

**CURRICULUM
OF
GENETICS
FOR
BS
&
MS/MPhil**

(Revised 2017)



**HIGHER EDUCATION COMMISSION
ISLAMABAD**

CURRICULUM DIVISION, HEC

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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.

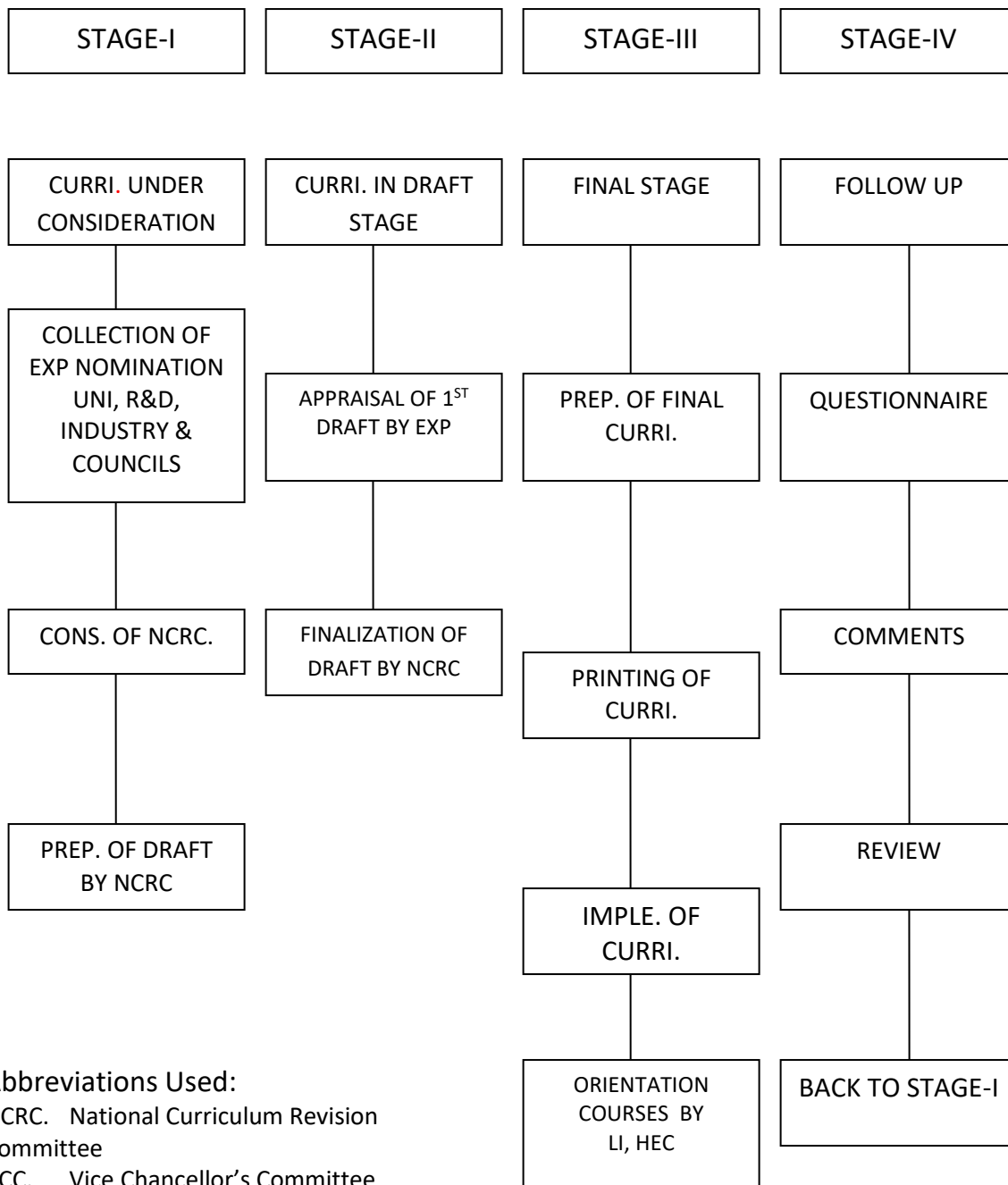
In order to impart quality education which is at par with indigenous needs and international standards, HEC NCRCs have developed unified framework/templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture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

