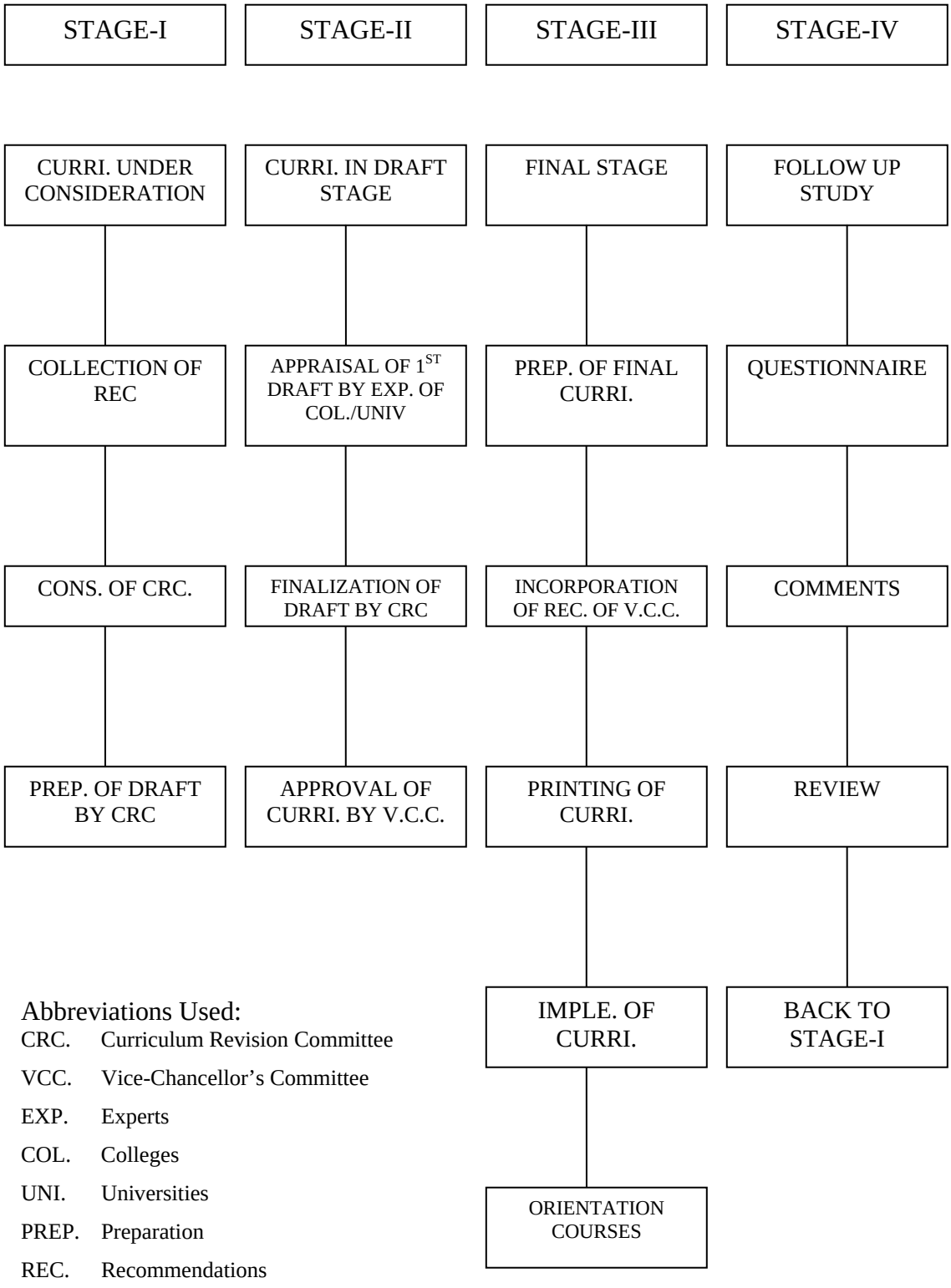
In exercise of the powers conferred by sub-section (1) of section 3 of the Federal Supervision of Curricula Textbooks and Maintenance of Standards of Education Act 1976, the Federal Government vide notification no. D773/76-JEA (Cur.), dated December 4, 1976, appointed University Grants Commission as 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 Higher Education Commission (HEC) is continually performing curriculum revision in collaboration with universities. According to the decision of the special meeting of 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 universities. Teachers from local degree colleges and experts from user organizations, where required, are also included in these committees. The National Curriculum Revision Committee for Genetics in its meeting held in May 15 – 17, 2006 at the HEC Regional Centre, Karachi revised the curriculum after due consideration of the comments and suggestions received from universities and colleges where the subject under consideration is taught. The final draft prepared by the National Curriculum Revision Committee duly approved by the Competent Authority is being circulated for implementation by architectural institutions.

(PROF. DR. ALTAF ALI G. SHAIKH)
Adviser (Acad/R&D)

August 2006

CURRICULUM DEVELOPMENT



Abbreviations Used:

CRC.	Curriculum Revision Committee
VCC.	Vice-Chancellor's Committee
EXP.	Experts
COL.	Colleges
UNI.	Universities
PREP.	Preparation
REC.	Recommendations

INTRODUCTION

Final meeting of the National Curriculum Revision Committee (NCRC) in Genetics was held at HEC Regional Center Karachi from 15th to 17th May, 2006. The Committee drafted the curriculum for BS (Hons) 4-year and MS (Hons) 2-year in the discipline of Genetics.

The following experts participated:

Sr.	Name & Address	Responsibility
1.	Prof. Dr. Hidayat-ur-Rahman, Chairman, Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar	Convener
2.	Prof. Dr. Farzana Nasir Naqvi, Professor & Chairperson, Department of Genetics, University of Karachi, Karachi	Member
3.	Dr. Ali Nawaz Channa, Professor, Department of Plant Breeding and Genetics, Sindh Agriculture University, Tandojam	Member
4.	Prof. Dr. Faqir Muhammad Azhar, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad	Member
5.	Prof. Dr. Ghulam Sarwar Markhand, Department of Botany, Shah Abdul Latif University, Khairpur	Member
6.	Prof. Dr. Nuzhat Ahmed, Director, Centre of Molecular Genetics, University of Karachi, Karachi.	Member
7.	Prof. Dr. Iftikhar H. Khalil, Associate Professor, NWFP Agricultural University, Peshawar	Member
8.	Dr. Rehana Asghar, Associate Professor, Department of Botany, University of Arid Agriculture, Rawalpindi	Member
9.	DR. Nazia Jamil, Lecturer, Department of Microbiology, University of the Punjab, Lahore	Member

10.	Mr. Waqar Ali, Lecturer, Department of Biotechnology, University of Malakand	Member
11.	Mrs. Erum Shoeb, Lecturer, Department of Genetics, University of Karachi, Karachi	Member
12.	Mr. Tanzeem Akbar Cheema, Department of Botany, Government College University, Katchery Road, Lahore	Member

The meeting started with the recitation of the Holy Qur`an. Muhammad Tahir Ali Shah, Assistant Director (Curriculum), HEC, Islamabad welcomed the participants on behalf of the Chairman Higher Education Commission. He briefed the participants regarding the need for review/revision and development of unified curricula for the universities and degree awarding Institutions at National level.

