# B.Sc. Genetics Syllabus

# Under Choice Based Credit System

# w.e.f

# 2019-20

**DEPARTMENT OF GENETICS**
NIZAM COLLEGE (AUTONOMOUS)
Osmania University, Hyderabad-5000 01.
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**Telangana State Council of Higher Education, Govt. of Telangana B.Sc.,**
**CBCS Common Core Syllabi for all Universities inTelangana**
**BScGENETICS**(*wef*2019-20)

| CODE | COURSE TITLE | COURSE TYPE | HPW | CREDITS |
|---|---|---|---|---|
| **FIRST YEAR- SEMESTER I** | | | | |
| BS 101 | Environmental Science/Basic Computer Skills | AECC-1 | 2 | 2 |
| BS 102 | English | CC-1A | 4 | 4 |
| BS 103 | Second language | CC-2A | 4 | 4 |
| **Bs 104** | **Optional I- Transmission Genetics** | DSC-1A | 4T+3P=7 | 4+1=5 |
| BS 105 | Optional II | DSC-2A | --------- | 4+1=5 |
| BS 106 | Optional III | DSC-3A | --------- | 4+1=5 |
| | **TOTAL** | | | **25** |
| **FIRST YEAR- SEMESTER II** | | | | |
| BS 201 | Gender Sensitization | AECC-2 | 2 | 2 |
| BS 202 | English | CC-1B | 4 | 4 |
| BS 203 | Second language | CC-2B | 4 | 4 |
| **BS 204** | **Optional I- Molecular Genetics & Genetic Engineering** | DSC-1B | 4T+3P=7 | 4+1=5 |
| BS 205 | Optional II | DSC-2B | ----- | 4+1=5 |
| BS 206 | Optional III | DSC-3B | ------- | 4+1=5 |
| | **TOTAL** | | | **25** |
| **SECOND YEAR- SEMESTER III** | | | | |
| **BS 301** | **Cytogenetic Analysis** | SEC-I | 2 | 2 |
| **BS 302** | **Genetic Analysis in Model Organisms** | SEC-2 | 2 | 2 |
| BS 303 | English | CC-1C | 3 | 3 |
| BS 304 | Second language | CC-2C | 3 | 3 |
| **BS 305** | **Optional I- Biostatistics & Bioinformatics** | DSC-1C | 4T+3P=7 | 4+1=5 |
| BS 306 | Optional II | DSC-2C | --------- | 4+1=5 |
| BS 307 | Optional III | DSC-3C | ---------- | 4+1=5 |
| | **TOTAL** | | | **25** |
| **SECOND YEAR- SEMESTER IV** | | | | |
| **BS 401** | **Biophysical and Molecular Biology techniques** | SEC-3 | 2 | 2 |
| **BS402** | **DNA Technology in Health Care and Transgenics** | SEC-4 | 2 | 2 |
| BS 403 | English | CC-1D | 3 | 3 |
| BS 404 | Second language | CC-2D | 3 | 3 |
| **BS 405** | **Optional I- Population Genetics & Evolution** | DSC-1D | 4T+3P=7 | 4+1=5 |
| BS 406 | Optional II | DSC-2D | -------- | 4+1=5 |
| BS 407 | Optional III | DSC-3D | --------- | 4+1=5 |
| | **TOTAL** | | | **25** |

| THIRD YEAR- SEMESTER- V | | | | |
|---|---|---|---|---|
| CODE | **COURSE TITLE** | **COURSE TYPE** | **HPW** | **CREDITS** |
| BS 501 | English | CC-1E | 3 | 3 |
| BS 502 | Second language | CC-2E | 3 | 3 |
| **BS 503** | **Basic & Applied Genetics** | GE | 4 | 4 |
| **BS 504** | **Optional I- A/B**<br>**A. Plant Genetics &Biotechnology**<br>**(or)**<br>**Animal Genetics and Biotechnology** | DSE -1E | 4T+3P=7 | 4+1=5 |
| BS 505 | Optional- II **A/B** | DSE -2E | ------ | 4+1=5 |
| BS 506 | Optional- III **A/B** | DSE -3E | ------- | 4+1=5 |
| | **TOTAL** | | | **25** |
| **THIRD YEAR- SEMESTER- VI** | | | | |
| **BS 601** | **Project in Genetics** | Project work | | 4 |
| **BS 602** | **English** | CC-1F | 3 | 3 |
| BS 603 | Second language | CC-2F | 3 | 3 |
| **BS 604** | **Optional I- A/B**<br>**A. Human Genome & Human Genetics**<br>**(or)**<br>**Cellular & Molecular Immunology** | DSE-1F | 4T+3P=7 | 4+1=5 |
| BS 605 | Optional- II **A/B** | DSE -2F | -------- | 4+1=5 |
| BS 606 | Optional- III **A/B** | DSE -3F | ------- | 4+1=5 |
| | **TOTAL** | | | **25** |
| | **TOTAL Credits** | | | **150** |

**Total credits= 164-12 (AECC 4 + SEC 8) =152**

**AECC: A**bility **E**nhancement **C**ompulsory **C**ourse
***SEC: S**kill **E**nhancement **C**ourse*
***DSC: D**iscipline **S**pecific **C**ourse*
***DSE: D**iscipline **S**pecific **E**lective*
***GE: G**eneric **E**lective*

**BSC GENETICS I**
**YEAR SEMESTER- I**
**DSC-Paper- I: TRANSMISSION GENETICS**

**Unit- 1: Mendelian inheritance and its extensions**

Mendel's experiments; Law of segregation, monohybrid cross, reciprocal cross, back cross, test cross; Law of independent assortment, dihybrid cross; Chromosomal theory of Inheritance.

Variations to dominance- Co-dominance and Incomplete dominance; Lethal and Sub-lethal genes, Penetrance and Expressivity; Pleiotropism; Multiple alleles- Eye colour in Drosophila, ABO blood groups in human; Rh Blood group incompatibility; Self incompatibility in plants.

