CURRICULUM
OF
GENETICS
FOR
BS
&
MS/MPhil
(Revised 2017)

HIGHER EDUCATION COMMISSION
ISLAMABAD
CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed  Chairman, HEC
Prof. Dr. Arshad Ali  Executive Director, HEC
Mr. Muhammad Raza Chohan  Director General (Acad)
Dr. Muhammad Idrees  Director (Curriculum)
Syeda Sanober Rizvi  Deputy Director (Curri)
Mr. Riaz-ul-Haque  Assistant Director (Curri)
Mr. Muhammad Faisal Khan  Assistant Director (Curri)
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Composed by: Mr. Zulfiqar Ali, HEC, Islamabad
PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo to achieve some specific objectives. It includes scheme of studies, objectives & learning outcomes, course contents, teaching methodologies and assessment/evaluation. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula regularly through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering.

It is hoped that this curriculum document, prepared by the respective NCRC’s, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC

http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx

(Muhammad Raza Chohan)
Director General (Academics)
CURRICULUM DEVELOPMENT

STAGE-I

CURRI. UNDER CONSIDERATION

COLLECTION OF EXP NOMINATION UNI, R&D, INDUSTRY & COUNCILS

CONS. OF NCRC.

PREP. OF DRAFT BY NCRC

STAGE-II

CURRI. IN DRAFT STAGE

APPRaisal OF 1ST DRAFT BY EXP

FINALIZATION OF DRAFT BY NCRC

FINAL STAGE

PREP. OF FINAL CURRI.

PRINTING OF CURRI.

FOLLOW UP

QUESTIONNAIRE

COMMENTS

IMPLE. OF CURRI.

PRINTING OF CURRI.

ORIENTATION COURSES BY LI, HEC

BACK TO STAGE-I

Abbreviations Used:
NCRC. National Curriculum Revision Committee
VCC. Vice Chancellor’s Committee
EXP. Experts
COL. Colleges
UNI. Universities
PREP. Preparation
REC. Recommendations
LI Learning Innovation
R&D Research & Development Organization
HEC Higher Education Commission
CONS Constitution
CURRICULUM DEVELOPMENT CYCLE

MINUTES OF THE FINAL MEETING:
The Final meeting of National Curriculum Revision Committee in the discipline of Genetics was held at HEC Regional Centre, Karachi from April 12-14, 2017, with the objective to finalize the preliminary curriculum of BS and MS Programme in Genetics prepared by the Committee in its previous meeting that was held from November 9-11, 2016 and to make recommendations for the promotion and development of the discipline. The following members attended the meeting:-

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name &amp; Address</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dr. Ghulam Sarwar Markhand, Professor, Department of Botany, Shah Abdul Latif University, Khairpur.</td>
<td>CONVENER</td>
</tr>
<tr>
<td>2.</td>
<td>Dr. Abdul Samad Mumtaz Associate Professor Department of Plant Sciences, Quaid-i-Azam University, Islamabad.</td>
<td>SECRETARY</td>
</tr>
<tr>
<td>3.</td>
<td>Dr. Hidayat ur Rahman, Meritorious Professor/Chairman, Department of Plant Breeding &amp; Genetics, The University of Agriculture, Peshawar.</td>
<td>MEMBER</td>
</tr>
<tr>
<td>4.</td>
<td>Dr. Ali Muhammad, Professor/Chairman, Department of Zoology, Islamia College University, Peshawar.</td>
<td>MEMBER</td>
</tr>
<tr>
<td>5.</td>
<td>Dr. Iftikhar Hussain Khalil, Professor, Department of Plant Breeding &amp; Genetics, University of Agriculture, Peshawar.</td>
<td>MEMBER</td>
</tr>
<tr>
<td>6.</td>
<td>Dr. Shaukat Iqbal Malik, Associate Professor, Department of Bioinformatics &amp; Biosciences, Capital University of Science and Technology, Islamabad Expressway, Sihala, Islamabad.</td>
<td>MEMBER</td>
</tr>
<tr>
<td>7.</td>
<td>Dr. Tayyaba Sultana, Professor,</td>
<td>MEMBER</td>
</tr>
<tr>
<td></td>
<td>Name</td>
<td>Position</td>
</tr>
<tr>
<td>---</td>
<td>------------------------------------------------</td>
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</tr>
<tr>
<td>8</td>
<td>Dr. Muhammad Ilyas</td>
<td>Director</td>
</tr>
<tr>
<td>9</td>
<td>Dr. Muhammad Qasim</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>10</td>
<td>Dr. Nadia Khan</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>11</td>
<td>Dr. Syed Kashif Nawaz</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>12</td>
<td>Dr. Syyeda Samra Jafri</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>13</td>
<td>Dr. Shahid Ali</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>14</td>
<td>Dr. Noor Muhammad</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>15</td>
<td>Dr. Amjad Ali</td>
<td>Assistant Professor</td>
</tr>
<tr>
<td>16</td>
<td>Mr. Riaz-ul-Haque</td>
<td>Assistant Director (Curriculum)</td>
</tr>
</tbody>
</table>
Following Members attended the Preliminary meeting but could not attend the final meeting:

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Institution</th>
<th>Location</th>
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</thead>
<tbody>
<tr>
<td>Dr. Habib Ahmed (TI)</td>
<td>(Honorary Member)</td>
<td>Professor/Vice Chancellor</td>
<td>Islamia College University, Peshawar</td>
</tr>
<tr>
<td>Dr. Raziuuddin</td>
<td>Professor</td>
<td>Department of Plant Breeding &amp; Genetics</td>
<td>The University of Agriculture, Peshawar</td>
</tr>
<tr>
<td>Dr. Syed Mehar Ali Shah</td>
<td>Associate Professor</td>
<td>Department of Plant Breeding &amp; Genetics</td>
<td>The University of Agriculture, Peshawar</td>
</tr>
<tr>
<td>Dr. Muhammad Naeem</td>
<td>Assistant Professor</td>
<td>Department of Plant Breeding &amp; Genetics</td>
<td>The Islamia University of Bahawalpur, Baghdad Campus, Bahawalpur</td>
</tr>
</tbody>
</table>

2. The meeting started with recitation of verses from the Quran-e-Majeed by Mr. Riaz-ul-Haque, Assistant Director, HEC. Mr. Javed Memon, Director Regional Centre, Karachi, HEC welcomed the participants and thanked all the members of the committee for sparing precious time for this national cause. He further added that their efforts will go long way in developing workable, useful and comprehensive degree programmes in Genetics.

Mr. Riaz ul Haque briefed the participants about the aims and objectives of the meeting with a particular focus on horizontal and vertical alignment of course contents, Course Learning Outcomes (CLO) according to Blooms Taxonomy, in order to make the curriculum compatible with international standards, indigenous demands as well as ensuring the uniformity of academic standards within the country.

3. The members of the Committee unanimously selected **Dr. Ghulam Sarwar Markhand**, Professor, Department of Botany, Shah Abdul Latif University, Khairpur and **Dr. Abdul Samad Mumtaz**, Associate Professor, Department of Plant Sciences, Quaid-i-Azam University, Islamabad, as **Convener** and **Secretary** of the NCRC, respectively. Mr. Riaz-ul-Haque then requested the Convener of the committee to head the proceedings of all technical sessions of meeting for three days.
The Convener thanked the participants for his selection and started proceedings of the meeting in accordance with the agenda. The Committee, during the proceedings of the meeting, considered the inputs given by the members of the Committee and incorporated their suggestions where necessary in the curriculum.

4. After thorough discussion and having three days deliberations, the committee achieved the following objectives:-

   i. **Finalized the Reviewed Curriculum of Genetics for BS and MS Programmes, so as to bring it at par with international standards.**

   ii. **Incorporated latest reading and writing material against each course.**

   iii. **Made recommendations for promotion and development of the discipline of Genetics.**

The Convener of the NCRC thanked the members for their inputs in finalizing the preliminary draft curriculum of Genetics by keeping in view of the requirements of the country and to make it more practical, competitive and effective.

5. Mr. Riaz-ul-Haque, Assistant Director Curriculum HEC thanked the Convener, the Secretary and all the members of the committee for sparing their precious time and valuable contribution towards preparation of the final draft curriculum in the discipline of Genetics.

6. The Committee appreciated the efforts made by the officials of HEC Regional Centre, Karachi and Assistant Director, Curriculum for making proper arrangements to facilitate the members of committee.

7. The meeting ended with vote of thanks to and from the chair.
Bachelor of Science (BS) 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 Genetics
(Total Credit Hours 136)

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<thead>
<tr>
<th>Course code</th>
<th>Semester-1</th>
<th>Cr. Hrs</th>
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<tbody>
<tr>
<td>ENG300</td>
<td>English – I</td>
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</tr>
<tr>
<td>GEN301</td>
<td>Cell Biology</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>MAT300</td>
<td>Mathematics - I</td>
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<tr>
<td>CS 300</td>
<td>Introduction to Computing</td>
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<tr>
<td>300</td>
<td>Elective – I**</td>
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<tr>
<td>300</td>
<td>Elective – II**</td>
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<tr>
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<td>Principles of Genetics</td>
<td>4 (3+1)</td>
</tr>
<tr>
<td>MAT300</td>
<td>Mathematics – II</td>
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<td>SOC300</td>
<td>1 course of Social Sci.*</td>
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<tr>
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<td>Elective – I**</td>
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<td>Cytogenetics</td>
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<td>GEN402</td>
<td>Principles of Biochemistry</td>
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<td>PS 400</td>
<td>Pakistan Studies</td>
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<td>Elective – I**</td>
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<td>ENG400</td>
<td>English (Communication Skills)</td>
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<td>GEN403</td>
<td>Molecular Biology</td>
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<td>Biometry – I</td>
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<td>ISL 400</td>
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<td>Elective-II**</td>
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<td>Cr. Hrs</td>
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<tr>
<td>GEN501</td>
<td>Genetics and Evolution</td>
<td>4 (4+0)</td>
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<tr>
<td>GEN502</td>
<td>Molecular Genetics</td>
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<tr>
<td>GEN503</td>
<td>Microbial Genetics</td>
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<tr>
<td>GEN504</td>
<td>Population Genetics</td>
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<tr>
<td>GEN505</td>
<td>Principles of Breeding</td>
<td>3 (2+1)</td>
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<tr>
<td><strong>Total</strong></td>
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<tr>
<td>GEN507</td>
<td>Genetic Engineering</td>
<td>4 (3+1)</td>
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<tr>
<td>GEN508</td>
<td>Human Genetics</td>
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<tr>
<td>GEN509</td>
<td>Biometry – II</td>
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<tr>
<td>GEN510</td>
<td>Bioinformatics</td>
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<th>Cr. Hrs</th>
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<td>Biosafety and Bioethics</td>
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<tr>
<td>GEN602</td>
<td>Developmental Genetics</td>
<td>3 (3+0)</td>
</tr>
<tr>
<td>GEN603</td>
<td>Biotechnology</td>
<td>3 (2+1)</td>
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<tr>
<td>GEN604</td>
<td>Research Techniques</td>
<td>4 (2+2)</td>
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<tr>
<td>GEN605</td>
<td>Genomics and Proteomics</td>
<td>3 (2+1)</td>
</tr>
<tr>
<td>GEN606</td>
<td>Seminar-I/Report Writing</td>
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<td>GEN608</td>
<td>Genetic Resources and Conservation Seminar-II</td>
<td>3 (2+1)</td>
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<tr>
<td>GEN609</td>
<td>Special Paper-I</td>
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<tr>
<td>GEN610</td>
<td>Special Paper II</td>
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<td>Or</td>
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<td>Research</td>
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* Select from Sociology, Psychology, Social work, Criminology, Psychiatry, Special Education
** Select from List of Minor (Elective Subject)
^ Student can opt for 2 special papers or 1 special paper and internship or research of 6 Cr. Hrs. Credit hrs for special paper (theory & practical) will be defined by the respective university