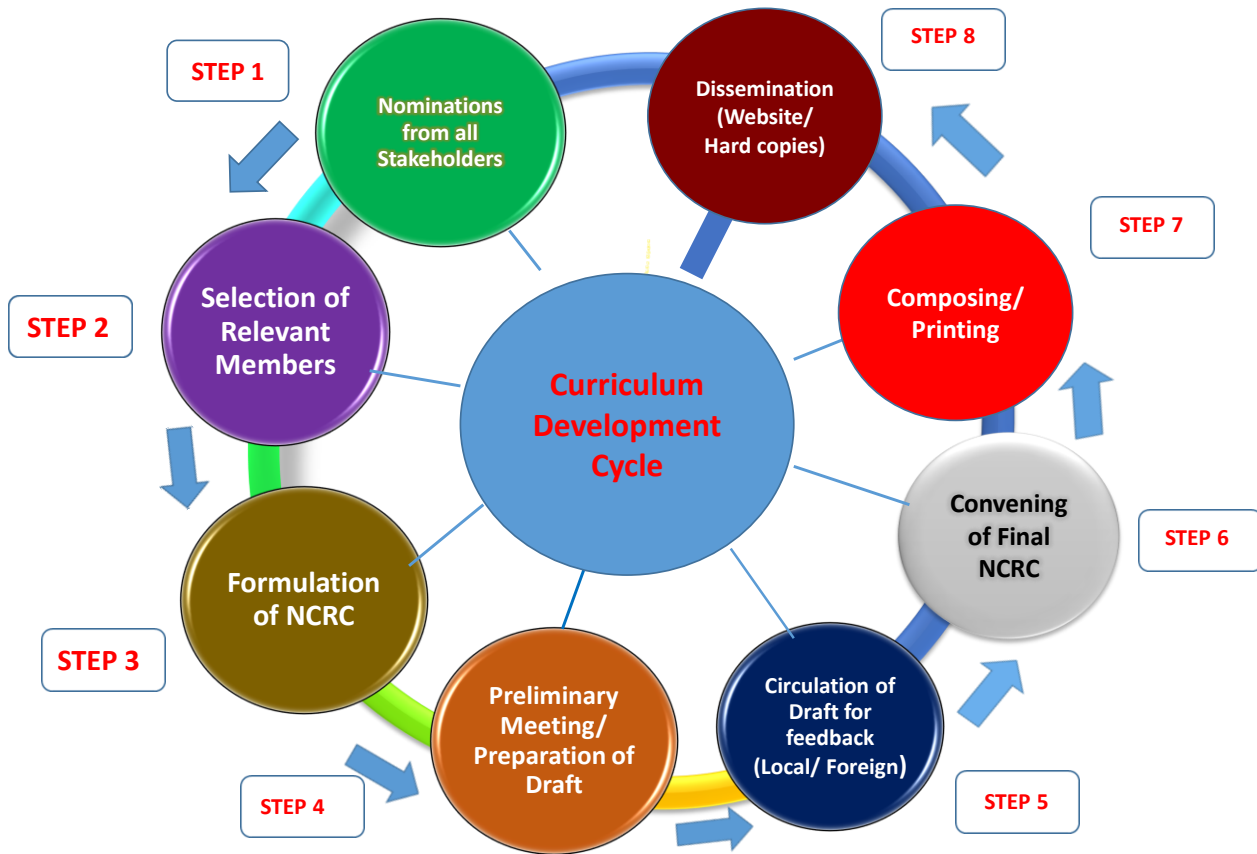
CURRICULUM DEVELOPMENT



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:-

Sr. No.	Name & Address	Status
1.	Dr. Ghulam Sarwar Markhand, Professor, Department of Botany, Shah Abdul Latif University, Khairpur.	CONVENER
2.	Dr. Abdul Samad Mumtaz Associate Professor Department of Plant Sciences, Quaid-i-Azam University, Islamabad.	SECRETARY
3.	Dr. Hidayat ur Rahman, Meritorious Professor/Chairman, Department of Plant Breeding & Genetics, The University of Agriculture, Peshawar.	MEMBER
4.	Dr. Ali Muhammad, Professor/Chairman, Department of Zoology, Islamia College University, Peshawar.	MEMBER
5.	Dr. Iftikhar Hussain Khalil, Professor, Department of Plant Breeding & Genetics, University of Agriculture, Peshawar.	MEMBER
6.	Dr. Shaukat Iqbal Malik, Associate Professor, Department of Bioinformatics & Biosciences, Capital University of Science and Technology, Islamabad Expressway, Sihala, Islamabad.	MEMBER
7.	Dr. Tayyaba Sultana, Professor,	MEMBER

	Department of Zoology, Government College University, Faisalabad.	
8.	Dr. Muhammad Ilyas, Director, Centre for Human Genetics, Hazara University, Mansehra.	MEMBER
9.	Dr. Muhammad Qasim, Assistant Professor, Department of Bioinformatics & Biotechnology, Government College University, Faisalabad.	MEMBER
10.	Dr. Nadia Khan, Assistant Professor, Department of Genetics, University of Karachi, Karachi.	MEMBER
11.	Dr. Syed Kashif Nawaz. Assistant Professor, Department of Zoology, University of Sargodha, Sargodha	MEMBER
12.	Dr. Syyeda Samra Jafri Assistant Professor, Department of Biochemistry Government College Women University, Madina Town, Faisalabad.	MEMBER
13.	Dr. Shahid Ali, Assistant Professor, Centre for Biotechnology & Microbiology, University of Swat, Swat.	MEMBER
14.	Dr. Noor Muhammad, Assistant Professor, Department of Biotechnology & Genetic Engineering, Kohat University of Science & Technology, Kohat.	MEMBER
15.	Dr. Amjad Ali Assistant Professor, Centre for Human Genetics, Hazara University, Mansehra.	MEMBER
16.	Mr. Riaz-ul-Haque, Assistant Director (Curriculum), Higher Education Commission	COORDINATOR

	Sector H-9, Islamabad.	
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Following Members attended the Preliminary meeting but could not attend the final meeting:

Dr. Habib Ahmed (TI), (Honorary Member) Professor/Vice Chancellor, Islamia College University, Peshawar.
Dr. Raziuddin, Professor, Department of Plant Breeding & Genetics, The University of Agriculture, Peshawar.
Dr. Syed Mehar Ali Shah Associate Professor, Department of Plant Breeding & Genetics, The University of Agriculture, Peshawar.
Dr. Muhammad Naeem Assistant Professor, Department of Plant Breeding & Genetics The Islamia University of Bahawalpur, Baghdad Campus, Bahawalpur.

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)

Course code	Semester-1	Cr. Hrs
ENG300	English – I	3 (3+0)
GEN301	Cell Biology	3 (2+1)
MAT300	Mathematics - I	3 (3+0)
CS 300	Introduction to Computing	2 (1+1)
300	Elective –I**	3 (2+1)
300	Elective – II**	3 (2+1)
	Total	17

Course code	Semester-2	Cr. Hrs
ENG300	English - II	3 (3+0)
GEN302	Principles of Genetics	4 (3+1)
MAT300	Mathematics – II	3 (3+0)
SOC300	1 course of Social Sci.*	2 (2+0)
300	Elective –I**	3 (2+1)
300	Elective –II**	3 (2+1)
	Total	18

Course code	Semester-3	Cr. Hrs
ENG400	English – III	3 (3+0)
GEN401	Cytogenetics	3 (2+1)
GEN402	Principles of Biochemistry	4 (3+1)
PS 400	Pakistan Studies	2 (2+0)
400	Elective –I**	3 (2+1)
400	Elective –II**	3 (2+1)
	Total	18

Course code	Semester-4	Cr. Hrs
ENG400	English (Communication Skills)	3 (3+0)
GEN403	Molecular Biology	3 (2+1)
GEN404	Biometry – I	3 (2+1)
ISL 400	Islamic Studies/Ethics	2 (2+0)
400	Elective-I**	3 (2+1)
400	Elective-II**	3 (2+1)
	Total	17

Course code	Semester-5	Cr. Hrs
GEN501	Genetics and Evolution	4 (4+0)
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)
	Total	18

Course code	Semester-6	Cr. Hrs
GEN506	Physiological Genetics	4 (3+1)
GEN507	Genetic Engineering	4 (3+1)
GEN508	Human Genetics	3 (2+1)
GEN509	Biometry – II	4 (3+1)
GEN510	Bioinformatics	3 (2+1)
	Total	18

Course code	Semester-7	Cr. Hrs
GEN601	Biosafety and Bioethics	3 (2+1)
GEN602	Developmental Genetics	3 (3+0)
GEN603	Biotechnology	3 (2+1)
GEN604	Research Techniques	4 (2+2)
GEN605	Genomics and Proteomics	3 (2+1)
GEN606	Seminar-I/Report Writing	1 (0+1)
	Total	17

Course code	Semester-8	Cr. Hrs
GEN607	Immunogenetics	3 (2+1)
GEN608	Genetic Resources and Conservation Seminar-II	3 (2+1)
GEN609	Special Paper-I	1 (0+1)
GEN610 onwards	Special Paper II Or Special Paper Internship Or Research	3 (0+0) 3 (0+0) 3 (0+0) 3 (0+3) 6 (0+6)
	Total	13

- * 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

Course No.	Courses	Credit Hours
GEN301 –	Cell Biology	3(2+1)
GEN302 –	Principles of Genetics	4(3+1)
GEN401 –	Cytogenetics	3(2+1)
GEN402 –	Principles of Biochemistry	4(3+1)
GEN403 –	Molecular Biology	3(2+1)
GEN404 –	Biometry – I	3(2+1)
GEN501 –	Genetics and Evolution	4(4+0)
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 –	Physiological Genetics	4(3+1)
GEN507 –	Genetic Engineering	4(3+1)
GEN508 –	Human Genetics	3(2+1)
GEN509 –	Biometry – II	4(3+1)
GEN510 –	Bioinformatics	3(2+1)
GEN601 –	Biosafety and Bioethics	3(2+1)
GEN602 –	Developmental Genetics	3(3+0)
GEN603 –	Introduction to Biotechnology	3(2+1)
GEN604 –	Research Techniques	4(2+2)
GEN605 –	Genomics and Proteomics	3(2+1)
GEN606 –	Seminar I/Report Writing	1(0+1)
GEN607 –	Immunogenetics	3(2+1)
GEN608 –	Genetic Resources and Conservation	3(2+1)
GEN609 –	Seminar II	1(0+1)
GEN610 –	Special Paper I/Special Paper II	3(0+0)
GEN610 –	Internship	3(0+3)
GEN610 –	Research	6(0+6)

