CURRICULUM

OF

GENETICS

For

BS (Hons) & MS (Hons)

(Revised 2006)

HIGHER EDUCATION COMMISSION
ISLAMABAD
CURRICULUM DIVISION, HEC

Prof. Dr. Syed Altaf Hussain  
Member (Acad/R&D)

Prof. Dr. Altaf Ali G. Shaikh  
Former Adviser (Acad/R&D)

Dr. Soofia Mumtaz  
Adviser (Acad)

Malik Ghulam Abbas  
Deputy Director

Miss Ghayyur Fatima  
Deputy Director (Curri)

Mr. M. Tahir Ali Shah  
Assistant Director

Mrs. Noshaba Awais  
Assistant Director

Mr. Shafiullah Khan  
Assistant Director

Composed by Mr. Zulfiqar Ali, HEC Islamabad
CONTENTS

1. Introduction 7

2. Curriculum for BS (Hons) level:
   i) Scheme of Studies 9
   ii) Details of Courses 11

3. Curriculum for MS (Hons) level:
   i) Scheme of Studies 28
   ii) Details of Courses 29

4. General Recommendations 35
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

STAGE-I
CURRI. UNDER CONSIDERATION
COLLECTION OF REC
CONS. OF CRC.
PREP. OF DRAFT BY CRC
APPROVAL OF CURRI. BY V.C.C.
IMPLEMENTATION OF CURRI.
ORIENTATION COURSES
BACK TO STAGE-I

STAGE-II
CURRI. IN DRAFT STAGE
APPRaisal OF 1ST DRAFT BY EXP. OF COL./UNIV
FINALIZATION OF DRAFT BY CRC
PRINTING OF CURRI.

STAGE-III
FINAL STAGE
PREP. OF FINAL CURRI.
INCORPORATION OF REC. OF V.C.C.

STAGE-IV
FOLLOW UP STUDY
QUESTIONNAIRE
COMMENTS

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:

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

<table>
<thead>
<tr>
<th>C No.</th>
<th>Semester 1</th>
<th>Cr. Hrs.</th>
<th>C No.</th>
<th>Semester 2</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG300</td>
<td>English</td>
<td>3 (3+0)</td>
<td>ENG300</td>
<td>English</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>GEN301</td>
<td>Cell Biology</td>
<td>3 (2+1)</td>
<td>GEN302</td>
<td>Principles of Genetics</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>MAT300</td>
<td>Mathematics - I</td>
<td>3 (3+0)</td>
<td>MAT300</td>
<td>Mathematics – II</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>CS300</td>
<td>Introduction to Computing</td>
<td>2 (1+1)</td>
<td>SOC300</td>
<td>Sociology</td>
<td>2 (2+0)</td>
</tr>
<tr>
<td>300 Elective –I*</td>
<td>3 (2+1)</td>
<td>300</td>
<td>Elective –I*</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>300 Elective – II*</td>
<td>3 (2+1)</td>
<td>300</td>
<td>Elective –II*</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17</td>
<td><strong>Total</strong></td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Semester 3**

<table>
<thead>
<tr>
<th>C No.</th>
<th>Semester 1</th>
<th>Cr. Hrs.</th>
<th>C No.</th>
<th>Semester 2</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG400</td>
<td>English</td>
<td>3 (3+0)</td>
<td>ENG400</td>
<td>Communication Skills</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>GEN401</td>
<td>Genetics and Evolution</td>
<td>3 (2+1)</td>
<td>GEN403</td>
<td>Molecular Biology</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>GEN402</td>
<td>Principles of Biochemistry</td>
<td>4 (3+1)</td>
<td>GEN404</td>
<td>Biometry – I</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>PS400</td>
<td>Pakistan Studies</td>
<td>2 (2+0)</td>
<td>ISL400</td>
<td>Islamic Studies/Ethics</td>
<td>2 (2+0)</td>
</tr>
<tr>
<td>400 Electro –I</td>
<td>3 (2+1)</td>
<td>400</td>
<td>Elective-I</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td>400 Elective –II</td>
<td>3(2+1)</td>
<td>400</td>
<td>Elective-II</td>
<td>3 (2+1)</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td><strong>Total</strong></td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Semester 5**