## List of Courses for 4 - Year BS Genetics

### A. Core Course

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<tr>
<th>Course No.</th>
<th>Courses</th>
<th>Credit Hours</th>
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<td>GEN301 –</td>
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<tr>
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<td>GEN401 –</td>
<td>Cytogenetics</td>
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<td>GEN403 –</td>
<td>Molecular Biology</td>
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<td>GEN404 –</td>
<td>Biometry – I</td>
<td>3(2+1)</td>
</tr>
<tr>
<td>GEN501 –</td>
<td>Genetics and Evolution</td>
<td>4(4+0)</td>
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<tr>
<td>GEN502 –</td>
<td>Molecular Genetics</td>
<td>4(3+1)</td>
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<tr>
<td>GEN503 –</td>
<td>Microbial Genetics</td>
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<td>GEN504 –</td>
<td>Population Genetics</td>
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<td>GEN505 –</td>
<td>Principles of Breeding</td>
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<tr>
<td>GEN506 –</td>
<td>Physiological Genetics</td>
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<td>GEN507 –</td>
<td>Genetic Engineering</td>
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<td>GEN508 –</td>
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<td>Biometry – II</td>
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<td>GEN510 –</td>
<td>Bioinformatics</td>
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<td>GEN601 –</td>
<td>Biosafety and Bioethics</td>
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<td>GEN602 –</td>
<td>Developmental Genetics</td>
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<td>GEN603 –</td>
<td>Introduction to Biotechnology</td>
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<td>GEN604 –</td>
<td>Research Techniques</td>
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<td>GEN605 –</td>
<td>Genomics and Proteomics</td>
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<tr>
<td>GEN606 –</td>
<td>Seminar I/Report Writing</td>
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<tr>
<td>GEN607 –</td>
<td>Immunogenetics</td>
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<td>GEN608 –</td>
<td>Genetic Resources and Conservation</td>
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<td>Seminar II</td>
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<tr>
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</table>
B. **Elective Courses to be opted in following disciplines**
   1. Microbiology
   2. Botany/Plant Sciences
   3. Zoology/Animal Sciences
   4. Physiology
   5. Chemistry
   6. Biochemistry
   7. Biotechnology

C. **Compulsory Courses to be opted in following disciplines**
   1. English
   2. Islamic Studies
   3. Pakistan Studies
   4. Mathematics
   5. Introduction to Computing

D. **Supporting Courses**
   1. Sociology
   2. Community Services
   3. Active Citizenship
   4. Psychology
   5. Management (Entrepreneurship Management)
DETAIL OF COURSES
FOR BS GENETICS
4 – YEAR DEGREE PROGRAM

GEN 301 - Cell Biology 3 (2 + 1)

Course Learning Outcomes:
This course will enable students to comprehend:

- Structure and basic components of prokaryotic and eukaryotic cells, membranes and organelles
- Cellular components used to generate and utilize energy in cells, the cellular components underlying cell division
- Apply the knowledge of cell biology to understand the cell function

Theory:

Practical:
- Introduction to laboratory equipment and safety measures.
- Handling and use of various types of microscopes.
- Demonstration of cell structure through micrograph of electron microscope.
- Cell structure of plant and animal specimen.
- Streaming movement of cytoplasm in staminal hairs of Tradescantia
- Histochemical staining of nucleic acids.
- Meiosis: smear preparation from insects and plants.
- Observation of plastids (leucoplasts, chloroplast and chromoplast)

Recommended Books:
GEN 302 – Principles of Genetics        4 (3+1)

Course Learning Outcomes:
This course will enable students to comprehend:

- Basic principles of inheritance at molecular, cellular and organismal levels;
- Causal relationships between molecular/cellular processes and organismal patterns of heredity
- Application of this knowledge in a variety of problem-solving situations

Theory:

Practical:
- Problems related to the topics in theory.
- Pedigree analysis
- Preparation of culture medium and maintenance of Drosophila cultures in lab.
- Detection of polytene chromosomes in Drosophila
- Blood groups-ABO blood groups and Rh factors
- Gene mapping
Recommended Books:
11. http://anthro.palomar.edu/mendel/mendel_1.htm

GEN 401 – Cytogenetics 3 (2+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- The theoretical scope of cytogenetics
- Its applications in genome biology, evolutionary genetics, crop improvement and clinical pathology.

