VIJAYA COLLEGE

BANGALORE UNIVERSITY

Jnana Bharathi, Bengaluru-560 056

B.Sc., GENETICS SYLLABUS

(I to VI Semesters)

(CBCS SCHEME)

(Three-Year Choice Based Credit System Syllabus)

Effective from 2018-19 ONWARDS

CENTRE FOR APPLIED GENETICS, BANGALORE UNIVERSITY
Jnana Bharathi, Bengaluru – 560 056
SCHEME OF THREE YEAR CBCS B.Sc., COURSE IN GENETICS

SCHEME OF EXAMINATION AND CREDITS

Paper No.	Title of paper	Type of paper	Hours/ Week	Duration of Exam (Hours)	IA Marks	Exam Marks	Total Marks	Credits
I SEMESTER								
GNT 101	Fundamentals of Cell Biology	T	4	3	30	70	100	2
GNP 101	Fundamentals of Cell Biology	P	3	3	15	35	50	1
II SEMESTER								
GNT 201	Principles of Genetics	T	4	3	30	70	100	2
GNP 201	Principles of Genetics	P	3	3	15	35	50	1
III SEMESTER								
GNT 301	Cytogenetics	T	4	3	30	70	100	2
GNP 301	Cytogenetics	P	3	3	15	35	50	1
IV SEMESTER								
GNT 401	Molecular Genetics	T	4	3	30	70	100	2
GNP 401	Molecular Genetics	P	3	3	15	35	50	1
V SEMESTER								
GNT 501	Recombinant DNA Technology	T	3	3	30	70	100	2
GNT 502	Basic Human Genetics	T	3	3	30	70	100	2
GNP 501	Recombinant DNA Technology	P	3	3	15	35	50	1
GNP 502	Basic Human Genetics	P	3	3	15	35	50	1
VI SEMESTER								
GNT 601	Developmental, Evolutionary and Biometrical Genetics	T	3	3	30	70	100	2
GNT 602	Applied and Behavioural Genetics	T	3	3	30	70	100	2
GNP 601	Developmental, Evolutionary and Biometrical Genetics	P	3	3	15	35	50	1
GNP 602	Applied and Behavioural Genetics	P	3	3	15	35	50	1

*** Submission of certified practical record is <u>MANDATORY</u> for attending practical examination.**

SCHEME OF EXAMINATION UNDER CBCS

Each paper carries a maximum of 100 marks as indicated below:

Theory of 3hrs duration……70 Marks

Internal Assessment*…… 30 Marks

Total – 100 Marks

Internal Assessment –

Theory	Attendance	- 10 marks
	Tests (Two)	- 10 marks
	Seminars / Assignment	- 10 marks
	Total	**- 30 Marks**

Practical of 3hrs duration……35 Marks

Practical	Attendance	- 05 marks
	Tests (One)	- 10 marks
	Total	**- 15 Marks**

SUBJECT (OPTIONALS) COMBINATION:

Biochemistry/Chemistry is the compulsory optional subject.

The other optional subject may be any one of the following:

1) Biotechnology, 2) Botany, 3) Microbiology, 4) Sericulture, and 5) Zoology.

B.Sc., Genetics I to VI Semester Syllabus

I Semester B.Sc., GENETICS

Theory Syllabus

Paper - GNT 101: FUNDAMENTALS OF CELL BIOLOGY

52 Hrs.

UNIT I **13 Hrs.**

A. Scope of Genetics

B. Microscopy

Magnification, Resolving power, Principles and Applications of Simple, Compound, Stereozoom, Phase contrast, Fluorescent and Electron microscopes (TEM & SEM).

C. Model Organisms

Life cycle and Genetic significance of: *Bacteriophage* (Lytic and Lysogeny), Bacteria- *E. coli*. (Binary fission and Conjugation), *Saccharomyces* (Budding and Sexual reproduction), *Coenorhabdites elegans*, *Drosophila*, *Arabidopsis thaliana and Rattus albicans*.

UNIT II **12 Hrs.**

Ultrastructure and functions of Cell:

Cell Theory, Organization of prokaryotic and eukaryotic cells, Cell wall (Plant): Ultrastructure, Chemical composition and Functions. Plasma membrane**:** Chemical composition**,** Ultrastructure- Fluid Mosaic model, Functions – Osmosis, Phagocytosis, Pinocytosis, Active Transport, Cell Junctions - Tight, Gap, Desmosomes and Plasmadesmata.

UNIT III **14 Hrs.**

Ultrastructure and functions of Cell organelles:

Ultrastructure, Chemical composition and Functions of Cytoplasmic organelles: Endoplasmic reticulum, Ribosomes, Lysosomes, Golgi bodies and Cytoskeleton. Mitochondria: Ultrastructure, Chemical composition and Functions- Kreb's cycle, Electron transport system & Oxidative phosphorylation. Plastids: Types, Ultrastructure of Chloroplast and role in Photosynthesis. Nucleus: Morphology, nuclear envelope, nucleoplasm, nucleolus and chromatin.

UNIT IV **13 Hrs.**

Cell cycle and Cell division:

Cell Cycle: G1, S, G2 and M phases, Check points. Mitosis: Stages, Mitotic apparatus, cytokinesis, Mitogens and Inhibitors, Significance. Meiosis: Stages, Synaptonemal complex, crossing over and chaisma formation, Significance. Cell senescence and Cell death (Apoptosis): Programmed cell death, Mechanism of cell death and significance.

I Semester B.Sc., GENETICS
Practical Syllabus
Paper - GNP 101: FUNDAMENTALS OF CELL BIOLOGY
15 practicals

1. **Microscopy:** **02 Prs.**
   Handling of Dissection, Stereo and Compound microscopes.
2. **Genetic study of model organisms and their significance:** **05 Prs.**
   a) *Bacteriophage - Lambda phage*
   b) *Bacteria: E. coli.*
   c) *Saccharomyces*
   d) *Coenorhabditis elegans*
   e) *Drosophila melanogaster*
   f) *Arabdopsis thaliana*
   g) *Rattus albicans*
3. **Staining Techniques:** **04 Prs.**
   a) RNA and DNA- Methyl green and Pyronin
   b) Mitochondria- Janus green
   c) *Lactobacillus* and *E. coli*- Gram Staining
4. **Observation of Mitotic stages in permanent slides** **01 Prc.**
5. **Temporary squash preparation of Onion root tips for mitosis** **03 Prs.**