Mr. Muhammad Tahir Ali Shah, in his opening remarks, informed the members that the HEC is striving hard to enhance quality of education by making curricula of the universities more compatible with international standards, job oriented and to match the needs of society. He informed the members of the committee of different academic programs of the commission which are aimed at facilitating the universities in the execution of their programs, including repair and maintenance of laboratories, provision of books for libraries, indigenous and overseas scholarships, digital library, provision of computers and other modern tools like internet etc.

Mr. Tahir Ali circulated the comments received from Dr. Jamal Nasir, expatriate Pakistani expert and Prof. Dr. Nuzhat Ahmad, Ex-Convener of the NCRC in Genetics on the draft curriculum in Genetics for consideration of the Committee.

Mr. Muhammad Tahir Ali Shah, Assistant Director (Curriculum) acted as Coordinator of meeting and facilitated all the technical sessions. He also briefed the members of the Committee regarding procedure for review/revision and development of the curriculum.

Prof. Dr. Hidyat ur Rahman thanked the house for posing confidence in him. The committee, after three days discussion finalized the curriculum for 4-year BS (Hons) and 2-year MS (Hons) in the discipline of Genetics.

Bachelor of Science BS (Hons) in Genetics

Eligibility

Intermediate or Equivalent with not less than 45% marks

Duration

Four years program spread over 8 semesters with two Semesters per Year.

Degree Requirement

Minimum of 130 Credits are required to complete Bachelor of Science in Genetics.

Evaluation

For the uniformity in the evaluation system, NCRC recommends that the minimum CGPA required to pass a semester is 2.0 out of 4.0 at undergraduate level.

Scheme of Study for 4 Year BS (Hons) Genetics

Total Credit Hours 136

C No.	Semester 1	Cr. Hrs.	C No.	Semester 2	Cr. Hrs.
ENG300	English	3 (3+0)	ENG 300	English	3 (3+0)
GEN301	Cell Biology	3 (2+1)	GEN302	Principles of Genetics	3 (2+1)
MAT300	Mathematics - I	3 (3+0)	MAT300	Mathematics – II	3 (3+0)
CS300	Introduction to Computing	2 (1+1)	SOC300	Sociology	2 (2+0)
300	Elective –I*	3 (2+1)	300	Elective –I*	3 (2+1)
300	Elective – II*	3 (2+1)	300	Elective –II*	3 (2+1)
	Total	**17**		**Total**	**17**
	Semester 3	**Cr. Hrs.**		**Semester 4**	**Cr. Hrs.**
ENG400	English	3 (3+0)	ENG400	English (Communication Skills)	3 (3+0)
GEN401	Genetics and Evolution	3 (2+1)	GEN403	Molecular Biology	3 (2+1)
GEN402	Principles of Biochemistry	4 (3+1)	GEN404	Biometry – I	3 (2+1)
PS400	Pakistan Studies	2 (2+0)	ISL400	Islamic Studies/Ethics	2 (2+0)
400	Elective –I	3 (2+1)	400	Elective-I	3 (2+1)
400	Elective –II	3(2+1)	400	Elective-II	3 (2+1)
	Total	**18**		**Total**	**17**
	Semester 5	**Cr. Hrs.**		**Semester 6**	Cr. Hrs.
GEN501	Cytogenetics	4 (3+1)	GEN506	Introduction to Biotechnology	3 (2+1)
GEN502	Molecular Genetics	4 (3+1)	GEN507	Genetic Engineering	4 (3+1)
GEN503	Microbial Genetics	4 (3+1)	GEN508	Human Genetics	3 (2+1)
GEN504	Population Genetics	3 (2+1)	GEN509	Biometry – II	4 (3+1)
GEN505	Principles of Breeding	3 (2+1)	GEN510	Bioinformatics	3 (2+1)
	Total	**18**		**Total**	**17**
	Semester 7	**Cr. Hrs.**		**Semester 8**	**Cr. Hrs.**
GEN601	Biosafety and Bioethics	3 (3+0)	GEN606	Immunogenetics	3(3+0)
GEN602	Developmental Genetics	3 (3+0)	GEN607	Germplasm Resources	3(2+1)
GEN603	Physiological Genetics	4 (3+1)			
GEN604	Research Techniques	4 (2+2)	GEN608	Special Paper-I	3(0+0)
GEN605	Project Planning and Report Writing	3 (3+0)	GEN609	Special Paper-II/Research Project.	1(0+1)
GEN608	Seminar-I	1 (0+1)		Seminar-II	
	Total	**18**		**Total**	**13**

*** Select from list of Minor (Elective Subjects)**

[$] Student can opt for special paper or research project in the 8th semester.

List of Courses for 4 - Year BS (Hons) Genetics

A. Core Course

Course No. Courses	Credit Hours
GEN301 – Cell Biology	3(2+1)
GEN302 – Introductory Genetics	3(2+1)
GEN401 – Principles of Genetics	3(2+1)
GEN402 – Principles of Biochemistry	4(3+1)
GEN403 – Molecular Biology	3(2+1)
GEN404 – Biometry – I	3(2+1)
GEN501 – Cytogenetics	4(3+1)
GEN502 – Molecular Genetics	4(3+1)
GEN503 – Microbial Genetics	4(3+1)
GEN504 – Population Genetics	3(2+1)
GEN505 – Principles of Breeding	3(2+1)
GEN506 – Introduction to Biotechnology	3(2+1)
GEN507 – Genetic Engineering	4(3+1)
GEN508 – Human Genetics	3(2+1)
GEN509 – Biometry – II	4(3+1)
GEN510 – Bioinformatics	3(0+3)
GEN601 – Biosafety and Bioethics	3(3+0)
GEN602 – Developmental Genetics	3(3+0)
GEN603 – Physiological Genetics	4(3+1)
GEN604 – Research Techniques	4(2+2)
GEN605 – Project Planning and Report Writing	3(3+0)
GEN606 – Immunogenetics	4(4+0)
GEN607 – Germplasm Resources	4(3+1)
GEN608 – Seminar	1(0+1)
GEN609 – Internship with Report Writing and Seminar	4(0+4)

B. Elective Courses

1. Microbiology
2. Botany
3. Zoology
4. Physiology
5. Chemistry
6. Biochemistry

C. Compulsory Courses

1. English
2. Islamiyat
3. Pakistan Studies

D. Supporting Courses

1. Mathematics
2. Sociology
3. Introduction to Computing

COURSE CONTENTS BS (Hons) GENETICS
4 – YEAR DEGREE PROGRAM

GEN301 - Cell Biology 3 (2 + 1)

Theory:

History, development, progress. Uniformity and differences in prokaryotic and eukaryotic cells. Ultrastructure of cell and cell organelles: plant, animal, bacteria and viruses. Cell wall: physico-chemical structure, Plasma membrane and permeability; receptor proteins and cell to cell interaction. Cytoskeleton (microtubles and microfilaments), endoplasmic reticulum, golgi complex, mitochondria, lysosomes, ribosomes (80s, 70s, 55s) plastids, nucleus and nucleolus.
Chromosomes: morphology and molecular structure of prokaryotic and eukaryotic chromosomes, significance of histones and high mobility proteins in packing of chromosome and gene expression. Cell Cycle:synchronizing and regulation of cell cycle.
General description of mitosis, organization and functional role of apparatus, cytokinesis and significance of mitosis. Meiosis, significance and genetic consequences of meiosis, comparison of mitosis and meiosis.