Gene interactions– types of epistasis (9:7; 9:3:4; 9:6:1; 12:3:1; 15:1).

Multifactorial inheritance: Features of quantitative inheritance- additive effect, Kernel colour and size in wheat /maize, skin color in man.

Sex linked inheritance – X-linked and Y-linked traits – holandric genes, SRY gene; Sex limited and sex influenced traits; Sex determination –mechanisms of sex determination in Drosophila and Human.

Non-medelian inheritance: Plastid inheritance – Variegation in *Mirabilusjalapa;* Maternal effects and inheritance – Shell coiling in snails, Poky mutants in *Neurospora*.

**Unit- 2: Linkage, Crossing over and Gene mapping**

Discovery of linkage – Phases of linkage
Chiasmata and Crossing over formation– Recombination
Cytological proof for crossing over – Curt Stern and McClintock experiments
Linkage analysis – Recombination frequencies, Two-point and Three-point crosses
Gene mapping – Coincidence and Interference, Determination of gene order
Gene mapping in Neurospora – Tetrad analysis; Mitotic recombination in *Aspergillus* and Drosophila

**Unit- 3: Cell division and Chromosome segregation.**

Eukaryotic Cell cycle – Phases of cell cycle G0, G1, S,G2.
Regulation of cell cycle cyclins, CDK proteins, role of $p^{53}$ in cell cycle.
Mitosis – Stages in mitotic cell division- significance of mitosis.
Meiosis – Formation of Synaptonemal complex, crossing over, chiasma formation, significance of meiosis.
Apoptosis – extrinsic & intrinsic pathways, & significance.
Senescence, Necrosis –characteristics & mechanisms

**Unit- 4: Chromosome structure, chromatin organization and variation**

Chromosome morphology- size and shape; Euchromatin and Heterochromatin- constitutive and facultative heterochromatin
Components of chromatin, histones &non-histones
Packing of DNA into chromatin – Nucleosome and higher order organization
Specialized Chromosomes – Lampbrush chromosomes, Polytene Chromosomes
Structural chromosomal aberrations - duplications, deletions, inversions & translocations with examples, Genetic consequences
Numerical chromosomal aberrations – aneuploidy, euploidy auto-polyploidy and allo-polyploidy, Genetic consequences

**PRACTICALS**

1. Identification of normal and mutant stocks of Drosophila
2. Drosophila- monohybrid and dihybrid segregation
3. Problems on Mendelian segregations- monohybrid, dihybrid and trihybrid crosses; multiple alleles, non-allelic interactions, multi-factorial inheritance; linkage and mapping of genes.
4. Neurospora – tetrad analysis
5. Study of Mitosis in Onion root tips
6. Study of Meiosis in Maize/Grasshopper
7. Preparation of Drosophila salivary gland chromosomes – Polytene chromosomes
8. Identification of structural and numerical aberrations

**RECOMMENDED BOOKS**


1. Genetics by Gardener
2. Theory and problems in Genetics by Stansfield
3. Introduction to Genetic Analysis by Suzuki, Griffith, Richard and Lewontin
4. Genetics by Strickburger
5. Genetics by Snustad& amp; Simmonds
6. Principles of Genetics by Tamarin
7. Cell & Molecular Biology – E.D.D. De Robertis& E.M.F. De Robertis
8. Molecular Biology of the Cell – Bruce Alberts

**BSC GENETICS I Year SEMESTER- II**
**DSC-Paper II: MOLECULAR GENETICS & GENETIC ENGINEERING**

**Unit-1: Nucleic acids, DNA replication & DNA repair**

DNA as the genetic material-Griffiths transformation experiment, Avery, MacLeod and McCarty's experiments and Hershey & Chase phage-labelling experiment; RNA as genetic material- tobacco mosaic virus

Chemistry of Nucleic acids- Nucleotides, Franklin's X-ray crystallography, Chargaff's rule, Watson-Crick model and forms of DNA (A, B & Z); types of RNA (r RNA, mRNA& t RNA)

DNA replication-conservative, semi-conservative and dispersive models, Meselson- Stahl experiment; Mechanisms of DNA replication-linear, circular, rolling circle, D- loop and θ-models

DNA replicative enzymes (DNA polymerases, helicase, primase, ligase, telomerase, nuclease & topoisomerases) and proteins (initiator protein & single strand bindingproteins);

Mutations: types of mutations- transition, transversion, frame shift, silent, mis-sense and non-sense; Induced mutations- physical and chemical mutagens; spontaneous mutations

DNA damage and repair mechanisms - direct, excision and mismatch, SOS non-homologous end joining(NHEJ)

**Unit-2: Gene expression in Prokaryotes & Eukaryotes**

Structure of prokaryotic gene; Structure of eukaryotic gene; structure and functions of RNA polymerase & it's sub units in prokaryotes

Transcriptional machinery in eukaryotes (RNA polymerases) and their structural and functional features

Genetic code-properties, deciphering of genetic code, Wobble hypothesis

Transcription mechanism-initiation, elongation & proof reading, termination (rho independent & rho dependent)

Transcription in eukaryotes-Initiation, elongation & termination factors

Translation mechanism- initiation, elongation and termination

**Unit-3: Gene regulation in prokaryotes & eukaryotes**

Prokaryotic transcriptional regulation (inducible system) – Operon concept- lac operon & glucose effect

Prokaryotic transcriptional regulation (repressible system) – tryptophan Operon

Post-transcriptional modifications- capping, poly- adenylation

Splicing and alternate splicing, r RNA and t RNA splicing

Post-translational modifications- glycosylation, lipidation, acetylation, ubiqutination and chaperones

Gal locus regulation in yeast- regulation of mating type

**Unit-4: Microbial Genetics & Genetic Engineering**

Transformation- competence of bacterial cells; mechanism of transformation; gene mapping by transformation; Transduction: generalized transduction, co-transduction and linkage; Mapping by co- transduction, Specialized transduction
Conjugation- unidirectional gene transfer- $F^+$ and $F^-$ High frequency recombination, Gene mapping by conjugation
Introduction to r-DNA technology; enzymes used in molecular cloning- restriction endonucleases, DNA modifying enzymes- methylases, polymerases, ligases and phosphatases
Vectors used in cloning: *E.Coli*, plasmid vectors- pBR322, pUC vectors; cosmids; shuttle vectors- yeast vectors
Strategies for genomic libraries and c DNA libraries construction
Screening for detection of cloned genes-antibiotic resistance, blue-white screening; Blotting techniques (Southern, Western & Northern), Applications of genetic engineering in agriculture and medicine.