I Semester B.Sc., GENETICS
Practical Examination
Paper - GNP 101: FUNDAMENTALS OF CELL BIOLOGY
Time: 3 Hrs. **Max. Marks: 35**

1. Prepare a temporary squash of the given material. Identify the stage and comment. (Mitosis) **08**
2. Stain, mount and comment on the given material. (Any one of RNA/DNA/Mitochondria/ *E.coli./Lactobacillus*. **07**
3. Identify and comment on any **four** spotters: **15**

i. Microscope- Any one (03)
ii. Mitotic stage- Any one (03)
iii. Model organisms- Any two (2x4.5=09)

4. Class Records **05**

I Semester B.Sc., GENETICS
Scheme of Valuation of Practical Examination
Paper - GNP 101: FUNDAMENTALS OF CELL BIOLOGY

1. Preparation of Mitotic slide **08**
(Preparation of slide- 04, Identification of stage- 01, Comment on the stage with diagram- 03)

2. Stain, mount and comment on the given material. **07**
(Staining and mounting- 04, comments- 03)

3. Spotters: Identify and comment on any **four** spotters **15**

i. Microscope- Any one
(Identification- 01, Working principle- 01, Applications-01)

ii. Mitotic stage- Any one
(Identification- 01, Diagram-01, Comments-01)

iii. Model organism- any two
(Identification with classification- 01, Comments on life cycle- 2.5, Genetic significance- 01)

4. Class Records **05**

References:

1. Biology: The Dynamic Science, 2nd Edition,Peter J. Russell, Paul E. Hertz.. Beverly Mc Millan publications. 2012
2. Cell and Molecular Biology, 4th Edition, P.K. Gupta. 2014
3. Cell Biology, 10th Edition, S.P. Singh and B. S. Tomar. 2014.
4. Cytogenetics, 1st Edition, P.K. Gupta. 2013
5. Instant notes in Microbiology. J. Nicklin *et al.*, 2003.
6. Microbiology, 3rd Edition, P.D. Sharma. 2012.
7. Molecular Biology of Cell, 5th Edition by Alexander Johnson. 2008

II Semester B.Sc., GENETICS
Theory Syllabus
Paper - GNT 201: PRINCIPLES OF GENETICS

52 Hrs.

UNIT I **13 Hrs.**

a. **History of Genetics:**
   Pre- Mendelian genetic concepts: Preformation,Epigenesis, Inheritance of acquired characters and Mutation theory.
   Heredity and Environment: Concepts of Phenotype, Genotype, Heredity, variation, Pure lines and Inbred lines.
b. **Biography of Mendel and his experiments on pea plants.**
c. **Law of Segregation**: Monohybrid cross, Back cross and Test cross, Problems related.
d. **Law of Independent Assortment**: Dihybrid cross in pea plant, Back cross and Test cross, Problems related.

UNIT II **13 Hrs.**

a. **Multiple Alleles:** Definition, ABO blood groups and Rh factor in Human, Genetic Problems related.
b. **Gene Interactions**
   - Deviations from Mendelism: Incomplete inheritance and Co-dominance
   - Inter allelic:-

➢ Complementary gene interaction (9:7) Ex: *Lathyrus odoratus*
➢ Supplementary gene interaction (9:3:4) Ex: Grain color in Maize.
➢ Epistasis - Dominant Ex.: Fruit color in *Cucurbita pepo*, Recessive - Ex.: Coat color in *Mice*.
➢ Non- Epistasis - Ex.: Comb pattern in Poultry.

UNIT III **13 Hrs.**

Elements of Biometry

- Measures of Central Tendency - Mean, Median and Mode
- Measures of Dispersion - Variance and Standard deviation
- Test of Hypothesis - Student's 't' Test, Chi square Test.
- Probability - Definition and rules.
- Distribution - Normal, Binomial and Poisson.

UNIT IV **13 Hrs.**

Sex Determination

- Chromosome theory of Sex determination: XX- XY, XX-XO, ZZ-ZW, Genic balance theory of Bridges, Intersexes and Super sexes in *Drosophila*, Y chromosome in sex determination of *Melandrium*.
- Environment and sex determination
- Hormonal control of Sex determination (Free martins).
- Gynandromorphs

- Dosage compensation in *Drosophila, Coenorhabditis elegans* and Man (Lyon's hypothesis).
- Sex differentiation in *Drosophila* and Man.

II Semester B.Sc., GENETICS
Practical Syllabus
Paper - GNP 201: PRINCIPLES OF GENETICS

15 Practicals

1. Temporary squash preparation of: **04 Prs.**
a. Onion Flower buds
b. Grasshopper testes lobes
2. Study of: **01 Prc.**
a. Flower colour in *Antirrhinum/ Mirabilis*
b. Coat colour in Mice
c. Comb pattern in Poultry
3. Blood Typing **01 Prc.**
4. Biometrical Computation of: **03 Prs.**
a. Mean, Median and Mode
b. Variance, Standard Deviation
5. Problems on: Student's 't' test and Chi square test **02 Prs.**
a. Genetic problems on:
b. Multiple alleles **02 Prs.**
c. Gene Interactions (Complemetary/ Supplementary/ Dominant Epistasis gene interactions) **02 Prs.**

II Semester B.Sc., GENETICS
Practical Examination
Paper - GNP 201: PRINCIPLES OF GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1. Prepare a temporary squash of the given material. Identify the stage and comment. (Meiosis) **10**
2. Detect the blood group of the given sample A and B. Report and comment on the results. 2.5x2= **05**
3. Identify and comment on any **two** spotters: 3x2= **06**
   i. One spotter from: *Antirrhinum/ Mirabilis*/ Comb pattern in Poultry/ Coat color in mice.
   ii. Meiotic stage.
4. Genetic Problems (03 only): 3x 3= **09**
   i. Biometry- one
   ii. Multiple Alleles - one
   iii. Gene interaction(Complementary/ Supplementary/ Dominant Epistasis gene interactions) – any one
5. Class Records **05**

II Semester B.Sc., GENETICS
Scheme of Valuation of Practical Examination
Paper - GNP 201: PRINCIPLES OF GENETICS

1. Preparation of temporary squash (Meiosis) **10**
(Preparation- 05, Identification of stage- 01, Comment on the stage with diagram- 04)