Practicals:

- Handling and use of various microscopes.
- Demonstration of cell structure through micrograph of electron microscope.
- Cell structure in plants and animal specimen.
- Histochemical staining of proteins, carbohydrates, lipids and nucleic acids.
- Mitosis: smear preparation of onion roots.
- Meiosis: smear preparation from insects and plants.

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. Alberts, B., A. Johnson, J. Lewis, M. Raff, K . Roberts, and P. Walter. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.
3. Alberts, B., D. Bray, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, Essential Cell Biology, 2nd Ed. Garland Publishing Inc. New York. 2002.
4. Lodish, H., D. Baltimore, A. Berk, S.L. Zipursky, P. Matsudaira, and J. Darnell, Molecular Biology of the Cell. 5th Ed. Scientific American Books, W.H. Freeman and Company, New York. 2005

GEN302 – Principles of Genetics 3(2+1)

Theory:

Definition and genesis (history) of genetics. Heredity and variation. Chromosomal theory of inheritance. Mendel's laws of inheritance. Gene interaction; genotypic and phenotypic ratios. Multiple alleles, Multiple factor hypothesis and use of binomial theorum. Linkage and crossing over and their calculations, gene mapping. Sex linkage, sex determination and sex linked inheritance, sex influenced, sex limited and holandric genes. Genetic material.

Gene and environment: penetrance, expressivity, pleiotropism and phenocopies. Twin studies, nature and nurture. Mutations. Extra–nuclear inheritance: maternal effects and maternal inheritance. Qualitative and quantitative inheritance.

Practicals:

- Preparation of culture medium and maintenance of *Drosophila* cultures in lab.
- Problems related to Mendelian inheritance, gene interaction, gene mapping.
- Blood groups-ABO blood groups and Rh factors

Recommended Books:

1. Dunlap J. C. and C-Ting Wu, Advances in Genetics: Homology Effects, Academic Press, Incorporated, 2002
2. Griffiths, A.J.F, J.H. Miller, D.T. Suzuki, R.C. Lewontin and M.W. Gelbart. Introduction to Genetic Analysis. W. H. Freeman Company, 2005
3. Gardner E.J., J. Simmons, and D.P. Snustad. Principles of Genetics, 3rd Ed. John Willey and Sons, New York. 2004.
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. Klug, W.S. and M.R. Cummings. Concepts of Genetics. Prentice Hall Inc. 2004.
7. RothWell N.V., Understanding Genetics. Second Edition. Oxford Univ. Press Inc. 1997
8. Brooker R.J. Genetics: Analysis and Principles. 2nd Ed. McGraw-Hill Book Co. Bostan. USA. 2005
9. Snustad D. P. , M. J. Simmons, Principles of Genetics, 4th Ed, John Wiley and Sons; 2006.

GEN401 – Genetics and Evolution 3(2+1)

Theory:

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.

Recommended Books:

1. Strickberger, M.W. Evolution. John and Bartlett, NY, USA. 2000.
2. Willis, K.J. and J.C. McElwain. Evolution of Plants. Oxford University press, Oxford, UK. 2002.

GEN402 – Principles of Biochemistry 4(3+1)

Theory:

Macromolecules: Introduction and biological role of macromolecules. Carbohydrates: Occurrence, classification, chemistry and metabolism. Optical activity, structure and molecular configuration, mutarotation and important reactions. Lipids: Occurrence, classification, structure and chemistry of fatty acids. Proteins: Amino acids occurrence, classification, structure, and chemistry. Classification of proteins: primary, secondary, tertiary and quarternary structure of proteins. Nucleic Acids: General introduction, purine and pyrimidine bases, nucleosides, nucleotides, structure and properties of DNA and RNA, types and functions of RNA, biosynthesis of oligonucleotides. General properties and role of enzymes, hormones and vitamins in metabolism.

Practicals:

- Preparation of standard solutions and buffers.
- Chromatographic separation of amino acids, carbohydrates, lipids, etc.
- Quantification of macro-molecules.
- Estimation of enzyme activity from plant or animal source.
- Estimation of vitamin in a given specimen.

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 4th edition Worth Publishing; 2004
3. Conn E. E. and P.K. Stumpf, Outlines of Biochemistry, John Wiley 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
7. Stryer, L. Biochemistry. 6th Ed. W.H. Freeman Co. 2006.

GEN403 – Molecular Biology 3(2+1)

Theory:

Introduction and history of molecular biology. Central dogma of molecular biology. Molecular nature of hereditary material, nucleic acid metabolism, relationship between DNA, chromosome and genome. DNA replication, transcription, initiation factors, *Cis/Trans* elements, post transcriptional modifications of RNA. Translation, post-translational modifications in polypeptides. Gene organization, gene expression in prokaryotes and eukaryotes. Mutagenesis. DNA repair mechanisms and DNA recombination.

Practicals:

1. Extraction and estimation of macromolecules (DNA, RNA and proteins)
2. Qualitative separation of macromolecules using electrophoresis.

Recommended Books

1. Albert, B., A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.
2. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., and Darnell, J. E. Molecular Cell Biology. 4th Ed. 2004, New York, USA.
3. Lewin, B. Genes-VIII. 8th Ed. Oxford University Press, UK. 2004.

GEN404 – Biometry – I 3(2+1)

Theory:

Introduction to biometry, population and samples. random samples, discrete and continuous variables. Presentation of data: Bar graph, Pie chart, frequency polygon, histogram. Measures of central value; mean median mode. Measures of variability: range, variance, standard deviation, standard error, co-efficient of variation. Probability: mutually exclusive events. 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-square tests: goodness of fit and test of association. F-test.

Practicals:

- Acquisition of random sample from a population, recording data about a continuous variable, and to plot bar graphs, array graphs histogram and frequency polygons.
- Calculations of the following statistics by different methods (hand method, coding method, by calculator and large sample methods): Mean, standard deviation, variance, standard error, co-efficient of variability.
- Solving problems on probability.
- Estimation of population mean
- Compressions of two population means through unpaired and paired t-tests.
- Testing various genetic ratios through Chi-square test of goodness of fit and heterogeneity.
- Problems on Chi-square test for independence.