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:

History and developments in cell biology. Features of prokaryotic and eukaryotic cells. Ultrastructure of cell, cell organelles and their functions (plant, animal, bacteria and viruses). Cell wall: physico-chemical structure. Plasma membrane (permeability, active transport, endocytosis and cell to cell interaction), endoplasmic reticulum, golgi complex, mitochondria, lysosomes, peroxisomes, glyoxysomes, ribosomes, plastids, vacuoles, centrioles, cytoskeleton (microtubules, intermediate filaments and microfilaments), nucleus and nucleolus. Chromosomes: morphology, physical and chemical composition in prokaryotes and eukaryotes. Cell Cycle and control of cell cycle. Mitosis; organizational and functional role of apparatus, cytokinesis and significance. Meiosis; significance and genetic consequences, comparison of mitosis and meiosis.

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.
- Mitosis: smear preparation of onion roots.
- Meiosis: smear preparation from insects and plants.
- Observation of plastids (leucoplasts, chloroplast and chromoplast)

Recommended Books:

1. Campbell Biology 10th Edition by Jane B. Reece, Lisa A. Urry Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson. Publisher Pearsons 2013.
2. Molecular Biology of the Cell, 6th Edition. by Bruce Alberts, Alexander

- Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter, Publisher Garland Science 2014.
3. Essential Cell Biology 3rd Edition by Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D Johnson, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts. Publisher Garland Science, 2009
 4. Molecular Cell Biology. 5th Edition by Lodish, H., D. Baltimore, A. Berk, S. L. Zipursky, P. Matsudaira, and J. Darnell, Scientific American Books, W. H. Freeman and Company, New York. 2005.
 5. Histology and Cell Biology: An Introduction to Pathology 3rd Edition by Abraham L Kierszenbaum , Laura L.Tres Published by Elsevier, 2011.
 6. www.cellsalive.com;
 7. <http://www.cellbiol.com>;
 8. <http://www.cellimagelibrary.org>

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:

Introduction and history of genetics. Heredity and variation. Mendel's laws of inheritance. Chromosomal theory of inheritance. Non-Mendelian inheritance (epistasis and its types, lethality and pleiotropism). Multiple alleles (ABO blood group system) and polygenic traits (Rh factor). Linkage and crossing over. Gene mapping. Sex linkage, sex determination and sex linked inheritance, sex influenced, sex limited, genomic imprinting and holandric genes. Qualitative and quantitative inheritance. Gene and environment: penetrance, expressivity, pleiotropism and phenocopies. Twin studies. Mutations. Extra-nuclear inheritance: maternal inheritance. Pedigree analysis.

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:

1. Principles of Genetics, 7th Edition. D. Peter Snustad, Michael J. Simmons published by Wiley, 2016.
2. Molecular Biology of the Cell, 6th Edition. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Publisher by Garland Science 2014.
3. Histology and Cell Biology: An Introduction to Pathology 3rd Edition by Abraham L Kierszenbaum, Laura L. Tres. Published by Elsevier, 2011.
4. Lewin's GENES XI by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Published by Jones & Bartlett Learning, 2013.
5. Genetics and Cytology: with an introduction to Evolution. Baquar, R. Published by National Book Foundation. 2007.
6. Genetics: A conceptual approach, 4th Edition. Benjamin Pearce, Published by Freeman and Company. 2012.
7. Genetics: Analysis and Principles. 4th Edition. Brooker R. J. McGraw-Hill Book Co. Bostan. USA. 2011.
8. Introduction to Genetic Analysis. Griffiths, A. J. F, J. H. Miller, D. T. Suzuki, R. C. Lewontin and M. W. Gelbart. Published by Freeman Company, 2005.
9. Essential Genetics: a genomic perspective. 5th edition. Hartl Daniel L. Published by Jones and Bartlett, USA. 2011.
10. <http://knowgenetics.org>
11. http://anthro.palomar.edu/mendel/mendel_1.htm
12. <http://waynesword.palomar.edu/lmexer5.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:

Introduction and history of cytogenetics. Cell and DNA containing organelles. Morphology and ultrastructure of chromosomes. Cell cycle: mitosis and meiosis. Synaptonemal complexes, its mechanism and cytological evidences. Nucleolar Organizing Regions (NORs). Chromosome function: Lyon hypothesis, special types of chromosomes: polytene, lampbrush and B-chromosomes. Position effects. Chromosomal aberrations: Numerical and structural chromosomal aberrations. Chromosome systems (parthenogenesis and apomixis). Induced chromosome doubling and behavior of chromosomes in interspecific and intraspecific crosses. Karyotyping and banding techniques. Molecular cytogenetic techniques (ISH, FISH, GISH)

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:

1. Principles of Genetics & Cytogenetics– Ponam Panday. Wiley Publishers. 7th Edition. 2015.
2. Cytogenetics Abnormalities: Chromosomal, FISH, and Microarray-Based Clinical Reporting and Interpretation of Results by Susan Mahler Zneimer, Wiley Blackwell, 2014
3. The Principles of Clinical Cytogenetics, Steven L. Gersen Martha B. Keagle, Springer, 2013
4. A text book of Molecular Cytogenetics, Ashok Kumar & Meena Srivastan, Narendra Publishing House, Delhi, 2012
5. Fundamentals of Cytogenetics and Genetics. Mahabal Ram. Published by Prentics Hall India Learning private limited 2010
6. Genetics and Cytology: with an introduction to Evolution. Baquar, R. National Book Foundation. 2007
7. Cytogenetics. Rajan, S. S. Anmol Publications. 2004.
8. Plants Cytogenetics. 2nd Ed. Singh, R. J. CRC Press, USA. 2002.
9. Cytogenetics: The chromosome in division, inheritance and evolution 2nd Edition. Swanson, C. P., Merz, T. and Young, W. J. Prentice – Hall Inc. 1990.
10. <http://cse.fra.affrc.go.jp/ksaitoh/C-banding-e.html>
11. https://www.utmb.edu/pedi_ed/CORE/MedicalGenetics/page_01.htm
12. <http://www.biology-questions-and-answers.com>
13. <http://bowlingsite.mcf.com/genetics>

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:

Introduction to biochemistry and its importance in life sciences. Macromolecules: (Carbohydrates, Proteins, Lipids and Nucleic acids) types and their biological role. Carbohydrates: Occurrence, classification, chemistry and metabolism, optical activity. Lipids: occurrence, classification, structure and chemistry of fatty acids. Proteins: Amino acids occurrence, classification,

structure, and chemistry. Levels of proteins: primary, secondary, tertiary and quaternary structures. Nucleic Acids: introduction, purine and pyrimidine bases, nucleosides, nucleotides, structure and properties of DNA and RNA, types and functions of RNA. Properties and role of enzymes, hormones and vitamins in metabolism.