**PRACTICALS**

1. Extraction of genomic DNA
2. Quantification of DNA by spectrophotometer
3. Agarose gel electrophoresis of DNA
4. Estimation of DNA by DPA method
5. Estimation of RNA by orcinol method
6. Effect of UV on bacterial growth
7. Preparation of competent cells of bacteria
8. Problems on restriction mapping

**RECOMMENDED BOOKS**


1. Principles of Genetics- Irwin Herscowitz
2. Molecular Biology of the gene- Watson, Hopkins, Roberts, Steitz and Weiner
3. Genes- Benjamin Levin
4. General virology- Luria, Darnell, Baltimore and Campbell
5. Molecular Biology- David Frefielder
6. Practical Microbiology- Aneja
7. Microbial Genetics ByMaloy, Freifelder
8. Molecular Genetics By Gunther and Stent
9. Genetic Analysis By Griffith, Suzuki and others
10. Gene cloning and DNA analysis: an introduction / T.A. Brown

**BSC GENETICS II YEAR**
**SEMESTER III BS 301 SEC 1**
**CYTOGENETIC ANALYSIS**

**Unit 1: Preparation of Chromosomes**

Cell culture – sterilizing techniques, growth media, variables affecting cell growth, contamination in tissue culture, preservation of cells

Sample collection and handling – peripheral blood, bone marrow, amniotic fluid, solid tissues

Culture initiation; harvesting, hypotonic treatment, slide preparation

Chromosome staining and banding - G-banding, Q-banding, R-banding, C-banding

Karyotyping – metaphase spread, counting of chromosomes

**Unit 2: Chromosome Analysis**

Microscopy – Bright-field microscopy, inverted and fluorescence microscopy

Chromosomal analysis - chromosome number, size & shape in humans; karyotyping chromosomes – ideogram

Chromosome abnormalities – Structural (breaks, gaps, deletions, insertions, duplications, inversions, translocations), numerical: aneuploidy (monosomy, trisomy & tetrasomy); polyploidy (triploidy, tetraploidy)

FISH&SKY – principle, applications and limitations

Screening Analysis - amniotic fluid sampling, chorionic villi sampling, bone marrow aspiration & biopsy analysis

**RECOMMENDED BOOKS**


1. AGT cytogenetics Laboratory Manual (2017) Arsham, Barch&Lawce, Wiley Blackwell publications
2. Human cytogenetics-A practical approach (2001) Rooney, Oxford University press
3. Manual of cytogenetics in Reproductive Biology (2014). PankajTalwar, Jaypee Brothers Medical Publishers (P) Ltd.
4. Clinical Biochemistry (2013) Gaw, Cowan, Murphy, Srivastava and O'Reilly, Elsevier

**BSC GENETICS II YEAR**

**SEMESTER III BS 302 SEC 2**

**GENETIC ANALYSIS IN MODEL ORGANISMS**

**Unit 1 - Lower Model Organisms**

*E.coli* - life cycle - *E.coli* genome – *E.coli* plasmids - Advantages of *E.coli* as model organism - pathogenic *E.coli* – *E.coli* data bases *E.coli* biotechnology applications.

Yeast - life cycle - mating and homothallic sporulation and meiosis tetrad analysis - dominance complementation test - yeast as model system -non- mendelian segregation - yeast resources

*Neurospora crassa* – life cycle - fine structure genetic analysis - *N .crassa* as model organism

*Chlamydomonas* - life cycle – reproduction - *Chlamydomonas* as model organism

Non- traditional model organisms – reasons for non-traditional models - examples

**Unit 2 - Higher Model Organisms**

*Caenorhabditis elegans*- life cycle , anatomy, development - reproduction - chromosomes – Genome of *C. elegans* - *C. elegans* as model organisms

Drosophila – life cycle – reproduction - genetic markers - classic genetic mutations, genome similarities to humans - development - sex determination - drosophila genetic resources

Maize - life cycle and physiology - maize genome - maize as a model organism for plant biology - maize as crop plant - maize genetic resources

Zebra fish - reproduction and developmental biology - zebra fish as model organism

Role of genetic model organisms in human diseases - cancer, neurological disorders , heart diseases ,ageing and age related diseases

**RECOMMENDED BOOKS**


**1.** R.H.Tamarin, principles of genetics,Mc Grawhill publication

**2.** Alberts.B,et al,Molecular Biology of the cell,J.D.Garland publishers,Oxford

**3.** David.T.Suzuki et al, Introduction toGenetic Analysis,W.H.Freeman publication,seventh edition.

**4.** Geoffrey M Cooper,The Cell A Molecular Approach ,Sunderland publication,eighth edition.

**5.** Redei, Genetics, Mc Millan publication

**BSC GENETICS II YEAR**
**SEMESTER III BS 305 DSC-IC**
**BIOSTATISTICS AND BIOINFORMATICS**

**Unit 1: Descriptive Biostatistics and Probability**

Introduction to biostatistics, kinds of data and variables- based on nature (numerical - discrete and continuous; categorical- ordinal and nominal) - based on source (primary and secondary data); sample size, sampling methods and sampling errors.