Theory:

Practical:
Microscopy; simple, compound, phase contrast, dark field, fluorescent and scanning, transmission electron microscopy
- Cell culture and staining techniques.
- 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.

**Recommended Books:**
5. Fundamentals of Cytogenetics and Genetics. Mahabal Ram. Published by Prentics Hall India Learning private limited 2010
11. https://www.utmb.edu/pedi_ed/CORE/MedicalGenetics/page_01.htm

**GEN 402 – Principles of Biochemistry 4 (3+1)**

**Course Learning Outcomes:**
This course will enable students to comprehend:
- Principles of biochemistry and role of biological molecules in cell
- The structure and function of major classes of biological molecules

**Theory:**

Practical:
- Preparation of standard solutions and buffers.
- Chromatographic separation of amino acids, carbohydrates, lipids, etc.
- Extraction and quantification of macro-molecules (RNA, DNA and Proteins).
- Estimation of enzyme activity from plant or animal source.
- Estimation of vitamin in a specimen.

Recommended Books:

GEN 403 – Molecular Biology 3 (2+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- The structure and function of nucleic acids and proteins
- Role and importance of the biomolecules in biological systems
**Theory:**

**Practical:**
- Extraction and quantification of DNA, RNA and proteins
- Qualitative separation of macromolecules using electrophoresis.
- Detection of mutants and mutagens e.g. AMES test
- AT/GC content estimation.

**Recommended Books:**
7. http://employees.csbsju.edu/hjakubowski/classes/ch331/bcintro/default.html

**GEN 404 – Biometry – I**

**Course Learning Outcomes:**
This course will enable students to comprehend:
- The theoretical basis of biometric analysis
- Interpreting experimentally derived biological data

**Theory:**
Introduction to biometry, population and samples, discrete and continuous variables. Likert scale and its analysis. Measures of central value: mean, median, mode. Measures of variability: range, variance, standard deviation, standard error, co-efficient of variation. Presentation of data: table formulation,
Bar graph, Pie chart, frequency polygon, histogram. Probability. Permutations.

Distributions: binomial, normal and poison distributions.

Introduction to inference: general statistical problem: estimation and hypothesis testing: t-distribution: hypothesis testing on population mean, comparing two means: t-test, F-test (confirm further from Samra). Chi-square tests: goodness of fit and test of association.

Practical:

- Introduction to utility of Minitab/SAS/SPSS/MSTAT etc.
- 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 basic statistics using various methods. Mean, variance, standard deviation, standard error, co-efficient of variability.
- Solving problems on probability.
- Comparison 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. Natural Resources Biometrics, Geneseo, NY: Open SUNY Textbooks, by Diane Kiernan and Epub with commentary at opensuny.org. 2014.

GEN 501 – Genetics and Evolution 4 (4+0)
Course Learning Outcomes:
This course will enable students to comprehend:
- Knowledge of extant species sharing descent from common ancestry and how this fact explains the traits of living species
- How changes in the genetic composition of populations be explained under natural selection and in the absence of selection

Theory:
The process and concepts of evolution, theories of origin in life, source of variability (point mutations, genetic recombination and chromosomal aberrations and their role in evolution), organization of genetic variability in population, synthetic theory of evolution and its development, evolution of genetic systems, Speciation and genetics of species formation, systems of reproductive isolation and their role in evolution. Theories of evolution (Lamarckism, Darwinism, Neo-Darwinism, Molecular evolution).

Recommended Books:
1. Evolution by Carl T Bergstrom Published by WW Norton and Co, 2015
2. Evolution by D Loxton, Jim WW Smit, 2010
11. http://beast.bio.ed.ac.uk

GEN 502 – Molecular Genetics 4 (3+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- Role of genes within cell
- Elucidation of the genetic code
- DNA organization in prokaryotes and eukaryotes

Theory:

Practical:
- Media preparation and bacterial culturing.
- Extraction of plasmid DNA.
- Detection of antibiotic resistant genes in bacteria
- Detection of mutants in bacteria, yeasts and plants.
- Induction of mutations in prokaryotes and eukaryotes.

Recommended Books:
GEN 503 — Microbial Genetics 4 (3+1)

Course Learning Outcomes:
This course will enable students to gain:
- Comprehension in principles and concepts of microbial genetics
- Insight into current exciting topics in microbial genetics
- Understanding of how microbial genetics has advanced science and society

Theory:

Practical:
- Growth curve of bacteria.
- Observation of plaque formation on lawn of Bacterial culture
- Chromosomal DNA extraction
- Transformation
- Detection of plasmids in bacterial strains (plate method and gel electrophoresis)
- Detection of mutants using replica plating techniques

Recommended Books:
GEN 504 – Population Genetics 3 (2+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- The quantitative nature of population genetics and its connection to the study of genetics
- The difference between microevolution and macroevolution
- The concept of Hardy-Weinberg equilibrium and the factors necessary to explain equilibrium
- The origin of new alleles in populations

Theory:

Practical:
- 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
- Calculation of co-efficient of inbreeding through pedigrees.
- Estimations of genetic covariance through pedigrees.