Recommended Books:

1. Benda tJ. S., A. G. Piersol, Random Data: Analysis and 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 and 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 and Principles, 1st edition, American Society for Quality; 2001
6. Norman G. R., Streiner, D. L. Streiner, Biostatistics: The Bare Essentials, 2nd edition, B C Decker; 2000
7. Lindsey, J.K. Introduction to Applied Statistics: A modeling approach. 2nd Ed.2004.
8. Mead, R., R.N. Curnow, and A.M. Hasted. Statistical methods in Agriculture and Experimental Biology. 3rd Ed. Chapman and Hall/CRC. 2003.

GEN501 – Cytogenetics 4 (3+1)

Theory:

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 and 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 apomixis). Induced chromosome doubling and behaviour of chromosomes in interspecific and intraspecific crosses, molecular cytogenetic techniques.

Practicals:

- Microscopy; simple , compound, phase contrast, dark field, fluorescent and scanning, transmission electron microscopy
- Study of mitosis and meiosis in plants and animals.
- Preparation of permanent slides.
- Study of special types of chromosomes.
- Problems on gametogenesis and chromosomal aberrations.
- 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.
6. Singh, R.J. Plants Cytogenetics. 2nd Ed. CRC Press, USA. 2002.

GEN502 – Molecular Genetics 4(3+1)

Theory:

Introduction to molecular genetics. Molecular basis of heredity. Structure and types of nucleic acids. Watson and Crick's model of DNA. DNA replication: models, mechanism and enzymes of replication. Genetic code. Properties and evidences, deviation from universality. Gene expression in pro and eukaryotes: Promotors and various consensus sequences, types of RNA polymerase initiation and termination of transcription, differences in pro

and eukaryotes. Mechanism of splicing and its control, translation of the message, post translational modifications. Gene regulation in pro and eukaryotes: Operon concept, *lac* operon and *his* operon, factors involved in eukaryotic gene regulation. Gene recombination. Molecular mechanisms of DNA recombination, gene conversion. Mutation: kinds and mutagenic agents. DNA damage and repair mechanisms.

Practicals:

- Bacteriological culture media preparation, autoclave handling, inoculation and handling of bacterial cultures.
- Quantitative estimation of DNA and RNA.
- Detection of biochemical mutants in bacteria, yeasts and plants.
- Induction of mutations in prokaryotes and eukaryotes.
- Numerical problems related 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. Rapley, R. Molecular analysis and genome discovery. John Wiley & Sons. 2004.
6. Lewin, B. Genes-VIII. 8th Ed. Oxford University Press, UK. 2004.

GEN503 – Microbial Genetics 4(3+1)

Theory:

Introduction to 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, bio-degradative and yeast plasmids. Transposable elements: IS elements (types and function), virulent and avirulent phages, bacteriophages and recombination. Mu-phage and HIV structure, life cycle integration and significance. Transposition, Integrons, Prions.

Practicals:

- Simple and differential staining of bacteria and yeasts.
- Growth curve of bacteria
- Induction of lytic cycle by U.V.
- Oligodynamic action of metals on bacteria and yeast.
- Detection of R-plasmids in bacterial strains.
- Curing of bacterial plasmids
- Detection of mutants using replica plating techniques
- Transfer of genetic markers through conjugation
- Gene mapping by interrupted mating in bacteria
- 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 and Bartlett Pub; 1994
2. Dale J. , Molecular Genetics of Bacteria**,** 3rd edition, John Wiley and Sons Ltd; 1998
3. Streips U. N., R. E. Yasbin, Modern Microbial Genetics 2nd edition, John Wiley and Sons;2002
4. Adolph K. W., Microbial Gene Techniques (Methods in Molecular Genetics, Vol. 6. Academic Press; 1995.
5. Trun, N. and J. Trempy. Fundamental bacteria genetics. Blackwell Pub Co. 2004.

GEN504 – Population Genetics 3(2+1)

Theory:

Introduction to population genetics. Genetic constitution of a population: Hardy-Weinberg (HW) equilibrium. Changes in gene and genotype frequency: migration, mutation, selection and genetic drift. Inbreeding, inbreeding coefficient. components of genetic variance: additive, dominance and epistatic. Repeatability. Covariance: genetic and environmental; offspring and one parent, offspring mid 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:

- Problems on changes in gene frequencies under migration, mutation, selection and genetic drift.
- Estimation of phenotypic, genotypic and environmental variances.
- Partitioning of genetic variance into additive, dominance and epistatic components, and estimation of heritability in broad and narrow sense.
- Calculation of co-efficient of inbreeding through pedigrees.

- Estimations of genetic covariance through pedigrees.

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. Kearsey 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 and Bartlett Pub; 2000

GEN505 – Principles of Breeding 3(2+1)

Theory:

Introduction to plant and animal breeding. Reproductive systems and population control in plants and animals. Incompatibility systems: Male sterility systems. Selection procedures. Creation of variation. 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. Breeding procedures in poultry and animals. Mutation breeding. Characters of wild and domestic species. Breeding for economic traits.

Practicals:

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

Recommended Books:

1. Allard R.W. Principles of Plant Breeding, 2nd Edition, John Wiley and 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. Chahal, G,S. and S.S. Gosal. Principles and Procedures of Plant Breeding. Narose Publishers, India. 2003.
4. Nettancourt D.De, Incompatibility and Incongruity in Wild and Cultivated Plants, Springer Verlag; 2nd edition 2000
5. Richards A. J., Plant Breeding Systems, Stanley Thornes Pub Ltd; 1997
6. Acram T. P. P. Kumar, Prakash Lakshmanan, In Vitro Plant Breeding Food Products Press. 2001
7. Bourdon, R.M. Understanding Animal Breeding. Prentice Hall Inc. Upper Saddle River New Jersey, USA, 2000
8. Ning L., and C. Yongfu, Animal Biotechnology, Intl Academic Pub House, 1997.

GEN506 – Introduction to Biotechnology 3(2+1)

Theory:

Concepts, historical background, conventional and modern biotechnology: kinds of biotechnology, Plant biotechnology: plant tissue culture and GM Crops. Environmental Biotechnology: Bioremediation. Biological control. Industrial biotechnology: fermentation techniques, bio products, (enzymes, amino acids etc). Medical biotechnology: diagnostic tools, health care products. Aquatic biotechnology: aqua culture, and sea food resources. Bio processing. Economic perspectives of biotechnology. Biotech COs and Bio Industries.