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:

1. Molecular Biology of the Cell, 6th Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Publisher Garland Science 2014.
2. Principles of Biochemistry 6th Edition by Lehninger A. L., David L. Nelson, Michael M. Cox, Publisher W.H. Freeman, 2012.
3. Essential Cell Biology 3rd Edition Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander D Johnson, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts. Publisher Garland Science, 2009
4. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Thomas M. Devlin ISBN: 978-0-470-60976-7 Es, 2010
5. Outlines of Biochemistry. Conn E. E. and P. K. Stumpf, John Wiley and Sons Inc. Publishing Co. New York. 2002.
7. Biochemistry, 3rd Edition, Mathews C. K., K. E. Van Holde, K. G. Ahern, Benjamin/Cummings; 2000.
8. Biochemistry. 6th Edition. Stryer, L. W.H. Freeman Co. 2006.
9. Biochemistry: a short course. Tymoczko, J. L., Berg, J. N., Stryer, L. W. H. Freeman. 2009.
10. <http://www.prenhall.com/horton/>
11. <http://spdbv.vital-it.ch/TheMolecularLevel/Biochem/Text/Topics.html>

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:

Introduction and concept of molecular biology. Molecular nature of hereditary material, prokaryotic and eukaryotic genomes. DNA replication in prokaryotes and eukaryotes, Central dogma in molecular biology. Transcription, initiation factors, *Cis/Trans* elements, post transcriptional modifications. Translation, post-translational modifications. Gene structure. Gene expression and regulation in prokaryotes and eukaryotes. Mutagenesis: DNA damage and repair mechanisms. DNA recombination. Latest topics in molecular biology.

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:

1. Molecular Biology of the Cell, 6th Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter Publisher Garland Science 2014.
2. Molecular Biology: Genes to Proteins. (Biological Science) 4th Edition by Tropp, Burton E. Tropp, Jones & Bartlett Publishers; 4 edition, 2011.
3. Molecular Biology 2nd Edition David Clark Nanette Pazdernik Imprint: Academic Cell Publishers 2012.
5. Molecular Biology: Genes to proteins 3rd Edition. Burton, E. Tropp. Jones and Bartlett Publishers. 2008.
7. Genes-XI. Lewin, B., J. E. Krebs, E. S. Goldstein, S. T. Kilpatrick. Jones & Bartlett Publishers, 2011.
8. Molecular Cell Biology. 8th Edition. Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., and Darnell, J. E. W. H. Freeman, USA. 2016.
9. <http://employees.csbsju.edu/hjakubowski/classes/ch331/bcintro/default.html>
10. <http://www.cellbio.com/protocols.html>

GEN 404 – Biometry – I

3 (2+1)

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 poisson 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.
2. Random Data: Analysis and Measurement Procedures. 3rd Edition, Benda T. S. and A. G. Piersol, Wiley-Interscience; 2000.
3. Introduction to Statistical Theory Part-I by Sher Muhammad Chaudhry by Ilmi Kitab Khan 2011.
4. Introduction to statistical theory Part-II by Sher Muhammad Chaudhry by Ilmi Kitab Khana Pakistan, 2013.
5. Introduction to Applied Statistics: A modeling approach. 2nd Edition. Lindsey, J.K. 2004.
6. Statistical methods in Agriculture and Experimental Biology. 3rd Edition. Mead, R., R.N. Curnow, and A.M. Hasted. Chapman and Hall/CRC. 2003.
7. Biostatistics: The Bare Essentials, 2nd edition, Norman G. R., Streiner, D. L. Streiner, B C Decker; 2000.
8. The Handbook of Applied Acceptance Sampling: Plans, Procedures and Principles, 1st Edition, Stephens, K. S., American Society for Quality, 2001.
9. <http://www.real-statistics.com>
10. <https://www.dmoz.org/Science/Math/Statistics/Software>
11. https://phpartners.org/health_stats.html
12. <https://reference.wolfram.com/language/guide/Statistics.html>
13. <http://www.claviusweb.net/statistics.html>

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
3. Vertebrates: Comparative Anatomy, Function Evolution by Kenneth V Kardong Published by MCGraw Hill, 2014
4. Genetics and Cytology: with an introduction to Evolution. Baquar, R. National Book Foundation. 2007.
5. Genetics and Evolution. Din-yan Yip. Manhatan-Marshal Cavendish Education. 2010.
6. Evolution. Strickberger, M. W. John and Bartlett Publishers International, USA. 2000.
7. Evolution of Plants. Willis, K. J. and J. C. McElwain. Oxford University Press, Oxford, UK. 2002.
8. http://evolution.berkeley.edu/evolibrary/article/evo_17
9. <http://life.mcmaster.ca/evoldir.html>
10. <https://popmodels.cancercontrol.cancer.gov/gsr/packages/>
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:

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 universal code. Gene expression in pro and eukaryotes: Promoters 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, post translational modifications. Gene regulation in pro and eukaryotes: Operon concept, lactose operon and histidine operon, factors involved in eukaryotic gene regulation. Gene recombination. Molecular mechanisms of DNA recombination, gene conversion. Mutation: molecular basis, types of mutagens. DNA damage and repair mechanisms. Transposable elements in pro and eukaryotes. Introduction to forensic genetics.

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:

1. Molecular Biology of the Cell, 6th Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter
Publisher Garland Science 2014.
2. Molecular Genetics of Bacteria, 4th Edition by Larry Snyder, Joseph E. Peters, Tina M. Henkin, Wendy Champness, Publisher: ASM Press; 2013
3. Molecular Genetics of Bacteria, 4th Edition Jeremy W. Dale, Simon F. Park ISBN: 978-0-470-09388-7, Published by Wiley. 2005.
4. Lewin's GENES XI 11th Edition by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning; 2013.
5. Principles of Genetics, 7th Edition D. Peter Snustad, Michael J. Simmons, 2016.
6. Gene cloning and DNA analysis 6th Edition TA Brown. Published by Wiley. 2010.
7. Molecular Genetics of Bacteria 3rd Edition. Snyder, L and W. Champness. ASM Press USA. 2007
8. Cloning, Gene Expression and Protein Purification: Experimental Procedures and Process Rationale, Hardin C. C. et al. Oxford University Press, 2001.
9. *E. coli* Gene Expression Protocols (Methods in Molecular Biology), Vaillancourt P. E., Humana Press, 2002.
10. Molecular analysis and genome discovery. Rapley, R. John Wiley & Sons. 2004.
11. http://abmagg.org/pages/training_accredprog.shtml

12. <http://mycology.cornell.edu/fgenetic.html>

13. <http://bioweb.ensam.inra.fr/spodobase/>

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:

Introduction to microbial genetics. Morphology and life cycle of bacteria; single and double stranded viruses and retroviruses. Genetic recombination in bacteria (transformation, transduction and conjugation), and its significance. Virulent and avirulent phages. Mu-phage and HIV structure, life cycle integration and significance. Integrons, Prions. Bacterial restriction enzymes. Gene mapping in bacteria: Mode of action of antibiotics and development of resistance. Extra chromosomal elements: Plasmid classification with emphasis on R- factors, bacteriocins, bio-degradative and yeast plasmids. Transposable elements and Transposons: IS elements (types and function), Transposition.