Recommended Books:
3. Genetics of Populations, Hedrick P.W., Jones and Bartlett Pub; 2000
8. Population Genetics; Matthew B. Hamilton, 2009
11. http://www.y-str.org

GEN 505 – Principles of Breeding 3 (2+1)

Course Learning Outcomes:
This course will enable students to gain:

- Understanding in principles of breeding
- Understanding the methods of varietal/breed development, testing and release
- Acquaintance with current challenges in plant and animal breeding.

Theory:

Practical:
- 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.
- Pollen morphology and germination.
- Estimation of inbreeding depression and heterosis in plants and animals.

Recommended Books:
2. Principles of Plant Genetics and Breeding 2nd Edition by George Acquaah Publisher: Wiley-Blackwell; 2012
GEN 506 – Physiological Genetics 4 (3+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- The complexity of cellular functions in plants and animals
- The gene structure, mechanisms and regulation of expression
- The molecular mechanisms by which genes function
- Basic requirements for expression of genes

Theory:

Principles of physiological genetics: sex determination (role of hormones and chromosomes with examples from Drosophila, Rat, Human, Bees and Wasps), hereditary metabolic blocks, heterozygosity in blood coagulation proteins and phenylalanine metabolism (dependence of physiological variability on genetic
factors). Balanced polymorphism: Heterozygote selective advantage (Sickle Cell Anemia), Serum Protein Polymorphism (Lymph proteins of *Drosophila*).

**Practical:**
- Physiological and morphological effects of various stresses on microbes, plants and animals.
- Characterization of heat shock/stress proteins by SDS–PAGE.

**Recommended Books:**
4. Evolutionary, Developmental and Physiological Genetics Edited by: Gerats, Tom, Strommer, Judy (Eds.) Springer 2009

**GEN 507 – Genetic Engineering**

**Course Learning Outcomes:**
This course will enable students to gain understanding of:
- Basic genetic mechanisms
- Knowledge to manipulate genes, cells and organisms to address emerging issues of food security, health and living standards.

**Theory:**
Basic concepts in recombinant DNA technology. DNA cloning: isolation and purification of DNA. Restriction enzymes and modification system. Cloning vectors: plasmids (bacterial and yeasts), viruses (CMV, SV40, lambda, M13), Cosmids and Phosmids, YACs, BACs and PACs. Cloning strategies (prokaryotic and eukaryotic); selection and characterization of recombinant molecules, amplification of desired genes. Construction and analysis of DNA libraries. Maximizing the cloned expression. Gel electrophoresis, hybridization, PCR, its types and gene transformation techniques. Site directed mutagenesis. DNA sequencing techniques. Applications of genetic engineering in medicine, agriculture and environment. Recent trends in genetic engineering.
Practical:
- 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 (supercoiled, linear and digested with restriction enzyme) chromosomal DNA and RNA.
- Plasmid transformation in *E. coli*.
- Primer designing
- DNA amplification by PCR

Recommended Books:
8. Genetic Engineering, Yount, L., Gale Group, 2002
10. http://learn.genetics.utah.edu/
11. [http://learn.genetics.utah.edu/content/addiction/pi/](http://learn.genetics.utah.edu/content/addiction/pi/)

**GEN 508  Human Genetics 3 (2+1)**

Course Learning Outcomes:
This course will enable students to comprehend:
- The principles of genetic implications
- The consequences of various hereditary diseases in humans.

Theory:

**Practical:**
- Study of different qualitative and quantitative traits.
- Pedigree drawing and analysis (screening of metabolic and other disorders).
- Chromosome preparation and identification
- Analysis of sex chromosomes in Inter-phase nuclei.
- Karyotyping of human chromosomes.
- Dermatoglyphics of healthy and affected subjects.
- SNP STRs and mtDNA based analyses
- Problems solving on human genetics.

**Recommended Books:**
15. http://archive.uwcm.ac.uk/uwcm/mg/hgmd0.html
**Course Learning Outcomes:**
This course will enable students to understand:

- The designing of experiments, analysis and interpretation of results using variety of software in Biometrics.

**Theory:**

**Practical:**
- Analysis of Variance: one way and two way following CRD, RCBD and Latin Square designs.
- Comparisons of means using LSD and DMR tests.
- Coefficient of linear regression and correlation.
- Data Analysis using software.

**Recommended Books:**
Course Learning Outcomes:
This course will enable students to comprehend:
- The computational practices in bioinformatics; protein structure prediction
- Data management and mining.

Theory and Practical:

Recommended Books:
6. www.embl.ac.uk
7. www.flybase.org (Drosophila)
8. www.ebi.ac.uk
10. www.primer3.ut.ee
11. www.hapmap.org
Course Learning Outcomes:
This course will enable students to comprehend:
- The safety procedures in experimental genetics
- How to address ethical issues emerging with the advancement in genetics.

Theory:
Introduction to biosafety and bioethics. Biosafety committees and their role. Role of institutional animal care committee. Biological, chemical, physical hazards. Storage, handling and transportation of bio, chemical and physical hazards. Laboratory waste disposal and management. Symbols used in bio, chemical and physical hazards. Types and use of biosafety cabinets and fume hood. Lab safety guidelines, good laboratory practices (GLPs) personal protective equipment (PPEs), laboratory standard operating procedures (SOPs). Emergency response plans (ERPs) Biosafety levels (BSLs), laboratory containment levels, lab spill management. Incident and accident reporting.


