Semester V		
Course No.	**Course Title**	**Credit**
BIOCHEM-352	Enzymology and Enzyme Technologies	2+1
BT-3510	Immunology	2+1
BT-3511	Molecular Genetics	2+0
BT-3512	Nanobiotechnology	2+0
BT-3513	Animal Biotechnology	3+1
BT-3514	Molecular Marker Technology	2+0
BT-3515	Genomics and Proteomics	3+0
BT-3516	IPR, Biosafety and Bioethics	2+0
ICT-352	Agricultural Informatics	2+1
EDNT-351	Educational Tour	0+1
Total		**20+5=25**

As per the decision taken during Review Meeting on the Status of Implementation of Recommendations of Fifth Deans' Committee held on 2-3 June, 2017 at Central Agril. Univ., Ranipool Campus, Gangtok, Sikkim, initially elective courses preferably on Plant Biotechnology should be offered to the students in the concerned colleges of Agricultural Universities in Maharashtra.

Semester VI		
Course No.	**Course Title**	**Credit**
BT-3617	Computational Biology	2+1
STAT-362	Biostatistics	2+1
Optional/ Elective Courses (6) PBTEL-361 to 366 ABTEL-361 to 366 MEBTEL-361 to 366 BIFEL-361 to 366	Electives (4): Only one to be chosen (each with six courses)	18
	1. Plant Biotechnology	12+6
	2. Animal Biotechnology	13+5
	3. Microbial and Environmental Biotechnology	14+4
	4. Bioinformatics	11+7
Total		**24**

Elective Courses in Biotechnology (one to choose), Each Elective: Total Credit Hours=18

Elective I. Plant Biotechnology		
Course No.	**Course Title**	**Credit**
PBTEL-361	Plant Tissue Culture and its Applications	2+1
PBTEL-362	Principles and Applications of Plant Genetic Transformation	2+1
PBTEL-363	Applications of Genomics and Proteomics	2+1
PBTEL-364	Molecular Breeding in Field Crops	2+1
PBTEL-365	Molecular Breeding of Horticultural Crops and Forest Trees	2+1
PBTEL-366	Epigenetics and Gene Regulation	2+1
Elective II. Animal Biotechnology		
ABTEL-361	Principles and Procedures of Animal Cell Culture	2+1
ABTEL-362	Animal Genomics	2+1
ABTEL-363	Embryo Transfer Technologies	2+1
ABTEL-364	Transgenic Animal Production	3+0
ABTEL-365	Molecular Diagnostics	2+1
ABTEL-366	Molecular Virology and Vaccine Production	2+1
Elective III. Microbial and Environmental Biotechnology		
MEBTEL-361	Microbial Biotechnology	2+1
MEBTEL-362	Bio-prospecting of Molecules and Genes	3+0
MEBTEL-363	Molecular Ecology and Evolution	3+0
MEBTEL-364	Fundamentals of Molecular Pharming and Biopharmaceuticals	2+1
MEBTEL-365	Food Biotechnology	2+1
MEBTEL-366	Green Biotechnology	2+1
Elective IV. Bioinformatics		
BIFEL-361	Programming for Bioinformatics	2+2
BIFEL-362	Bioinformatics Tools and Biological Databases	2+1
BIFEL-363	Structural Bioinformatics	2+1
BIFEL-364	Pharmacogenomics	2+1
BIFEL-365	Metabolomics and System Biology	2+1
BIFEL-366	Computational Methods for Data Analysis	1+1

SEMESTER-V

Course No : **BIOCHEM-352** Course Title : **Enzymology& Enzyme Technologies**
Credit : **3(2+1)** Semester **: V**

Theory

UNIT I

Classification and nomenclature of enzymes; General characteristics of enzymes, active site, cofactors, prosthetic groups; Metalloenzymes; Isolation, purification, characterization and assays of enzyme and international units; Criteria for purity.

UNIT II

Enzyme kinetics: effect of pH, temperature, determination of Km and Vmax; Regulation of enzyme activity; Enzyme inhibition: competitive, non-competitive and uncompetitive; Isoenzymes, schizomers and isoschizomers; Ribozymes; Immobilization of enzymes; Applications of enzymes: biotechnology, industry, environment, agriculture, food and medicine.

Practical

Isolation, purification and assay of enzymes;Determination of optimum pH and optimum t;emperature of enzymes; Thermostability of enzymes; Activators and inhibitors of enzyme catalysis; Determination of kinetic parameters of enzymes; Immobilization of enzymes; Isoenzymes analysis.

Teaching Schedule-Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
1	History, importance and scope of enzymes	3
2	Enzyme nomenclature, common and systemic name of enzymes	4
3	Classification of enzymes	3
4-5	Enzyme structure, specificity and concept of active sites	6
6-7	Concept of free energy, transition state, activation energy in relation to enzyme catalysis	5
8-9	Concept of cofactors, prosthetic, Metalloenzymes; group, their structures and functions	10
10-11	Basic principles of enzyme isolation, purification and measurement of enzyme activities	10
12-13	Enzyme kinetics: Michaelis- Menten equation, Lineweaver – Burk plot, effect of pH, temperature, determination of Km and Vmax and its significance.	12
14-16	Regulation of enzyme activity : regulation of enzyme activity at protein level, compartmentalization of enzymes. Covalent modification, allosteric regulation	10
17-19	Enzyme inhibition: competitive, non-competitive, un-competitive and irreversible inhibitions.	10
20-22	Isoenzymes, schizomers and isoschizomers; Ribozymes	05
23-24	Enzymes Immobilization: immobilization process, Technique for immobilization	10
25	Application of immobilization.	

26-27	Enzymes in recombinant DNA technology:	6
28-30	Applications of enzymes: biotechnology, industry	2
31	Applications of enzymes : environment, agriculture	2
32	Applications of enzymes: food and medicine	2
	Total:	**100**

Practical Exercises

Exercise No.	Title
1-2	Isolation and estimation of amylase activity from germinating seeds
3	Determination of optimum temperature of amylase enzyme
4	Determination of optimum pH of amylase enzyme
5	Determination of V max of amylase enzyme
6	Determination of Km value for amylase enzyme
7-8	Isolation and estimation of polyphenol oxidase activity from plant tissues
9-10	Isolation and estimation of peroxidase activity from plant tissues
11-12	Isolation and estimation of alkaline phosphatase from sugar cane juce
13-14	Isolation and estimation of acid phosphatase from sugar cane juce
15-16	Isolation and estimation of P5CS activity from stressed sorghum seedlings

Text Books:

1 Bhatia SC, 1984, Biochemistry in Agricultural Sciences, Shree Publication House, New Delhi.
2 Purohit SS. 2009, Biochemistry - Fundamentals and Applications, Agrobios, Jodhpur
3 Singh M. 2011, A Textbook of Biochemistry, Dominant Publishers & Distributors, New Delhi
4 Veerkumari L. 2007, Biochemistry, MIP Publishers, Chennai
5 Jain JL, Jain S and Jain N. 2005. Fundamentals of Biochemistry. S. Chand & Company Ltd. New Delhi.
6 Rastogi SC. *2003* – Biochemistry, Tata McGraw-Hill Education, New Delhi.
7 Rama Rao AVSS, *2002* A Textbook of Biochemistry. Edition, 9, illustrated. Publisher, Sangam Books Limited, New Delhi.

Reference Books:

1 Com EE &Stumpf PK. 2010.Outlines of Biochemistry.5th Ed. John Wiley Publications.
2 Donald Voet and Judith G. Voet. 2011. Biochemisry, 4th Ed. John Wiley and Sons, Inc., NY, USA.
3 Goodwin, TW & Mercer EI. 1983. Introduction to Plant Biochemistry. 2nd Ed. Oxford, New York.Pergaman Press.
4 David L. Nelson and Michael M. Cox.2012. Lehninger Principles of Biochemisry, 6th Ed Macmillan Learning, NY, USA
5 Jeremy M. Berg, John L. Tymoczko, LubertStryer and Gregory J. Gatto, 2002.Biochemisry, 7th Ed. W.H. Freeman and Company, NY, USA

6 Jayaram. T. 1981. Laboratory manual in biochemistry, Wiley Estern Ltd. New Delhi:
7 Plummer D. 1988. An Introduction to Practical Biochemistry. 3rd ed. Tata McGraw Hill, New Delhi.
8 Practical biochemistry: R. L. Nath. A treatise on Analysis of Food, Fats and Oils: A. R. Sen, N.K. Pramanik and S.K. Roy
9 Sadasivam *S*, Manickam *A (1996)* Biochemical methods. 2nd edition, New Age International (p) Ltd. Publisher, New Delhi.

Course No :**BT-3510** Course Title : **Immunology**

Credit :**3(2+1)** Semester : **V**

Theory

UNIT I

History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin structure and functions; Molecular organization of immunoglobulins and classes of antibodies; Antibody diversity; antigens, haptens, antigens antibody interactions; Immuno-regulation and tolerance.

UNIT II

Allergies and hypersensitive response; Immunodeficiency; Vaccines; Immunological techniques; Immunological application in plant science, monoclonal antibodies and their uses; Molecular diagnostics.

Practical

Preparation of buffers and reagents; Precipitation and agglutination test; HA, HI test; Immunoblotting, immunoelectrophoresis and fluorescent antibody test; Enzyme immunoassays including ELISA variants, western blotting; Raising of antisera in laboratory animals; Collection and preservation of antisera – separation, filtration and aliquoting.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1	**History and scope of immunology:** Historical landmarks, Applications of immunology in medical and allied fields.	6
2-5	**Components of immune system: organs, tissues and cells,** Primary and secondary lymphoid organs T-cells B-cells NK cells, blood cells such as neutrophiles, basophiles, WBCs: structure and their role in immune response.	5
6	**Immunoglobulin structure and functions** Defination of immunoglobins ,immune sera ,structure of immunoglobulinH-chain L-chain kappa and Lambda chains, properties of immunoglobulin	8
7	**Classes of immunoglobins** Structure and function of IgG, IgA IgD IgE IgM Theories of antibody synthesis.	8
8-9	**Antibody diversity.** VDJ arrangement ,surface IgM,IgD expressing B cells Exposure to Antigen ,helper T cells	8
10-11	**Antigens, haptens,** : Defination of antigenes.Properties of antigens, functions of antigens .Classification of antigenes.concept of antigenecity.Defination of hapten	8

	antigenic specificity	
12-13	**Antigens antibody interactions;** Basis of antigen antibody reactions.,serological reactions precepitation test,immune electrophoresis, aggulutination test immune diffusion, RIA Haemagglutination	4
14-16	**Immuno-regulation and tolerance.** Balance between activator and suppressor T cells Mechanism of unresponsiveness, immunological ignorance, central tolerence of T cells and B cells, clonal deletion central and peripheral tolerence in B cells and T cells, Regulation of T cell homeostasis during immune responses	10
UNIT II		
17-18	**Allergies and hypersensitive response** Defination and classification, IgE mediated Type I Hypersensitivity: Allergy, IgG and IgM mediated type II Hypersensitivity, Immune complex mediated Type III Hypersensitivity, Delayed type IV Hypersensitivity.	5
19	**Immunodeficiency** Primary and secondary immunodefeciency ,causes,types autoimmunity	7
20-22	**Vaccins :** Defination, Principles of vaccination, Antibody mediated protection, Cell mediated immunity, Active and passive immunization, antigenic preparation, Adjuvants .	8
22-23	**Immunological techniques;** ELISA, Flow cytometry, immune histochemistry	6
24-25	**Immunological application in plant science :** Radioimmunoassay for cytokinin determination ,immune detection of phytochrome .The Measurement of Low-Molecular-Weight, Non-Immunogenic Compounds by Immunoassay	5
28-29	**Monoclonal antibodies and their uses;** Definition, production of monoclonal antibodies,hybridoma technology, antibody heterogenecity	7
30-32	**Molecular diagnostics**: Defination, assays of molecular diagnostics, applications of molecular diagnostics .	5
	Total:	**100**

Practical Exercise

Exercise No.	Title
1-2	Preparation of buffers and reagents
3.	Study on Precipitation
4.	Study on Agglutination
5.	Study on HA Test
6.	Study on HI test
7-8	Immunoblotting
9.	Immunoelectrophoresis ;
10.	Fluorescent antibody test
11-12	Enzyme immunoassays including ELISA variants,
13-15	western blotting
16.	Raising of antisera in laboratory animals; Collection and preservation of antisera – separation, filtration and aliquoting.

Reference Books:

1. Murphy K. 2012. *Janeway's Immuno Biology*.8th Ed. Garland Science/ Taylor & Francis Group.
2. Owen JA, Punt J, Kuby J & Sharon A. 2013. *Kuby Immunology*. 7th Ed. W.H. Freeman
3. Cube Fundamentals of immunology. 7th edition. Freeman publication
4. Roitte. Essential immunology. 11th Edition, Willy Publication.
5. Thimmaiah. Practical Biochemistry.
6. Willam Paul, Fundamentals of Immunology, LWW Publication

Text Books:

1. Cube Fundamentals of immunology. 7th edition. Freeman publication
2. Roitte. Essential immunology. 11th Edition, Willy Publication.
3. Thimmaiah. Practical Biochemistry
4. Nandini Shetty, Introductory textbook of Immunology,New age publication.

Course No : **BT-3511** **Co**urse Title : **Molecular Genetics**
Credit : **2(2+0)** Semester : **V**

Theory

UNIT I

Structures, properties and modification of DNA; Molecular mechanisms of DNA replication, repair, mutation, and recombination; Centromere and telomere sequences and DNA packaging; Synthesis and processing of RNA and proteins; Regulation of gene expression; Mutations and DNA repair.