<table>
<thead>
<tr>
<th>C No.</th>
<th>Semester 1</th>
<th>Cr. Hrs.</th>
<th>C No.</th>
<th>Semester 2</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN501</td>
<td>Cytogenetics</td>
<td>4 (3+1)</td>
<td>GEN506</td>
<td>Introduction to Biotechnology</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>GEN502</td>
<td>Molecular Genetics</td>
<td>4 (3+1)</td>
<td>GEN507</td>
<td>Genetic Engineering</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>GEN503</td>
<td>Microbial Genetics</td>
<td>4 (3+1)</td>
<td>GEN508</td>
<td>Human Genetics</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>GEN504</td>
<td>Population Genetics</td>
<td>3 (2+1)</td>
<td>GEN509</td>
<td>Biometry – II</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>GEN505</td>
<td>Principles of Breeding</td>
<td>3 (2+1)</td>
<td>GEN510</td>
<td>Bioinformatics</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td><strong>Total</strong></td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Semester 7**

<table>
<thead>
<tr>
<th>C No.</th>
<th>Semester 1</th>
<th>Cr. Hrs.</th>
<th>C No.</th>
<th>Semester 2</th>
<th>Cr. Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN601</td>
<td>Biosafety and Bioethics</td>
<td>3 (3+0)</td>
<td>GEN606</td>
<td>Immunogenetics</td>
<td>3(3+0)</td>
</tr>
<tr>
<td>GEN602</td>
<td>Developmental Genetics</td>
<td>3 (3+0)</td>
<td>GEN607</td>
<td>Germplasm</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN603</td>
<td>Physiological Genetics</td>
<td>4 (3+1)</td>
<td>GEN608</td>
<td>Resources</td>
<td></td>
</tr>
<tr>
<td>GEN604</td>
<td>Research Techniques</td>
<td>4 (2+2)</td>
<td>GEN609</td>
<td>Special Paper-I</td>
<td>3(0+0)</td>
</tr>
<tr>
<td>GEN605</td>
<td>Project Planning and Report Writing</td>
<td>3 (3+0)</td>
<td>GEN609</td>
<td>Special Paper-II/Research Project</td>
<td>1(0+1)</td>
</tr>
<tr>
<td>GEN608</td>
<td>Seminar-I</td>
<td>1 (0+1)</td>
<td>GEN609</td>
<td>Seminar-II</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>18</td>
<td><strong>Total</strong></td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* 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

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

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 (microtubules and microfilaments), endoplasmic reticulum, golgi complex, mitochondria, lysosomes, ribosomes (80s, 70s, 55s) plastids, nucleus and nucleolus.


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.
- Meiosis: smear preparation from insects and plants.

Recommended Books:

**Theory:**


**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:**

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:

GEN402 – Principles of Biochemistry  4(3+1)

Theory:


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:
GEN403 – Molecular Biology

Theory:

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

Recommended Books

GEN404 – Biometry – I

Theory:
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, coefficient of variability.
- Solving problems on probability.
- Estimation of population mean.
- Comparisons 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:

GEN501 – Cytogenetics      4 (3+1)

Theory:

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:

GEN502 – Molecular Genetics      4(3+1)

Theory:

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:


**GEN503 – Microbial Genetics**

**Theory:**

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:
2. Dale J., Molecular Genetics of Bacteria, 3rd edition, John Wiley and Sons Ltd; 1998

GEN504 – Population Genetics 3(2+1)

Theory:

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:**
5. Weir B., Genetic Data Analysis III, Sinauer Assoc; 2002
7. Hedrick P.W., Genetics of Populations, Jones and Bartlett Pub; 2000

**GEN505 – Principles of Breeding 3(2+1)**

**Theory:**


**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:**

**GEN506 – Introduction to Biotechnology 3(2+1)**

**Theory:**


**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**
GEN507 – Genetic Engineering

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:

4. Yount L., Genetic Engineering, Gale Group, 2002
GEN508 – Human Genetics

Theory:

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 retarded individuals.
- Problems solving on genetic counseling.