Data tabulation and representation methods: Graphical methods- stem and leaf plot, line diagram, bar graphs, histogram, frequency polygon, frequency curves; Diagrammatic method- pie diagram

Measures of Central tendency – mean, median, mode; merits and demerits

Measures of Dispersion-range, variance, standard deviation, standard error and coefficient of variation; merits and demerits

Concepts of probability - random experiment, events, probability of an event, probability rules (Addition and Multiplication rules), permutations and combinations, random variables (Discrete and Continuous)

Probability Distributions: Binomial & Poisson distributions for discrete variables, Normal distribution for continuous variables

**Unit 2: Applications of Biostatistics**

Hypothesis testing - Steps in testing for statistical hypothesis, null and alternative hypothesis, level of significance- type-1 and type-2 errors

Test of significance for small samples- Student's t-test (one sample and two sample)

Test of significance for large samples- Z-test of means and proportions

Chi-square test and its applications- goodness of fit, independence

Analysis of Variance (ANOVA) – one way analysis

Correlation- Definition, Simple and Linear analysis, Karl Pearson's correlation coefficient

**Unit 3: Introduction to bioinformatics and biological databases**

Bioinformatics definition, history, scope and applications

Bioinformatics tools and resources- internet basics, role of internet, free online tools, downloading free softwares and installation.

Bioinformatic web portals – NCBI, EBI, ExPASy

Biological databases: Classification of databases – primary (GenBank), secondary (PIR) and tertiary or composite (KEGG) databases

DNA sequence databases (ENA &DDBJ)

Protein sequence databases (Swissprot& PROSITE)

**Unit 4: Sequence Alignment**

Basics of sequence alignment - match, mismatch, gaps, gap penalties, scoring alignment

Types of sequence alignment - pairwise and multiple alignment, local and global alignment

Dot matrix comparison of sequences

Scoring matrices - PAM and BLOSUM

Pairwise sequence similarity search by BLAST and FASTA

Concepts of phylogenetic tree- character based (maximum likelihood & maximum parsimony method)

**PRACTICALS**

1. Calculation of mean, median, mode, standard deviation, variance, standard error, coefficient of variation for a variable
2. Construction of bar diagram, pie diagram, line diagram, histogram and box plot for a data
3. Problems on hypothesis testing using Z test, t-test and Chi-squared test
4. Problems on probability and probability distributions
5. Exploring web portals – NCBI, EBI &ExPASy
6. Literature search through PubMed and PubMed Central
7. Sequence retrieval from GenBank, ENA, Swissprot
8. Pairwise homology search by BLAST and FASTA

**RECOMMENDED BOOKS**

1. Khan &Khanum (2004), Fundamentals of Biostatistics, II Revised Edition, Ukaaz Publication
2. Bailey, N.T.J, Statistical methods in Biology, Cambridge Univ. Press
3. Fundamentals of Biostatistics, P HanmanthRao and K.Janardhan
4. Danial, W. W, Biostatistics, Wiley
5. Introduction to Bioinformatics by Aurther M lesk
6. Developing Bioinformatics Computer Skills By: Cynthia Gibas, Per Jambeck
7. Bioinformatics second edition By David M mount
8. Essential Bioinformatics by Jin Xiong
9. Bioinformatics Computing By Bryan Bergeron
10. Bioinformatics: Concepts, Skills & Applications by R.S. Rastogi
11. Queen, J. P., Quinn, G. P., &Keough, M. J. (2002). *Experimental design and data analysis for biologists*.Cambridge University Press.
12. Mahajan, B. K. (2002). *Methods in biostatistics*.Jaypee Brothers Publishers.

**BSC GENETICS II YEAR**
**SEMESTER IV BS 401 SEC-3**
**BIOPHYSICAL AND MOLECULAR BIOLOGY TECHNIQUES**

**Unit 1: Biophysical techniques**

Spectroscopy – principle, instrumentation, ultraviolet and visible light spectroscopy, applications
Chromatography– types of chromatographic techniques (paper, ion exchange chromatography, size exclusion chromatography)- principle & applications
Centrifugation–principles of sedimentation, preparative centrifugation (differential centrifugation & density gradient centrifugation), applications
Electrophoretic techniques- types (Agarose gel electrophoresis,SDS PAGE), principle & applications
Mass spectrometry- principle & applications
Microscopy- principle & applications of Phase contrast microscope and confocal microscopy

**Unit 2: Molecular Biology techniques**

PCR –Types (Allele-Specific PCR, ARMS PCR, Reverse Transcriptase PCR)- principle and applications.
Quantitative Real Time PCR– principle and applications.
DNA Sequencing – principle and applications.
Microarray- DNA and protein arrays - principle and applications.
Blotting techniques- Southern blot, Northern blot and Western blot- principle and applications.
Fluorescence &Chemiluminescence Imaging- principle and applications

**RECOMMENDED BOOKS**


1. Principles and Techniques of Biochemistry and Molecular Biology edited by Keith Wilson, John Walker Cambridge University Press,-2010
2. Basic Techniques in Biochemistry and Molecular Biology by R. K. SharmaI. K. International Pvt Ltd, 2008
3. Techniques in Molecular Biology. Textbook Student Edition; Agrawal S. International Book Distributing Company, 2008
4. Analytical Techniques in Biochemistry and Molecular Biology; By RajanKatoch Springer Science & Business Media, 2011

**BSC GENETICS II YEAR**
**SEMESTER- IV BS 402 SEC 4**
**DNA TECHNOLOGY IN HEALTH CARE AND TRANSGENICS**

## Unit 1: DNA Technology in Health care

Methods of DNA analysis – DNA probes, PCR, signal amplification, DNA chip, RFLP analysis, DNA fingerprinting.
Diagnosing infectious diseases – AIDS, tuberculosis.
Identifying genetic disease –DMD, Huntingtons disease.
Gene therapy- ADA deficiency and Cystic fibrosis.
Pharmaceutical products of DNA technology – Recombinant insulin, recombinant growth hormone, recombinant vaccines-Hepatitis-B