UNIT II

Repetitive DNA sequences and transposable elements; Promoters and their isolation; Transcription factors **–** their classification and role in gene expression; Epigenetic control of gene expression; Small RNAs, RNA interference and its applications.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1	**Structure of DNA:** Double Helical Structure of DNA (Watson and Crick Model), Different Structural Forms of DNA(A,B,Z and H)	8
2	Functions of DNAand Packaging of DNA,	2
3	**Properties of DNA:** Physical and chemical properties,Base Pairing, DNA Grooves, DNA Super coiling,	4
4	DNA Conformations, DNA Sense and Antisense.	1
5	**Modification of DNA:** DNA nicking, DNA end modification,	4
6-7	DNA repair, DNA methylation,	6
7	**Molecular mechanisms of DNA replication**- DNA polymerase, DNA ligase, Sliding clamp for DNA polymerase, Nuclease that removes RNA primers, DNA helicase, Primase.	4
8-9	**Repair**-Mismatch repair, excision repair, Base excision repair Error-Prone repair, Recombination-Repair System, Homologous recombination flawless repair	6
10	**Centromere and telomere sequences and DNA packaging:** Centromere and Telomere sequences-replication problem, G-rich repetitive sequences, DNA duplex loop formation, General structure of a telomere;	3
11	**DNA packaging**- Nucleosome, Model for packing of DNA in chromatin.	2
12-13	**Synthesis and processing of RNA and proteins:** Basic eukaryotic gene structure Exons, Introns, transcription,	5
14	Splicing pathway in GU–AG introns and translation.	5
15	**Regulation of gene expression:**	2

	General principles of gene regulation; Gene regulation in bacterial cells;	
16	Eukaryotic gene regulation- Chromatin structure and gene regulation,	2
17	Transcriptional control in eukaryotic cells,	2
18	Gene regulation through messenger RNA processing, RNA stability, RNA silencing, translational and post translational control..	4
19	**Mutations and DNA repair:** importance of mutation categories of mutations- somatic mutation, germ-line mutation, gene mutations, causes of mutation;	3
20	DNA repair- Mismatch repir, direct repair, base-excision repair, nucleotide-excision repair, other types of DNA repair	2
UNIT II		
21-22	**Repetitive DNA sequences and transposable elements:** **Repetitive DNA sequences:** Satellite DNAs, middle repetitive DNA sequences,Telomere, and Functions.	5
23	**Transposable elements:** Nature, structure and evolution of transposable element	5
24-25	Promoters and their isolation	5
26-27	**Transcription factors (TF) –**classification: functional and Structural TF eg. TFIIA, TFIID, TFIIB,TFIIF, TFIIE, TFIIH). Role of TF in gene expression.	5
28-29	Epigenetic control of gene expression:	5
30	**Small RNAs, RNA interference and its applications:Small RNAs:** siRNA, miRNA, PaciRNA- structure, mechanism and functions	5
31-32	**RNA interference and its applications:** Concept, Principle, Applications: Transient and Stable Gene Silencing, Temporal and Spatial Control of RNAi, RNAi in functional gene analysis, Insect, pest and disease resistance, weed resistance, drought tolerance, improvement of nutritional values and Limitations	5
Total:		**100**

Text Book:

1. Allison LA. 2011. Fundamental Molecular Biology. Wiley Global Education.
2. Brown TA. 1998. Genetics: A Molecular Approach. 3rd Ed. Stanley Thornes.
3. Lewin B. 2009. Genes 9. Jones & Bartlett Learning.
4. Tropp BE. 2014. Principles of Molecular Biology. Jones & Bartlett Learning.
5. Tropp BE. 2012. Molecular Biology Genes to Proteins.4th Ed. Jones & Bartlett Learning.

Reference Books:

1. Pierce BA. Genetics A Conceptual Approach, 6th Ed,.. W.H. Freeman and Company.
2. Gardner EJ, Simmons MJ, Snustad DP. 2006. Principles of Genetics. 8th Ed. John Wiley & Sons.

Course No : **BT-3512** Course Title : **Nanobiotechnology**
Credit : **3(2+1)** Semester : **V**

Theory

UNIT I

Introduction to nanotechnology; Concepts and Terminology; Nano-Bio Interface; Biological based Nanosystems, molecular motors, biosensors and other devices.

UNIT II

Self assembly of molecules for nanotechnology applications; Biomimetics, Biotemplating and *de novo* designed nanostructures and materials; DNA-Nanotechnology; Nanomanipulations, material design, synthesis and their applications.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT I	
1	**Introduction to nanotechnology:** Milestones in Nanotechnology effect of length scale on properties.	1
2	overview of nanoscale material	1
3	top-down and bottom-up approach of nanoparticle synthesis	1
4	challenges and opportunities associated with nanoscale materials	
5	**Concepts and Terminology**: list of terms used in a field	**2**
6	**Nano-Bio Interface**: Introduction, colloidal forces as well as dynamic biophysicochemical interactions	**1**
7	Designing of nanobiointerface	2
8	Biocompatible or bioadverse outcomes and applications	2
9	**Biological based Nanosystems** : Introduction; Butterfly wings; Lotus effect;	**5**
10	**Molecular motors**: Introduction, ; Life is Motion; Cytoskeleton system,	5
11	Applications of molecular motor in Nanotechnology.	5
12	**Biosensors**: Definition, components, Principles of detection	4
13	Using Antibodies in Biosensors: Immunoassays, Cantilevers as Nano-Biosensors,	3
14	Micro- and Nanosensors and Applications of Optical Nanosensors.	3
15	**Other devices:** Types-i) solid state devices (CMOS, quantum)	2
16	ii) molecular devices (electrochemical, electromechanical, photoactive, quantum)	3
	UNIT II	
17	**Self assembly of molecules for nanotechnology applications:** Introduction, mechanism of self assembly- i) Self Assembly by Molecular Interactions- intermolecular interaction, Hamaker interaction, and some examples of self assembly	5
18	ii) Externally Directed Self Assembly-electric and magnetic field,	

	flow field, microscopic viscous flow, large amplitude oscillatory shear (LAOS), combination of fields.	
19	**Biomimetics**: Biomimetic Design of Molecules, Some Key Principles of Biological Self-Assembly in nanotechnology	3
	Biomimetic Nanomaterials- nonotubes, nanofibers etc	3
20	**Biomimetic Nanoengineering-** Nano-engineering of Colloidal Particles, antigen presenting cells, Synthetic Biomimetic Blood Cells, etc.	4
21	Biotemplating-definition, mechanism, materials, advantages, limitations, future perspectives	5
22	*de novo* designed nanostructures and materials: De Novo-Designed α-Helix Coiled-Coil Nanofibers	5
23	**DNA-Nanotechnology**: Introduction; History, DNA nanostructure;	3
24	Capabilities, possibilities and limitation of DNA nanostructure;	3
25	DNA origami. Applications of DNA nanotechnology	4
26	**Nanomanipulations** : Introduction; Types-AFM, STM, In situ SEM, In situ TEM manipulation, Applications	5
27	**Material design**: Techniques	5
28	**Nanomaterial synthesis**: Physical method 1) mechanical-high energy ball milling, melt mixing 2) Vapour-physical vapour deposition, laser ablation, sputter deposition, electric arc deposition, ion implantation ,	4
29	Chemical method-collide, sol gel method	2
30	Biological method of nanomaterial synthesis-Green synthesis by microorganisms, fungi, plant extracts	2
31	Advantages and drawbacks of each method.	2
32	**Applications :** application of nanotechnology in Medical; Agriculture and food; in space, Defense and Engineering; Domestic appliances; in cosmetics; textiles; automobiles; energy	5
Total:		**100**

Text Books:

1. Hornyak GL, Moore JJ, Tibbals HF and Dutta J. 2008. Fundamentals of Nanotechnology. CRC Press.
2. Yubing Xie. 2012. The Nanobiotechnology Handbook. CRC Press.
3. Kulkarni SK. 2014. Nanotechnology: Principles and Practices. CP Publishing, New Delhi.
4. Murty BS, Shankar P, Raj B, Rath BB and Murday J. 2012. Textbook of Nanoscience and Nanotechnology. Springer.
5. Chattopadhyay KK and Banerjee AN. 2009. Introduction to Nanoscience and Nanotechnology. PHI Publication.
6. Goodshell DS. 2004. Bionanotechnology-Lessons from Nature. John Wiley Publications.

Reference Books:

1. Reisner DE. 2009. Bionanotechnology: Global Prospects. CRC Press.
2. De la Fuente JM and Grazu V. 2012. Nanobiotechnology: Inorganic nanoparticles *vs* Organic nanoparticles. Elsevier.
3. Poole Jr. CP and Owens FJ. 2003. Introduction to Nanotechnology. Wiley-Interscience; 1st ed.
4. Trivedi PC. 2008. Nanobiotechnology. Pointer Publishers.
5. Ramsden J. 2009. Essentials of Nanotechnology. Ventus Publishing APS.
6. Alarcon E. , Griffith M. and Udekwu KI. (Eds.) 2015. Silver Nanoparticles Applications:In the Fabrication and Design of Medical and Biosensing Devices. Springer.
7. Baglioni P., Chelazzi D. and Giorgi R. 2015. Nanotechnologies in the Conservation of Cultural Heritage: A compendium of materials and techniques. Springer.

Course No : **BT-3513** Course Title : **Animal Biotechnology**
Credit : **4(3+1)** Semester : **V**

Theory

UNIT-I

History and development of animal biotechnology; Basic techniques in animal cell culture: Introduction to embryo biotechnology: oocyte collection and maturation; Sperm preparation; in vitro fertilization; Cryopreservation of oocyte, sperm and embryos; Embryo transfer technology.

UNIT II

Breeds of livestock and their characteristics; Marker assisted breeding of livestock; Introduction to animal genomics: RFLP, RAPD, SSRs, QTL, SNP, STR, Mitochondrial DNA polymorphism; Rumen and its environment: Rumen microbes- manipulation of rumen microbes for better utilization of feed; Introduction to nutrigenomics; Milk biome; Manipulation of lactation by biotechnological tools; Application of biotechnology in meat and meat products.

UNIT III

Genome and protein based diagnostics of important animal diseases: FMD, brucellosis, PPR, Mastitis, Blue tongue, Newcastle disease; Introduction to vaccinology: live attenuated vaccines, killed vaccines, cell culture based vaccines, recombinant vaccines.

Practical

Basic cell culture techniques; oocyte aspiration from ovaries; sperm preparation; In vitro fertilization; PCR based detection of animal pathogens; PCR-RFLP; Immunohistochemical localization of protein marker in tissues/cells – meat species identification by PCREDIT

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1-2	**History and development of animal biotechnology:** Introduction to Animal Biotechnology- Def., Contribution of various Scientist, Steps/Mile stones in development of Animal Biotechnology.	4
3	**Basic techniques in animal cell culture:** Dissociation/ Disaggregation Tech., Primary and secondary cell culture. Cell line and their types.	8
4-6	**Introduction to embryo biotechnology:** **Oocyte collection and maturation:** Collection methods and *in vitro* culture and maintenance of Oocyte.	5
7-9	**Sperm preparation:** Collection of sperms, Evaluation, Scaling up and preservation.	4
10	***In vitro* fertilization:** Causes of infertility, Fusion of sperms and *In vitro* culture Oocyte, Zygote and Embryo growth and development.	4
11	**Cryopreservation of Oocyte, sperm and embryos:** Preparation, Methods of freezing, Storage, Thawing and recultured.	4

12-14	**Embryo transfer technology**: Artificial insemination, Freezing techniques.	4
15	Selection of Donor and recipients, Super ovulation.	2
16	Estrous synchronization, Applications of ETT.	2
	UNIT-II	
17-18	**Breeds of livestock and their characteristics**: Classification, Indian and exotic breeds of Cattle, Buffalo, Sheep, Goat and Poultry Bird.	5
19	Their origin and distribution.	3
20	Distinguishing characteristics and their production.	2
21	**Marker assisted breeding of livestock**: Marker assisted selection, Advantages-limitations, Applications in Animal Breeding.	3
22	**Introduction to animal genomics**: Def., Gene isolation, Sequencing.	3
23	Applications of molecular markers such as RFLP, RAPD, SSRs.	3
24	QTL, SNP, STR.	2
25	Mitochondrial DNA polymorphism.	2
26	**Rumen and its environment**: Rumen micro flora, Rumen microbes- role of rumen microbes in digestion.	2
27	Genetic manipulation of rumen microbes for better utilization of feed.	3
28	**Introduction to nutrigenomics:** Concept Nutragenomics,Role of nutrition on gene expression and applications of nutragenomics.	3
29	**Milk biome**: Terminology, Types of microbes present in milk.	4
30	Bacterial load during different lactation stages.	2
31	Manipulation of lactation by biotechnological tools.	3
32	**Application of biotechnology in meat and meat product**: Growth factors related genes.	3
33	Transgenic animals for the meat production.	3
	UNIT-III	
34	**Genome and protein based diagnostics of important animal diseases** : FMD, Brucellosis.	3
35	PPR, Mastitis,Blue tongue.	6
36	Newcastle disease: Etiology.	
37-41	Symptoms, pathogenesis, Diagnosis and treatment for each disease.	
42-43	**Introduction to vaccinology**: History, Development of vaccines, Types of vaccines, Live attenuated vaccines.	3
44-45	Killed vaccines, Cell culture based vaccines.	2
46-48	Recombinant vaccines.	3
Total:		**100**

Practical Exercise

Exercise No.	Title
1	Study of laboratory requirements.
2-3	Design and layout of laboratory of animal biotechnology.
4	Study of laboratory rules and regulations.
5	Media requirements, preparation and sterilization.
6-7	Study of basic cell culture techniques; Isolation, dissociation and suspension culture.
8	Study of oocyte aspiration from ovaries.
9	Study of oocyte culture
10	Study of sperm preparation
11	Study of*in vitro* fertilization
12	Study of embryo culture
13-14	Detection of animal pathogens by using PCR based technique (RFLP)
15-16	Immuno histochemical localization of protein marker in tissues/cells – meat species identification by PCREDIT

Text Books:

1. Aberle ED, Forrest JC, Gerrard DE & Mills EW. 2012. Principles of Meat Science. 5th Ed. Kendall Hunt Publishing.
2. Lawrie RA & Ledward D. 2006. Lawrie's Meat Science. 7th Ed. Woodhead Publishing.
3. Sukumar De. 1997. Outlines of Dairy Technology. Oxford University Press-New Delhi.
4. Varnam A & Jane P. 1994. Milk and Milk Products: Technology, Chemistry and Microbiology. Sutherland Springer Science & Business Media.

Reference Books:

5. Sharma BD. 1999. Meat and Meat Products Technology: Including Poultry Products Technology. Jaypee Bros. Medical Publishers.

Course No : **BT-3514** Course Title : **Molecular Marker Technology**
Credit : **2(2+0)** Semester : **V**

Theory

UNIT I

Types of molecular markers- RFLP; PCR based markers like RAPD,SCAR, SSR, STS, CAPS, AFLP, SNP and their variants; Uses of molecular markers: Application as a genetic tool for genotyping and gene mapping; Mapping populations: F_2, DH, RILs, NILs; Bulked segregant analysis; Linkage maps; Physical maps.