Practical:
- Lab spill response materials
- Use of biosafety cabinets, fume hoods etc.
- Guidelines for safe use of PPEs,
- SOPs and display of biosafety symbols.
- Demonstration of aseptic techniques
- Disposal of laboratory waste material
- Handling of microorganisms

Recommended Books:
2. IPR, Biosafety and Bioethics Kindle Edition by, Deepa Goel, Shomini Parashar Publisher: Pearson; 2013
14. www.siut.org/bioethics

GEN 602 Developmental Genetics  3 (3+0)

Course Learning Outcomes:
This course will enable students to comprehend:
- Fundamentals of developmental biology,
- Theory of differential gene expression,
- Concepts of gene regulation, principles of induction and autonomous regulation.

Theory:

Recommended Books:
11. http://www.hudsen.org/
12. https://dmdd.org.uk/
15. http://virtualhumanembryo.lsuhs.edu/

GEN 603  Biotechnology  3 (2+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- Basic concepts of biotechnology
- Various methods and applications of biotechnology.

Theory:

Practical:
- Bio degradation of toxic chemicals especially aromatics (pesticides & crude oil components)
- Bio accumulation/Bio absorption of heavy metals by bacteria, fungi, protozoa, and plants.
- Solubilizing insoluble metal complexes by bacteria.
- Plant tissue culture technology, callogenesis and organogenesis.

Recommended Books:
1. Introduction to Biotechnology and Genetic Engineering A. J. Nair, Infinity
GEN 604  Research Techniques  4 (2+2)

Course Learning Outcomes:
This course will enable students to train and equip:
  - Various laboratory techniques for appropriate research activities.

Theory:
Microscopy, centrifugation, spectroscopy, chromatography, HPLC, LCMS and electrophoresis. Genomic DNA extraction and purification, plasmid extraction, PCR, DNA finger-printing, protein extraction and foot-printing. ELISA, transformation, screening of transformed cells, restriction enzyme analysis, sequencing and genotyping. Cloning, knockout mutagenesis, TILLING and microarray technique.

Practical:
  - Practical demonstration of techniques discussed in the theory.

Recommended Books:
GEN 605 Genomics and Proteomics 3 (2+1)

Course Learning Outcomes:
This course will enable students to develop:
- Understanding of the structural and functional genomics and proteomics and their applications.

Theory:

Practical:
- Genome and proteome analysis on aspects given in the theory.
- Complete genome investigation of E. coli and Neurospora.
- Genome Analysis of Arabidopsis.
- Isolation and identification of various proteins using different techniques

Recommended Books:
11. http://www.personalgenomes.org

GEN 606  Seminar-I/Report Writing  1 (0+1)
Presentation on recent topics in genetics in consultation with the departmental faculty.

GEN 607  Immunogenetics  4 (3+1)

Course Learning Outcomes:
This course will enable students to comprehend:
- The advances in the field of immuno-genetics
- Genetics of disease resistance
- Immune response through experimentation in different disease models

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

Practical:
- Coomb’s test
- Agglutination test (WIDAL, RF, CRP)
- Precipitin test (Radio-immunodiffusion technique)
- ELISA
- Immunochromatographic technique
- *Immunoflourescent technique for the detection of Autoantibodies produced in autoimmune diseases
- *PCR for infectious diseases (HBV, TORCH, HIV)
- *HLA Typing
• *FISH
• Problem based learning in immunology

* If facilities are not available for IF Tech, PCR, HLA typing, FISH then there should be visit to any diagnostic lab where these techniques are in function.

**Recommended Books:**
1. Methods and Applications in Clinical Practice, Ch Immunogenetics, Editors: Frank T. Christiansen, Brian D. Tait 2012.
11. http://www.imgt.org

**GEN 608 Genetic Resources and Conservation 3 (2+1)**

**Course Learning Outcomes:**
This course will enable students to gain:

• Understanding of options and challenges in the management and use of genetic resources at national and international level.

**Theory:**
Introduction to national and international germplasm banks. Introduction to Convention of Biodiversity, CITES, IPRs and SMTA.

Practical:
- Collection and identification of important plant and animal species.
- Isolation and characterization of bacteria and fungi from different sources.
- Visits to botanical gardens, national parks, museums, herbaria, gene banks and hatcheries.

Recommended Books:
1. Conservation Genetics in the Age of Genomics; Amato, G., R. DeSalle, O. A. Ryder, and Howard C. Rosenbaum 2009
11. http://www.bostoncommons.net/best-biotechnology-websites

GEN 609 Seminar-II 1 (0+1)
Presentation on recent topics in genetics in consultation with the departmental faculty.

GEN 610 onwards - Special Paper I & II 3 (0+0)
Departments will offer special papers/courses according to the expertise available. (Each special paper will comprise of 3 credit hours and the codes will be as defined in the curriculum of respective departments).

GEN 000 Entrepreneurship Management 3(3+0)
(Note: The above cited course may be opted with the consideration of Management Sciences faculty of respective university)
| GEN 000 | Internship     | 3 (0+3) |
|         | Research       | 6 (0+6) |
MS/MPhil. (2-year) Program in Genetics

MS/M.Phil. (2-years program, 18-years of education) in Genetics will spread over 4-semesters, comprising two semesters of course work and two semesters of research. The students will be required to complete course work of 24 credit hours. In addition, there will be 6-credit hours of research thesis. The courses will be framed by the respective institutes according to the available expertise and statutes of the university. A list of the proposed courses is given below; however, more subjects can be added as per requirements of the institute/university.