Practicals:

- Bio degradation, toxic chemicals especially aromatics (pesticides & crude oil components)
- Bio accumulation/Bio absorption of heavy metals by bacteria, fungi, protozoa, and plants.
- Solubalization of insoluble metal complexes.
- Production of bio polymers
- Plant tissue culture technology

Recommended Books

1. Bernard R. Glick and Jack J Pastermak (ASM Press). *Molecular Biotechnology*. 2003.
2. Chopra, V. L., V. S., Malik, and S. R. Bhat. Plant Biotechnology. Oxford IBH Publishers New Delhi. 2000.
3. Attedge, C. R. and B. Kristiansen. 2001. Basic Biotechnology, Cambridge University, Press UK.

GEN507 – Genetic Engineering 4(3+1)

Theory:

Basic concepts in recombinant DNA technology. Restriction and modification system: types, enzymes, classification, nomenclature, genetics and applications.

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 vectors: plasmids (Bacterial and yeasts), viruses (WES lambda, CMV, SV40, BPV) phages (lambda, Mu, M13) Cosmids and phasmids, YACs, BACs and PACs. 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 and molecular biology.

Practicals:

- Isolation of plasmid and chromosomal DNA from bacteria and yeast.
- Screening of bacteria for plasmid by electrophoresis of total cell lysate.
- Gel electrophoresis of plasmid DNA chromosomal DNA and RNA.
- Plasmid transformation in *E. coli.*
- Comparing plasmids of different molecular weights using molecular weight markers.
- PCR technique
- RFLP analysis

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

GEN508 – Human Genetics 3(2+1)

Theory:

Introduction to human genome. Karyotyping. Patterns of transmission of single gene traits: Pedigree analysis with criteria for identification of various modes of inheritance. Genetic defects in prenatal development; oncogenes and cancer, normal chromosomes, congenital malformations. Metabolic variation and diseases: In-born errors of metabolism, Errors in transport system, Inherited variations, genetic linkage: family method, somatic cell hybridization, deletion mapping and duplication mapping. Eugenics. Twin studies. Human genome project.

Practicals:

- Study of different qualitative and quantitative traits.
- Pedigree analysis.
- Analysis of sex chromosomes in Inter-phase nuclei.
- Karyotyping of normal and abnormal human chromosomes.
- Screening of metabolic and other disorders.
- Dermatology of normal and mentally retarted individuals.
- Problems solving on genetic counseling.

Recommended Books:

1. Strachan, T., A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor & Francis. 2003.
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.

GEN509 – Biometry – II 4(3+1)

Theory:

Analysis of variance and covariance. Correlation and regression Analysis. Completely randomized design, randomized complete block design, Latin Square, split plot arrangements and factorial design. Mean separation test: LSD and DMR. Concepts of heritability and their role in selection of biological organisms.

Practicals:

- Analysis of Variance of data involving one and two factors following CRD, RCBD and Latin Square designs.

- Comparisons of means using LSD and DMR tests.
- Co-efficients of linear regression and correlation.
- Data Analysis using computer programme.

Recommended Books

1. Bendat J. S., A. G. Piersol, Random Data: Analysis and 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 and 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 and Principles, 1st edition, American Society for Quality; 2001
6. Norman G. R., Streiner, D. L. Streiner, Biostatistics: The Bare Essentials, 2nd edition, B C Decker; 2000.
7. Kearsey, M.J. and M.S. Pooni. The Genetical Analysis of Quantitative Traits. Chapman and Hall Ltd., London, UK. 1996.

GEN510 – Bioinformatics 3(2+1)

Theory:

Introduction to bioinformatics, computer applications in biology, softwares for data retrieving and analysis, plant genome and human genome. Genomics and proteomics data, Pairwise sequence alignment, Multiple sequence alignment, Construction of phylogenetic trees.

Practicals:

- Different search engines for nucleotides and proteins

Recommended Books:

1. David Mount. 2001. Bioinformatics: Sequence and Genome Analysis. ISBN: 9-87969-608-7.
2. R. Durbin, S. Eddy, A. Krogh and G. Mitchison. 1998. Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids. ISBN: 0-521-62971-3.

GEN601 – Biosafety and Bioethics 3(3+0)

Theory:

Personnel monitoring, laboratory monitoring, biohazards, pathogens and viral safety, radioactive elements and their handling, protection from carcinogenic elements. Safety regulations of GMOs. Transgenic crops and biopesticides. Biosafety rules. Uses and abuses of genetic information. Documentation. Intellectual property rights.

Ethical, moral and religious issues regarding LMOs. Reproductive technologies. Artificial insemination; *in vitro* fertilization (IVF), gamete intrafallopian transfer (GIFT), zygote intrafallopian transfer (ZIFT), surrogacy; drug abuse during pregnancy. RU-486, involuntary sterilization. Genetic screening, gene therapy, transgenic organisms, agricultural applications. Fetal tissue transplantation; xenografts, AIDS, disclosure, transmission- health care industry, right-to-die transplantation and Xenografting, advance directives, living wills, physician assisted Suicide.

Recommended Books:

1. O'Mahony, P.J. Nature, Risk and Responsibilities: Discourses of Biotechnology. Rothedge Publishers. 1999.
2. Cutter, S.I. Environmental Risks and Hazards. Prentice Hall. 1993.
3. Torrance, I. Bioethics for New Millennium. Saint Andrew Press. 2000.
4. Donnellan, C. The Ethics of Genetic Engineering. Independent Educational Publications. 1998.
5. Donnellan, C. Cloning (Issues). Independent Educational Publications. 2002.

GEN602 – Developmental Genetics 3(3+0)

Theory:

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. Introduction to stem cell research and gene therapy.

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.
5. Plomin R., John C. Defries, Gerald E. McClearn, McGuffin, Behavioral Genetics W H Freeman and Co.; 4th edition 2000.
6. Christine R. B. B., Quantitative Genetic Studies of Behavioral Evolution University of Chicago Press; 1994.
7. Plomin R., Nature and Nurture: An Introduction to Human Behavioral Genetics, Wadsworth Pub Co; 1990.

GEN603 – Physiological Genetics 4(3+1)

Theory:

Plants, microbes and environment. Genes and proteins related to biotic and abiotic stress. Physiological and genetic mechanisms of stress tolerance. Gene families responsible for stress resistance (DREB, HAL, RAB, LEA, Dehydrin, CRY). Genes controlling the pathways responsible for salt, drought, heat, cold, radiation, and oxygen stresses.

Practicals:

- Effect of various concentrations of salts on seed germination and seedling growth
- Effect of various stresses on microbial growth.
- Characterization of heat shock proteins by SDS – PAGE.

Recommended Books:

1. Hall, A. Crop Response to Environment. CRC Press. 2000.
2. Hails, R.S., J. Beringer, and H.C.J. Godfray. Genes in the Environment. Blackwell Publishing.
3. Heribert, H. and K. Shinozaki. Plant Responses to abiotic Stress. 4th Ed. Springer Verlag. 2003.