UNIT II

Application of molecular markers: Assessing genetic diversity, variety protection; Marker-assisted breeding for accelerated introgression of trait/transgene and quantitative traits; Human and animal health: Association with genetic-based diseases, Paternity determinations; Forensic studies.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
1	**Types of molecular markers-** Morphological markers, Biochemical Markers and Genetic markers.	4
2-3	Dominant and co-dominant nature of markers with their specific applications.	4
4-7	Study of different markers systems with their limitations and strengths viz. RFLP; PCR based markers like RAPD,SCAR, SSR, STS, CAPS, AFLP, SNP and their variants.	14
8-10	**Uses of molecular markers**: Applications of molecular markers in various fields with special reference to crop improvement, Application as a genetic tool for genotyping and gene mapping.	10
11-12	**Mapping populations**: Different types of mapping populations viz. F_2, DH, RILs, NILs.	4
13	Methods of development and segregation pattern in each type of population. Merits and demerits of each population.	4
14	Evaluation criteria for each type of population. Application of mapping population in molecular marker studies	2
15-16	**Bulked segregant analysis:** Analysis technique used for Bulked segregant analysis. Applications of Bulked segregant analysis.	10
17-18	**Linkage maps; Physical maps:** Construction of linkage map and physical map. Application of Linkage maps and Physical maps	10
19-20	**Application of molecular markers:** Assessing genetic diversity, variety protection.	08
21-22	**Application of molecular markers:** Marker-assisted breeding for accelerated introgression of trait/transgene	5

23-24	Marker-assisted breeding for quantitative traits	5
25-26	**Application of molecular markers:** **Human and animal health: Association with genetic-based diseases:**	04
27	Genetic variations in the human genome,	
28	Genetic testing for genetic-based diseases	
29-30	**Application of molecular markers:** Paternity determinations: Determinations of paternity by molecular genetic "fingerprinting".Advantages of DNA fingerprints for determination of correct paternity, for gentic linkage and pedigree studies.	08
31	**Application of molecular markers:** **Forensic studies:** Applications, implications	08
32	**Limitations of Molecular forensics.**	
	Total:	**100**

Text Books:

1. Huges S. & Moody A. 2007. PCR: Methods Express. Royal College of General Practitioners.
2. Chawla HS. 2002. Introduction to Plant Biotechnology. Science Pub. Inc.

Reference Books:

1. Singh BD, Biotechnology Expanding Horizon 3rd ed. Kalyani Publication.
2. Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.

Course No : **BT-3515** Course title : **Genomics and Proteomics**
Credits : **3(3+0)** Semester : **V**

Theory

UNIT I

Introduction to Genomics, Functional Genomics and Proteomics; Structural genomics: Classical ways of genome analysis, BAC and YAC libraries; Physical mapping of genomes; Next generation sequencing; Genome analysis and gene annotation; Genome Projects: *E. coli*, Arabidopsis, Bovine, Human; Comparative Genomics: Orthologous and Paralogous sequences, Synteny, Gene Order, Phylogenetic footprinting.

UNIT II

Functional genomics: Differential gene expression techniques: ESTs, cDNA-AFLP, microarray, Differential display, SAGE, RNAseq, Real time PCREDIT

UNIT III

Introduction to proteomics; Analysis of proteome: Native PAGE, SDS PAGE, 2D PAGE; Edmann Degradation; Chromatographic techniques: HPLC, GC, Mass Spectrometry: MALDI-TOF, LC-MS; Post Translational modifications.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
UNIT I		
1-2	Introduction to Genome and Genomics, terminology involved and History	2
3-6	Central dogma: Structure of genomics i.e.Functional Genomics, Structural genomics and Comparative Genomics	3
7-9	Techniques in genome analysis- DNA microarray, Nanopore technology, High -throughput sequencing, Southern hybridization, Expressed sequence tag, DNA sequencing	5
10-11	cDNA library construction and development of BAC and YAC libraries, PCR Amplifications	3
12	Gene sequencing, Principles and types of sequencing (Next generation sequencing in detail)	4
13-14	Genome mapping and different methods of mapping, Physical mapping of genomes and different techniques involved in physical mapping	4
15	Genesequence analysis and annotation by using annotation models	4
16	Case study: Genome Projects: *E. coli*	3
17	Case studies: Genome Projects: Arabidopsis, Bovine	3
18	Case study: Genome Projects: Human genome project	4
19	Brief about Comparative Genomics and techniques involved in it and Synteny	2
20	Orthologous and Paralogous sequences	2
21	Gene Order, Phylogenetic footprinting.	2
UNIT II		

22	Introduction to Functional genomics	2
23	Analogy for gene expression and involved techniques	3
24	Principles and procedure of ESTs, cDNA-AFLP	4
25	Principle and types of microarray and its application in functional genomics	4
26-27	Functional analysis of genome by Differential display techniques like SAGE, RNAseq, Real time PCREDIT	5
28-29	Principal, procedure and applications of SAGE RNAseq, Real time PCREDIT	3
30	Principal, procedure and applications of Real time PCREDIT	2
UNIT III		
31-32	Introduction to proteome and proteomics terminology and history, Protein synthesis i.e translation	2
33-34	Protein isolation techniques i.e Chromatographic techniques: HPLC, GC	3
35	Protein Purification techniques from crude extract	2
36-37	Protein separation by Native PAGE, SDS PAGE, 2D PAGE and its Principles and procedure	4
38	Protein staining techniques i.e Silver staining ,Coomassie blue staining, Sypro Ruby staining	2
39	Techniques of protein digestion i.e Edmann Degradation and peptide purification	2
40-41	Protein analysis by Mass Spectrometry: MALDI-TOF, LC-MS, Electrospray ionization (ESI)	4
42	Principles and procedure of MALDI-TOF	3
43	Peptide fingerprint analysis	
44	Mass Spectrometric Identification of Proteins - Mapping	3
45	Protein identification: Peptide mass fingerprint, Tandem Mass Spectrometry (MS/MS)	4
46-47	Types Post Translational modifications: Methylation of cytidine residues in the DNA, The modifications of the histones and of CpG methylation	3
48	Application of genomics and proteomics in crop development	4
	Total	**100**

Text Book:

1. Hunt S. & Livesy F. 2000. Functional Genomics: A Practical Approach. Series, 235. Oxford Univ. Press.
2. Gupta PK. 1997. Elements of Biotechnology. Rastogi Publ.
3. Lewin B. 2008. Genes IX. John Wiley & Sons.
4. Lodish H, Berk A & Zipursky SL. 2004. Molecular Cell Biology. 5th Ed. WH Freeman & Co.

Reference Books:

1. Nelson DL & Cox MM. 2005. Lehninger's Principles of Biochemistry. WH Freeman & Co.
2. Russell PJ. 1996. Essential Genetics. Blackwell Scientific Publ.
3. Schleif R.1986. Genetics and Molecular Biology. Addison-Wesley Publ.
4. Chopra VL & Nasim A. 1990. Genetic Engineering and Biotechnology: Concepts, Methodsand Applications. Oxford & IBH.

Course No : **BT-3516** Course Title : **IPR, Biosafety and Bioethics**
Credits : **2(2+0)** Semester : **V**
Theory

UNIT I

Introduction to Intellectual Property, concepts and types; International treaties for protection of IP's; Indian Legislations for the protection of various types of Intellectual Property; Patent search, filing process; Material transfer agreements.

UNIT II

Biodiversity definition, importance and geographical causes for diversity; Species and population biodiversity, maintenance of ecological biodiversity hot spots in India; Convention on biological diversity; Cartagena Protocol of bio-safety, and risk management for GMO's; Bio-safety guidelines, rules and regulations and regulatory frame work for GMOs in India.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1	Introduction to Intellectual property,	4
2	Definition, History of IPs in India, Nature and Scope	
3	Why IPR, How and Where to apply for IPR	2
4-5	Types of IPR, Copyright, Trademark, Patent, Plant Breeders Right	4
6-7	International Treaties for Protection of IPs; TRIPs, India and TRIPs, Roles	6
8-10	Indian legislations for the protection of various types of Intellectual property; Indian Copyright Act-1957, IPR Organization and Laws, Patents Act-1970	10
11	Patent Search, Sec.2(1) (j) of the patents Act-1970	2
12	Filing Process; Drafting, Application for grant of patent, IDF, IPEC	4
13-15	Material transfer agreement; Light of TRIPs agreement, Impact of TRIPs on Developing countries, FDI, Pharmaceutical Industry and TRIPs, Biopiracy, Terminator Crops	8
	UNIT-II	
16-18	Biodiversity Definitions; Norse and Mc Manus (1980), Reid and Miller (1989), ICPB-1992, Factors responsible for Biodiversity, levels of Biodiversity, Types of Diversity, Importance of Diversity, Conservation of Biodiversity	10
19-21	Species Biodiversity; status of survey,endemic species, cultivated plants/Agrobiodiversity, Populationbiodiversity;Development pressure	5
22-23	Maintenance of ecological biodiversity hot spots in India; Legal instruments relevant to biological diversity in India, Endangered species Act, Federal role in wild life preservation	8
24	Convention on Biological diversity; FAO and NBA	4
25-26	Cartagena protocol of Biosafety; Definition, objectives, LMOs,	10

	Pracautionary approach, main features, applications	
27	Risk management of GMOs	5
28-30	Biosafety guidelines in India; EPA-1986, DBT, MOEF, IBC, RCGM, GEAC, Rules and Regulations of Biosafety	10
31-32	Regulatory framework for GMOs in India; GEAC, SBCC, DLC, RDAC, IBSC, RCGM	8
	Total:	**100**

Text Books:

1. Singh BD. 2007. Biotechnology: Expanding Horizon. Kalyani Publishers
2. Kumar U. and Asija M. 2009. Biodiversity: Principles and Conservation. Agrobios (India).
3. Mu Ramkumar 2008. Intellectual Property Rights Demynstified. New India Publishing Agency.

Websites

1. http;//patentoffice.nic.in
2. www.wipo.org
3. www.dbtindia.nic.in
4. www.dbtbiosafety.nic.in

Course No : **ICT-352** Course Title : **Agricultural Informatics**
Credits : **3(2+1)** Semester : **V**

Theory

UNIT I

Introduction to computers; Anatomy of computers; Memory concepts, units of memory; Operating system, definition and types; Applications of MS-Office for creating, editing and formatting a document; Data presentation, tabulation and graph creation; Statistical analysis, mathematical expressions; Database, concepts and types, creating database; Uses of DBMS in Agriculture; Internet and World Wide Web (WWW), concepts, components and creation of web; HTML & XML coding.

UNIT II

Computer programming, concepts; Documentation and programme maintenance; Debugging programmes; Introduction to Visual Basic, Java, Fortran, C/ C++, etc.; Standard input/output operations; Variables and constants; Operators and expressions; Flow of control; Inbuilt and user defined functions; Programming techniques for agriculture.

UNIT III

e-Agriculture, concepts, design and development; Application of innovative ways to use information and communication technologies (IT) in agriculture; ICT for data collection; Formation of development programmes, monitoring and evaluation; Computer models in agriculture: statistical, weather analysis and crop simulation models - concepts, structure, input-output files, limitations, advantages and application for understanding plant processes, sensitivity, verification, calibration and validation; IT application for computation of water and nutrient requirement of crops; Computer-controlled devices (automated systems) for agri-input management; Smartphone mobile apps in agriculture for farm advice, market price, post-harvest management, etc; Geospatial technology, concepts, techniques, components and uses for generating valuable agri-information; Decision support systems, taxonomy, components, framework, classification and applications in agriculture; Agriculture Information/Expert System; Soil Information Systems, etc. for supporting farm decisions; Preparation of contingent crop-planning and crop calendars using IT tools.

Practical

Study of computer components, accessories; Practice of important DOS commands; Introduction of different operating systems such as windows, Unix, Linux; Creating files and folders; File management; Use of MS-WORD and MS Power point for creating, editing and presenting a scientific document; Handling of tabular data; Animation, video tools, art tool, graphics, template and designs; MS-EXCEL - Creating a spreadsheet, use of statistical tools, writing expressions, creating graphs, analysis of scientific data, handling macros; MS-ACCESS: Creating database, preparing queries and reports, demonstration of agri-information system; Introduction to World Wide Web (WWW) and its components, creation of scientific website, presentation and management agricultural information through web; Introduction of programming languages - Visual Basic, Java, Fortran, C, C++, and their components; Hands-on practice on writing small programmes; Hands-on practice on Crop Simulation Models (CSM); DSSAT/Crop-Info/CropSyst/ Wofost; Preparation of input file for CSM and study of model outputs; Computation of water and nutrient requirements of crop using CSM and IT tools; Use of smart phones and other devices in agro-advisory and dissemination of market information; Introduction of Geospatial Technology; Demonstration of generating information important for agriculture; Hands on practice on preparation of Decision Support System.

Teaching Schedule- Theory with Weightage (%)

Lecture No.	Topic	Weightage (%)
1	Introduction to computers.	3
2	Anatomy of computers.	3
3	Memory concepts, units of memory.	6
4	Database, concepts and types, creating database.	5
5	Uses of DBMS in Agriculture.	10
6 -7	Concepts, components and creation of web.	5
8- 9	HTML & XML coding.	6
10-11	Computer programming, concepts;	5
12-13	Documentation and programme maintenance; Debugging programmers'.	5
14-16	Introduction to Visual Basic, Java, Fortran, C/ C++ Comparative study	12
17-18	Standard input/output operations.	6
19-20	Variables and constants; Operators and expressions with Examples	5
21-22	e-Agriculture, concepts, design and development; Application of innovative ways to use information and communication technologies (IT) in agriculture;	6
23	ICT for data collection; Formation of development programmes, monitoring and evaluation	3
24 -26	Computer models in agriculture: statistical, weather analysis and crop simulation models - concepts, structure, input-output files, limitations, advantages and application for understanding plant processes, sensitivity, verification, calibration and validation;	5
27-28	IT application for computation of water and nutrient requirement of crops; Computer-controlled devices (automated systems) for agri-input management; Smartphone mobile apps in agriculture for farm advice, market price, post-harvest management, etc;	6
29-30	Geospatial technology, concepts, techniques, components and uses for generating valuable agri-information; Decision support systems, taxonomy, components, framework, classification and applications in agriculture;	5
31-32	Agriculture Information/Expert System; Soil Information Systems, etc. for supporting farm decisions; Preparation of contingent crop-planning and crop calendars using IT tools.	4
Total:		**100**

Practical Exercise

Exercise No.	Title
1	Study of computer components, accessories.;
2	Practice of important DOS commands
3- 4	Introduction of different operating systems such as windows, Unix, Linux; Creating files and folders; File management
5- 6	Creating a spreadsheet,
7 -8	Use of statistical tools, writing expressions, creating graphs, analysis of scientific data, handling macros
9 -10	Creating database, preparing queries and reports, demonstration of agri-information system
11	Introduction to World Wide Web (WWW) and its components, creation of scientific website, presentation and management agricultural information through web
12	Introduction of programming languages - Visual Basic, Java, Fortran, C, C++, and their components; Hands-on practice on writing small programmes
13-14	Hands-on practice on Crop Simulation Models (CSM); DSSAT/Crop-Info/CropSyst/ Wofost; Preparation of input file for CSM and study of model outputs; Computation of water and nutrient requirements of crop using CSM and IT tools;
15	Use of smart phones and other devices in agro-advisory and dissemination of market information
16	Demonstration of generating information important for agriculture; Hands on practice on preparation of Decision Support System

Text Books:

1. Singh G, Singh R & Saluja KK. 2003. Fundamentals of Computer Programming and Information Technology. Kalyani Publishers.
2. Bal HP. 2003. Perl Programming for Bioinformatics.Tata McGraw-Hill Education.
3. Kumar A. 2015. Computer Basics with Office Automation. IK International Publishing House Pvt Ltd.
4. Maidasani D. 2016. Learning Computer Fundamentals, MS Office and Internet & Web Technology. 3rd Ed. Laxmi Publications.