## Unit 2: Applications of Transgenic Technology

Custom Made Animals – Human mouse, Oncomouse, Alzheimer's mouse, Knockout mouse; Diagnosing infectious disease – AIDS and tuberculosis.
Animal bioreactors- Pharm Animals**.**
Enhancing resistance in plants – ice-minus experiments, resistance to biological agents, and resistance to herbicides. Coat protein-mediated protection against virus infections, genetic engineering of crops for insect resistance using genes of plant origin**.**
Bioengineered foods – Vegetable vaccines, GM foods**.**
Energy applications – biohydrogen, bioethanol, biomethanol, biobutanol

## RECOMMENDED BOOKS


1. DNA Technology: The Awesome Skill By I. Edward AlcamoGulf Professional Publishing, 2001.
2. Recombinant DNA TechnologyKeya Chaudhuri The Energy and Resources Institute (TERI), 2013.
3. Recombinant DNA Technology edited by Sardul Singh Sandhu I. K. International Pvt Ltd, 2010.
4. From Genes to Genomes: Concepts and Applications of DNA Technology By Jeremy W. Dale, Malcolm von Schantz, John Wiley & Sons, 2011

**BSC GENETICS II YEAR**
**SEMESTER IV BS 405 DSC**
**POPULATION GENETICS & EVOLUTION**

**Unit 1: Principles of Population genetics**

Population structure, Random mating population, Concepts of a population (gene pool, deme and panmictic unit)

Genetic and phenotypic variation in a population, allele frequencies and genotype frequencies at a locus

Hardy-Weinberg Law- assumptions and implications, establishment of Hardy-Weinberg equilibrium for single gene locus

Extension of Hardy-Weinberg Law for multiple alleles

Establishment of Hardy-Weinberg Law for X- linked genes

Linkage disequilibrium – haplotypes, coefficient of linkage disequilibrium, coupling gametes and repulsion gametes

**Unit 2: Selection, Mutation & Migration**

Selection– fitness, patterns of natural selection, general selection equation, equilibrium under selection

Selection favoring heterozygotes: stable equilibrium, balanced polymorphism (sickle cell anemia, heterozygote advantage)

Selection against heterozygotes: unstable equilibrium (Rh incompatibility); complete elimination of recessive genes

Mutation– influence of mutation on allele frequencies, balance between forward and backward mutation

Genetic load – mutational and segregational

Gene flow– Migration - Wahlund effect

**Unit 3: Inbreeding, Genetic Drift and Quantitative inheritance**

Inbreeding– non-random mating, Identity by descent, selfing

Construction of pedigrees- Raw & forked pedigrees - inbreeding coefficient

Effect of inbreeding on genotypic frequencies and inbreeding depression

Genetic Drift - Bottle neck effect, Founder effect

Effective population size, consequences of a decreasing population size

Quantitative vs qualitative traits – genetic and environmental values - measures of variances

**Unit 4: Genetic Variation and Molecular Evolution**

The origin of genomes- Acquisition of new genes by gene duplication and from other species. Origin of non-coding DNA, transposable elements and introns. Molecular phylogenetics- DNA sequence and protein sequence phylogenetics. Molecular Evolution–neutral theory. Establishment of evolutionary relationship – molecular clock. Construction of molecular phylogenetic trees – UPGMA, NJ methods.

**PRACTICALS**

1. Calculating allele and genotypic frequencies
2. Testing of gene frequencies for Hardy-Weinberg equilibrium – monogenic alleles
3. Testing of gene frequencies for Hardy-Weinberg equilibrium –multiple alleles and X-linked loci
4. Testing for deviation of HW equilibrium using chi-square test
5. Estimation of mutation rates
6. Calculation of gene frequencies under different types of selection
7. Construction of pedigrees – raw and forked pedigrees
8. Estimation of inbreeding coefficient using pedigrees

**RECOMMENDED BOOKS**


1. Hedrick P.W. -Jones & Bartlett, Genetics of Population
2. Hartl D. L. And Clark A. G., Principle of Population Genetics, Sinauer Associates
3. Falconer, D (1995) Introduction to Quantitative Genetics, 4th edition, Longman, London
4. Stickberger, M. W (1990) Evolution, Jones and Bartlett, Boston
5. Population Genetics- C C L

**BSC GENETICS III YEAR**
**SEMESTER V GE 502**
**BASIC& APPLIED GENETICS**

**Unit 1: Introduction to Genetics**

Genotype & phenotype; homozygous & heterozygous; dominant& recessive; gene & allele

Mendelian genetics –Principle of dominance, Principle of segregation,Principle of Independent Assortment

Trait Inheritance – ABO blood groups in human; eye color in Drosophila

Polygenic Inheritance –Kernel colour in Maize, skin colour in man

Sex-linked Inheritance – haemophilia and colour blindness in man

Non-Mendelian inheritance-Maternal inheritance-Variegation in leaves of higher plants-Mirabilis Jalapa

**Unit 2: Cellular & Molecular basis of Inheritance**

DNA structure and its alternative forms (A, B & Z)

RNA - types of RNA (rRNA, mRNA &tRNA)

Ultra structure of prokaryotic cell (cell membrane and plasmids, Nucleoid)

Ultra structure of eukaryotic cell (nucleus, mitochondria, chloroplast, endoplasmic reticulum, golgi apparatus)

Chromosomes: Packaging of DNA in to Chromosomes, structure( centromere and telomere), karyotype

Cell division – stages of mitosis, meiosis I&II& fertilization

**Unit 3: Genomes &Genetic Engineering**

Prokaryotic genomes – genome size & organization

Eukaryotic genomes-features of eukaryotic nuclear and organellar genomes

Human genome project –goals and achievements

Genetic Engineering - Transgenic plants-Bt cotton, Golden rice

Genetic Engineering - Transgenic animals -Molecular pharming-Buffalo and Goat

Genetic Engineering: Environment- bioremediation

**Unit 4: Human Genetics**

Human nuclear genome –general features, protein coding genes, RNA coding genes, non-coding DNA