Recommended Books:

GEN509 – Biometry – II

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, RCBBD 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

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:
GEN601 – Biosafety and Bioethics 3(3+0)

Theory:

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:

GEN602 – Developmental Genetics 3(3+0)

Theory:

Recommended Books:

**GEN603 – Physiological Genetics**

**Theory:**


**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:**


**GEN604 – Research Techniques**

**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:
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:
**GEN607  Germplasm Resources 3(2+1)**

**Theory:**


**Practicals:**

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

**Recommended Books:**


**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

<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN701 –</td>
<td>Advanced Cytogenetics</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN702 –</td>
<td>Advanced Molecular Genetics</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN703 –</td>
<td>Biometrical Techniques in Genetics</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN704 –</td>
<td>Bioinformatics</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN795 –</td>
<td>Seminar</td>
<td>1(0+1)</td>
</tr>
</tbody>
</table>

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 1st 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)
Theory:


Practicals:

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

Recommended Books:

GEN702 – Advanced Molecular Genetics  3(2+1)

Theory:

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

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

Theory:
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:

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:
Optional Courses

CONTENTS FOR OPTIONAL COURSES
(SAMPLE)

GEN706 – Clinical Genetics

Theory:

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:

GEN707 – Biosafety and Bioethics

Theory:
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:

GEN708 –Evolutionary Genetics

Theory:

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:
RECOMMENDATIONS

1. The National Curriculum Revision Committee (NCRC) recommends that BS 4–Year program in Genetics should be introduced in all public 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**