Course No : **ET-351** Course Title : **Educational Tour**

Credits : **1(0+1)** Semester : **III**

Syllabus:

Educational Tour for Maharashtra State

Identified Institutes/Universities for Maharashtra state educational tour.

1. National Chemical Laboratory (NCL), Pune
2. ICAR-National Research Centre for Grape, (NRC-Grape) Manjri, Pune
3. Vasantdada Sugar Institute (VSI), Manjri, Pune.
4. College of Agriculture, Pune.
5. ICAR- National Institute of Abiotic Stress Management, Baramati, Pune
6. Institute of Chemical Technology, Mumbai
7. Bhabha Atomic Research Centre (BARC), Trombay, Mumbai
8. Central Institute of Fisharies Education(CIFE), Andheri West
9. University of Mumbai, Mumbai
10. National Institute of Oceanography, Goa.
11. Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri
12. National Centre for Cell Science (NCCS), Pune.
13. ICAR- National Research Centre for Pomegranate (NRC-Pomegranate), Solapur

Study Tour Evaluation

Sr. No	Particulars	Marks
1.	Inquisitiveness	10
2.	Report	15
3.	Presentation	10
4.	Assignment (Leadership role, group activities during Educational Tour etc.)	10
5.	Viva	05
Total		**50**

SEMESTER-VI

Course : **BT-3617** Course Title : **Computational Biology**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

Introduction to computational biology; Web based servers and software for genome analysis: Ensembl, UCSC genome browser, MUMMER, BLASTZ; Sequence submission.

UNIT II

Protein interaction databases: BIND, DIP, GRID, STRING, PRIDE; Principles of Protein structure prediction; Fold Recognition (threading); Homology modeling; SCOP, CATH, PDB, PROSITE, PFAM; Methods for comparison of 3D structures of proteins.

UNIT III

Phylogenetic analysis: Evolutionary models, tree construction methods, statistical evaluation of tree methods; PHYLIP, dendroscope, MEGA; DNA barcoding database-BOLD.

Practical

Application of Genome browsers in genomic research; Exploring protein-protein interaction databases; Working with protein structural classification databases; SNP and SSR identification tools; PHYLIP.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
1	**Introduction to computational biology :** Definition and application	06
2-4	**Web based servers and software for genome analysis:** Genome Analysis an overview : approaches and methods of genome analysis, Web based servers for genome analysis : OBRC: Online Bioinformatics Resources Collection, Web based software for genome analysis : DNA Sequence Quality – Phred, EGassember, Tools at server genometools.org	08
5-6	**Ensembl**: Processing your data, Accessing Ensembl data, BLAST/BLAT, BIoMART. **UCSC genome browser** : analysis tools at server	08
7-9	**MUMMER** : Analysis genome data using this tool, components and its applications **BLASTZ;** Use of BLASTZ for analysis of genome sequences, methods and output validation. **Sequence submission** : Submission of data through BankIT and Sequin tools	06
10-12	**Protein interaction databases:** Introduction and overview of protein interaction. **BIND :** To query, view and submit records, Functional Alignment	08

	Search Tool(FAST) **DIP :** Structure of The Database, State of The Database, The JDIP Visualization Tool, **STRING**: Search Protein sequences, by protein name, search protein multiple sequences. **PRIDE**: Submit data and browse the data in PRIDE.	
13-15	**Principles of Protein structure prediction:** Primary, secondary and tertiary structure prediction, online tools for the protein structure prediction at EXPASY server	07
16-17	**Fold Recognition (threading) :** Introduction, definition, methods and software for the threading and its applications	08
18-19	**Homology modeling** : Methods and tools for homology modeling for nucleotide and protein data	08
20-23	**SCOP, CATH, PDB, PROSITE, PFAM**: Introduction to these databases, how to retrieve information from these database and pattern searching from the database.	08
24-25	**Methods for comparison of 3D structures of proteins** : Sequence-dependent vs. sequence-independent methods, Superimposition-based vs. superimposition-independent methods, Distance-based measures of protein structure similarity : Root Mean Square Deviation (RMSD)	05
26-27	**Phylogenetic analysis:** Importance, different Methods of phylogenetic analyses and their application with biological data.	06
28-29	**Evolutionary models**:Models for DNA and protein evaluation, Continuous-time Markov chains. Deriving the dynamics of substitution.Ergodicity, Time reversibility. Scaling of branch lengths, JC69 model (Jukes and Cantor, 1969), K80 model (Kimura, 1980), F81 model (Felsenstein 1981). **Tree construction methods, Statistical evaluation of tree methods**	08
30-31	**PHYLIP, dendroscope, MEGA**: introduction and its use to biological data analysis.	08
32	**DNA barcoding database-BOLD :** How to access the database and identify the species	06
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	To study the Ensembl genome browser database and their applications to understand the genome structure and functions
2	To study the PlantGDB database and their applications to understand the genome structure and functions
3	To study the Genome database and their applications to understand the genome structure and functions
4	Study of protein-protein interaction databases : String
5	Study of protein-protein interaction databases from Expasy server
6	Study of protein interaction databases : Bio GRID
7	Study of protein structural database: Access secondary protein database
8	Pattern searching using secondary databases
9	Protein family searching using secondary databases.
10	Study of SNP and SSR identification tools using genome and EST Databases
11	Multiple sequence alignment for DNA and protein sequences
12	Phylogenetic analysis of DNA sequences using PHYLIP package
13	Phylogenetic analysis of protein sequence Data using in PHYLIP package
14	Phylogenetic analysis using morphological data
15	Visualization of phylogenetic analysis results using MEGA and Tree viewer
16	Designing primers using primer 3 software

Text Books:

1. Mount D. 2001. Bioinformatics: Sequence and Genome Analysis, 2nd Ed. Cold Spring Harbor Laboratory Press.
2. Campbell MA & Heyer LJ. 2007. Discovering Genomics, Proteomics and Bioinformatics. 2nd Ed. Benjamin Cummings.

Reference books:

1. Creighton TE. 1993. Proteins: Structures and Molecular Properties. 2nd Edition. WH Freeman.
2. Stekel D. 2003. Microarray Bioinformatics. 1st Ed. Cambridge University Press.
3. Joao S & Joao M. 2004. Introduction to Computational Molecular Biology. PWS Publishing Company.

Course No	**: STAT-362**	Course Title	: **Biostatistics**
Credits	: **3(2+1)**	Semester	: **VI**

Theory

Unit I

Random variables: expected value and its variance; probability distribution of random variables; Conditional probability; Baye's theorem and its applications; Introduction to Uniform, Binomial, Poisson, Normal, Exponential and Gamma probability distributions.

Unit II

Random mating populations, Hardy-Weinberg Law; Introduction to Poisson process and Markov chains: Transition probability matrix, n-step transition probabilities, steady state. Random walk models; Sensitivity and specificity.

Unit III

Chi-square test: testing heterogeneity, use in genetic experiment, detection of linkage, linkage ratios and its estimation; Analysis of variance: One-way and two-way classification with interaction; Analysis of covariance; Incomplete block designs; Estimation and significance of genotypic and phenotypic variation.

Practical

Expected value and variance of discrete and continuous distributions; Uniform, Binomial, Poisson, Normal, Exponential and Gamma Probability distributions; Hardy-Weinberg Law; Construction of transition probability matrix in Markov Chains; Calculation of sensitivity and specificity; Detection and linkage using Chi-square test; One-way and two-way analysis of variance; Analysis of covariance; Incomplete block designs; Testing of heritability.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
1-2	Certain impossible and random events, random variable expected value and its variance.	5
3-5	Probability distribution of random variable, Conditional probability and its most elementary basic formulae, Baye's theorem and its applications.	5
6-7	Computationofposterior Probability,discrete Uniform distribution, concept, properties and its applications.	5
8-9	Bernouli trials, the law of large numbers, Definition of Binomial and Poisson distributions their properties and applications.	6
10-11	Fitting of Binomial and Poisson distribution.	5
12-13	Definition of Normal distribution, Standard Normal Distribution and its properties, numerical problems on Normal distribution.	5
14-15	Definition of Exponential and Gamma probability distributions. and its properties.	6
16-17	**Genetical statistics**: Random mating populations, Sex linked characters, selection, Hardy-Weinberg Law.	6

18-19	Introduction to Poisson process.	5
20-21	**Markov chain:** Definition, Transition probability matrix, steady states, transient chains, periodic chains.	6
22-23	Random walk models, Sensitivity and specificity.	6
24	Chi-square test: testing heterogeneity and homogeneity.	5
25-26	Detection and estimation of linkage, linkage ratios and its estimation, use in genetic experiment.	6
27-28	Estimation of component of variation due to interaction between G x E (genotypic x environment) and its significance.	7
29	**Analysis of variance**: One-way analysis.	6
30	Two-way classification.	6
31	Analysis of covariance with one auxiliary character.	6
32	Concept of incomplete block designs.	4
Total:		**100**

Practical Exercises

Exercise No.	Title
1	**Probability distribution:** Problems on Expected value and variance of discrete and continuous distributions.
2	Problems of discreteUniform distribution, Finding of Mean and Variance.
3	Fitting of Binomialdistribution.
4	Fitting of Poisson distribution.
5	Problems ofNormaldistribution.
6	Problems ofExponential distributionand Finding of Mean and Variance.
7	Problems on Gamma Probability distributions and Finding of Mean and Variance.
8	**Genetical statistics**: Computations based on Hardy-Weinberg Law.
9-10	Construction of transition probability matrix in Markov Chains.
11-12	Calculation of sensitivity and specificity, Detection and linkage using Chi-square test.
13	**Analysis of variance**: One-way analysis of variance.
14	Two-way analysis of variance.
15	Analysis of covariance with one auxiliarycharacter.
16	Testing of heritability.

Text Books

1. Narayan P, Bhatia VK & Malhotra PK. 1989. Handbook of Statistical Genetics. Indian Agricultural Statistics Research Institute, New Delhi, India.
2. Rangaswami R. 2009. A Text book of Agricultural Statistics. New Age International (P) Limited, Hyderabad.
3. Nageshwar Rao G. 2007. Statistics for Agricultural Sciences. New Delhi : BS Publications

Reference Books

1. Panse VG and Sukhatme PV. 1985. Statistical methods for Agricultural workers. Indian Council of Agricultural Research New Delhi.
2. Gupta SC and Kapoor VK. 1971. Fundamentals of Mathematical Statistics. Sultan Chand and Sons, New Delhi.
3. Snedecor GW & Cochran WG. 1989. Statistical Methods. Iowa State University Press.
4. Biswal PC. 2009. Probability and Statistics. PHI Learning Pvt. Ltd.
5. Kaps M & Lamberson W. 2007. Biostatistics for Animal Science. CABI Publishing.
6. Pal N & Sarkar S. 2009. Statistics–Concepts and Applications. 2nd Ed. PHI Learning Pvt. Ltd.
7. Das MN and Giri NC. 1986. Design and Analysis of Experiments. Wiley Eastern Ltd., New Delhi.
8. Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons. New York.
9. Gupta SC. 2016. Fundamentals of Statistics. Himalaya Publishing House, Mumbai, , Maharashtra, India.
10. Kapoor VK. 2007. Fundamentals of Applied Statistics.. Sultan Chand and Sons, New Delhi.

ELECTIVE I: PLANT BIOTECHNOLOGY

Course : **PBTEL-361** Course Title : **Plant Tissue Culture and its Applications**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

Historical benchmarks of plant cell and tissue culture; Culture media components and modifications; Sterilization techniques; Various types of culture: callus, suspension, nurse, root, meristem; *In vitro* differentiation: Organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on *in vitro* culture and regeneration.

UNIT II

Applications: Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; Production of secondary metabolites; Synthetic seeds; *In vitro* fertilization; Embryo rescue in wide hybridization; Endosperm culture; Protoplast isolation, culture and regeneration; Somatic hybridization: cybrids, asymmetric hybrids; *In vitro* germplasm conservation.