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:

1. Microbial Gene Techniques (Methods in Molecular Genetics), Vol. 6. Adolph K. W., Academic Press; 1995.
2. Bacterial and Bacteriophage Genetics. 5th Edition, Birge, E. A. Springer, 2006.
3. Molecular Genetics of Bacteria, 3rd Edition, Dale J., John Wiley and Sons Ltd; 1998
4. Microbial Genetics, 3rd Edition, Maloy S. R., J. Jr Cronan. Jones and Bartlett Pub; 2008.
5. Modern Microbial Genetics 2nd Edition, Streips U. N., R. E. Yasbin, John Wiley and Sons; 2002
6. Fundamental bacteria genetics. Trun, N. and J. Trempy. Blackwell Pub Co. 2004.
7. <http://www.methods.info/index.html>

8. <http://www.academicinfo.net/bioimage.html>
9. <http://www.biology-pages.info/C/Caen.elegans.html>
10. <http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/W/Welcome.html>

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:

Introduction and scope of population genetics. Structure and genetic constitution of a population: Hardy-Weinberg (HW) equilibrium. Changes in gene and genotype frequency: migration, mutation, selection and genetic drift. Inbreeding and inbreeding coefficient, heterosis. Components of genetic variance: additive, dominance and epistatic. Variance, Covariance and correlation (genetic and environmental); population mean, average effects, breeding value, dominance deviation, offspring mid parent, half sibs, full sib deviation. Familial aggregations, relative risk, family studies, twin studies, adoption studies. Estimation of heritability and genetic advance. Repeatability. Selection: response and its prediction. Changes of mean and variance in inbred and crossbred populations. Emerging trends in population genetics.

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:

1. Principles of Population Genetics, 4th Edition, Daniel L. Hartl and Andrew G. Clark, 2007
2. Introduction to Quantitative Genetics Addison-Wesley Pub Co; 4th Edition Falconer D. S., F. C. Trudy MacKay, 1996
3. Genetics of Populations, Hedrick P.W., Jones and Bartlett Pub; 2000
4. Population Genetics: A Concise Guide, John H. Gillespie, 2004
5. Quantitative Genetics, Genomics, and Plant Breeding, Kang M.S., CABI Publishing, CAB International; 2002

6. Genetical Analysis of Quantitative Traits, Kearsley M. J., H. S. Pooni. Stanley Thornes Pub Ltd; 1996
7. Evolution and Selection of Quantitative Traits, Lynch M., B. Walsh, Sinauer Associates, Incorporated, 2002
8. Population Genetics; Matthew B. Hamilton, 2009
9. Genetic Data Analysis III, Weir B., Sinauer Assoc; 2002.
10. <http://dna-view.com>
11. <http://www.y-str.org>
12. <http://www.cellmark.ie>

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:

Introduction to plant and animal breeding. Reproductive systems and population control in plants and animals. Incompatibility and male sterility systems. Selection procedures. Creation of variation. Genetic consequences of hybridization. Genetic basis of inbreeding depression, heterosis and estimation of combining ability. Breeding methods for self and open pollinated populations. Pure line breeding and mass selection, pedigree and bulk methods in plants, development of hybrid and synthetic varieties. Breeding for disease and insect resistance in plants. Breeding methods in poultry and animals. Marker Assisted Selection (MAS). Breeding for economic traits.

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:

1. Understanding Genetics: DNA, Genes, and Their Real-World Application. David Sadawa. The Great Courses, 2013
2. Principles of Plant Genetics and Breeding 2nd Edition by George Acquaah Publisher: Wiley-Blackwell; 2012

3. Plant Breeding Reviews, Volume 37. Jules Janick (Editor) ISBN: 978-1-118-49795-1, 2013, Wiley-Blackwell.
4. Principles of Plant Breeding. Allard R.W., John Wiley and Sons; 2nd Ed. 1999.
5. Understanding Animal Breeding. Bourdon, R. M. Prentice Hall Inc. Upper Saddle River New Jersey, USA, 2000
6. Principles and Procedures of Plant Breeding: Biotechnological and Conventional Approaches, Chahal G. S., S. S. Gosal, CRC Press; 2002.
7. Principles of plant genetics and breeding, George Acquah, John Wiley & Sons; 2007.
8. Plant breeding. Lee M. and K. R. Lamkey, the Arnel R. Hallauer International Symposium; 2006.
9. Animal Biotechnology, Ning L., and C. Yongfu, Intl Academic Pub House, 1997.
10. Breeding Field Crops. Pohlman, J. 1987
11. Plant Breeding Systems, Richards A. J., Stanley Thornes Pub Ltd; 1997
12. <http://ecoursesonline.iasri.res.in/course/view.php?id=134>
13. http://plantbreedingfordroughttolerance.colostate.edu/online_course.html
14. <http://articles.extension.org/pages/60426/webinar-registration-and-archive>
15. <http://rye-gene-map.de/plant-breeding-update/>

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:

Introduction and scope of physiological genetics. Effect of environment on plants, animals and microbes. Genes and proteins related to biotic and abiotic stresses. Physiological and genetic mechanisms of stress tolerance. Gene families responsible for stress tolerance. Genes controlling the pathways responsible for salt, drought, heat, cold, radiation and oxygen stresses. Genetics of host-pathogen interaction.

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:

1. Introduction to Animal Physiology and Physiological Genetics. E. M. Pantelouris, G. A. Kerkut. Pergamon Press Ltd, Headington Hill Hall, Oxford. 2013
2. Physiological Genetics. Richard Benedict Goldschmidt. Biblio Life Publishers. 2015.
3. Epigenetics: How Environment Shapes Our Genes by Richard C. Francis Publisher: W. W. Norton & Company, 2012
4. Evolutionary, Developmental and Physiological Genetics Edited by: Gerats, Tom, Strommer, Judy (Eds.) Springer 2009
5. Crop Response to Environment. Hall, A. CRC Press. 2000.
6. Genes in the Environment. Hails, R. S., J. Beringer, and H. C. J. Godfray. Blackwell Publishing.
7. Plant Responses to abiotic Stress. 4th Ed. Heribert, H. and K. Shinozaki. Springer Verlag. 2003.
8. Cassidy Management of Genetic Syndromes. Suzanne B. C. and J. E. Allanson, 2010.
9. <http://www.concordcarlisle.org/rmahoney/cp-biology-useful-links/#>

GEN 507 – Genetic Engineering

4 (3+1)

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:

1. Lewin's GENES XI by Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick Jones & Bartlett Learning; 2013.
2. Principles of Genetics, 7th Edition D. Peter Snustad, Michael J. Simmons 2016.
3. Gene cloning and DNA analysis 6th Edition TA brown Blackwell Science Inc 2010 Published by Wiley.
4. An Introduction to Genetic Engineering; Desmond S. T. Nicholl. Cambridge University Press, 2008.
5. Genetic Engineering: Manipulating the Mechanisms of Life (Genetics & Evolution). Hodge R. and N. Rosenthal, 2009.
6. Molecular Cloning: A Laboratory Manual (3-Volume Set), Sambrook J., D. W. Russell, J. Sambrook. Cold Spring Harbor Laboratory Press, 2001
7. Biotechnology and Genetic Engineering (Library in a Book); Yount, L. 2008.
8. Genetic Engineering, Yount, L., Gale Group, 2002
9. http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml
10. <http://learn.genetics.utah.edu/>
11. <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:

Introduction to human genetics. Study tools in human genetics: pedigree, chemical and biochemical analyses. Chromosomal studies. Karyotype analysis. Congenital malformations: Genetic defects in prenatal development, oncogenes and genetical basis of cancer. Epigenetics. Metabolic variation and diseases: In-born errors of metabolism, errors in transport system, inherited

variations, genetic linkage: family method, somatic cell hybridization. Gene mapping: deletion and duplication. Eugenics. Forensic DNA study. Twin studies (MZ, BZ etc.). Population analysis (mtDNA, Y-STRs), SNPs, haplotyping. Ethical, legal and social issues in human genetics. Genetic Counseling.