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Electronic balance Analytical Digital Top Loading</td>
</tr>
<tr>
<td>2</td>
<td>Stereomicroscope binocular</td>
</tr>
<tr>
<td>3</td>
<td>Compound Microscope</td>
</tr>
<tr>
<td>4</td>
<td>Incubator Digital</td>
</tr>
<tr>
<td>5</td>
<td>Magnetic stirrer with Hot Plate</td>
</tr>
<tr>
<td>6</td>
<td>Orbital shaker</td>
</tr>
<tr>
<td>7</td>
<td>Gel electrophoresis</td>
</tr>
<tr>
<td>8</td>
<td>Electric Supply for electrophoresis (Power Pack)</td>
</tr>
<tr>
<td>9</td>
<td>Ovens</td>
</tr>
<tr>
<td>10</td>
<td>Gel documentation System</td>
</tr>
<tr>
<td>11</td>
<td>Tissue homogenizer</td>
</tr>
<tr>
<td>12</td>
<td>Thermal Cycler (PCR)</td>
</tr>
<tr>
<td>13</td>
<td>UPS 10,000 Watt (local)</td>
</tr>
<tr>
<td>14</td>
<td>UPS 20,000 Watt (local)</td>
</tr>
<tr>
<td>15</td>
<td>UPS Running All Lab APCC 2.6KVA</td>
</tr>
<tr>
<td>16</td>
<td>-25 °C Freezer Upright Digital</td>
</tr>
<tr>
<td>17</td>
<td>Autoclave</td>
</tr>
<tr>
<td>18</td>
<td>pH Meter</td>
</tr>
<tr>
<td>19</td>
<td>Ordinary Digital Balance</td>
</tr>
<tr>
<td>20</td>
<td>Fume Hood</td>
</tr>
<tr>
<td>21</td>
<td>Vortex Mixer</td>
</tr>
<tr>
<td>22</td>
<td>Ice Making Machine (Flaked)</td>
</tr>
<tr>
<td>23</td>
<td>Laminar Flow Hood</td>
</tr>
<tr>
<td>24</td>
<td>Rotary Shaker</td>
</tr>
<tr>
<td>25</td>
<td>Computer P IV</td>
</tr>
<tr>
<td>26</td>
<td>Printer HP Laserjet 1300</td>
</tr>
<tr>
<td>27</td>
<td>8 – Multi - Channel Research Pipettes</td>
</tr>
<tr>
<td></td>
<td>i) 0.5-10ul</td>
</tr>
<tr>
<td></td>
<td>ii) 10-100 ul</td>
</tr>
<tr>
<td></td>
<td>iii) 30-300ul</td>
</tr>
<tr>
<td>28</td>
<td>12- Multi - Channel Research Pipettes</td>
</tr>
<tr>
<td></td>
<td>i) 0.5-10ul</td>
</tr>
<tr>
<td></td>
<td>ii) 10-100 ul</td>
</tr>
<tr>
<td></td>
<td>iii) 30-300ul</td>
</tr>
<tr>
<td>29</td>
<td>Single Channel Research Pipettes (Various Sizes)</td>
</tr>
<tr>
<td>30</td>
<td>Repeater Pipettor</td>
</tr>
<tr>
<td>31</td>
<td>Combitips plus</td>
</tr>
<tr>
<td>32</td>
<td>Microtome Digital</td>
</tr>
<tr>
<td>33</td>
<td>UV Biophotometer</td>
</tr>
<tr>
<td>34</td>
<td>Growth Chamber (Local)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>35</td>
<td>HPLC</td>
</tr>
<tr>
<td>36</td>
<td>UV Lamp</td>
</tr>
<tr>
<td>37</td>
<td>Autostill</td>
</tr>
<tr>
<td>38</td>
<td>Incubator Shaker</td>
</tr>
<tr>
<td>39</td>
<td>Power Station 2.6 KVac</td>
</tr>
<tr>
<td>40</td>
<td>drying cabinet</td>
</tr>
<tr>
<td>41</td>
<td>multiple tube rack vortex mixer</td>
</tr>
<tr>
<td>42</td>
<td>vacuum filtration assembly</td>
</tr>
<tr>
<td>43</td>
<td>Rotary Evaporator</td>
</tr>
<tr>
<td>44</td>
<td>Chiller</td>
</tr>
<tr>
<td>45</td>
<td>Digital Camera 5 Mega pixel for Field</td>
</tr>
<tr>
<td>46</td>
<td>vacuum pump</td>
</tr>
<tr>
<td>47</td>
<td>water tap operated vacuum pump</td>
</tr>
<tr>
<td>48</td>
<td>cold room cabinet</td>
</tr>
<tr>
<td>49</td>
<td>double pan balance manual</td>
</tr>
<tr>
<td>50</td>
<td>fraction collector</td>
</tr>
<tr>
<td>51</td>
<td>Chromatography columns complete set</td>
</tr>
<tr>
<td>52</td>
<td>peristaltic pump</td>
</tr>
<tr>
<td>53</td>
<td>UV code</td>
</tr>
<tr>
<td>54</td>
<td>centrifuges low and high speed with rotors and accessories</td>
</tr>
<tr>
<td>55</td>
<td>2 - D Gel Electrophoresis</td>
</tr>
<tr>
<td>56</td>
<td>nitrogen cylinder</td>
</tr>
<tr>
<td>57</td>
<td>CO₂ Incubator</td>
</tr>
<tr>
<td>58</td>
<td>Water baths</td>
</tr>
<tr>
<td>59</td>
<td>Refrigerators</td>
</tr>
<tr>
<td>60</td>
<td>Double Distillation Unit with ionizer and reverse osmosis</td>
</tr>
<tr>
<td>61</td>
<td>DNA sequencer Single Adjustable</td>
</tr>
<tr>
<td>62</td>
<td>Camera Digital 7.2 mega pixel</td>
</tr>
<tr>
<td>63</td>
<td>Laboratory washer</td>
</tr>
</tbody>
</table>