Practical

Establishment of callus/ cell suspension cultures; Induction of plant regeneration; Micropropagation – Explant establishment, shoot multiplication, root induction, Hardening and transfer to soil; Monitoring of growth and differentiation of cells, Seed/Embryo culture; Ovary culture, Anther /pollen culture, Suspension cultures and production of secondary metabolites.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1	**Historical benchmarks of plant cell and tissue culture:** History of Plant tissue culture, Introduction, Scope and Importance, Applications of Plant tissue culture	4
2	**Culture media components and modifications:** Different constituents of media (Inorganic nutrients, Carbon and energy sources, Organic supplements, Growth regulators, Solidifying agents, pH of medium and their roles; MS basal medium and different types of medium	4
3	**Sterilization techniques:** Types of sterilization, Importance of sterilization	4
4-7	**Various types of culture:** callus, suspension, nurse, root, meristem: concept, principal, types, methodology and applications.	12
8-10	***In vitro* differentiation:** Organogenesis and somatic embryogenesis: Concept, Principle, types, methods and importance and applications.	10
11-12	**Plant growth regulators:** Auxins and Cytokinins their mode of action, effects on *in vitro* culture and regeneration	8
	UNIT-II	

13-14	**Applications: Micropropagation; Anther and microspore culture;**	8
15	**Somaclonal variation:** Concept, Principle, Methods	2
16	Factors affecting and causes of Somaclonal variation	2
17	Importance and applications of Somaclonal variation along with examples.	2
18-19	***In vitro* mutagenesis:** Concept, type of mutagen, methods of *in vitro* mutagenesis, their confirmation, merit, demerits and applications.	6
20-21	**Production of secondary metabolites:** Concept, types, methods and applications.	4
22-23	**Synthetic seeds:** Concept, Principle, Method, factors affecting, Importance & Applications	4
24-25	***In vitro* fertilization; Embryo rescue in wide hybridization:** Principle, methods with merits & demerits, Importance & Applications	6
26-27	**Endosperm culture:** Concept, principle, method, importance and applications	4
28-29	**Protoplast isolation, culture and regeneration:** concept, Principle, Methods of protoplast isolation, culture methods, culture conditions, Importance and Applications	4
30	**Somatic hybridization:** concept, methods of somatic hybridization, selection of hybrid cell and regeneration, merits, demerits and Applications.	6
31	**Cybrid and asymmetric hybrid-** concept, methodology and importance	4
32	***In vitro* germplasm conservation:** cryopreservation, methods, limitations and applications	6
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	Establishment of callus/ cell suspension cultures
2	Induction of plant regeneration
3-5	Micropropagation – Explant establishment, shoot multiplication, root induction
6-7	Study of hardening and aftercare of tissue cultured plantlets
8-9	Monitoring of growth and differentiation of cells
10-11	Seed/Embryo culture
12	Ovary culture
13	Study of Anther culture
14	Study of pollen culture
15	Suspension cultures.
16	Production of secondary metabolites

Suggested Readings:

Text Books:

1. Bhojwani SS & Razdan MK. 1996. Plant Tissue Culture: Theory and Practice. Elsevier.
2. Debergh PC & Zimmerman RH. 1991. Micropropagation: Technology and Application. Kluwer Academic.
3. Chawla HS.2002.: Introduction to Plant Biotechnology. Science Pub. Inc.
4. De KK. 2013. Plant Tissue Culture. New Central Book Agency (P) Ltd.

Reference Books:

1. Dixon RA & Gonzales RA. 2003. Plant Cell Culture: A Practical Approach. Oxford University press.
2. George EF, Hall MA & Klerk GJD. 2007. Plant Propagation by Tissue Culture. 3rd Ed. Volume 1. Springer Science & Business Media

Course: **PBTEL-362** Course Title: **Principles and Applications of Plant Genetic Transformation**

Credits: **3(2+1)** **Semester : VI**

Theroy

UNIT I

Gene transfer methods: Direct and Indirect; Marker free transformation; *In planta*transformation; Vectors for plant transformation, molecular characterization of transgenic plants using PCR, real time PCR, Southern, Northern and western analysis; Bioassays with transgenic plants; Evaluation and selection of transgenic events for target trait.

UNIT II

Genetic engineering of crop plants for useful traits: Over expression, inducible, tissue specific and gene silencing systems; Biosafety concerns and regulatory mechanisms; Commercialization of transgenic products, GMO's, transgenic plants for the production of biopharmaceuticals; Molecular farming of plants for applications in medicine systems, heterologous protein production in transgenic plants; Successful case studies.

Practical

Gene isolation and gene cloning; Gene constructs and their maintenance; *Agrobacterium* mediated genetic transformation; Particle gun mediated genetic transformation. Histochemical GUS assays; PCR screening of putative transgenic plants; Raising transgenic under containment and field conditions.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT-I	
1-2	**Gene transfer methods**: Direct and Indirect methods: principle, methodology, merits, demerits,.	9
3	Factors influencing, applications of gene transfermethods	3
4-6	**Marker free transformation:** Concept, Need, Strategies for Marker free transformation, Merits demerits and achievement's with suitable examples	6
7	***In planta* transformation:** Concept, Types, methodology, merits, demerits, applications and future prospects	4
7-8	**Vectors for plant transformation:** Physical map, features and suitability of vector; Plasmids,binary vector,	4
9	Cosmid,	2
10	Virus vectors, Bacteriophage	2
11-14	**Molecular characterization of transgenic plants using PCR, real time PCR, Southern, Northern and Western analysis:** concepts, Methods of transgenic plant detection and characterization, Zygosity test, Copy number detection, and gene expression analysis.	10
15-16	**Bioassays with transgenic plants:** Methods and importance and prospects.	8
17-20	**Evaluation and selection of transgenic events for target trait:**	8

	Concept of event, detection methods, characterization and evaluation of event characterization and evaluation of event	
UNIT II		
21-22	**Genetic engineering of crop plants for useful traits**: Concept, importance, Methods, merits, demerits and applications **Over expression**	4
23-24	**Over expression, Inducible expression, tissue specific expression**	8
25-26	**Gene silencing systems:** Concept, Methods, merits, demerits and applications	6
27-28-	**Biosafety concerns and regulatory mechanisms:** Guidelines, biosafety framework,regulatory process and approval mechanism	10
29-30	**Commercialization of transgenic products, GMO's, transgenic plants for the production of biopharmaceuticals:** Concept, Methods, harvesting, packaging, labeling and marketing with examples, applications and limitations	6
31-32	**Molecular farming of plants for applications in medicine systems, heterologous protein production in transgenic plants; Successful case studies:** Concept, types and Methods of molecular farming, merits, demerits, applications with successful case studies	10
Total:		**100**

Practical Exercises

Exercise No.	Title
1-2	Isolation of gene
3-4	Cloning of gene
5	Development of gene constructs
6-8	*Agrobacterium* mediated genetic transformation
9-10	Particle gun method of genetic transformation
11	Histochemical GUS assays
12-13	PCR screening of putative transgenic plants
14-16	Procedure for rising transgenic under containment & confined field trials.

Text Book:

1. Singh B.D. (2015). Biotechnology Expanding Horizon, Kalyani Publication
2. Chawla HS. 2002. Introduction to Plant Biotechnology. Science Pub. Inc.
3. Stewart NC Jr. 2008. Plant Biotechnology and Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc.

Reference Books:

1. Green MR & Sambrook J. 2014. Molecular Cloning: A Laboratory Manual. 4th Ed. Vol I, II & III. Cold Spring Harbor Laboratory Press.
2. Grierson D. 2012. Plant Genetic Engineering. Springer Netherlands.
3. Primose SB & Twyman RM. 2006. Principles of Gene Manipulation and Genomics, 7th Ed. Blackwell Publishing.
4. Sambrook J. and Russel D. 2001. Molecular Cloning: A Laboratory Manual. 3rd Ed Cold Spring Harbor Laboratory Press.

Course No : **PBTEL-363** Course Title : **Applications of Genomics and Proteomics**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

Structure of genomes: *Arabidopsis*, rice, tomato, pigeon pea, wheat; DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Site directed mutagenesis; Transposon tagging; Transient gene expression: VIGS and FACS based, targeted genome editing technologies.

UNIT II

Bio-informatics in proteomics: Protein 3D structure modelling (Homology modelling and crystallography); Proteome analysis; Protein- protein interaction: FRET, yeast two hybrid and co-immunoprecipitation. Applications of genomics and proteomics in agriculture, human health and industry.Metabolomics and ionomics for elucidating metabolic pathways.

Practical

SDS_PAGE; 2D Electrophoresis; Protein characterization through HPLC; Specialized crop based genomic resourses: TAIR, Gramene, Graingenes, Maizedb, Phytozome, Cerealdb, Citrusdb; miRbase.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT I	
1	Introduction to genomics and proteomics, terminology, History	2
2	Genomics of *Arabidopsis*	3
3	Genomics of rice,	3
4	Genomics of tomato,	3
5	Genomics of pigeon pea,	3
6	Genomics of wheat;	3
7	Introduction to Transcriptomics and techniques involved in its analysis	2
8	Principles, methods, types, procedure and application of DNA chips/Miicroarray in transcript analysis	4
9	forward and reverse genetic approaches	3
10	Types of mutation, types of mutagen, mutant and its application in functional genomics	3
11	Principal and mechanism of RNAi in functional genomics	3
12-13	Applications of RNAi Technology in crop improvement	4
14	Principle and application of Site directed mutagenesis with its mechanism	6
15	Transposon tagging its principle, procedure and mechanism and application in functional genomics	3
16	Transient gene expression by VIGS and FACS Principle, procedure and application of VIGS in genomics	4

17	Principle, procedure and application of VIGS in genomics FACS	2
18	Introduction , components and applications of targeted genome editing technologies: CRISPR, TALLENS etc	4
UNIT II		
19	Proteomics study in relation to bioinformatics and different components of proteomics	2
20	Proteome analysis by MALDI-TOF	3
21	Proteome expasy tools study to analysis the protein	3
22	Structural analysis of protein	3
23	Protein 3D structure modeling by different modules and its procedure:Homology modelling and crystallography	4
24	Study of protein-protein interaction and techniques involved in the interactive study of protein	4
25	Principal, analysis, mechanism of FRET and its application in proteomics	3
26	yeast two hybrid system for analysis of protein-protein interaction at molecular level	4
27	Principal, mechanism and application of co-immunoprecipitation in proteomics	4
28	Success case study on application of genomics and proteomics in health and industry	3
29	Introduction to Metabolomics and ionomics and techniques involved in metabolite analysis	3
30	Procedure, steps, components involved in metabolite analysis	3
31	Principal and Application of Nuclear Magnetic Resonance Spectroscopy (NMR), Mass Spectrometry (MS) in metabolite analysis	3
32	Application of genomics and proteomics in crop improvement	3
Total:		**100**

Practical Exercises

Exercise No.	Title
1	Principal and procedure of SDS PAGE
2-3	Principal and procedure of 2D Electrophoresis
4-5	Protein analysis and characterization through HPLC
6	Specialized crop based genomic resources: databases and analysis of genomics and proteomics of a crops, Introduction to NCBI
7-8	TAIR, PDB, PIR,EMBL,DDBJ
9-10	Analysis using Gramene database
11	Analysis using Graingenes database
12	Analysis using Maizedb database
13	Analysis using Phytozome database
14	Analysis using Cerealdb database
15	Analysis using Citrusdb database
16	Analysis using miRbase database

Text Books:

1. Singh BD. 2005. Biotechnology, Expanding Horizons. Kalyani.
2. Gupta PK. 2013. Biotechnology and Genomics. Rastogi Publications, Meerut
3. Chahal GS & Ghosal SS. 2002. Principles and Procedures of Plant Breeding - Biotechnological and Conventional Approaches. Narosa Publ.

Reference Books:

1. Chopra VL. 1997. Plant Breeding. Oxford & IBH.
2. FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH.
3. Ghosh P. 2004. Fibre Science and Technology. Tata McGraw Hill.
4. Hay RK. 2006. Physiology of Crop Yield. 2nd Ed. Blackwell.
5. Nigam J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.
6. Singh RK, Singh UK & Khush GS. 2000. Aromatic Rices. Oxford & IBH.
7. Brown TA. 2002. Genomes. Wiley-LISS.
8. Hackett PB, Fuchs JA & Messing JW. 1988. An Introduction toRecombinant DNA Technology - Basic Experiments in Gene Manipulation. 2nd Ed. BenjaminPubl. Co.
9. Sambrook J & Russel D. 2001. Molecular Cloning- a Laboratory Manual. 3rd Ed. Cold Spring Harbor Lab. Press.

Course No : **PBTEL-364** Course Title :**Molecular Breeding in Field Crops**
Credits : 3(**2+1)** Semester : **VI**

Theory

UNIT I

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Development of specific mapping populations.

UNIT II

QTL mapping using structured populations; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers.

UNIT III

Marker assisted selection (MAS): Foreground and background selection; MAS for majorand minor genes, Marker assisted pyramiding, Marker assisted recurrent selection; Transgenic breeding; MAS for specific traits with examples; Commercial applications of MAS.

Practical

Working on some genotyping and phenotyping datasets for Linkage mapping using softwares such as Mapmaker, MapDisto and QTL mapping softwares such as WinQTL cartographer; Use of gene based and closely linked markers for foreground selection for target traits in target crops; Marker assisted detection of the transgene.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
UNIT I		
1	**Principles of plant breeding:** Definition, introduction,Principles of plant breeding	3
2	Stages of plant breeding programme	2
3-4	**Breeding methods for self and cross pollinated crops:** different methods of breeding in self and cross pollinated crops along with examples, advantages and limitations	10
5-6	**Heterosis breeding:** introduction, definition, hybrid vigour, concept of heterosis, steps involved	5
7	**Limitations of conventional breeding:** limitations of conventional plant breeding, advantages of molecular plant breeding	5
8	**Development of specific mapping populations:** different types of mapping populations, advantages and limitations	5
UNIT II		
9	**QTL mapping using structured populations:** introduction to QTL mapping, qualitative and quantitative traits	3

10	Different types of molecular markers	4
11	Pre-requisites for QTL mapping, mapping populations,	2
12	Linkage mapping,	3
13	Different methods of QTL mapping,	2
14	Factors affecting QTL mapping	1
15	**Fine mapping of genes/QTL:** scope, pre-requisites for fine mapping,	6
16-17	Steps involved in fine mapping, applications	4
18	**Map based gene/QTL isolation and development of gene based markers:** steps involved,	3
19	Gene-targeted markers,	3
20	Functional markers, applications of map based cloning	4
UNIT III		
21	**Marker assisted selection (MAS):** Foreground and background selection, ,	4
22-23	MAS for major and minor genes, advantages of MAS	4
24	Stages of MAS	2
25	**Transgenic breeding:** steps involved, applications, examples	5
26-27	**Marker assisted pyramiding:** steps involved, advantages	5
28	**Marker assisted recurrent selection:** steps involved, application of MARS	5
29-30	**MAS for specific traits with examples:** MAS for disease resistance breeding in major crops, rust resistance in wheat	5
31-32	**Commercial applications of MAS:** MAS for bacterial blight resistance and sub-mergence tolerance in rice	5
Total:		**100**

Practical Exercises

Exercise No.	Title
1	Working on some genotyping and phenotyping datasets for Linkage mapping using softwares such as Mapmaker, MapDisto
2	Introduction to different databases: GrainGenes
3	Introduction to different databases: Gramene
4	Data retrieval from databases
5	Introduction to different software used for linkage mapping: Mapmaker
6	Working with MapDisto
7	QTL mapping softwares such as WinQTL cartographer
8	Introduction to WinQTL Cartographer
9	Single marker analysis
10	Simple interval mapping
11	Composite interval mapping
12	Multiple interval mapping
13	Comparison between different methods of QTL mapping
14	Use of gene based and closely linked markers for foreground selection for target traits in target crops: Case study
15-16	Marker assisted detection of the transgene

Text Books:

1. Nagat T, Lorz H &Widholm JM. 2008. Biotechnology in Agriculture and Forestry. Springer.
2. Trivedi PC. 2000. Plant Biotechnology: Recent Advances. Panima Publishers.
3. Newbury HJ. 2003. Plant Molecular Breeding. Blackwell Publ.
4. XuYunbi 2010. Molecular Plant Breeding, CABI International
5. Singh BD & Singh AK. 2016. Marker-assisted Plant Breeding: Principles and Practices. Springer

Reference Books:

1. Gupta PK. 2013. Biotechnology and Genomics. Rastogi Publications, Meerut

Course No : **PBTEL-365** Course Title : **Molecular Breeding of Horticultural**
Credits : **3(2+1)** **Crops and Forest Trees**
Semester : **VI**

Theory

UNIT I

Reproductive biology of major fruit and forest crops; Basic methods of fruit crop improvement; Target traits in major fruit crops; Limitations of fruit crop breeding; Breeding methods of self and cross pollinated vegetable crops; Breeding of commercial flower crops.