2. Detect the blood group of the given sample A and B. Report and comment on the results. **2.5 x2= 05**
(Performance-01, Result- 0.5, Comment on result- 01 per sample)

3. Identify and comment on any **two** spotters: **3x2= 06**
(Identification – 01, Comments with diagram- 02)

4. Genetic Problems: (03 only) **3x3=09**
(For each problem- 03)

5. Class Records **05**

References:

1. Advanced Genetics. G. S. Miglani. Alpha Science International, Ltd. 2012.
2. Cell and Molecular Biology, 4th Edition, P.K. Gupta. 2014
3. Fundamentals of Biostatistics. 2nd Edition. Khan & Khanum. 2004. Ukaaz publications.
4. Genes- IX, 9th Ed., Benjamin Lewin. Jones and Bartlett Publishers, 2008.
5. Genetics – Classical to modern, 1st Edition. P.K. Gupta. 2013.
6. Principles of Genetics, 7th Edition, Robert H. Tamarin. 2002. Tata- Mc Graw Hill publications.
7. Theory and Problems of Genetics. W. D. Stansfield. 2002. Mc Graw Hill publications.

III Semester B.Sc., GENETICS
Theory Syllabus
Paper – GNT 301: CYTOGENETICS

52 Hrs.

UNIT I **14 Hrs.**

a. Physical Basis of Inheritance:

- Definition, Description of chromatin structure, Chromosome theory of inheritance.
- Eukaryotic Chromosome: Macro-molecular organization. Primary and Secondary constriction, Sat-bodies, Telomeres, Histones, DNA, Nucleosome
- Heterochromatin and Euchromatin and its significance.
- Ultra structure of Chromosome - Nucleosome model, Karyotype and Idiogram.

b. Special types of Chromosomes:

- Structure and Significance of Special type of Chromosomes: Polytene
- Chromosome - Salivary gland chromosome in *Drosophila*, Lampbrush chromosome in amphibian Oocyte.
- Supernumerary B Chromosome.

UNIT II **13 Hrs.**

a. Sex Linkage:

- Definition of sex linkage
- Meiotic behavior of chromosome and non - disjunction. Bridges theory of non-disjunction.
- Sex linkage in *Drosophila*.
- Sex linked genes in poultry, moths and man
- Sex linked inheritance in man (Colour-blindness, Haemophilia)
- Attached X-chromosome.

b. Extra Chromosomal Inheritance / Cytoplasmic Inheritance:

- Characteristic features of Cytoplasmic Inheritance.
- Inheritance of : Mitochondrial DNA, Chloroplast DNA, Kappa articles in *Paramecium*, Sigma factor in *Drosophila*, Shell coiling in snail.
- Cytoplasmic Male Sterility (CMS) in maize.

UNIT III **14 Hrs.**

a. Linkage:

- Definition of Linkage, Coupling and Repulsion hypothesis, Linkage group- *Drosophila*, maize and man, Types of linkage-complete linkage and incomplete linkage, Factors affecting linkage- distance between genes, age, temperature, radiation, sex, chemicals and nutrition, Significance of linkage.

b. Crossing over:

- Crossing over- definition and types of crossing over: Germinal and Somatic crossing over.
- Cytological basis of crossing over: Stern's experiments in *Drosophila,* Creighton and Mc Clintock experiment in maize.
- Mechanism of crossing over: Chiasma type theory, Breakage first theory, Contact first theory, Strain or torsion theory.
- Molecular mechanism of crossing over - Holiday model, Crossing over in *Drosophila*.
- Interference and coincidence, Steps in Construction of genetic map *(Drosophila)*.

UNIT IV **11 Hrs.**

Chromosomal aberrations:

Numerical: Euploidy (Monoploidy, Haploidy and Polyploidy)
Polyploidy- Autopolyploidy and Allopolyploidy.
Aneuploidy- Monosomy, Nullisomy and Trisomy.

Structural - Deletions (Terminal, Interstitial), Duplication (Tandem, Reverse tandem and Displaced), Translocation (Simple, Isochrome, Reciprocal, Displaced) and Inversions (Pericentric and Paracentric).

Significance of chromosomal aberrations.

III Semester B.Sc., GENETICS
Practical Syllabus
Paper – GNP 301: CYTOGENETICS

15 Practicals

1. A .Culturing and Handling of *Drosophila*: **02 Prs.**

a) Media Preparation
b) Cleaning and Sterilization of bottles
c) Handling of *Drosophila*

B. Morphology and Sexual dimorphism

2. Study of at least five types of *Drosophila*: **02 Prs.**

a) Body color mutant- Ebony body and Yellow body.
b) Wing mutant- Curly wing and Vestigial wing.
c) Eye color mutant- Bar eye, White eye, Sepia eye.

3. Mounting of Sex Comb of *Drosophila melanogaster*. **01 Prc.**

4. Salivary gland Chromosome- **04 Prs.**

a) Dissection of Salivary glands.
b) Preparation of Polytene chromosome.

5. Study of Chromosomal Aberrations: **03 Prs.**

a) Observation of permanent slides of chromosomal aberrations.
b) Inversion- Salivary gland chromosomes of *Drosophila nasuta*.
c) Translocation- Flower buds of *Rhoeo discolor*.

d) Induction of polyploidy in Onion root tips.

6. Genetic Problems on Linkage and Crossing over: 03 Prs.

a) *Drosophila*. b) Maize. c) Human (Sex Linkage).

III Semester B.Sc., GENETICS
Practical Examination
Paper – GNP 301: CYTOGENETICS

Time: 3 Hrs. Max. Marks: 35

1. Prepare the Salivary gland Chromosomes from the given material and comment on its salient features. **10**

2. Prepare a temporary anther squash of *Rhoeo* for catenation ring and comment with neat diagram

OR

Mount the Sex comb of *Drosophila melanogaster* and comment with a diagram. **09**

3. Identify and comment with neat labeled diagrams for the following spotters 3 X 2= **06**

a) Any **Two** mutants of *Drosophila melanogaster*.

b) Any **One** Chromosomal Aberration (Inversion/ polyploidy).