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:

1. Genetics in Medicine Thompson & Thompson, Robert L. Nussbaum, Roderick R. McInnes, Huntington F. Willard, Ada Hamosh. Elsevier, 2007.
2. Lewin's GENES XI by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning; 2013.
3. Principles of Genetics, 7th Edition D. Peter Snustad, Michael J. Simmons, 2016
4. Gene cloning and DNA analysis TA brown 6th Edition Published by Wiley. 2010.
5. Human Genetics 11th Edition by Ricki Lewis, McGraw-Hill Education, 2014.
6. Annual Review of Genomics and Human Genetics, Vol 17, 2016.
7. Current topics in human genetics, Deng, Hong-Wen, Hui Shen, Yong-Jun Liu, World Scientific; 2007.
8. The Human Genome, 3rd edition, Julia E. Richards, R. Scott Hawley, Academic press 2010.
9. Human Natures: Genes, Cultures and the Human Prospect, 1st Edition, Ehrlich P. R., Penguin USA Paper, 2002.
10. Human Genetics: Concepts and Applications. 10th International edition, Lewis, R. McGraw Hill Higher Education; 2011.
11. Genetics and the Search for Modern Human Origins. Relethford J. H., Wiley-Liss 2001.
12. Human Molecular Genetics; Strachan, T. and Andrew Read, Garland Science/Taylor & Francis. 2010.
13. <https://www.dnalc.org/>
14. <http://www.hgmp.mrc.ac.uk/omim>
15. <http://archive.uwcm.ac.uk/uwcm/mg/hgmd0.html>

16. <http://vector.cshl.org/dnaftb/>

17. <http://www.nhgri.nih.gov/100001772>

GEN 509 Biometry – II

4 (3+1)

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:

Homogeneity of variance. Analysis of variance and covariance. Correlation and regression analysis. Odds Ratio. Allele frequency analysis, Hardy-Weinberg Equilibrium, Factor Analysis, General Linear Model, completely randomized design, randomized complete block design, Latin Square, split plot arrangements and factorial design. Mean separation test: LSD test, Tukey test, Duncan test, Mann-Whitney U test, Wilcoxon Rank-Sum test, Levene's test. Use of statistical software: Excel, SPSS, MINITAB, MSTAT and R.

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:

1. Statistical procedures for Agricultural research. IRRI. 2nd Edition Gomez, A. K. & A. A. Gomez. John Wiley & Sons, Singapore. 1984.
2. Guide to Biometrics for Large-Scale Systems Technological, Operational, and User-Related Factors, 1st Edition. Ashbourn, Julian. 2011,
3. Random Data: Analysis and Measurement Procedures 3rd Edition, Bendat, J. S. and A. G. Piersol, Wiley-Interscience; 2000
4. The Genetical Analysis of Quantitative Traits. Kearsey, M. J. and M. S. Pooni. Chapman and Hall Ltd., London, UK. 1996.
5. Biostatistics: The Bare Essentials, 2nd Edition, Norman G. R., Streiner and D. L. Streiner, B C Decker; 2000.
6. Biometry: The Principles and Practices of Statistics in Biological Research Sokal, R. R. and F. James Rohlf September, 2011.
7. Principles and Procedures of Statistics: A Biometrical Approach, 3rd Edition, Steel R. G. D., J. H. Torrie, and D. A. Dickey, McGraw-Hill Higher Education; 1996
8. The Handbook of Applied Acceptance Sampling: Plans, Procedures and Principles, 1st Edition, American Society for Quality; Stephens, K. S., 2001
9. Biostatistical Analysis, 4th edition, Zar J. H., Prentice Hall Co. 1998

10. <http://www.spss-tutorials.com/basics/>
11. <http://www.psych.utoronto.ca/courses/c1/spss/toc.htm>
12. <https://www.minitab.com/en-us/support/videos/>
13. <https://mcardle.wisc.edu/mstat/help/help/Mhelp-2.html>

GEN 510 Bioinformatics

3 (2+1)

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:

Introduction to bioinformatics and global bioinformatic centres. Introduction to genomics and genome browsers. Introduction to nucleic acids and protein sequence databases, sequence motif databases, protein structure databases. File formats. Alignment: local, global, pairwise and multiple sequence alignment, similarity of homology, conserved regions, insertions/deletion score, statistical significance. Structural and functional analysis of nucleic acids and protein. Protein modeling. Introduction to systems biology: gene regulatory networks, introduction to drug designing. Primer designing and in-silico analysis. Dynamic programming. Uses of various bioinformatics tools for solving biological problems.

Recommended Books:

1. Exploring Bioinformatics: A Project-Based Approach 2nd Edition by Caroline St. Clair, Jonathan E. Visick, Jones & Bartlett Learning; 2013.
2. Bioinformatics: sequence and Genome Analysis David W. Mount, , CSHL Press, 2004.
3. Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids. Durbin, R., S. Eddy, A. Krogh and G. Mitchison. ISBN: 0-521-62971-3. 1998.
4. Essential bioinformatics. Jin Xiong. 2006.
5. Bioinformatics and Functional Genomics. Jonathan Pevsner, 2009.
6. www.embl.ac.uk
7. www.flybase.org (*Drosophila*)
8. www.ebi.ac.uk
9. www.ncbi.nlm.nih.gov
10. www.primer3.ut.ee
11. www.hapmap.org
12. <http://bioinformatics.weizmann.ac.il/cards/>
13. <http://silkworm.genomics.org.cn>
14. <http://www.ii.uib.no/~inge/list.html>

GEN 601 Biosafety and Bioethics

3 (2+1)

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.

Introduction to bioethics. Commercialization and benefit sharing of biotechnology. Ethical and legal aspect of genetic engineering, optimizing safety and benefits of genetic testing. Experimentations on human embryos. Biotechnology approach and perspectives of several religions. Stem cell research and religion. Bioterrorism and justice. National bioethic policies, patent laws at national and international level.

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:

1. Bioethics and Biosafety–by M K Sateesh. 2008
2. IPR, Biosafety and Bioethics Kindle Edition by, Deepa Goel, Shomini Parashar Publisher: Pearson; 2013
3. Environmental Risks and Hazards, Cutter, S. I. Prentice Hall, 1993.
4. Cloning (Issues). Donnellan, C., Independent educational Publication 2002
5. The ethics of genetic engineering, Donnellan, C. Independent Educational Publication. 1998.