Human chromosome anomalies: Down's syndrome and Klinefelter's syndrome

Single gene disorders-Hemoglobinopathies(Sickle cell disease, Thalassemias)

Complex genetic diseases –Hypertension, Diabetes mellitus

Genetic testing: Prenatal screening (Invasive methods and Non- invasive techniques, Neonatal screening (PKU),Preclinical screening (Alzheimer's)

Therapeutics : Conventional treatment modalities- PKU; Gene therapy: Types- somatic and germ line gene therapy; Gene therapy trials: ADA deficiency

**RECOMMENDED BOOKS**


1. The Foundations of Genetics By F. A. E. Crew Elsevier, 2014
2. Concepts of Genetics, 7/E By Klug Pearson Education India, 2002
3. Genetics ByKarvita B. Ahluwalia New Age International, 2009
4. Genetics byM. YadavDiscovery Publishing House, 2003 By M. Yadav
5. Human Genetics: The Basics ByRicki Lewis Taylor & Francis, -2016
6. Essentials of Human Genetics (Rev) By Bhatnagar, S.M. Orient Blackswan, 1999
7. DNA Technology: The Awesome Skill By I. Edward Alcamo Gulf Professional Publishing, 2001
8. Recombinant DNA TechnologyKeyaChaudhuri The Energy and Resources Institute (TERI), 2013
9. Recombinant DNA Technology edited by Sardul Singh Sandhu I. K. International Pvt Ltd, 2010

**BSC GENETICS III YEAR**
**SEMESTER V BS 504**
**ANIMAL GENETICS AND BIOTECHNOLOGY**

**Unit 1: Livestock Genetics**

Domestication of livestock, important breeds of livestock with economic importance

Mating systems for different livestock - genetic and phenotypic consequences and applications of inbreeding and outbreeding

DNA markers (RAPD, SNPs), genotyping for identification, parentage verification, and determination of specific homozygous/heterozygous gene mutations in animals for diseases and physical traits – marker assisted selection.

Livestock improvement – Role of AI/frozen semen/embryo transfer/ONBS/MOET in animal breeding; embryo sexing

Animal genetic resources in India – evaluation and characterization of indigenous breeds of livestock, *ex-situ* and *insitu* conservation of genetic resources– cryogenic preservation of animal germplasm

**Unit 2: Laboratory Animal Genetics**

Laboratory animal species – mice, rat, rabbit – chromosome number – genome size – major genes

Physiological, nutritional and reproduction parameters of mice, rat and rabbit

Pedigree recording, planned mating, selection and mating methods, monogamous, polygamous

Ethics and legislation for management and use of laboratory animals;Institutional Animal Ethical committee guidelines

Importance of Laboratory Animal Genetics in health, genetic and environmental monitoring

**Unit 3: Mouse models for Human disease**

Mouse as model –advantages of mouse models - similarities and differences of mouse and human genomes

Nomenclature of strains, inbred lines in mice

Methods of generating mouse models – non-targeted and targeted strategies – knock-in and knock-out mouse

Transgenic Mouse models in cancer – oncomouse

Mouse models for human genetic diseases – – Neurodegenerative disease (Alzheimer's&, Parkinson's disease)

4. **Unit 4: Animal Cell Culture &Biotechnology**

Animal cell culture - types of animal cell culture, cell lines, culture media Applications of animal cell culture

Stem cell – properties of stem cells, embryonic stem cells, adult stem cells, tissue engineering.

DNA based diagnostics and genetically engineered vaccines for animals – rabies virus – commercial DNA rabies vaccines, West Nile virus – commercially available WNV vaccines, Vaccines against bovine respiratory synctitial virus & Vaccines against bovine viral diarrhea disease.

Cloning adult animals by somatic cell nuclear transfer – significance of Dolly experiment

Transgenic animals – methods for producing transgenic animals, examples of transgenic animals – Super fish, Glo fish, Enviro pig, ANDi; Transgenesis in the improvement of production traits - growth and meat traits, wool production, milk composition

**PRACTICALS**

1. Laboratory animal species maintenance and specific utility-mice and rat
2. Management and use of laboratory animals-ethics and legislation
3. Strains and inbred lines-nomenclature
4. Preparation of animal cell culture media
5. Sterilization of cell culture media
6. Cell counting by microscopy

**REFERENCE BOOKS**

1. Text book of Animal Biotechnology by B Singh. The Energy and Resources Institute (teri)
2. Genetics for Animal Sciences by WH Freeman. Van Vleck LD, Pollak EJ &Bltenacu EAB. 1987.
3. Cancer Cell Culture: Methods and Protocols: 731 (Methods in Molecular Biology) Humana; 2nd ed. 2011 edition (28 April 2011)
4. Genetic Engineering by V.K.Agarwal and P.S. Varma, S. Chand & Company Ltd, 2009

**BSC GENETICS III YEAR**
**SEMESTER V BS 504**
**PLANTGENETICS & BIOTECHNOLOGY**

**Unit 1: Basics of Plant Life Cycle and Genetics**

Overview of plant development and life cycle – sporogenesis, gametogenesis, pollination, fertilization, embryogenesis (development of monocot & dicot embryos)
Seed (monocot & dicot) development and seed germination
Meristems – root apical meristems & root development; shoot apical meristems & leaf development; flower and fruit development
Plant hormones and their actions - auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassinosteroids
Plant Nuclear Genome Organization – General features, Variation of Genome size among plants, fine structure of plant gene
Plant Organellar Genome Organization – Mitochondria, Chloroplast