4. Solve the given genetic problem on Linkage map / Sex Linkage. **05**

Note: *For construction of linkage map data of two point / three point crosses should be provided.*

5. Class Records. **05**

III Semester B.Sc., GENETICS
Scheme of Practical Examination
Paper – GNP 301: CYTOGENETICS

Time: 3 Hrs. Max. Marks: 35

1. Preparation of Salivary gland Chromosomes and comment.
(Preparation - 06, Comments with diagram – 04) **10**

2. Preparation of a temporary anther squash of *Rheo* and comment with diagram. **OR**
Mounting of the Sex comb of *Drosophila melanogaster* and comment with diagram. **(Preparation / Mounting – 05, Comment with diagram– 04)** **09**

3. Spotters. 3X2= **06**
(Each spotter: Identification – 01, Comment with diagram – 01)

4. Genetic Problem **05**

5. Class Records **05**

References:

1. Chromosomal Abberrations: Basic and Applied aspects by Obe.G. and A.T. Natarajan (1990) Springer Verlag, Berlin.
2. Cytogenetics, Plant Breeding and evolution by U.Sinha and Sunita Sinha , Vikas Publishing House Private, Limited, 1998.
3. Cytology, Genetics and Molecular Biology by P.K.Gupta (2002), Rastogi publications.
4. Elements of Genetics by Phundan Singh, Kalyani Publishers. 2009.
5. Genetic Maps, 6th edition by O'Brien, S (1993) Book 3: Lower Eukaryotes. Book 4: Nonhuman Vertebrates. Book 5: The Human maps. Book 6: Plants. Cold Spring Harbor Lab press New York.
6. Genetics, 2nd Edition, by Weaver, R.F. and Hendrick, P.W. (1992). W.C. Brown.
7. Instant notes in Genetics by P.C.Winter, G.I. Hickey and H.L.Fletcher (2003) Viva Books Pvt.Ltd.
8. Principles of Genetics by E.J.Gardener, M.J.Simmons and D.P.Snustad.J.Wiley and Sons pubs (1998).

IV Semester B.Sc., GENETICS
Theory Syllabus
Paper – GNT 401: MOLECULAR GENETICS

52Hrs.

UNIT I **13 Hrs.**

a. Chemical Basis of Heredity:

DNA as genetic material- Experiments of Griffith; Avery, Mc Leod and Mc Carty; Harshey and Chase.

RNA as genetic material- Experiment of Fraenkel and Singer.

b. Nucleic acids:

Molecular structure of DNA, Chargaff's rule, Forms of DNA- A, B and Z forms.

RNA types and structure – mRNA, tRNA (clover leaf model), rRNA. Ribozymes

c. DNA Replication:

Meselson and Stahl Experiment.

DNA Replication in prokaryotes – Initiation, Continuous and discontinuous synthesis, Events at the replication fork, Termination, Enzymology.

Rolling circle replication in φX174 virus.

DNA Replication in eukaryotes.

UNIT II **13 Hrs.**

a. Genome organization

Fine structure of the Gene- Cistron, muton and recon.

Organization of Chloroplast and mitochondrial genome.

b. Gene expression:

Transcription: initiation, elongation and termination (rho- dependent and rho- independent).

Post transcriptional modifications: methylation, polyadenylation, RNA splicing.

Translation: Genetic code and its properties; process of translation- Initiation, elongation and termination. Post-traslational modifications of proteins.

UNIT III **13 Hrs.**

a. Gene regulation:

Concept of operon, Inducible operon - Lac operon – structure and mechanism, Catabolite repression. Repressible operon - Tryptophan operon - structure and mechanism.

b. Bacterial Genetics:

Transformation, Transduction-Generalized and specialized;

Conjugation: F factor mediated, *Hfr* and Sexduction.

c. Introduction to Genomics, Proteomics, metabolomics, microbiome.

UNIT IV **13 Hrs.**

a. Transposable elements: Bacteria, Yeast, Maize and *Drosophila*.

b. Mutations:

Introduction and Types of Gene mutations - Base substitution (Transition and transversion), Frame shift mutation, insertion, deletion, missense, nonsense, reverse, suppressor and lethal mutations).

Pleiotropy- definition and examples.

Mutagens – Physical (ionizing and non- ionizing radiations) and chemical (Base analogs, Alkylating agents, Acridine dyes, Deaminating agents, Hydroxylating agents, Tobacco carcinogens); Oncogenic Viruses.

DNA repair mechanisms (Mismatch repair, photoreactivation, excision and SOS repair).

Mutation as raw material for evolution.

Beneficial effects of mutation.

Analogs

IV Semester B.Sc., GENETICS
PRACTICAL SYLLABUS
Paper - GNP 401: MOLECULAR GENETICS

15 Practicals

01 INSTRUMENTATION: **02 Prs.**

Centrifuge, Ultra centrifuge, pH meter, Electrophoretic unit, Micropipette, Glass homogenizer, Autoclave, Shaker incubator.

02 EXTRACTION OF DNA : **04 Prs.**

From Cauliflower, Coconut endosperm, Bacteria, Animal Tissue.

03 PAPER CHROMATOGRAPHY FOR SEPERATION : **03 Prs.**

Leaf pigments, *Drosophila* eye pigments, Amino acids

04 ELECTROPHORESIS (DEMONSTRATION) **02 Prs.**

Agarose gel electrophoresis, PAGE (Polyacrylamide gel electrophoresis)

05 MUTATIONS : **04 Prs.**

a. Study of examples of mutations :

- Sickle cell Anaemia: Mis – sense mutation.
- Thalassemia – frame shift mutation.
- Identification of point mutation types based on the given representation

b. Induction of Mutation in *Drosophila* and detection of sex- linked lethal by *Muller 5 stock*.

IV Semester B.Sc., GENETICS
Practical Examination
Paper - GNP 401: MOLECULAR GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1. Extract DNA from the given material. Write the protocol. **10**

2. Perform Paper Chromatography for the given mixture, calculate the Rf value and comment on the principle. **8**

3. Identify and comment on any four: the given spotters **4 x 3 = 12**

i) Instrument (Any two),
ii) DNA / Protein Profile,
iii) Spotter from Mutation Study

4. Class Records **5**

IV Semester B.Sc., GENETICS
Scheme of Valuation of Practical Examination
Paper - GNP 401: MOLECULAR GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1. Extraction of DNA **10**
(Extraction – 07 marks, Protocol-03)

2. Paper Chromatography **8**
(Performance – 02, Calculation of Rf value - 04, Principle of chromatography – 02)

3. Spotters **4 x 3 = 12**
(Identification – 01, Comments – 02 (for instrument, Comments should be written on the working principle)

4. Class Records **5**

References:

1. Advanced Genetics by G.S.Miglani. 2002.
2. Advanced Molecular Biology by Twyman R.M (1998) Viva Books Ltd.
3. Cell Biology and Molecular Biology by EDP Robertis and EMF Robertis, Saunder College. 1980.
4. Genes- IX, 9th Ed., Benjamin Lewin. Jones and Bartlett Publishers, 2008.
5. Genetics – Analysis of Genes and genomes – VII edition - Daniel L. Hartl and Elizabeth W. Jones. 2011.
6. Genetics – from genes to genomics – Leland Hartwell, Leroy Hood, Charles (Chip) Aquadro, Michael L. Goldberg, Maria Papaconstantinou, Fischer, Janice, Jim Karagiannis. McGraw-Hill Education, 2017.
7. Genomes by T.A. Brown (2002) Viva Books.
8. Instant Notes in Biochemistry 2 edition B.D.Hames and N.M.Hooper (2002) Viva Books.
9. Instant Notes in Molecular Biology by P.C.Turner etal (2002) Viva Books.
10. Molecular cell Biology, 2nd edition by Darnell.J, H.Lodish and D.Baltimore (1990), Scientific American Books, New York.
11. Molecular Genetics by D.N.Bharadwaj. Kalyani, 2008

V Semester B.Sc., GENETICS
Theory Syllabus
Paper – GNT 501: RECOMBINANT DNA TECHNOLOGY

40 Hrs.

UNIT I **14 Hrs.**

a. Introduction to RDT:

Overview of major steps involved

b. Tools for RDT:

Enzymes:

Restriction endonucleases: Types, Nomenclature, Recognition sequences, cleavage pattern; Modification of cut ends DNA ligases

Other enzymes: A brief account of alkaline phosphatase, Polynucleotide kinase, Exonuclease III, DNase I, Klenow fragment, Terminal nucleotidyl transferase, RNA dependent DNA polymerase and S_1 endonuclease.

Vectors:

Properties of an ideal vector, Cloning and expression vectors in prokaryote and eukaryotes.

Cloning vectors:

i) Prokaryotic vectors:

Plasmids- pBR 322; pUC 18;

Bacteriophages- Lambda phage, Cosmids.

ii) **Eukaryotic vectors:** YAC vectors; Shuttle vectors- Yeast and *E. coli*.

iii) For higher plants**:**

Integrative DNA transfer- *Agrobacterium* vectors-Ti plasmid

Non integrative- DNA transfer-Plant viral vectors (CaMV)

For animals: Animal viral vectors- SV 40, SV- GT5, Retroviruse and Adenoviruse.

UNIT II **13 Hrs.**

a. Isolation and construction of a desired gene:

mRNA isolation

cDNA library

Genomic library

b. Gene transfer methods:

Agrobacterium mediated gene transfer- Binary and Cointegration method.

Direct gene transfer methods:

Chemical method-Calcium phosphate method and DEAE **-(Diethylaminoethyl) Dextran mediated DNA transfer**

Lipofection

Electroporation

Microinjection

Gene gun method

c. Synthesis of gene:

Sangers di deoxy method

Organo chemical synthesis

d. Selection and screening of recombinants:

Identification and selection of transformed cells:

Direct methods-Insertional inactivation, Visual screening method, Plaque formation, Complementation of mutation /nutrition

Indirect methods- Colony hybridization, Immunochemical detection

Use of selectable and scorable genes:

a) Selectable genes: Plants- npt; Animals-*TK*

b) Scorable genes: Plants-Gus; Animals-*lux*

UNIT III **13 Hrs.**

a. Technique for RDT:

Gel electrophoresis: AGE and SDS-PAGE

PCR - Principle and applications

Hybridization: Southern; Northern; Western;

Autoradiography – Principle and applications

DNA foot prints

DNA microarray and DNA chips.

b. Applications:

Transgenic animals: Methodology to create transgenic animals (mouse).

Applications of Transgenic Knock-out Mouse, Sheep, Fish, Cow.

Transgenic Plants: Resistance to diseases (Pathogen resistance to viral, fungal and bacterial); insects (*Bt* gene transfer).

Fertilizer management – organization of *nif* gene in *Rhizobium*.

V Semester B.Sc., GENETICS
Practical Syllabus
Paper – GNP 501: RECOMBINANT DNA TECHNOLOGY

15 Practicals.

1. **Instrumentation:** 03 Prs.
   a) Gel doc
   b) Microneedle
   c) Magnetic Stirrer
   d) UV Transilluminator
   e) Thermocycler
2. **Vectors:** 02 Prs.
   a) pBR 322 and Cosmid
   b) YAC
   c) Ti plasmid - Binary vector
   d) SV 40 (any one type- same example from theory)

3. **Transgenic organisms:** 01 Prc.
   Plants: Bt cotton and Animals: Knock out Mouse
4. **Experiments:** 05 Prs.
   a) Quantification of DNA by DPA method
   b) Quantification of RNA by Orcinol method
5. **Demonstrations:** 04Prs.
   a) Restriction Enzyme digestion
   b) Ligation of DNA fragment

V Semester B.Sc., GENETICS
Practical Examination
Paper – GNP 501: RECOMBINANT DNA TECHNOLOGY

Time: 3 Hrs. **Max. Marks :35**

1. Quantify DNA / RNA from the given sample and comment on the principle involved.
   (Standard graph to be prepared by students only) **12**

2. Identify and Comment on the working principle of instruments (any two from Instrumentation) **2x3= 6**

3. Identify and comment on any two of the following spotters: **2x3= 6**

a) Transgenic plant / animal
b) Vector (Any one type)

4. Comment on the methodology of any two of the following profiles: **2x3= 6**
   DNA Profile: **i)** Plasmid profile **ii)** Restriction profile **iii)** Ligation profile
   (Chart / Photograph of any two to be provided)

5. Class Records. **5**

V Semester B.Sc., GENETICS
Scheme of Valuation of Practical Examination
Paper – GNP 501: RECOMBINANT DNA TECHNOLOGY

1. DNA / RNA Quantification. **12**
(Principle - 2, Performance and Observation table – 5, Standard graph- 3, Result- 2).