UNIT II

Molecular markers for germplasm characterization and genetic diversity analysis; Pseudo test cross mapping strategy in fruit crops; Molecular mapping in vegetable crops; Marker assisted breeding in horticultural crops and forest plants; Micropropagation for variety dissemination; Mutation breeding and characterization of mutants; Genomic resources for marker development; Transgenic approaches with tree crops and utility.

Practical

Modifications in DNA extraction methods for horticultural and forest crops; Agarose gel electrophoresis, and DNA quantification; Map maker; Diversity analysis using UPGMA; Identifying repeat sequences using MISA; Standard Gene cloning methods including construct making with the use of Restriction enzymes; DNA ligases and standard molecular approaches.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT I	
1-2	**Reproductive biology of major fruit and forest crops:** introduction, major fruit and forest crops, sexual system, flower types	5
3-4	Distribution of flower types among species, asexual as well as sexual reproductive systems	5
5-6	**Basic methods of fruit crop improvement:** introduction, stages of plant breeding programme	5
7-8	**Target traits in major fruit crops:** major fruits crops (Orange, grapes, pomegranate, mango, banana, papaya, etc), traits of importance in these crops (quality parameters)	5
9	**Limitations of fruit crop breeding:** limitations of conventional breeding, advantages of molecular breeding	5
10	**Breeding methods of self pollinated vegetable crops:** different methods along with examples, advantages and limitations	6
11-12	**Breeding methods of cross pollinated vegetable crops:** different methods, along with examples, advantages and limitations	4
13	**Breeding of commercial flower crops:** introduction, selection, domestication, polyploid for varietal development, Role of heterosis, Production of hybrids,	6
14	Male sterility, incompatibility problems, seed production of flower	4

	crops, constraints and achievements made in commercial flowers	
UNIT II		
15-16	**Molecular markers for germplasm characterization and genetic diversity analysis:** different types of molecular markers,	7
17	Scope and applications of molecular markers, genetic diversity	3
18-19	**Pseudo test cross mapping strategy in fruit crops:** introduction, importance, analysis of data, utility in tree species, examples	5
20	**Molecular mapping in vegetable crops:** introduction to linkage mapping, mapping populations	7
21	QTL analysis: Introduction, methodology	3
22	**Marker assisted breeding in horticultural crops and forest plants:** introduction to MAS, steps involved,	3
23	Association mapping: Introduction, advantages and limitations	4
24	Case studies in horticultural crops and forest plants, advantages of MAS	3
25	**Micropropagation for variety dissemination:** introduction, stages of micropropagation	5
26	Different methods of micropropagation	
27	**Mutation breeding and characterization of mutants:** introduction, different types of mutagens,	5
28	Scope and application of mutation breeding in horticulture and forest trees	
29	**Genomic resources for marker development**: introduction to DNA sequencing, ESTs,	5
30	Development of markers from data available in the databases	
31	**Transgenic approaches with tree crops and utility:** introduction, scope, importance,	5
32	Methods of transgenic development, examples in horticultural crops	
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	Modifications in DNA extraction methods for horticultural and forest crops: Introduction to various instruments used and their working principle, laboratory safety guidelines
2	Preparation of stock solutions and buffers
3	Genomic DNA isolation using CTAB method
4	Agarose gel electrophoresis, and DNA quantification: Preparation of agarose gels, electrophoresis
5	Qualitative and quantitative analysis of DNA
6	PCR amplification using markers (RAPD/ISSR/SSR)
7	Mapmaker: Introduction to MapMaker, preparation of input files
8	Preparation of linkage map using MAPMAKER
9	Diversity analysis using UPGMA: scoring of marker data, preparation of input files
10	Different software for preparation of dendrogram, cluster analysis

11	Identifying repeat sequences using MISA: introduction to MISA, Identification of repeat sequences
12	Standard Gene cloning methods including construct making with the use of Restriction enzymes: Different Restriction enzymes
13	Digestion of plasmid DNA with different REs and visualization of bands on gel by electrophoresis
14	Vectors, different methods of cloning
15	DNA ligases and standard molecular approaches: Types of ligases
16	Application of DNA ligases in molecular biology research, mechanism

Text Books:

1. Bal JS. 2013. Fruit Growing. Kalyani Publishers.
2. Kumar N. 2006. Breeding of Horticultural crops: Principles and Practices. New India Publishing Agency.
3. Chada KL. 2012. Handbook of Horticulture. ICAR.
4. Kumar J. Prasad. 2010. Handbook of Fruit Production. Agrobios.
5. Schnell RJ & Priyadarshan PM. 2012. Genomics of Tree Crops. Springer
6. Singh Jitender. 2014. Basic Horticulture. Kalyani Publishers.
7. Singh Ranjit. 2012. Fruits. National Book Trust.
8. Spangenberg G. 2001. Molecular Breeding of Forage Crops. Kluwer Academic Publishers.
9. XuYunbi 2010. Molecular Plant Breeding, CABI International
10. Singh BD &Singh AK. 2016. Marker-assisted Plant Breeding: Principles and Practices. Springer

Reference Books:

1. Gardner VR, Braford FC &Hooker HD Jr. 1992. Fundamentals of Fruit Production. McGraw-Hill Book Company, Inc.
2. Brown TA. 1998. Genetics: A Molecular Approach. 3rd Ed. Stanley Thornes
3. Singer M & Berg P. 1991. Genes & Genome, University Science Books
4. Winnacker EL. 2003. From Genes to Clones: Introduction to Gene Technology. 4th Ed., Panima Publishers.
5. Sambrook J.F. and Russell DW, ed., Molecular Cloning: A Laboratory Manual, 3rd Ed., Vols. 1, 2 and 3 Cold Spring Harbor Laboratory Press.
6. Gupta PK. 2013. Biotechnology and Genomics. Rastogi Publications, Meerut.

Course : **PBTEL-366** Course Title : **Epigenetics and Gene Regulation**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

DNA methylation and histone modifications: DNA methylases, methyl binding proteins and histone modifiers; Epigenetic changes in response to external stimuli leading to changes in gene regulation; Role of DNA methylation in plant development: mutant case studies.

UNIT II

Introduction to small RNAs: History, biogenesis; *Insilico* predictions, target gene identification, methylation of heterochromatin by het associated siRNAs; Gene regulation by small RNA other classes of siRNAs; Role in epigenetics; Jacob Monod model; RNA editing, Genome imprinting.

Practical

In silico study of structural components of histone modifiers and DNA methylases of model plants; *In silico* prediction of siRNAs and miRNAs; Small RNAs electrophoresis using PAGE; Blotting of small RNAs on nylon membrane; miRNA target finding; Detection of small RNAs using fluorescent labelled probes; Bisulphite sequencing for methylation; qRT-PCR for quantitative analysis of small RNAs in developmental phases.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage (%)
	UNIT I	
1	Introduction to epigenetics and factors contributing to it	2
2	Epigenetics Mechanisms: interaction between DNA methylation, Histone modifications and RNA interference and there interaction with effect on gene expression	5
3	DNA, Chromatin, Histone protein	3
4	Chromatin remodeling and DNA methylation	4
5	Histone and there modifications in relation to DNA methylation	2
6	Histone acetylation and methylation and its impact on transcription activation	3
7	Reasons for DNA methylation and important enzymes participating in it; DNA methylases	4
8	Mechanism of DNA Methylation	4
9	Natural Roles of DNA Methylation in Mammalian System	3
10	Histone Phosphorylation and its modifiers	4
11	Role of DNA methylation in plant development	4
12	Transcription factors and its role in epigenetics	3
13	Epigenetic changes in response to external stimuli leading to changes in gene regulation	3
14	epigenetic processes: paramutation, bookmarking, imprinting, gene silencing, X chromosome inactivation, position effect,	4

	reprogramming, transvection,etc.	
15	mutant case studies	3
UNIT II		
16	Introduction to all RNA and there role in gene regulation and importance of small RNAs in gene expression	2
17	History and biogenesis of small RNAs	2
18	Principle, methods and mechanism of gene prediction	3
19	Types of gene prediction and Principle and applications of *In silico* predictions	4
20	Identification of targeted gene by different genomic approaches eg. Chip technology	3
21	Heterochromatin and euchromation methylation	2
22	CpG sites	2
23	Heterochromatin methylation systems: het associated siRNAs	3
24	Gene regulation by small RNA and Other classes of siRNAs; features and characteristic and mode of action in gene regulation	4
25	Prokaryotic gene arrangement	2
26	Bacterial gene regulation: Operon model-Jacob Monod model its components and functions in gene regulation	3
27	RNA editing: editing by deletion, addition and deamination process and its mechanism	4
28	Types of RNA editing: C to U, Ato I,Alternative mRNA editing	4
29	RNA editing in eukaryotic system	3
30	RNA editing in Prokaryotic system	2
31	Genome imprinting, introduction, mechanism and imprinted gene	4
32	Role of epigenetics in crop improvements	2
Total:		**100**

Practical Exercises

Exercise No.	Title
1	*In silico* study of model pant with its structural components of histone modifiers
2	Development procedure for SiRNA
3	Development procedure for miRNA
4	*In silico* prediction of siRNAs and miRNAs and there mechanisum
5	Isolation of Small RNAs form sample
6	separation of Small RNAs by electrophoresis using PAGE
7	Principle and applications of Northern Blotting
8	miRNA targeting mechanism
9	Methods of RNA labeling
10	Procedure for development of probes
11	Detection of small RNAs using fluorescent labeled probes
12	Principles of sequencing Methods and types
13	Principal and procedure of Bisulphite sequencing method
14	Types of PCR and their use in epigenetics
15	Principal and procedure of qRT-PCR for quantitative analysis of small RNAs in developmental phases
16	Principal and procedure of Genome imprinting.

Text Books:

1. Brown TA. 1998. Genetics: A Molecular Approach. 3rd Ed. Stanley Thornes.
2. Lewin B. 2009. Genes 9. Jones & Bartlett Learning.
3. Karp G. 2004. Cell and Molecular Biology: Concepts and Experiments. John Wiley.
4. Klug WS & Cummings MR 2003. Concepts of Genetics. Scot, Foreman & Co.

Reference Books:

1. Tropp BE. 2012. Molecular Biology Genes to Proteins.4th Ed. Jones & Bartlett Learning.
2. Benjamin A Pierce. Genetics A conceptual Approach, 2nd edition. WH Freeman and Company.
3. Green MR & Sambrook J. 2014. Molecular Cloning: A Laboratory Manual. 4th Ed. Vol I, II & III Cold Spring Harbor Laboratory Press.
4. Mohanpuria P, Kumar V, Mahajan M, Mohammad H & Yadav SK. 2010. Gene Silencing: Theory, Techniques and Applications: Genetics-Research and Issues. Nova Science Publishers.
5. Lewin B, 2004. Genes VIII. Pearson Prentice Hall
6. Bruce A. 2004. Essential Cell Biology. Garland

ELECTIVE II: ANIMAL BIOTECHNOLOGY

Course No : **ABTEL-361** Course Title : **Principles and procedures of animal cell culture**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

History, importance and development of animal cell culture techniques; Basic requirements for animal cell culture; Sterilization procedures for cell culture work; Different types of cell culture media, growth supplements, serum free media and other cell culture reagents.

UNIT II

Different cell culture techniques including primary and secondary cultures; continuous cell lines, suspension culture, organ culture etc; Commonly used animal cell lines: CHO, HeLa, BHK-21, VERO, Sf9, C636; Their origin and characteristic, growth kinetics of cells in culture, differentiation of cells; Characterization and maintenance of cell lines; Applications of animal cell cultures.

UNIT III

Cryopreservation and revival of cells; Hybridoma technology; Scaling up methods; bioreactors; Overview of insect cell culture; Stem cell culture and its application; Common cell culture contaminants and their management.