**Unit 2: Plant Tissue culture**

Media and culture conditions, sterile technique
Regeneration methods of plants in culture - organogenesis, somatic embryogenesis; Somaclonal variation
Induction of callus and cell suspension cultures
Protoplast culture techniques – production of somatic hybrids and cybrids
Anther/microspore culture - production of haploids and double haploids and their uses
Somatic embryo culture and production of synthetic seeds

**Unit 3: Plant Breeding& Hybrid seed production**

Mating systems – Self fertilization, Cross fertilization and Apomixis
Methods of breeding in Self-pollinating species – pedigree breeding, single-seed descent, bulk breeding method
Methods of breeding in Cross-pollinating species – mass selection, recurrent selection
Hybrid seed production – genetic male sterility( procedure for hybrid seed production by using GMS)
Hybrid seed production based on cytoplasmic genetic male sterility (seed production of CMS lines (A), maintainer line (B), restorer line (R)
Hybrid seed production based on functional male sterility system –gametocides and their use in hybrid seed production

**4. Unit 4: Transgenic plants production and applications**

Transformation based transgenic plants production – *Agrobacterium tumefaciens* and viral vectors

Direct gene transfer based transgenic plants production - particle bombardment, electroporation, silicon carbide whiskers, sonication, laser micro puncture, nanofiber arrays, chemical methods

Genetically modified crops for insect resistance - Bt crops, microbes & plant derived toxins

Genetically modified crops for Virus resistance - coat protein mediated cross protection, antisense and sense mediated resistance, satellite RNA protection pathogen targeted protection

Genetically modified crops for Disease resistance – pathogenesis related proteins, anti microbial proteins, engineering toxin insensitivity, phytoalexins, manipulation of disease resistance genes

Transgenic plants for product quality – improved storage, longer shelf life, nutritionalquality (Golden Rice).

**PRACTICALS**

1. Histological studies of embryos at different stages
2. Seed testing for germination
3. Introduction to Plant tissue culture laboratory -equipment
4. Sterilization methods in plant tissue culture laboratory –aseptic technique
5. Preparation of stock solutions of MS basal medium and plant growth regulators
6. Isolation of explants, establishment and maintenance of callus
7. Culture of anthers and establishment of haploid plants
8. Preparation of synthetic seeds

**RECOMMENDED BOOKS**


1. Principles of Plant Genetics and Breeding (2012) by George Acquaah, Second Edition Wiley – BlackwellPublishers
2. Plant Tissue Culture: Techniques and Experiments (2013) by Roberta H. Smith, Academic Press, U.K
3. Plant Tissue Culture and Biotechnology: Emerging Trends (2003) by P.B. KaviKishor, Universities Press
4. Plant Tissue Culture: Basic and Applied (2005) by TimirBaranJha, Universities Press
5. Plant Biotechnology: Practical Manual (2007) by C. C. Giri, ArchanaGiri,I.K International Publishers
6. From Plant Genomics to Plant Biotechnology (2013) edited by PalmiroPoltronieri, NatalijaBurbulis, CorradoFogher, Woodhead Publishing Limited, New Delhi
7. Plant Genomics and Biotechnology (2016) Isabelle Nickel, Syrawood Publishing House
8. Plant Biotechnology and Agriculture: Prospects for the 21st Century (2012) edited by Arie Altman, Paul M. Hasegawa, Elsevier
9. PlantCell Biotechnology by Rudolf Endress, Springer-Verlag Berlin.

**BSC GENETICS III YEAR**
**SEMESTER VI BS 604**
**HUMAN GENOME & HUMAN GENETICS**

**Unit 1: The Human Genome**

Human nuclear genome organisation- gene size and density, organisation of protein coding genes

Gene families - globin gene family , histone gene family

Non-coding RNA genes- rRNA, tRNA& microRNA

Repetitive elements -LINES, SINES, LTR elements, satellites, minisatellites, microsatellites, Transposons

Human Mitochondrial genome organization

Human Genome variation- DNA sequence variants, genetic polymorphisms, gene duplication and evolution

**Unit 2: Human Genome Project – Applications**

Human genome project – Goals and achievements, Applications & Ethics

Comparative genomics-evolutionary constrained sequences, diversified sequences, G –Valve paradox

Transcriptomics- Transcriptome analysis-Microarrays, RNA sequencing (RNA-Seq), Gene expression profiling

Epigenomics- Epigenetic modifications (DNA methylation, Histone modifications); genomic imprinting

Proteomics- Proteome analysis, Protein arrays and their applications.

Pharmacogenomics – role of SNP in drug response Ex. G6PD

**Unit 3: Chromosomal & Genetic defects in Human**

Human chromosomal disorders- Disorders due to Autosomes and sex chromosomes: Abnormalities due to Chromosome number and structure

Inborn errors of metabolism- Amino acid metabolism (Phenyleketonuria), Protein metabolism (Duschenne muscular dystrophy)

Single gene disorders- Pattern of inheritance - Autosomal disorders: Dominant- Huntington's disease, Recessive- Haemophilia; X-linked disorders: dominant- Fragile X syndrome, Recessive- DMD

Complex disorders- Multifactorial inheritance (Diabetes mellitus, Hypertension), threshold effect

Genetics of cancer-Types of genes- proto-oncogenes, oncogenes, tumor suppressor genes - Breast and Colon cancers

Mitochondrial inheritance and associated disorders- Lebers Hereditary Optic Neuropathy, Kearns-sayersyndrome

**Unit 4: Genetic counseling, testing and therapeutics**

Genetic counseling and risk assessment for autosomal dominant, autosomal recessive, sexlinked inherited diseases

Prenatal diagnosis - invasive (Amniocentesis, Chorianic villus sampling) and non-invasive (Ultrasonography, fetoscopy)

New born screening(PKU), Pre-clinical screening- Sickle cell anemia

Ethical, legal and Social Issues of Genetic testing and screening

Traditional treatment modalities- PKU,ADA

Gene therapy: Types-somatic and germ line gene therapy; Gene therapy trials :ADA deficiency, Cysticfibrosis