2. Instrumentation. **2x3=6**
(Identification – 0.5 Mark, Working Principle with application – 2.5 Marks for each).

3. Spotters: **2x3=6**
(Identification – 1, Comments– 2 for each).

4. Profile **(Methodology – 3 Marks for each).** **2x3=6**

5. Class Records. **5**

References:

1. Agricultural Biotechnology- S.S. Purohit Agro Botanical Publishers, 1999.
2. An introduction to Genetic engineering (2nd ED). Desmond S.T. Nicholl I South Asian Edition, 2002, Cambridge University Press.
3. Biotechnology Fundamentals and applications - S.S. Purohit, student Edition, Jodhpur, 2003.
4. Biotechnology; B.D. Singh, Kalyani publishers. 2016.
5. Biotechnology; U. Satyanarayana; 2008. Books and Allied (P) Ltd., Kolkata,.
6. Gene cloning- T. A. Brown. Stanley Thornes (Publishers), 1998.
7. Genes-Volumes, Benjamin Lewin, Oxford University Press, Oxford.
8. Genetic engineering: Principles and practice; Sandhya Mitra, 2008. MacMillan India Ltd..
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10. Molecular Biology of the gene- Watson. 2008.
11. Molecular Biotechnology. Primrose. Wiley, 1992
12. Molecular Biotechnology; Principles and practices, Channarayappa, 2006. University press (India) Private Limited
13. Transgenic animals by Madhur Mohan Ranga. Agrobios (India), 2006

V Semester B.Sc., GENETICS
Theory Syllabus
Paper – GNT 502: BASIC HUMAN GENETICS

40 Hrs.

UNIT I **13 Hrs.**

a. Human Chromosomes:

Normal Human Karyotype: Paris Nomenclature, Flow karyotyping (Quantification of DNA of individual chromosomes) FACS-Fluorescence Activated Cell Sorter

b. Genetic Diseases and Inheritance Pattern:

Autosomal inheritance- Dominant

(Ex. Adult polycystic kidney, Achondroplasia and Neurofibromatosis)

Autosomal inheritance- Recessive

(Ex. Albinism, Sickle cell anaemia, Phenylketonuria)

X-linked – Recessive: (Ex. Duchenne muscular dystrophy-DMD)

X-linked- Dominant : (Ex. Xg blood group)

Y-linked inheritance : Holandric gene (Ex. Testes determining factor - TDF)

Multifactorial inheritance :

(Ex.Congenital malformations: Cleft lip and palate, Rheumatoid arthritis and Diabetes)

Mitochondrial diseases: (Ex. Leber's hereditary optic neuropathy)

c. Pedigree studies and Genetic Counselling:

Symbols used in pedigree studies, Pedigree analysis and construction, Pedigree analysis for the inheritance pattern of genetic diseases, Genetic Counselling.

- Stage 1: History and pedigree construction
- Stage 2: Examination
- Stage 3: Diagnosis
- Stage 4: Counselling
- Stage 5: Follow up

UNIT II **14 Hrs.**

a. Immunology and Immunogenetics:

Introduction to immunology- antigens, antibodies, B and T Cells
Immunity- Innate and acquired.
Immune response - Humoral and Cell mediated
Genetics of immune system – Antibody gene rearrangement and class switching.
Inherited immunodeficiency- Ex. X- linked agammaglobulinaemia.
Major Histocompatibility Complex- Types,
HLA disease associations.
Transplantation, graft-rejection and immunosupressors
Concept of immunization

b. Oncogenetics:

A brief account of cancer-definition, types-Benign and Malignant; Sarcoma, Carcinoma, Lymphoma and Leukaemia

Properties of malignant cells,

Types of genes - Proto oncogenes, Oncogenes, Difference between V-onc and C – onc oncogenes, Tumor Suppressor genes-p53, pRb.

Chromosomal abnormalities associated with the specific malignancies- Acute Promyelocytic Leukaemia(APL),Chronic Myeloid Leukaemia(CML) and Acute lymphoblastic leukaemia *(*ALL)

UNIT III **13 Hrs.**

Dermatoglyphics:

Introduction and Patterns.

Dermatoglyphics in clinical disorders- Down's syndrome, Turner's syndrome, Klinefelter's syndrome and Cri du chat syndrome.

Clinical applications, Advantages and Limitations.

b. Prenatal Diagnosis:

Introduction and types

Invasive Prenatal diagnosis - Amniocentesis, Chorionic villus sampling.

Non – Invasive Prenatal diagnosis – Ultrasonography.

c. Genetics and Society:

Eugenics: Positive and negative, Euthenics, Euphenics

Human genome project – introduction and significance

Gene therapy with reference to SCID

Stem cells- Properties, types and sources.

A brief account on Cord blood banking and Stem cell therapy.

V Semester B.Sc., GENETICS
Practical Syllabus
Paper – GNP 502: BASIC HUMAN GENETICS

15 Practicals

1. **Study of Karyotypes I**: Normal Karyotyping in Human **1Prc.**
   - Male (46,XY)
   - Female (46, XX).
2. **Study of Karyotypes II:** Abnormal Karyotypes **1 Prc.**
   - Down's syndrome (autosomal).
   - Turner's syndrome (sex chromosomal)
   - Klinefelter's syndrome (sex chromosomal)
3. **Sex chromatin:** **3 Prs.**
   - Study of Barr body in the Buccal epithelial cells.
   - Study of drum sticks in Neutrophils of Blood smear.
4. **Blood Cell counting using Haemocytometer (RBC and WBC) 3 Prs.**
5. **Pedigree analysis and construction:** **2 Prs.**

Symbols used and problems associated with autosomal recessive disorder, autosomal dominant disorder, Sex linked inheritance (X and Y)

6. Dermatoglyphics: **2 Prs.**

- Recording of print of fingertips and palm.
- Classifying ridges on the Finger tips: arch, loop, and whorl.
- Palm print - area demark as hypothenar, thenar and inter - digital areas, Recording presence or absence of Simian crease.
- Ridge Counting and angle calculation.