List of MS/MPhil Courses

Compulsory Courses:
1. Research Methodology 3(3+0)
2. Biostatistics 3(3+0)

Course Title:
1. Advanced Cytogenetics
2. Advanced Molecular Genetics
3. Advances in Plant Genomics
4. Advances in Population Genetics
5. Animal Biotechnology
6. Animal Breeding
7. Applied Genetic Analysis
8. Aquatic Biotechnology
9. Behavioral Genetics
10. Gene Therapy
11. Advances in Bioinformatics
12. Biometrical Techniques in genetics
13. Bioremediation and Biodegradation
14. Biosafety and Bioethics
15. Cancer Genetics
16. Cancer Biology
17. Cell and Tissue Culture
18. Clinical Genetics
19. Conservation Genetics
20. DNA Damage and Repair
21. Drug Discovery
22. Ecological Genetics
23. Evolutionary Genetics
24. Forensic Genetics
25. Functional Genomics
26. Gene Mapping
27. Medical Genetics
28. Genetic engineering and its applications
29. Genetics of Ageing
30. Advances in Genomics
31. Human Molecular Genetics
32. Advances in Laboratory Research Techniques
33. Metabolomics
34. Industrial Biotechnology
35. Modern Languages (any foreign language)
36. Molecular Genetics of Bacteria
37. Molecular Microbial Ecology
38. Molecular Techniques in Crop Improvement
39. Molecular Virology
40. Nanobiotechnology
41. Advances in Physiological Genetics
42. Plant Biotechnology
43. Advances in Plant Breeding
44. Plant Microbe Interaction
45. Probiotics
46. Proteomics
47. Quantitative Genetics
48. Recombinant DNA technology
49. Technical Writing Skills
50. Signal Transduction
51. Special Problem
52. Stem Cell Biology
53. Advances in Biotechnology
54. Research Project
55. Epigenetics
56. Biostatistics
57. NeuroGenetics
58. Pharmaco-genomics
59. Genetic Epidemiology
60. Genetics of Infectious Diseases
61. Mitochondrial Genetics

**GEN799 Thesis 6 (0+6)**

**Research Methodology**

**Course Learning Outcomes:**
This course will enable students to understand:
- How to conduct research,
- Collect and analyze data,
- Publish the results.
Course Contents:


Recommended Books
RECOMMENDATIONS

The National Curriculum Revision Committee (2017) in Genetics recommends that:

1. The two years Associate Degree in Genetics may be introduced in colleges with appropriate curriculum.

2. As Genetics is also 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.

3. Computing and internet facilities should be provided to BS and MS students to keep up with the pace of developments in the field of Genetics.

4. A fully equipped state of art laboratory needs to be established in major institutions of the country offering degree program in Genetics.

5. It is pertinent to mention that an animal research facility may be established in the department of genetics with animal care committee which could address animal ethical issues.

6. Refresher courses may be arranged for concerned faculty members for capacity building.

7. Adequate funds be allocated for replenishing the departmental libraries with latest text books and online access to scientific journals.

8. Universities/DAIs should initiate with the assistance of HEC, a program for MS/PhD students to conduct part of research at the universities/RI where advanced research facilities are available.

9. In view of the emerging industrial trends in science of genetics, universities/DAIs should launch degree programs in genetics with the cooperation of HEC.
Course Learning Outcomes:
Enhance language skills and develop critical thinking

Course Contents:
Basics of Grammar
Parts of speech and use of articles
Sentence structure, active and passive voice
Practice in unified sentence
Analysis of phrase, clause and sentence structure
Transitive and intransitive verbs
Punctuation and spelling

Comprehension
Answers to questions on a given text

Discussion
General topics and every-day conversation (topics for discussion to be at the discretion of the teacher keeping in view the level of students)

Listening
To be improved by showing documentaries/films carefully selected by subject teachers

Translation skills
Urdu to English

Paragraph writing
Topics to be chosen at the discretion of the teacher

Presentation skills
Introduction

Note: Extensive reading is required for vocabulary building

Recommended Books:
1. Functional English
   a) Grammar
b) Writing

c) Reading/Comprehension

d) Speaking

**English II (Communication Skills)**

**Course Learning Outcomes:**
Enable the students to meet their real-life communication needs.

**Course Contents:**

- **Paragraph writing**
  Practice in writing a good, unified and coherent paragraph

- **Essay writing**
  Introduction

- **CV and job application**
  Translation skills
  Urdu to English

- **Study skills**
  Skimming and scanning, intensive and extensive, and speed reading, summary and précis writing and comprehension

- **Academic skills**
  Letter/memo writing, minutes of meetings, use of library and internet

- **Presentation skills**
  Personality development (emphasis on content, style and pronunciation)

*Note: documentaries to be shown for discussion and review*

**Recommended Books:**

**Communication Skills**

a) Grammar

b) Writing

c) Reading
2. Reading and Study Skills by John Langan

English III (Technical Writing and Presentation Skills)

Course Learning Outcomes:
Enhance language skills and develop critical thinking

Course Contents:

Presentation skills

Essay writing
Descriptive, narrative, discursive, argumentative

Academic writing
How to write a proposal for research paper/term paper
How to write a research paper/term paper (emphasis on style, content, language, form, clarity, consistency)