GEN604 – Research Techniques 4(2+2)

Theory:

Microscopy, centrifugation, spectroscopy, chromatography, and electrophoresis. Genomic DNA extraction, plasmid extraction, PCR, DNA fingerprinting. Transformation, screening of transformed cells, restriction enzyme analysis and genotyping, dialysis.

GEN605 – Project Planning and Report Writing 3(3+0)

Theory:

Planning research project: definition of research, problem identification and feasibility analysis, validity of problem, objectives and goals, development of hypothesis, source and review of literature, reference writing for books, journals, anonymous, internet etc. Use of digital libraries for research.

Preparation of a research report, types of research reports, structure, graphics, initial writing, rewriting and editing, evaluation of a research report, general evaluation criteria, types-specific evaluation criteria.

Recommended Books:

1. Arifullah, S. and K. M. Bhatti. 1998. Research process simplified. PanGraphic (Pvt) Limited, Islamabad.
2. Jones, A., R. Reed and J. Weyers. 1994. Practical skills in Biology. Longman Scientific and Technical.
3. O'Connor, M. 1993. Writing successfully in science. Chapman anf Hall. N. Y.
4. Hashmi, N. 1983. Style manual of technical writing. Pakistan Economic Analysis
5. Network Project. Islamabad

GEN606 – Immunogenetics 3(3+0)

Theory:

Introduction to components of immune system, anti-body response; nature of anti-bodies, structure and heterogeneity of immunoglobulin, allelic exclusion; monoclonal anti bodies. Inheritance of immune response capacities; Immune tolerance; specific immune response variations, human IR genes, anti-genic variation: genetic pathways for synthesis of A, B &O antigens, secretor loci, Rh factor, other blood groups. Compatibility of blood antigens. Histo compatibility: transplantation: HLA complex, HLA haplotypes, MHC/HLA and diseases, Immunological diseases: immune deficiency diseases, AIDS, auto immune diseases, inherited abnormalities of complement system.

Recommended Books:

1. Myrvik, W. Fundamentals of immunology. 2nd Ed. LEA & Febiger. 1984.
2. Veir, D,M. Immunology. 5th Ed. Churchill Living Stone. 1983.
3. Abbas, A.K., A.H. Lichtman, J,S. Pober. Cellular and molecular immunology. 4th Ed. WB Saunders Co. 2000.
4. Roitt, I and P.J. Delves. Roitts Essential Immunology. 10th Ed. Blackwell Science. 2001.
5. Dixon, F.J., F. Alt, and K.F. Austen. Advances in Immunology. Vol. 75. Academic Press. 2000.

GEN607 Germplasm Resources 3(2+1)

Theory:

Importance of genetic resources in genetic research. Centers of origin and distribution pattern of crop and animal species. Synthetic crop species. Exploration of genetic resources. Wild relatives of cultivated crops. Principles and strategies of germplasm collection, maintenance, evaluation and conservation. Role of molecular techniques in identification and preservation of genetic resources. Introduction to national and international germplasm banks.

Practicals:

- Collection and identification of crop species.
- Visits to botanical gardens, museums, gene banks, hatcheries.

Recommended Books:

1. Muhammad, A., R. Aksel and R.C. Vonborstel. Genetic Diversity in Plants. Plenum Press NY, USA. 1977.
2. Brown, A.H.D., O.H. Frankel, D.R. Marshall, and J,T. Williams. The use of Plant Genetic Resources. Cambridge University Press, UK. 1989.
3. Bhillon, B.S., R.K. Tyagi and A. Lal. Plant Genetic Resources Management, Narosa, N. Delhi, India. 2004.

GEN608 – Seminar-I 1(0+1)

Presentation on recent topics in genetics in consultation with the departmental faculty.

GEN609– Seminar-II 1(0+1)

Presentation on recent topics in genetics in consultation with the departmental faculty.

MS (Hons) (2-year) Program in Genetics

MS 2-year program in Genetics will spread over 4-semesters, comprising two semesters of course work and two semesters of research. The students will be required to submit course work having 24 credit hours. In addition, there will be 6-credit hours of thesis research. The core courses will be compulsory for all students and 3-4 optional courses to be recommended by the supervisory committee of the student concerned.

List of MS Courses

A. Core Courses

Course No. Course	Credit Hours
GEN701 – Advanced Cytogenetics	3(2+1)
GEN702 – Advanced Molecular Genetics	3(2+1)
GEN703 – Biometrical Techniques in Genetics	3(2+1)
GEN704 – Bioinformatics	3(2+1)
GEN795 – Seminar	1(0+1)

B. Optional Courses

Each optional course will carry 3-credit hours. The student will be required to take 3-4 optional courses from the following during the ist year of the MS program.

GEN705 – Genomics
GEN706 – Clinical Genetics
GEN707 – Biosafety and Bioethics
GEN708 – Evolutionary Genetics
GEN709 – Behavioral Genetics
GEN710 – Biochemical Genetics
GEN711 – Cancer Genetics
GEN712 – Ecological Genetics
GEN713 – Molecular Genetics of Yeast
GEN714 – Gene Mapping
GEN715 – Proteomics
GEN716 – Aquatic Biotechnology
GEN717 – Human Molecular Genetics
GEN718 – Treatment of Genetic Diseases
GEN719 – Animal Breeding
GEN720 – Plant Breeding
GEN721 – Bioremediation and Biodegradation
GEN722 – Bionanotechnology

C. Research Project

GEN799 – Thesis 6(0+6)

GEN701 – Advanced Cytogenetics 3(2+1)

Theory:

Cell cycle and division. Chromosome morphology, heterochromatic and euchromatic chromosomes. Chromosome banding. Changes in chromosome structure and number, aneuploidy, its origin and sources. Trisomics, monosomics, nullisomics, transmission and factors influencing transmission, breeding and genetic behaviour, genetic ratios and uses of trisomics and monosomics. Euploidy: autopolyploidy; occurrence and general characteristics. Haploids vs monoploids artificial production of haploids and dihaploids. Theoretical genetic ratios for single gene locus, genetic data, linkages in autopolyploids. Allopolyploid; origin, evidences of homology between chromosomes. Univalents: genetic and breeding behaviour. Aneuploids in plants, insects and animals. Chromosomal identification in different genomes. Chromosome mapping. Special methods of locating genes. Polyploidy and evolution, polyploidy in speciation. Apomixis and its role in plant breeding.