## PRACTICALS

1. Karyotyping (normal male/normal female)
2. Identification of chromosome anomalies using Idiograms– Autosomal disorders (Down Syndrome / Edward's syndrome)
3. Identification of chromosome anomalies using Idiograms – X-linked disorders – (Klienefelter's syndrome / Turner's syndrome)
4. Screening for Barrbodies
5. Construction of pedigrees and identification of mode of inheritance of a trait.
6. Estimation of risk analysis using pedigrees
7. Diagnosis of diseases by PCR based methods

## RECOMMENDED BOOKS


1. A.G. Motulsky and F. Vogel (1986) HumanGenetics
2. R. F. Mueller and I.D Yound (2001) Emery's Elements of MedicalGenetics
3. Curt Stern (1960) Principles of HumanGenetics
4. Gardner, A. and Davies, T. (2009) Human Genetics-Scion Publishing,2nd ed.
5. Lewis, R. (2008) Human Genetics: Concepts and Applications, McGraw Hill Publishing, New York,8th ed.
6. Lewis, R. (2011). Human Genetics —The Basics , Routledge,London
7. Mange, E.J. and Mange, A.P. (1999). Basic Human Genetics.Sinauer, Sunderland
8. Scriver, C.R. A.L. Beudit, W.S. Sty and D. Valle, Molecular Basis of Inherited Diseases, (6th Edition 1989) by EdsOMcGrawHill, NewYork.
9. Tom Strachan and Andrew Read (1996) Human MolecularGenetics.

**BSC GENETICS III YEAR**
**SEMESTER VI BS 604**
**CELLULAR & MOLECULAR IMMUNOLOGY**

**Unit 1: Innate and Adaptive Immunity**

Introduction to Immune System, types of immunity-innate and adaptive
Innate immunity – anatomical barriers & physiological barriers, phagocytic barrier
Cellular components of immunity – Lymphoid cells (B cells, T cells and NK cells), Myeliod cells (Neutrophils, Eosinophils, basophils, mast cells, macrophages and dendritic cells)
Lymphoid organs- Primary lymphoid organs (Bonemarrow&thymus); secondary lymphoid organs (lymph node andspleen)
Antigens- Immunogens, epitopes
Haptens and types of adjuvants

**Unit 2: Humoral and MHC immune responses**

Basic structure of Immunoglobulin- Immunoglobulin domains- variable region and constant region domains; isotypes, allotypes, idiotypes

Immunoglobulin classes and its functions- IgG, IgM, IgA, IgD,IgE

Polyclonal antibodies, Monoclonal antibodies- its production and applications

Structure and organization of MHC class I and class II molecules.

MHC molecules- cellular distribution & immune responsiveness

Types of grafts: Role of HLA typing in organ transplantation

3. **Unit 3: Cell-mediated Immune responses and vaccines**

Cell mediated immunity: Structure and functions of T-cell receptors; Antigen presenting cells (APCs), ternary complex (TCR, peptide and MHC);Cytokines
Hypersensitivity- Types (I, II, III &IV)
Autoimmunity- mechanisms of autoimmunity and autoimmune diseases (thyroid and Rheumatoid arthritis)
Immunodefeciency disorders- primary immunodeficiency disorders (SCID), secondary immunodeficiency disorders (AIDS)

Vaccines- historical background and principle; passive & active immunization, attributes of effective vaccinesTypes of vaccines- live attenuated and inactivated killed vaccines, sub-unit vaccines, DNA vaccines, edible vaccines

**Unit 4: Immunological techniques**

General features of ag-ab reactions- Agglutination, neutralization, complement fixation,opsonisation

Immunoprecipitation, immunoelectrophoresis, immunodiffusion tests

ELISA – Types (Sandwich, Indirect, Dot ELISA)- Principle and applications

Immuno fluorescence assays (direct & indirect)- Principle and applications

Western blot -Principle, procedure and applications

Flow cytometry -Principle, methodology and applications

**PRACTICALS**

1. ABO blood typing
2. Differential count of lymphocytes
3. Single Radial Immunodiffusion
4. ELISA
5. Agglutination
6. Haemagglutination test
7. Coomb's test
8. WesternBlot

**RECOMMENDED BOOKS**


1. Essential Immunology by I.Roitt,Publ:Blackwell
2. Immunology by G. Reever & I.Todd,Publ:Blackwell
3. Immuno diagnostics by S.C.Rastogi, Publ:NewAge
4. Immunology by Richard A.Golds by, Thomas J Kindt, Barbaraa. Osborne, Janiskuby
5. Fundamental immunology by WilliamE.Paul
6. Basic Immunology by Bhoosreddy G.L. and WadherB.J.
7. Text book of immunology by BarujBenacerraf
8. Immunology by Kuby:Publ:Freema

**QUESTION PAPER PATTERN FACULTY OF SCIENCE**
**Title of the Paper: B.SC. GENETICS**

**[Duration: 3 Hours] [Max Marks=80M]**

**SECTION-A**

**Short Answer type questions**
**Answer any EIGHT questions (TWO FROM EACH PART) [8x4=32M]**

**PART A:**
1. **Unit - I**
2. **Unit –I**
3. **Unit –I PART B:**
4. **Unit – II**
5. **Unit - II**
6. **Unit – II PART C:**
7. **Unit -III**
8. **Unit -III**
9. **Unit – III PART D:**
10. **Unit -IV**
11. **Unit -IV**
12. **Unit –IV**

**SECTION-B**
**Essay Answer type question**
**Answer all questions [4x12=48M]**

**13.**
**(a) Unit –I**
**OR**
**(b)Unit –I**

**14.**
**(a) Unit –II OR**
**(b)Unit-II**

**15.**
**(a) Unit – III OR**
**(b)Unit – III**

**16.**
**(a) Unit-IV**
**OR**
**(b)Unit- IV**