Technical Report writing

Progress report writing

Note: Extensive reading is required for vocabulary building

Recommended Books:
Technical Writing and Presentation Skills

a) Essay Writing and Academic Writing


b) Presentation Skills

c) Reading

The Mercury Reader. A Custom Publication. Compiled by Northern Illinois University. General Editors: Janice Neulib; Kathleen Shine Cain; Stephen Ruffus and Maurice Scharton. (A reader which will give students exposure to the best of twentieth century literature, without taxing the taste of engineering students).
Pakistan Studies (Compulsory)

Course Learning Outcomes:
- Develop vision of historical perspective, government, politics, contemporary Pakistan, ideological background of Pakistan.
- Study the process of governance, national development, issues arising in the modern age and posing challenges to Pakistan.

Course Outline
1. **Historical Perspective**
   b. Factors leading to Muslim separatism
   c. People and Land
      i. Indus Civilization
      ii. Muslim advent
      iii. Location and geo-physical features.

2. **Government and Politics in Pakistan**
   Political and constitutional phases:
   a. 1947-58
   b. 1958-71
   c. 1971-77
   d. 1977-88
   e. 1988-99
   f. 1999 onward

3. **Contemporary Pakistan**
   a. Economic institutions and issues
   b. Society and social structure
   c. Ethnicity
   d. Foreign policy of Pakistan and challenges
   e. Futuristic outlook of Pakistan

Recommended Books:
Course Learning Outcomes:

This course is aimed at:
1. To provide basic information about Islamic Studies
2. To enhance understanding of the students regarding Islamic Civilization
3. To improve Students skill to perform prayers and other worships
4. To enhance the skill of the students for understanding of issues related to faith and religious life.

Detail of Courses

Introduction to Quran Studies
- 1) Basic Concepts of Quran
- 2) History of Quran
- 3) Uloom-ul-Quran

Study of Selected Text of Holy Quran
- 1) Verses of Surah Al-Baqara Related to Faith (Verse No-284-286)
- 2) Verses of Surah Al-Hujrat Related to Adab Al-Nabi (Verse No-1-18)
- 3) Verses of Surah Al-Mumanoon Related to Characteristics of faithful (Verse No-1-11)
- 4) Verses of Surah al-Furqan Related to Social Ethics (Verse No.63-77)
- 5) Verses of Surah Al-Inam Related to Ihkam (Verse No-152-154)

Study of Selected Text of Holy Quran
- 1) Verses of Surah Al-Ihzab Related to Adab al-Nabi (Verse No. 6, 21, 40, 56, 57, 58)
- 2) Verses of Surah Al-Hashar (18,19,20) Related to thinking, Day of Judgment
- 3) Verses of Surah Al-Saf Related to Tafakar, Tadabar (Verse No-1,14)

Seerat of Holy Prophet (S.A.W) I
- 1) Life of Muhammad Bin Abdullah (Before Prophet Hood)
- 2) Life of Holy Prophet (S.A.W) in Makkah
- 3) Important Lessons Derived from the life of Holy Prophet in Makkah

Seerat of Holy Prophet (S.A.W) II
- 1) Life of Holy Prophet (S.A.W) in Madina
- 2) Important Events of Life Holy Prophet in Madina
- 3) Important Lessons Derived from the life of Holy Prophet in Madina
Introduction to Sunnah
1) Basic Concepts of Hadith
2) History of Hadith
3) Kinds of Hadith
4) Uloom –ul-Hadith
5) Sunnah & Hadith
6) Legal Position of Sunnah

Selected Study from Text of Hadith

Introduction to Islamic Law & Jurisprudence
1) Basic Concepts of Islamic Law & Jurisprudence
2) History & Importance of Islamic Law & Jurisprudence
3) Sources of Islamic Law & Jurisprudence
4) Nature of Differences in Islamic Law
5) Islam and Sectarianism

Islamic Culture & Civilization
1) Basic Concepts of Islamic Culture & Civilization
2) Historical Development of Islamic Culture & Civilization
3) Characteristics of Islamic Culture & Civilization
4) Islamic Culture & Civilization and Contemporary Issues

Islam & Science
1) Basic Concepts of Islam & Science
2) Contributions of Muslims in the Development of Science
3) Quran & Science

Islamic Economic System
1) Basic Concepts of Islamic Economic System
2) Means of Distribution of wealth in Islamic Economics
3) Islamic Concept of Riba
4) Islamic Ways of Trade & Commerce

Political System of Islam
1) Basic Concepts of Islamic Political System
2) Islamic Concept of Sovereignty
3) Basic Institutions of Govt. in Islam

Islamic History
1) Period of Khlaft-E-Rashida
2) Period of Ummayyads
3) Period of Abbasids

Social System of Islam
1) Basic Concepts of Social System of Islam
2) Elements of Family
3) Ethical Values of Islam

Reference Books:
1) Hameed ullah Muhammad, “Emergence of Islam”, IRI, Islamabad
2) Hameed ullah Muhammad, “Muslim Conduct of State”
3) Hameed ullah Muhammad, ‘Introduction to Islam
4) Mulana Muhammad Yousaf Islahi,”
6) Ahmad Hasan, “Principles of Islamic Jurisprudence” Islamic Research Institute, International Islamic University, Islamabad (1993)
9) Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)