7. Immunology: Demonstration of **3 Prs.**

- Ouchterlony Double Diffusion (ODD)
- Radial ImmunoDiffusion (RID)
- Dot ELISA

V Semester B.Sc., GENETICS
Practical Examination
Paper – GNP 502: BASIC HUMAN GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1) Prepare a Buccal smear / Blood smear for sex chromatin and comment. **07**

2) Count the RBC / WBC in the blood sample. Calculate and report the results. **07**

3) Construct pedigree for the given data / analyse the given Pedigree **06**

4) Identify and comment on the given Karyotype **04**

5) Identify and comment on the given Spotters (**Two**). 2 x 3=**06**

i) Dermatoglyphic pattern

ii) ODD / RID / DOT ELISA

6) Class Records **05**

V Semester B.Sc., GENETICS
Scheme of Valuation of Practical Examination
Paper - GNP 502: BASIC HUMAN GENETICS

Time: 3 Hrs **Max. Marks: 35**

1) Buccal smear / Blood smear
(Slide Preparation - 05, Comments - 02) **07**

2) Count the RBC / WBC
(Preparation - 03, Calculation - 03, Report - 01) **07**

3) Pedigree Construction / Analysis with **explanation** **06**

4) Karyotype **(Identification – 01, Comments – 03)** **04**

5) Spotters **(Identification – 01, Comments – 02)** **02 x 03=06**

6) Class Records **05**

References:

1. Basic Human Genetics by EJ. Manage and A.P. Manage (1997 India Reprint) a Rastogi Publications, Meerut.
2. Emery's Elements of Medical Genetics- Peter Turnpenny, SlanEllard 15th Edition. 2017.
3. Essentials of Human Genetics by S.M. Bhatnagaretal (1999) IV edition. Orient Longman.
4. Genetic basis of common diseases by R. A. King *et al*, Oxford University Press 2002.
5. Genetics in Medicine by M.W. Thompson *et al*, 5 Edition, W.B. Sounders Company, London 1996.
6. Human Cytogenetics. Denise Rooney Oxford University Press, 2001.
7. Human Genetics – Bruce.R.Korf. 2000
8. Human Genetics : Concepts and Applications by Lewis R (2001) McGrawHi; Boston.
9. Human Genetics by S.D. Gangane (2nd edition-Reprint 2001), B.L Churchill Livingstone Pvt. Ltd., New Delhi.
10. Medical Genetics. Lynn Jorde John CareyMichael Bamshad. 2015.
11. Mendelian inheritance in Man by-Mc. Kusick V.A, (1998), 12 Edition, John Hopsins University Press.
12. Molecular Basis of Inherited Diseases, (6th Edition-1989) by Scriver, C.R. A.L. Beudit, W.S. Sty abnd D. Valle (EdsOMcGrawHill, New York.

VI Semester B.Sc., GENETICS
Theory Syllabus
Paper - GNT 601: DEVELOPMENTAL, EVOLUTIONARY AND BIOMETRICAL GENETICS

40 Hrs.

UNIT I **14 Hrs.**

a. **Developmental Genetics**: Early embryonic development in Frog- cleavage, blastula and gastrula. Nuclear transplantation experiments in Amphibians and *Acetabularia*

b. Genetics of development in plants – *Arabidopsis*: Flower development (Floral morphogenesis and Homeotic gene expression).

c. **Genetics of development in Animals** - *Drosophila*: Early development; Origin of anterior-posterior and dorso-ventral polarity: Role of Maternal genes, Zygotic genes- Segmentation genes (gap, pair rule and segment polarity genes) and Homeotic selector genes.

d. Switching genes on and off during development- Ex. Differential expression of haemoglobin

UNIT II **13 Hrs.**

a. Evolutionary and Population Genetics:

Darwinism, Neo Darwinism and Synthetic Theory.

Evolution at molecular level: - Nucleotide sequence.

Gene pool, Gene and genotype frequencies: Hardy-Weinberg principle, Evolutionary agents: Selection – differential selection, gametic selection, zygotic selection, fitness; Migration; Mutation and Random drift.

Speciation: Methods of speciation-Allopatric and Sympatric, Isolation-Pre-mating and Post mating isolating mechanisms, role of isolation in Speciation.

b. Quantitative characters and inheritance:

Quantitative Characters:-Types- Continuous, meristic and threshold characters with examples.

Quantitative inheritance:-Features of polygenic traits in relation to oligogenic traits. Inheritance of Kernel color in wheat, and Skin colour in human.

Transgressive inheritance in Poultry.

Environmental effects-IQ in Humans

Significance of polygenic inheritance-Twin study

UNIT III **13 Hrs.**

Biometrical Genetics:

An introduction to Correlation, Regression and ANOVA (Analysis of Variance)

Genetic analysis of quantitative trait: - Ear length in Corn

Variances in polygenic traits: - Phenotypic, genotypic, environmental, additive, dominance and Epistatic variance; Genotype and environmental interaction.

Heritability: - Broad sense and Narrow sense heritability, Quantitative trait loci (QTL). Problems related to Variance and Heritability

VI Semester B.Sc., GENETICS
Practical Syllabus
Paper - GNP 601: DEVELOPMENTAL, EVOLUTIONARY AND BIOMETRICAL GENETICS

15 Practicals.

1. Early embryonic development in Frog- Egg, cleavage, blastula and gastrula **02 Prs.**
2. Genetics of development in *Arabidopsis* – ABC model Homeotic gene expression (Slide/Chart) **01 Prc.**
3. Genetics of development in *Drosophila* - Anterior-posterior/dorso-ventral polarity (Slide/Chart) **03 Prs.**
4. Study of Quantitative inheritance in Kernel colour in Wheat/Skin colour in man (Chart) **01 Prc.**
5. Biometrical problems (Minimum 3 problems in each topic) **08 Prs.**
   - Genetic problems on polygenic variance, Heritability and ANOVA.
   - Problems in Population Genetics.

VI Semester B.Sc., GENETICS
Practical Examination
Paper - GNP 601: Developmental, Evolutionary and Biometrical Genetics

Time: 3 Hrs. **Max. Marks: 35**

1. Identify and comment on A and B (Frog embryology) 2x3= **6**

2. Identify and comment on the given spotters **(Any Three)** 3x3= **9**

i) Genetics of development of *Arabidopsis*

ii) Genetics of development of *Drosophila*

iii) Quantitative inheritance of Kernel color in wheat/ Skin color in man

3. Genetic Problems: 3x5=**15**

a) Polygenic variability/Heritability – **Any one**

b) ANOVA – **Any one**

c) Gene and genotype frequencies – **Any one**

4. Class Records **05**

VI Semester B.Sc., GENETICS
Scheme of Practical Examination

Paper - GNP 601: DEVELOPMENTAL, EVOLUTIONARY AND BIOMETRICAL GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1. Identify and comment on A and B
   (Identification – 1 mark, Comments – 2 marks) 2x3= **6**
2. Identify and comment on the given spotters (Three) 3X3=**9**
   i) Genetics of development of *Arabidopsis*
   ii) Genetics of development of *Drosophila*
   iii) Quantitative inheritance of Kernel color in wheat/skin color in man **(Identification – 1mark, Comments -2 marks for each)**
3. Genetic Problems: 3x5=**15**
   a) ANOVA
   b) Polygenic variability and Heritability
   c) Gene and genotype frequencies
4. Class Records **5**