Practical

Basic equipments used in animal cell culture laboratories; Washing, packing and sterilization of glass and plastic wares for cell culture; Preparation of media and reagents for cell culture; Primary culture technique of chicken embryo fibroblast; Culture and sub-culturing of continuous cell lines; Viability assay by trypan blue dye exclusion method; Isolation and cultivation of lymphocytes; Cryopreservation of primary cultures and cell lines; Cytopathic effect of viruses on cultured mammalian cells.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightages (%)
	UNIT – I	
1	**History and importance of animal cell culture**	2
2	**Development of animal cellculture techniques:** Primary cell culture, Secondary cell cultures,	2
3	Cell Line and Monolayer cultures	2
4	Suspension cultures. Immobilized Cultures	2
5	Culture of Primary Chick Embryo Fibroblasts (CEF): Formulations of Media and Solutions, Transfer of Cell Cultures, Preservation of Cultured Cells by Freezing	2
6	**Basic requirements for animal cell culture**: Choice of materials: Cell type, Source of tissue, Subculture,	5
7	Selection of medium, Gas phase, Culture system, Substrate,	3

	Medium, Cell culture	
8	**Sterilization procedures for cell culture work**: **Sterilization of apparatus-** Glasswares, Filter assembly **Sterilization of reagents and media-** Water, BSS, Serum, media	3
9	**Different types of cell culture media:** Introduction, Serum media, Serum free media	4
10	Complete media, Synthetic media	2
11	**Other cell culture reagents and growth supplements:** Amino acid, Hydrolysates, Embryo extracts, Conditioning medium, Antibiotics and Antimycotics.	3
	UNIT – II	
12	**Different cell culture techniques including primary and secondary cultures:** **Primary culture:** Disaggregation of cells	4
13	Initiation of primary cell culture**,** Explant culture	3
14	Subculture of cells and secondary culture, cell lines Cell counting- viable count	3
15	Continuous cell lines, suspension culture,	3
16	Organ culture etc.	3
17	Commonly used animal cell lines: CHO, HeLa, BHK-21, VERO, Sf9, C636; their origin and characteristic	3
18	**Growth kinetics of cells in culture-** monolayer and suspension culture, Cell proliferation	3
19	**Differentiation of cells:** Expression of the *in-vivo* phenotype, stages,	3
20	Cell lineage, cell strain, Markers of differentiation, Induction of differentiation	3
21	**Characterization and maintenance of cell lines:** Need, parameters, Cell morphology, Microscopy and Chromosome content	3
22	DNA analysis, RNA and protein expression, antigenic markers	3
23	**Applications of animal cell cultures:** **Basic application-** Intracellular activity, Intracellular flux, Genomics, Proteomics, Cell-cell interaction etc.	3
24	**Appliedapplication-** Cell products, Immunology, Pharmacology, Tissue engineering, Toxicology etc.	3
	UNIT III	
25	**Cryopreservation and revival of cells:** Need and consideration for freezing, Principles	4
26	Methodology for cryopreservation. Vitrification and cell banks	4
27	**Hybridoma technology:** Historical background and methodology of hybridomas	3
28	**Scaling up methods:** Scaling up in suspension, Scaling up in monolayer	2

29	**Bioreactors:** Controlled bioreactor- Stirred, Airlift, Hollo-fibre, Packed-bed, Fixed bed, Fluidized-bed reactor Large scale bioreactor Wave bioreactor	8
30	**Overview of insect cell culture:** Cell growth- Characteristics and media development, Small scale culture, Cell line development and its application	3
31	**Stem cell culture and its application:** Derivation, Subculture Propagation of mouse and human embryonic stem cell Passaging hES cells.	3
32	**Common cell culture contaminants and their management:** Sources and types of microbial contamination Monitoring of contamination,Disposal of contaminated culture,Eradiation of contamination,Cross contamination	3
	Total	**100**

Practical Exercises

Exercise No.	Title
1	Study of basic equipments used in animal cell culture laboratories
2	Preparation of washing, packing and sterilization of glass and plastic wares for cell culture
3	Preparation of media and filtration for cell culture
4	Preparation of chicken embryo fibroblast
5	Subculture of cell culture
6	Isolation and preparation of lymphocyte culture
7	Viability assay by trypan blue dye exclusion method
8	Preparation of inoculum for virus isolation
9	Virus inoculation: Cell culture
10	Cryopreservation of cells
11	Cytopathic effect staining
12	Preparation of buffers and reagents for cell culture
13	Extraction of RNA by Trizol method
14	Extraction of DNA by Chelax method
15	Quantitation of nucleic acid
16	Disease diagnosis by RT-PCR

Text Books:

Freshney RI. 2011. Culture of Animal Cells: A manual of basic technique and specialized applications. 6th Ed. John Wiley & Sons.

Reference Books:

Butler M. 2003. Animal Cell Culture & Technology. Garland Science.

Course No : **ABTEL-362** Course Title : **Animal Genomics**

Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

Genome organization in eukaryotes; Satellite DNA: VNTRs & families, LINE & SINE; Sex determination: Chomosomal basis of sex determination, Molecular markers for sexdetermination, environmental sex determination; Chromosomal aberrations: Euploidy, Chromosomal Non-disjunction and Aneuploidy, Polyploidy, Induced Polyploidy, Syndromes, Structural aberrations, Robertsonian Translocations, Position Effect, Chromosomal Mosaics, Chromosomal aberrations and evolution.

UNIT II

Molecular Markers: Markers, Genetic Markers: RAPD, STR, DNA fingerprinting, SSCP, RFLP, SNP, EST; SNP Analysis; karyotyping, Somatic cell hybridization; Radiation hybrid maps; FISH technique; Major Histocompatibility Complex: Concept and its relevance in disease resistance & immune response; Quantitative trait Loci; Marker Assisted Selection: Concept, Linkage Equilibrium, Application in Animal Sciences; Genomic Selection: Concept, Linkage Disequilibrium, Methodologies of economic Selection; Mitochondrial DNA analysis and its application in livestock; Applying DNA markers for breed characterization.

Practical

Extraction of genomic DNA from peripheral blood; Analysis of DNA by agarose or polyacrylamide gel electrophoresis; Checking the quality & quantity of genomic DNA; Restriction digestion & analysis; Sanger Sequencing data analysis; Extraction of mitochondrial DNA; Extraction of RNA from PBMC; Quality checking of total RNA; cDNA synthesis.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightages (%)
UNIT – I		
1	Genome organization in eukaryotes; Satellite DNA	3
2	VNTRs & families	3
3	LINE & SINE	3
4-5	Sex determination: Chomosomal and molecular basis of sex determination	10
6	Molecular markers for sex determination	3
7	Environmental sex determination	3
8	Chromosomal aberrations: Introduction, Euploidy, Chromosomal Non-disjunction	6
9	Aneuploidy, Polyploidy, Induced Polyploidy	4

10	Syndromes, Structural aberrations, Robertsonian Translocations	10
11	Position Effect, Chromosomal Mosaics, Chromosomal aberrations and evolution.	7
UNIT – II		
12-14	Molecular Markers: Markers, Genetic Markers: RAPD, STR, SSCP, RFLP, SNP, EST, DNA fingerprinting;	6
15	SNP Analysis	2
16	Karyotyping,	2
17	Somatic cell hybridization	3
18	Radiation hybrid maps	3
19	FISH technique	3
20	Major Histocompatibility Complex:	5
21	Concept and its relevance in disease resistance & immune response	3
22-23	Quantitative trait Loci	3
24	Marker Assisted Selection	3
25	Concept, Linkage Equilibrium, Application in Animal Sciences	3
26	Genomic Selection: Concept	2
27-28	Linkage Disequilibrium	4
29	Methodologies of economic Selection	1
30	Mitochondrial DNA analysis and its application in livestock	2
31-32	Applying DNA markers for breed characterization	3
Total		**100**

Practical Exercises

Exercise No.	Title
1	Isolation of genomic DNA from peripheral blood
2	Analysis of DNA by agarose gel electrophoresis
3	Analysis of NA/Protein by polyacrylamide gel electrophoresis
4	Qualitative and quantitaive analysis of genomic DNA by spectrophotometric method
5	Restriction enzymes digestion of DNA
6	Polymerase Chain Reaction
7	Southern blot analysis of DNA
8	Study of DNA sequencing by Sanger's method
9	Sanger Sequencing data analysis
10	Isolation of mitochondrial DNA
11	Analysis of mt-DNA by agarose gel electrophoresis
12	Isolation of RNA from Peripheral blood mono nuclear cell (PBMC),
13	Analysis of isolated RNA from PBMC by agarose gel electrophoresis
14	Northern blot analysis of RNA
15-16	cDNA synthesis

Text Books:

1. Brown TA. 2006. Genomes. 5th Ed. Wiley-Blackwell.
2. Green MR & Sambrook J. 2014. Molecular Cloning: A Laboratory Manual.4th Ed. Vol I, II & III. Cold Spring Harbor Laboratory Press.

Reference Books:

1. Dale JW, Schantz MV & Plant N. 2012. From Genes to Genomes: Concepts and Applications of DNA Technology. John Wiley & Sons.
2. Reece RJ. 2004. Analysis of Genes & Genomes.Wiley.

Course No : **ABTEL-363** Course Title : **Embryo Transfer Technologies**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

History, advantages, limitations and scope of embryo transfer technology; Estrus cycle and its detection in animals; Methodology of super ovulation; Ovum pick up (OPU);Preparation of sperm for *in vitro* fertilization (IVF); Embryo grading and culture; Micromanipulation and immuno-modulation for enhancement of fecundity.

UNIT II

Different methods of gene transfer and their limitations; embryo splitting; embryo sexing by different methods; production of transgenic livestock by nuclear transfer and its application; regulatory issues (social, ethical, religious and environmental); Cloning of domestic animals; Conservation of endangered species; Characterization of embryonic stem cells and applications.

Practical

Demonstration of estrus detection methods; Estrus synchronization; Superovulation; Oocyte collection from slaughterhouse ovaries; Grading of oocytes from slaughterhouse ovaries; collection and preparation of semen samples; *In vitro* fertilization; Collection of embryos using non-surgical procedures; Grading and culture of embryos; Embryo sexing by different methods; Embryo splitting; Embryo freezing.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightages (%)
UNIT – I		
1	History, advantages of embryo transfer technology	3
2	Limitations and scope of embryo transfer technology	3
3	Estrus cycle and its detection in animals;	6
4	Methodology of super ovulation; Ovum pick up (OPU);	6
5-6	Preparation of sperm for *in vitro* fertilization (IVF);	6
7	Embryo grading	6
8-9	Embryo culture	6
10-11	Micromanipulation and immuno-modulation for enhancement of fecundity.	10
UNIT – II		
12-14	Different methods of gene transfer and their limitations	6
15	Embryo splitting	6
16-17	embryo sexing by different methods	6
18-19	Production of transgenic livestock by nuclear transfer and its application	6
20-21	Regulatory issues (social, ethical)	6
22-23	Regulatory issues (religious and environmental)	6
24-26	Cloning of domestic animals	6

27-30	Conservation of endangered species	6
31-32	Characterization of embryonic stem cells and applications	6
Total		**100**

Practical Exercises

Exercise No.	Title
1	Demonstration of estrus detection methods
2	Study of Estrus synchronization
3	Study of Superovulation
4	Oocyte collection from slaughterhouse ovaries
5	Grading of oocytes from slaughterhouse ovaries
6	Collection and preparation of semen samples
7	*In vitro* fertilization
8	Collection of embryos using non-surgical procedures
9	Grading and culture of embryos
10	Embryo sexing by different methods
11	Evaluation of embryo
12	Embryo collection in cow
13	Embryo splitting
14	Embryo freezing
15	Transfer of embryo
16	Study of managing donor and recipient herds

Text Books:

Gordon I. 2004. Reproductive Technologies in Farm Animals. CABI.

Hafez ESE. 2000. Reproduction in Farm Animals. Lippincott, Williams & Wilkins.

Reference Books:

Gwatkin RBL. 1986. Developmental Biology, Vol. 4: Manipulation of Mammalian Development. New York, Plenum Press.

Daniel JC Jr. 1978. Methods in Mammalian Reproduction. Orlando, USA, Academic Press.

Brackett BG, Seidel GE Jr. & Seidel SM. 1981. New Technologies in Animal Breeding. Orlando, USA, Academic Press.

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Course No : **ABTEL-364** Course Title : **Transgenic Animal Production**
Credit : **3(3+0)** Semester : **VI**

UNIT I

History of transgenesis; Isolation of gene, preparation of gene construct; Methods of transgenic animal production: Calcium chloride mediated transfection, lipofection, electroporation, microinjection, nanodelivery.

UNIT II

Production of gene knockouts: cre-lox, zinc finger nucleases; CRISPR; TALENs; Production of chimeric animals; gene silencing by lentivirus system.

UNIT III

Stem cell technology: Isolation and characterization of stem cell lines from different sources: embryo, mesenchymal, induced pluripotent stem cell; Introduction to animal cloning; Application of stem cells in transgenesis and animal cloning.

UNIT IV

Fundamental assays of transgenic products: confirmation of integration of transgene; Validation of transgenic products like isolation of transgenic protein from milk and characterization; Application of transgenics in production of disease resistance models and carcinogenesis. Regulatory issues associated with transgenic animal production.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
	UNIT I	
1	**History of transgenesis**	03
2	**Isolation of gene**	02
3	**Preparation of gene construct**	03
4-6	**Methods of transgenic animal production:-** **a.** Calcium chloride mediated transfection: **b.** Lipofection: **c.** Electroporation: **d.** Microinjection:	04
7-8	Nanodelivery:- Physico-chemical properties of the penetrant molecules (Partition coefficient, pH conditions, Penetrant concentration) Physico-chemical properties of drug delivery systems (Release characteristic, Enhancement of transdermal permeation)	04
9-10	Physiological and pathological condition of skin (Reservoir effect of horny layer, Lipid film, Skin hydration, Skin temperature, Regional variation, Pathological injuries to the skin, Cutaneous self metabolism) Routes of drug penetration through the skin	04
	UNIT II	
11-13	**Production of gene knockouts:** (1) Construction of the targeting vector. (2) Gene targeting in embryo-derived stem (ES) cells. (3) Selection of gene-targeted cells (inset).	02