6. Gene and Future People: Philosophical Issues in Human Genetics. Glannon, W. Westview Press, 2002.
7. The work environment; Healthcare, Laboratories and Biosafety. Hansen, D. J., Lewis Publishers. 1992.
8. Responsible Genetics: The Moral responsibility of Geneticists for the Consequences of Human Genetics Research, Nordgren, A. Kluwer Academic Publishers, 2001.
9. Nature, Risk, and Responsibility: Discourses of Biotechnology. O' Mahony, P. J.: Routledge Publisher, 1999.
10. Bio-ethics for new Millennium, Torrance, I. Saint Andrew Press. 2000.
11. Bioethical Dilemmas in Pakistani Context. Muhammad Ilyas, Mukhtar Alam and Habib Ahmad. LAP Lambert Academic Publishing Germany. 2013
12. <http://www.ornl.gov/hgmis/publicat/genechoice/index.html>
13. <http://www.nuffield.org/bioethics/index.html>
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:

The constancy of genome. Evaluation and function of genes underlying fundamental cellular, developmental and physiological processes such as differentiation and growth, regeneration and evolution, program cell death, cell-cell communication, cell movement, tissue patterning. Gene activity such as generating transgenic organisms. Role of heterochromatin. Cytoplasmic regulation of gene expression during development: nuclear-cytoplasmic interactions. Metamorphosis and regeneration: sexual differentiation in mammals. An overview of developmental processes in model organisms (*Drosophila* sp., *Mus musculus*, *Arabidopsis thaliana*, *Caenorhabditis elegans*). Introduction to stem cell research and gene therapy.

Recommended Books:

1. Principles of Developmental Genetics, 2nd Edition Academic Press S MOODY 2014.
2. Essential Developmental Biology, 3rd Edition Jonathan M. W. Slack, Wiley-Blackwell. 2012
3. Quantitative Genetic Studies of Behavioral Evolution. Christine R. B. B., University of Chicago Press; 1994.

4. Genes and Future People: Philosophical Issues in Human Genetics, Glannon W., Westview Press, 2002.
5. Law and Ethics of Genetic Privacy. Laurie G., Cambridge University Press, 2002.
6. Developmental Genetics. Miglani, G. S. 2007
7. Principles of Developmental Genetics. Moody, S. A. 2007.
8. Responsible Genetics: The Moral Responsibility of Geneticists for the Consequences of Human Genetics Research, Nordgren A., Kluwer Academic Publishers, 2001.
9. Behavioral Genetics. 4th Edition. Plomin R., John C. Defries, Gerald E. McClearn, McGuffin, W. H. Freeman and Co. 2000.
10. Nature and Nurture: An Introduction to Human Behavioral Genetics, Plomin R., Wadsworth Pub Co; 1990.
11. <http://www.hudsen.org/>
12. <https://dmdd.org.uk/>
13. http://www.med.unc.edu/embryo_images/unit-welcome/welcome_htms/contents.htm
14. <http://www.medicalmuseum.mil/index.cfm?p=collections.hdac.index>
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:

Concepts, historical background, conventional and modern biotechnology. Plant biotechnology: plant tissue culture and GM Crops. Environmental biotechnology: Bioaccumulation and Bioremediation. Biological control. Industrial biotechnology: fermentation techniques, bio products (enzymes, amino acids etc.). Health biotechnology: animal and human tissue culture, diagnostic tools, health care products. Bio-processing. Economic perspectives of biotechnology. Biotech Companies. Biotech entrepreneurship.

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

- Science Press, 2008
2. Basic Biotechnology, Attedge, C. R. and B. Kristiansen. Cambridge University, Press UK. 2001
 3. Molecular Biotechnology. Bernard R. Glick and Jack J Pastermak. ASM Press 2003.
 4. Introduction to Biotechnology. Herren, R. V.; 2012.
 5. Introduction to Biotechnology. Saini, B. L., Laxmi Publications, Ltd.,2010.
 6. Introduction to Biotechnology (3rd Edition). Thieman, W. J. and M. A. Palladino, 2012.
 7. <http://biotechlearn.org.nz>
 8. <https://www.aphis.usda.gov/aphis/ourfocus/biotechnology>
 9. <http://www.bioedonline.org>
 10. <http://www.biotechpicklist.com/bioinvesting/>
 11. <https://gradpages.wustl.edu/bec>
 12. <http://cabe-africa.org/index.php/important-links>
 13. <https://www.irem.uzh.ch/en/teaching/bioentrepreneurship.html>

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:

1. Molecular Cloning, A Laboratory Manual (3rd Edition): J. Sambrook and D. Russell, Cold Spring Harbor Laboratory Press, 2001.
2. Molecular Biology Techniques An Intensive Laboratory Course: J. Ream and K. G. Field, Academic Press, 1999.
3. Research Methods in Education. 6th Edition. Cohen L., L. Manion, K. Morrison, 2011.
4. Introduction to Research Methods, 3rd Edition. Howitt, D., D. Cramer. 2010
5. <http://vector.cshl.org/resources/BiologyAnimationLibrary.htm>
6. http://www.protocol-online.org/prot/Molecular_Biology/index.html

7. <http://www.hhmi.org/biointeractive/immunology/vlab.html>
8. <http://www.protocol-online.org/prot/Immunology/index.html>

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:

Concepts of genomics and proteomics. Structural Genomics: Genetics and physical maps, genome sequencing, single nucleotide polymorphism, copy number variations, expressed sequence tags, bioinformatics, metagenomics, synthetic biology. Functional Genomics: Prediction of function from sequences, gene expression and microarrays, gene expression and reporter sequences, genome wide mutagenesis. Comparative Genomics: Origin of genomics, prokaryote genomics, eukaryotic genomics, comparative *Drosophila* genome, the human genome. Proteomic Analysis: Determination of cellular proteins, affinity capture, protein microarrays, structural proteomics. Prediction of protein coding gene, prediction of RNA coding gene, Promoter prediction through feature recognition, functional categories of genes, Genome scale gene mapping, Genome perspective on horizontal gene transfer (HGT).

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:

1. Genomics and Proteomics: Principles, Technologies, and Applications Devarajan Thangadurai, Jeyabalan Sangeetha, Apple Academic Press. 2015
2. Concepts and Techniques in Genomics and Proteomics: A volume in Woodhead Publishing Series in Biomedicine, N. Saraswathy and P. Ramalingam. 2011
3. Genomics and Proteomics Engineering in Medicine and Biology Akay M. John Wiley and Sons, Inc. 2007.
4. Bioinformatics, genomics and proteomics, getting the big picture. Batiza A. F. Infobase publishers. 2006.
5. Plant Genomics and Proteomics. Cullis A. C. John Wiley and Sons Inc. Hoboken, New Jersey. 2004.
6. Data Mining for Genomics and Proteomics: Analysis of Gene and Protein Expression Data. Dziuda M. D. John Willey & Sons, Inc, New Jersey USA. 2010.