References:

1. Developmental biology by Scott.F.Gilbert. Sinauer Associates, Sunderland. 2000.
2. Evolution - Stickberger, M. W (1990) Jones and Bartlett, Boston.
3. Evolutionary Genetics by Maynard Smith J (1989), Oxford University press.
4. Genetics and Analysis of Quantitative traits by Lynch. M and B. Walsh (1997). Senauer Associates, Sunderland.
5. Introduction to Quantitative Genetics by Falconer, D (1995) 4th edition Longman, London
6. Introduction to Quantitative Genetics by Falconer, D (1995) 4th edition Longman, London.
7. Population Genetics and Quantitative Genetics by Mari selvi K. Kalyani Publications. 2008.
8. Principles of Development by Lewis Wolpert *et al*. 5th Edition. oxford University press 2015.

VI Semester B.Sc., GENETICS
Theory syllabus
Paper – GNT 602: APPLIED AND BEHAVIORAL GENETICS
40 Hrs.

Unit I

a. Genetics in Medicine and Industry **13 Hrs.**

Production of recombinant insulin, interferon and human growth hormone (HGH)
Vaccines: Hepatitis B vaccine
Preparation of molecular probes, Monoclonal antibodies and diagnostic kits
Microarray

b. DNA Fingerprinting

Methodology of DNA fingerprinting
Molecular markers –RAPD, RFLP, Microsatellite, SNPs, STR
Applications in Forensic science, Medicolegal aspects.

c. Bioinformatics

Introduction to bioinformatics
Tools of Bioinformatics - FASTA, BLAST, RASMOL
Applications of Bioinformatics

Unit II

a. Genetic resources and Biodiversity **15 Hrs.**

Germplasm, Classification, Germplasm activities and organization associated with germplasm (NBPGR, IBPGR) Genetic erosion, biodiversity, Red data book, endangered species, *ex- situ* and *in-situ* conservation, Vavilovian center for biodiversity.
Gene bank and cryopreservation – Types and methods.

b. Behavioral Genetics

Mating behavior in *Drosophila*
Hygienic behavior in Honeybee
Nesting behavior in Ants
Territoriality and conflict behavior in Primates.

c. Molecular markers as diagnostic tools

Her2 testing for breast cancer – (FISH), Frigile X syndrome –
Microsatellite marker analysis

UNIT III **12 Hrs.**

Heterosis in animal and plants

Introduction to heterosis and characteristics.

a. In Animals:

Animal breeding –Introduction, inbreeding , grading, cross breeding, artificial insemination in cattle

Fish breeding (Selection, Induced Polyploidy, Gynogenesis and Androgenesis, Inbreeding).
Breeding strategies for improvement of livestock for milk, meat, wool production.
Breeding strategies for improvement of Poultry –Giriraja.

b. In plants:

Genetic concepts – Dominance and Over dominance.
Hybridization techniques – Intergeneric and interspecific hybridization, Identification of hybrid plants.
Inbreeding depression.
Hybrid vigor exploitation in Rice and Tomato.

VI Semester B.Sc., Genetics
Practical syllabus
Paper - GNP 602: APPLIED AND BEHAVIORAL GENETICS

15 practicals.

1.	Study of Diagnostic kits -WIDAL and VDRL.	**2 prs.**
2.	Study of Pollen fertility	**1 prc.**
3.	Study of hybrid plants - Rice, cotton, chilly and tomato	**1 prc.**
4.	Study of hybrid animals – Poultry, dairy and fishery.	**1 prc.**
5.	Study of Mating behavior in *Drosophila*	**2 prs.**
6.	Study of Hygienic behavior in Honeybee	**1 prc.**
7.	Study of Nesting behavior in ants	**1 prc.**
8.	One day field visit to Plant/animal breeding institutes	**1 prc.**
9.	Project work on -	**5 prs.**

- Bioinformatics
- Biodiversity
- Behavioral Genetics - *Drosophila*
- Animal/Plant breeding.

VI Semester B.Sc., GENETICS
Practical Examination
Paper - GNP 602: APPLIED AND BEHAVIORAL GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1.	Study of diagnostic kits – WIDAL/VDRL (any one)	**6**
2.	Study the Pollen fertility of the given material.	**5**
3.	Identify and comment on the given spotters :	3X3=**9**
	a. Hybrid plant (Rice/Tomato) - **Any one**	
	b. Hybrid Animal (Fish/Poultry/Cattle) - **Any one**	
	c. Behavioural Genetics (Ant/ Honeybee) - **Any one**	
4.	Project Report and viva	**10**
5.	Class Records	**5**

VI Semester B.Sc., GENETICS

Scheme of valuation of practical examination

Paper - GNP 602: APPLIED AND BEHAVIORAL GENETICS

Time: 3 Hrs. **Max. Marks: 35**

1. Study of diagnostic kits – WIDAL / VDRL **6**
   (Performance – 3, Principle – 2, Result and discussion – 1)
2. Pollen fertility of the given material **5**
   (Performance – 3, Calculation of % of fertility – 1 mark, Result – 1 mark)
3. Identify and comment on the given spotters: 3x3=**9**
   (Identification – 01, Comment -02)
4. Project Report and viva **(7+3=10)**
5. Class Records **5**

References:

1. Biotechnology, Satyanarayana U (2010) Books and allied (P) Ltd., Kolkata
2. Cancer Biology, Raymond W.R (2007) Oxford University Press, Newyork
3. Essentials of plant Breeding, Phundan Singh, Kalyanai publishers, 2015
4. Gene cloning and DNA analysis, T.A.Brown (2010) 6th edition, Wiley-Blackwell publication
5. Human Molecular Genetics, Peter Sudbery (2002) 2nd Edition, Prentice Hall
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7. Molecular Biotechnology, Principales and application of recombinant DNA Glick and Pasternak. 2010.
8. Plant breeding Principles and methods, B.D. Singh 2015, Kalyanai publishers.
9. Principles of gene manipulation, Old R.W. and S.B. Primrose (1994) Boston Blackwell Scientific Publication