Practicals:

- Karyotyping.
- Chromosome banding techniques.
- Chromosomal aberrations.
- Special chromosomes.
- In-situ hybridization, GISH and FISH

Recommended Books:

1. Schulz-Schaeffer, J. 1981. Cytogenetics. Plants, animal, humans. Springer-Verlag, New York. USA.
2. Srivastava, S. 1996. Chromosome and Inheritance. Recent Advances in Genetic Series.
3. Swanson, C.P., T. Merz and W.J. Young. 1981. Cytogenetics. 2nd ed. Prentice Hall international Inc., englewood Cliff, NJ, USA.
4. Snustad, D.P., M.J. Simmons and J.B. Jenkin,.1997. Principles of Genetics. John Wiley and Sons Inc. New York.
5. Lodish, H., D. Baltimore, A. Berk, S.L. Zipursky, P. Matsudaira, and J. Darnell, Molecular Biology of the Cell. 5th Ed. Scientific American Books, W.H. Freeman and Company, New York. 2005.
6. Clive, R.E. Cytogenetics of Animals. 1989.
7. Henderson, D.S. Drosophila Cytogenetics Protocols. Humana Press. 2004.

GEN702 – Advanced Molecular Genetics 3(2+1)

Theory:

Nucleic acids. Plant and animal viruses (DNA and RNA) and their importance in molecular biology. Tumor viruses, retroviruses, conjugation, gene mapping, transformation and transduction, Integration of viral DNA, consequences of Integration. Transposition: transposable elements, detection of transposition in bacteria, types of bacterial transposons, modes of transposition in bacteria. Genetic phenomena mediated by transposons, transposable elements in prokaryotes and eukaryotes. Gene expression in pro- and eukaryotes. Genetic transformation (all kinds). Regulation of simple and complex transcription unit. Current developments in molecular genetics: molecular techniques viz. Southern, Northern and Western blotting, PCR, RFLP, AFLP's, RAPDs, Micro-sattelites, SNPs.

Practicals:

- Isolation of nucleic acids, qualitative and quantitative measurement of concentration, digestion with specific restriction enzymes and gel electrophoresis.
- Plasmid isolation and characterization.
- Denaturation and renaturation of DNA.
- Orientation with different molecular techniques including PCR, RFLP, AFLPs, RAPDs, etc.

Recommended Books

1. Alberts, B., A. Johnson, J. Lewis, M. Raff, K . Roberts, and P. Walter. Molecular Biology of the Cell, 4th Ed. Garland Publishing Inc. New York. 2002.
2. Watson, J,D., T.A. Baker, S.P. Bell, A. Gann, M. Levine, and R. Losick. Molecular biology of the gene. Pearson Education. 2004.
3. Snyder, L. and W. Chapness. Molecular Genetics of bacteria. ASM Press, 2003.
4. Lewin, B. Gene-VIII. Oxford University Press, Oxford, UK. 2004.

GEN703 – Biometrical Techniques in Genetics 3(2+1)

Theory:

Objectives and scope: law of probability, binomial and normal distributions. Expectations of mean square for main effects and interactions in ANOVA. Use of regression and correlation in selection, reliability of path analysis. Estimation of variance components using various biometrical techniques. Estimation of heritability and its use in selection. Covariance analysis. Genotype vs environment interaction and adaptation; the biological complexity of genotype vs environment interaction. Scaling tests, degree of dominance and potence ratio. Nested and confounding experiments.

Practicals:

- Assumptions behind the analysis.
- Normality, homogeneity, additivity, transformation of data for theoretical reasons. Genotypic and phenotypic correlations, their estimation with test of significance. Correlated response to selection.
- Analytical methods to assess stability.
- Estimation of genetic components from generation mean analysis.

Recommended Books:

1. Becker, W.L. 1993. Manual of Quantitative Genetics. Washington State University Press, Pullman, Washington, USA.
2. Falconer, D.S. and T.F.C. Mackay. 1996. Introduction to Quantitative Genetics. Longman Group Ltd. London, U.K.
3. Comstock, R.E. 1996. Quantitative Genetics with special reference to Plants and animal breeding. Ist ed. Iowa State University Press, Ames, Iowa, USA.
4. Singh, R.K and B.D. Chaudhary. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, N. Delhi, India. 1997.
5. Kearsey, M.J. and M.S. Pooni. The Genetical Analysis of Quantitative Traits. Chapman and Hall Ltd., London, UK. 1996.

GEN704 – Bioinformatics 3(1+2)

Theory:

Softwares for data retrieving and analysis, Genome projects: microbes, plants, animals and human. Genomic and proteomic data, pair-wise sequence alignment, predicting the structure and function of DNA, RNA, and proteins from their primary sequences. Multiple sequence alignment, Construction of phylogenetic trees. Sequence analysis, genome annotation, computational evolutionary biology, measuring biodiversity, gene expression and regulation analysis, protein analysis, mutations analysis in cancer, structure prediction, modeling biological systems, high throughput image analysis.

Practicals:

- Different search engines for nucleotides and proteins.

Recommended Books:

1. Mount, D. Bioinformatics: Sequence and Genome Analysis. 2001.
2. R. Durbin, S. Eddy, A. Krogh and G. Mitchison. Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids. 1998.
3. Krawetz, A,. and D. Womble. Introduction to Bioinformatics. (A Theoretical and Practical Approach). Shumana Press, USA. 2002.
4. Rastugi, S.C., N. Mendiratta and P. Rastugi. Bioinformatics: concepts, skills and applications. CBS Publishers. 2003.

Optional Courses

CONTENTS FOR OPTIONAL COURSES
(SAMPLE)

GEN706 – Clinical Genetics

Theory:

Molecular approach in understanding various inherited disorders: cystic fibrosis, *thalassaemia*, sickle cell anemia, haemophilia, Huntington's chorea, muscular dystrophies, diabetes. Pharmacogenetics, Genetics of cancer, oncogenes, tumor suppresser genes, heritable cancer. *In vitro* fertilization and embryo transfer. Eugenics: genetic screening, prenatal diagnosis, approaches to linkage polymorphism. Gene therapy and genetic counseling.

Practicals:

- Qualitative separation of normal and defective haemoglobins.
- Detection of carrier and infected individuals in natural population; *thallasaemia.*
- Inherited variation in different isozyme patterns: acid phosphatase; G-6-P-dehydrogenase.
- Comparative analysis of serum protein in normal and disease individuals: cancer.
- Detection and calculation of gene frequency of various blood groups.
- Problem solving on linkage polymorphism.
- Visit to hospitals

Recommended Books:

1. Strechan, T., and A. P. Read, Human Molecular Genetics, 3rd edition, Garland Science/Taylor & Francis. 2003.
2. Lewis, R. Human Genetics: concepts and applications. 6th ed. McGraw Hill. 2005.

GEN707 – Biosafety and Bioethics

Theory:

Definition and history of laboratory acquired bloodborne infections. Risk associated with handling human/animal blood, body fluids, tissue samples (including human and animal cell lines). Significant exposure. Risks associated with microbes. The classification of organisms on the basis of hazard. Precautions, prevention and minimizing risks. Vaccination requirements. Post-exposure management. Biosafety in laboratory. Viral vectors. The application of fundamental biosafety principles to recombinant microbes. Biosafety of the common agents, potential hazards of radioisotopes, external/internal protection techniques, external/internal

dosimetry, instrumentation, policies and procedures. Personnel monitoring and documentation. Ethical, moral and religious issues regarding LMOs. Reproductive technologies. Artificial insemination; *in vitro* fertilization (IVF), gamete intrafallopian transfer (GIFT), zygote intrafallopian transfer (ZIFT), surrogacy; drug abuse during pregnancy. RU-486, involuntary sterilization. Genetic screening, gene therapy, transgenic organisms, agricultural applications. Fetal tissue transplantation; xenografts, AIDS, disclosure, transmission- health care industry, right-to-die transplantation and Xenografting, advance directives, living wills, physician assisted suicide.