7. Cancer genomics and proteomics, methods and protocols. Fisher B. P. Humana Press Inc. 2007.
8. Genomics and proteomics, functional and computational aspects. Suhai S. Kluwer Academics Inc. 2002.
9. <http://genomesunzipped.org>
10. <http://thepersonalgenome.com>
11. <http://www.personalgenomes.org>
12. <http://expasy.org>
13. <http://proteome.dc.affrc.go.jp/Soybean/>
14. <http://www.oilseedproteomics.missouri.edu/>

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
- *Immunofluorescent 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.
2. Cellular and molecular immunology. 4th Ed. Abbas, A. K., A. H. Lichtman, J, S. Pober. W. B. Saunders Co. 2000.
3. Advances in Immunology. Dixon, F. J., F. Alt, and K. F. Austen. Vol. 75. Academic Press. 2000.
4. Immunogenetic: Webster's Timeline History, Icon Group International, 1950 – 2007. 2010
5. Fundamentals of immunology. 2nd Edition. Myrvik, W. LEA & Febiger. 1984.
6. Immunogenetics of Autoimmune Disease. Oksenberg, J. R.; B. David (Eds.) 2006
7. Roitts Essential Immunology. 10th Edition. Roitt, I and P.J. Delves. Blackwell Science. 2001.
8. Immunology. 5th Edition. Veir, D, M. Churchill Living Stone. 1983.
9. <https://www.pharmgkb.org/>
10. <http://www.pgrn.org/>
11. <http://www.imgt.org>
12. <http://www.immunogenetics.nl>
13. http://www.ufrgs.br/imunovet/molecular_immunology/immunogenetics.html

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 genetic resources. Significance of genetic resources in genetic research. Centers of origin and distribution pattern of important microbes, plants 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. 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
2. Plant Genetic Resources Management, Bhillon, B. S., R. K. Tyagi and A. Lal. Narosa, N. Delhi, India. 2004.
3. The use of Plant Genetic Resources. Brown, A. H. D., O. H. Frankel, D. R. Marshall, and J, T. Williams. Cambridge University Press, UK. 1989.
4. Genetic Diversity in Plants. Muhammad, A., R. Aksel and R.C. Vonborstel. Plenum Press NY, USA. 1977.
5. The Global Diversity of Taro: Ethnobotany and Conservation; V. Ramanatha Rao, P. J. Matthews, P. B. Eyzaguirre, D. Hunter (eds.) 2010
6. Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources; Walter Simon De Boef, Abishkar Subedi, Nivaldo Peroni and Marja Thijssen, 2012
7. <http://agbioworld.org/links/index.html>
8. <http://www.goldenrice.org>
9. <http://biotech.alltop.com>
10. <http://biotechprimer.com>
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)

GEN 000 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:

Introduction to research, history of research, Indicators of quality research and good researcher, Plagiarism policy and use of available software classification of research, sample collection, data collection. Questionnaire for research data collection and characteristics. Interview types; advantages and disadvantages. Data analysis and interpretation. Research report, synopsis, thesis, review/paper writing criteria. Patent filing (local and international).

Recommended Books

1. Knowledge and policy. Anderson, D.S and Biddle, BJ (eds), London, Falmer, 1991.
2. Field research: A source book and field manual, Burgess, R.G (eds), London, Allen and Unwin, 1982.
3. The research process in educational settings, Burgess, R.G. (eds), London, Faber, 1984.
4. Educational research: competencies for analysis and applications, Gay, L.R. Newjersy, Prentice hall, 1996.
5. Research Methods Marshall, Peter, Oxford How to books-ltd, Oxford, 1998.
6. Research Design, Hakim, C. London, Allen and Unwin, 1987.

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.

English I (Functional English)

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

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 1. Third edition. Oxford University Press. 1997. ISBN 0194313492
2. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press. 1997. ISBN 0194313506

- b) Writing
 - 1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 20-27 and 35-41.
- c) Reading/Comprehension
 - 1. Reading. Upper Intermediate. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 453402 2.
- 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

1. Practical English Grammar by A. J. Thomson and A. V. Martinet. Exercises 2. Third edition. Oxford University Press 1986. ISBN 0 19 431350 6.
- b) Writing
1. Writing. Intermediate by Marie-Christine Boutin, Suzanne Brinand and Françoise Grellet. Oxford Supplementary Skills. Fourth Impression 1993. ISBN 0 19 435405 7 Pages 45-53 (note taking).
 2. Writing. Upper-Intermediate by Rob Nolasco. Oxford Supplementary Skills. Fourth Impression 1992. ISBN 0 19 435406 5 (particularly good for writing memos, introduction to presentations, descriptive and argumentative writing).
- c) Reading
1. Reading. Advanced. Brian Tomlinson and Rod Ellis. Oxford Supplementary Skills. Third Impression 1991. ISBN 0 19 453403 0.
 2. Reading and Study Skills by John Langan
 3. Study Skills by Richard York.

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
 1. Writing. Advanced by Ron White. Oxford Supplementary Skills. Third Impression 1992. ISBN 0 19 435407 3 (particularly suitable for discursive, descriptive, argumentative and report writing).
 2. College Writing Skills by John Langan. McGraw-Hill Higher Education. 2004.
 3. Patterns of College Writing (4th edition) by Laurie G. Kirszner and Stephen R. Mandell. St. Martin's Press.
- 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 Scharon. (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

- a. Ideological rationale with special reference to Sir Syed Ahmed Khan, Allama Muhammad Iqbal and Quaid-e-Azam Muhammad Ali Jinnah.
- 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:

1. Burki, Shahid Javed. *State & Society in Pakistan*, The MacMillan Press Ltd 1980.
2. Akbar, S. Zaidi. *Issue in Pakistan's Economy*. Karachi: Oxford University Press, 2000.
3. S. M. Burke and Lawrence Ziring. *Pakistan's Foreign policy: An Historical analysis*. Karachi: Oxford University Press, 1993.
4. Mehmood, Safdar. *Pakistan Political Roots & Development*. Lahore, 1994.
5. Wilcox, Wayne. *The Emergence of Bangladesh*, Washington: American Enterprise, Institute of Public Policy Research, 1972.
6. Mehmood, Safdar. *Pakistan Kayyun Toota*, Lahore: Idara-e-Saqafat-e-Islamia, Club Road, nd.

7. Amin, Tahir. *Ethno - National Movement in Pakistan*, Islamabad: Institute of Policy Studies, Islamabad.
8. Ziring, Lawrence. *Enigma of Political Development*. Kent England: Wm Dawson & sons Ltd, 1980.
9. Zahid, Ansar. *History & Culture of Sindh*. Karachi: Royal Book Company, 1980.
10. Afzal, M. Rafique. *Political Parties in Pakistan*, Vol. I, II & III. Islamabad: National Institute of Historical and cultural Research, 1998.
11. Sayeed, Khalid Bin. *The Political System of Pakistan*. Boston: Houghton Mifflin, 1967.
12. Aziz, K. K. *Party, Politics in Pakistan*, Islamabad: National Commission on Historical and Cultural Research, 1976.
13. Muhammad Waseem, *Pakistan Under Martial Law*, Lahore: Vanguard, 1987.
14. Haq, Noor ul. *Making of Pakistan: The Military Perspective*. Islamabad: National Commission on Historical and Cultural Research, 1993.

**ISLAMIC STUDIES
(Compulsory)****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 Holly 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 Holly 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,"
- 5) Hussain Hamid Hassan, "An Introduction to the Study of Islamic Law" leaf Publication Islamabad, Pakistan.
- 6) Ahmad Hasan, "Principles of Islamic Jurisprudence" Islamic Research Institute, International Islamic University, Islamabad (1993)
- 7) Mir Waliullah, "Muslim Jurisprudence and the Quranic Law of Crimes" Islamic Book Service (1982)
- 8) H. S. Bhatia, "Studies in Islamic Law, Religion and Society" Deep & Deep Publications New Delhi (1989)
- 9) Dr. Muhammad Zia-ul-Haq, "Introduction to Al Sharia Al Islamia" Allama Iqbal Open University, Islamabad (2001)