Recommended Books:

1. O'Mahony, P.J. Nature, Risk and Responsibilities: Discourses of Biotechnology. Rothedge Publishers. 1999.
2. Cutter, S.I. Environmental Risks and Hazards. Prentice Hall. 1993.
3. Torrance, I. Bioethics for New Millennium. Saint Andrew Press. 2000.
4. Donnellan, C. The Ethics of Genetic Engineering. Independent Educational Publications. 1998.
5. Donnellan, C. Cloning (Issues). Independent Educational Publications. 2002.

GEN708 –Evolutionary Genetics

Theory:

Theories of evolution. Origin of life and genome integration. Evolution of genetic code. Different mechanisms of gene change. Effect of changes in gene frequencies and change of recombinational potential on speciation. Modes of selection under natural conditions. Role of mutation in evolution: spontaneous and induced mutations, Molecular basis of mutations. Phylogenetic classification and evolution from pro to eukaryotes. Evolution of chromosomes. Genetic polymorphism and heterozygosity. Evolution of different plants and animals.

Practicals:

- Mutation induction by physical and chemical mutagens, industrial wastes, Agrochemicals in Bacteria, Yeast, Germinating Seeds, *Drosophila*
- Inter and intra-specific variations in plants/animals
    - Morphological traits
    - Biochemical parameters
- Use of database on computers.

Recommended Books:

1. Ridley, M. Evolution. 3rd Ed. Blackwell. 2004.
2. Moore J. A., and J. A. Moore. From Genesis to Genetics: The case of Evolution and Creationism, University of California Press ,2002

3. Spears W.M. , Evolutionary Algorithms : The Role of Mutation and Recombination (Natural Computing Series), Springer-Verlag, 2000
4. Burger R. The Mathematical Theory of Selection, Recombination, and Mutation (Wiley Series in Mathematical and Computational Biology), John Wiley and Sons; 2000
5. Van Harten A. M. Mutation Breeding: Theory and Practical Applications Cambridge University Press; 1998
6. Woodruff R.C. and John N. Thompson, Mutation and Evolution (Contemporary Issues in Genetics and Evolution, V. 7), Kluwer Academic Publishers;1998
7. Taylor G. R. Laboratory Methods for the Detection of Mutations and Polymorphisms in DNA, CRC Press; 1997

RECOMMENDATIONS

1. The National Curriculum Revision Committee (NCRC) recommends that BS 4–Year program in Genetics should be introduced in all pubic sector Universities.
2. The committee recommends that Genetics in 2 years B.Sc. program should be introduced as an optional subject in colleges.
3. As Genetics is a vital component of biomedical sciences, therefore the committee reaffirms that Genetics should be taught as a compulsory subject at all medical and dental colleges.
4. The curriculum should be revised at regular intervals.
5. The committee recommends that computer lab facilities should be provided to BS (Hons) and MS (Hons) students to keep up with the pace of developments in the field of Genetics and Bioinformatics.
6. The committee recommends that a model lab (Annexure – I) having minimum facilities of microscopy, cell, tissue and organ culture, PCR, chromatography, electrophoresis, dialysis, spectrophotometry etc. needs to be established at all institutions of the country offering degree program in Genetics.
7. Refresher courses for faculty members of the institutions, offering degree program in Genetics, needs to be organized by HEC frequently, to update the faculty with latest developments in their area of expertise.
8. All the universities/institutions should arrange mandatory trainings of health and safety for faculty, staff and students handling hazardous materials in the lab.
9. The committee recommends that the HEC should provide sufficient funds to cater the financial needs for the newly introduced internship program (research project) for the final year students of BS and MS degree programs.
10. Adequate funds be allocated for replenishing the departmental libraries with latest text books and scientific journals.
11. HEC should initiate and finance a program for bright students to study special courses in other universities where better facilities and expertise are available.
12. The committee suggests that the revised curricula for Genetics be placed on HEC website for seeking suggestions for possible improvement.

MODEL LAB EQUIPMENT REQUIREMENTS FOR BS (Hons) and MS (Hons) GENETICS DEGREE PROGRAMMES

Annexure - I

No.	**Equipment**
1	Electronic balance Analytical Digital Top Loading
2	Stereomicroscope binocular
3	Compound Microscope
4	Incubator Digital
5	Magnetic stirrer with Hot Plate
6	Orbital shaker
7	Gel electrophoresis
8	Electric Supply for electrophoresis (Power Pack)
9	Ovens
10	Gel documentation System
11	Tissue homogenizer
12	Thermal Cycler (PCR)
13	UPS 10,000 Watt (local)
14	UPS 20,000 Watt (local)
15	UPS Running All Lab APCC 2.6KVA
16	- 25 ºC Freezer Upright Digital
17	Autoclave
18	pH Meter
19	Ordinary Digital Balance
20	Fume Hood
21	Vortex Mixer
22	Ice Making Machine (Flaked)
23	Laminar Flow Hood
24	Rotary Shaker
25	Computer P IV
26	Printer HP Laserjet 1300
27	8 – Multi - Channel Research Pipettes i) 0.5-10ul ii) 10-100 ul iii) 30-300ul
28	12- Multi - Channel Research Pipettes i) 0.5-10ul ii) 10-100 ul iii) 30-300ul
29	Single Channel Research Pipettes (Various Sizes)
30	Repeater Pipettor
31	Combitips plus
32	Microtome Digital
33	UV Biophotometer
34	Growth Chamber (Local)

35	HPLC
36	UV Lamp
37	Autostill
38	Incubator Shaker
39	Power Station 2.6 KVac
40	drying cabinet
41	multiple tube rack vortex mixer
42	vaccuum filteration assembly
43	Rotary Evaporator
44	Chiller
45	Digital Camera 5 Mega pixel for Field
46	vaccuum pump
47	water tap operated vaccuum pump
48	cold room cabinet
49	double pan balance manual
50	fraction collector
51	Chromatography columns complete set
52	peristaltic pump
53	UV code
54	centrifuges low and high speed with rotors and accessories
55	2 - D Gel Electrophoresis
56	nitrogen cylinder
57	CO_2 Incubator
58	Water baths
59	Refrigerators
60	Double Distillation Unit with ionizer and reverse osmosis
61	DNA sequencer Single Adjustable
62	Camera Digital 7.2 mega pixel
63	Laboratory washer