	Three outcomes are possible.	
14	**Cre-lox:** Conditional gene targeting, Cre (Cause recombination), Use in conditional gene targeting, Generation of a conditional knockout mouse using the Cre–loxP system,	02
15	Chromosomal Engineering Using the Cre–loxP System, Cre-lox technology for targeted homologous recombination of transgenes	02
16	**Zinc finger nucleases:** Definition of ZFN, consists of two functional domains, Benefits, Target Applications, ZFN-Mediated Targeted Genome Editing	02
17-18	**CRISPR:** Defination and types of CRISPR, Genome editing glossary, application of CRISPR, Targeting Efficiency and Off-target Mutations, T7 Endonuclease I Targeting Efficiency Assay	03
19-20	**TALENs:** Defination and overview of transcription activator-like effector nucleases **(**TALEN**s),** TALENs strategy for efficient and specific modifications of genome, *In vivo* genome editing	02
21-23	**Production of chimeric animals:** Culture of embryonic stem (ES) cells to offspring derived from the germline chimera is either derived from the genetics of the ES cells or that of the host embryo.	05
24-25	**Characterization:** -Fluorescent labeling of cell membranes. -Tracking cell contribution to the fetus or offspring. -Use of beta- galactosidase gene (beta-gal) -Transgenic reporter gene -Transgenic ES cells contribution -The final proof that these cell lines are indeed ES cells	05
26	**Gene silencing by lentivirus system:** -Vectors for somatic cell gene therapy -Advantages and Disadvantages of lentivirus	03
27-28	**Mechanism of RNA interference-** RNAi pathway triggered by the introduction into cells of either viral double stranded RNA (dsRNA).	06
	UNIT III	
29-30	**Stem cell technology:-** Isolation of stem cell lines from different sources:- Embryo stem cell: Mesenchymal stem cell and its production from human bone marrow: Induced pluripotent stem cell: Characterization of stem cell lines:-	06
31-32	**Introduction to animal cloning:-** Definition of clone, Cloning by embryo splitting, case study of Dolly, Cloning by somatic cell nuclear transfer (SCNT), constraints of cloning , Safety concerns of milk or meat from cloned animals and their progenies Regulatory authorities for animal cloning	06
33	**Applications of stem cells in transgenesis and animal cloning:-** Clinical applications of cultured human stem cells, Commercial benefits of domestic animal embryonic stem cells, Commercial uses of animal cloning	06

	technology, Transgenesis in mice	
UNIT IV		
34-35	**Fundamental assays of transgenic products:** -PCR, Southern blotting, Western blotting, and Enzyme linked immunosorbant assay (ELISA) -Transgenic animal mutagenecity assays - Use of transgenic assays in the detection of gene mutations in germ cells	03
36-37	**Confirmation of integration of transgene:** • Transgene detection by PCR • Transgene copy number detection by quantitative PCR (q-PCR) Fluorescent in situ hybridization (FISH)	03
38	**Validation of transgenic products:-** **Isolation of transgenic protein from milk:**	03
39-40	**Characterization:** A. Genetic Stability B. Stability of expression Characterization of the transgenic founder (F0) animal	03
41	**Application of transgenics in production of disease resistance models and carcinogenesis:-** **Application of transgenics:** Improved growth rates (e.g., shrimp and lobster), Improved size or appearance, Improved nutrition (low cholesterol), Disease resistance,	02
42	Chemical production (bioreactors), Biomedical research models (therapy and toxicity)	02
43	**Application of Transgenic Models to Drug Development:** Disease Models- **Description**- Models to determine disease causation or therapy development	02
44	**Example**- Breast cancer, neurologic disorders, cardiac disease, Alzheimers/aging	02
45	**Carcinogenicity testing-** -Three different types of transgenic strains have been employed in the generation of transgenic mice for carcinogenicity testing:	04
46	**Regulatory issues associated with transgenic animal production:-** **Principles include:** Establishing high standards for safeguarding human health and animal health and welfare.	02
47	Developing clear technical standards and assessment guidelines, Providing a sound scientific basis for evaluating associated risk.	02
48	Consulting and involving stakeholders and the general public in the development of regulations, Building upon existing regulations and technical standards, Maintaining genetic diversity and conserving the environment.	02
Total:		**100**

Text Books:

1. Ramadass P. 2008. Animal Biotechnology: Recent Concepts and Developments. MJP, Publishers.
2. Ranga MM. 2007. Animal Biotechnology. Agrobios.

3. Singh BD. 2010. Biotechnology expanding Horizons. Kalyani Publishers.

Reference Books:

1. Singh B, Gautam SK, Chauhan MS and Singla SK. 2015. Textbook of Animal Biotechnology. The Energy and Resources Institute, TERI.

Course No : **ABTEL-365** Course Title : **Molecular Diagnostics**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

Principle and applications of molecular diagnostic tests; Nucleic acid based diagnostics for detection of pathogenic organisms: Application of restriction endonuclease analysis for identification of pathogens; Polymerase chain reaction (PCR) and its variants; Reversetranscriptase polymerase chain reaction (RT PCR); isothermal amplification (LAMP); LCR, nucleic acid sequence-based amplification (NASBA); Real-Time PCR; DNA Probes; Southern blotting; Northern blotting; Protein based assays: SDS-PAGE, Western Blot, Dot-blot, ELISA and lateral flow device.

UNIT II

Advantages of Molecular diagnostics over conventional diagnostics; serodiagnostics; DNA array technology; Protein array; tissue array; Biosensors and nanotechnology; Development and validation of diagnostic tests.

Practical

Preparations of buffers and reagents; Collection of clinical and environmental samples for molecular detection of pathogens (bacteria/virus); Extraction of nucleic acids (DNA & RNA) from the clinical specimens; Restriction endonuclease digestion and analysis using agarose gel electrophoresis; Polymerase chain reaction for detection of pathogens in blood and animal tissues; RT-PCR for detection of RNA viruses; PCR based detection of meatadulteration in processed and unprocessed meats; PCR based detection of pathogens in milk, eggs and meat; Lateral flow assay; ELISA.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
	UNIT – I	
1	**Principle and applications of molecular diagnostic tests**	3
2	**Nucleic acid based diagnostics for detection of pathogenic organisms:** Types of nucleic acids and Target pathogens/ diseases	4
3	PCR, DNA and RNA Hybridization assays	4
4-5	Nucleic acid sequencing and NGS approaches in diagnostics	4
6	**Application of restriction endonuclease analysis for identification of pathogens:** RE enzymes, Restriction fingerprints of pathogens for diagnosis, etc.	3
7	**Polymerase chain reaction (PCR) and its variants;** Multiplex PCR, Nested, RT-PCR,	4
8	Real-time PCR, ARMS and related technologies, etc.	4
9-10	**Reverse transcriptase polymerase chain reaction (RT PCR)-** Pathogens with RNA genome, RNA isolation, cDNA synthesis and PCR, etc.	4

11	**Isothermal amplification (LAMP)** - Principle, methodology and applicationsin animal disease diagnosis, etc.	3
12	**LCR**- Principle, methodology and applications in animal disease diagnosis, etc.	4
13	**Nucleic acid sequence-based amplification (NASBA**)-Principle, mechanism/methodology and applications/ advantages, etc.	4
14	**Real-Time PCR**- Chemistries/ types of probes, Principle, methodology and applications/ advantages, etc.	4
15	**DNA Probes**- Probes, types, synthesis and applications, etc.	4
16	**Southern blotting, Northern blotting**- Principle, methodology with examples in animal disease diagnosis, etc.	4
17	**Protein based assays-** SDS-PAGE, Western Blot, Dot-blot, antibody based assays, etc.	5
18-19	**Dot-blot, ELISA –** Principle, methodology and examples/applications, etc.	5
20	**Lateral flow device**- importance, principle, methodology, applications/examples, etc.	5
UNIT II		
21	**Advantages of Molecular diagnostics over conventional diagnostics**	5
22-23	**Serodiagnostics;** Methods, importance and applications, etc.	4
24-25	**DNA array technology**; principle, methods/types, applications, etc.	4
26	**Protein array;tissue array**- principle, methods, applications, etc.	4
27- 28	**Biosensors and nanotechnology;** Principles, methods/types and applications in animal disease diagnosis, etc.	5
29-30	**Development and validation of diagnostic tests:** OIE stages/ pathway of diagnostic assay development, etc.	5
31- 32	Validation- OIE stages/ pathway of assay validation Validation status retention, etc.	5
Total		**100**

Practical Exercises

Exercise No.	Title
1-2	Preparations of buffers and reagents
3-4	Collection of clinical and environmental samples for molecular detection of pathogens (bacteria/virus)
5	Extraction of DNA from the clinical specimens
6	Extraction of RNA from the clinical specimens
7	Restriction endonuclease digestion and analysis using agarose gel electrophoresis
8	Polymerase chain reaction for detection of pathogens in blood and animal tissues
9	RT-PCR for detection of RNA viruses
10-11	PCR based detection of meat adulteration in processed and unprocessed meats
12-13	PCR based detection of pathogens in milk, eggs and meat
14-15	Lateral flow assay for disease diagnosis
16	ELISA for animal disease diagnosis

Text Books:

1. Debnath M, Prasad GBKS & Bisen PS. 2010. Molecular Diagnostics: Promises and Possibilities. Springer Science & Business Media
2. Singh BD. 2010. Biotechnology Expanding Horizons. Kalyani Publishers.

Reference Books:

1. Wilson K & Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Viljoen GJ, Nel LH & Crowther JR. 2005. Molecular Diagnostic PCR Handbook. Springer Science & Business Media.

Course No : **ABTEL-366** Course Title : **Molecular Virology andVaccine Production**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

Properties of viruses; Classification of viruses; Virus replication; Cell transformations, Cultivation of viruses, assay techniques for detection/quantification; Important Animal viruses; Virus-Host interactions; Viral infections; Immune responses to viruses: Interferon and other cytokines; Bio-safety and bio-security principles.

UNIT II

Properties of an ideal vaccine; Classification of vaccines; Methods of inactivation and attenuation of viruses; New generation vaccines: subunit, synthetic, rDNA, marker and edible; Adjuvants and vaccine delivery systems; Novel immunomodulators and vaccine delivery using nanotechnology; Vaccine preparation: Stabilizers, preservatives and vehicles; Quality control and testing of vaccines; Sero-surveillance and sero-monitoring.

Practical

Processing of clinical specimens for isolation of viruses; Cultivation of viruses in cell cultures and embryonated eggs; Harvesting of virus; Study of cytopathic effects; Titration of virus and estimation of $TCID_{50}$;Haemagglutination and Haemagglutination Inhibition test; Detection of virus by SNT, AGID and ELISA.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightages (%)
1	Properties of viruses; Classification of viruses	4
2	Virus replication	5
3-4	Cell transformations	5
5-6	Cultivation of viruses	5
7-8	Assay techniques for detection/quantification	6
9	Important Animal viruses	4
10-11	Virus-Host interactions	6
12	Viral infections	5
13	Immune responses to viruses	4
14-15	Interferon and other cytokines, Bio-safety and bio-security principles	10
16	Properties of an ideal vaccine	3
17	Classification of vaccines	5
18	Methods of inactivation and attenuation of viruses	5
19-20	New generation vaccines: subunit, synthetic rDNA, marker, edible	6
21-22	Adjuvants and vaccine delivery systems	4
23	Novel immunomodulators	3
24	Vaccine delivery using nanotechnology	5
25-26	Vaccine preparation: Stabilizers, Preservatives and vehicles	5
27-29	Quality control and testing of vaccines	5
30-32	Sero-surveillance and sero-monitoring.	5
	Total	**100**

Practical Exercises

Exercise No.	Title
1-2	Processing of clinical specimens for isolation of viruses
3-4	Cultivation of viruses in cell cultures
5-6	Cultivation of viruses in embryonated eggs
7	Harvesting of virus
8	Study of cytopathic effects
9	Titration of virus and
10	Estimation of $TCID_{50}$
11	Study of Haemagglutination
12-3	Haemagglutination inhibition test
14	Detection of virus by SNT
15	Detection of virus by AGID
16	Detection of virus by ELISA

Text Books:

1. John CJ & Saunders V. 2007. Virology: Principles and Applications.2nd Ed. Wiley.
2. Morrow WJW, Sheikh NA, Schmidt CS and Davies DH. 2012. Vaccinology: Principles and Practice. John Wiley & Sons.
3. Sharma S & Adlakha S. 1996. Textbook of Veterinary Microbiology. Vikas Publishing House Pvt. Ltd.

Reference Books:

1. Stephenson J & Warnes R. 1998. Diagnostic Virology Protocols. Springer Science & Business Media.

ELECTIVE III: MICROBIAL AND ENVIRONMENTAL BIOTECHNOLOGY

Course No : **MEBTEL-361** Course Title : **Microbial Biotechnology**

Credit : **3 (2+1)** Semester : **VI**

Theory

UNIT I

Microbial biotechnology, scope and techniques; Industrially important microorganisms; Gene transfer mechanisms in microbes: Transformation, transduction, conjugation and recombination; Genetic variability in microorganisms; Biotechnological tools to improve the microbial strains with respect to industry and agriculture.

UNIT II

Biotransformation and biodegradation of pollutants, biodegradation of lignocelluloses and agricultural residues; Biotechnological treatment of waste water, sewage and sludge; Industrial production of alcohols, ethanol, acids (citric acid, acetic acid), solvents (glycerols, acetone, butanol), antibiotics (penicillin, streptomycine, tetracycline), amino acids (lysine, glutamic acid), single cell proteins; Recombinant and synthetic vaccines.

Practical

Isolation and preservation of industrially important microorganisms; Microbial fermentation, production of proteins and enzymes using bacteria, yeast and fungus; Microbial biomass production, utilization of plant biomass by recombinant microorganisms; Production of secondary metabolites from microbes.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightages (%)
1	Microbial biotechnology: Introduction	2
2	Microbial biotechnology: Scope	2
3	Techniques of microbial biotechnology	4
4	Industrially important microorganisms	4
5	Gene transfer mechanisms in microbes: Transformation, ,	2
6	Transduction	2
7	Conjugation	2
8	Gene transfer mechanisms in microbes: Recombination	2
9	Genetic variability in microorganisms	4
10	Biotechnological tools to improve the microbial strains with respect to industry	2
11	Biotechnological tools to improve the microbial strains with respect to agriculture	4
12	Biotransformation and biodegradation of pollutants	2
13	Biodegradation of lignocelluloses	4
14	Biodegradation of agricultural residues	4
15	Biotechnological treatment of waste water	4
16	Biotechnological treatment of sewage	4
17	Biotechnological treatment of sludge	2

18	Industrial production of alcohols	4
19	Industrial production of ethanol	4
20	Industrial production of solvents i. e. butanol	2
21	Industrial production of glycerols	4
22	Industrial production of acetone	2
23	Industrial production of citric acid	4
24	Industrial production of acetic acid	4
25	Industrial production of antibiotics i. e. penicillin	4
26	Industrial production of streptomycine	4
27	Industrial production of tetracycline	4
28	Industrial production of amino acids i. e. lysine	2
29	Industrial production of glutamic acid	4
30	Industrial production of single cell proteins	4
31	Recombinant vaccines	2
32	Synthetic vaccines	2
Total		**100**

Practical Exercises

Exercise No.	Title
1	Isolation and preservation of industrially important microorganisms
2	Microbial fermentation, production of proteins and enzymes using bacteria.
3	Microbial fermentation, production of proteins and enzymes using yeast &fungus
4	Microbial biomass production
5	Utilization of plant biomass by recombinant microorganisms
6	Production of secondary metabolites from microbes
7	Production of alcohols
8	Production of ethanol
9	Production of solvents i. e. butanol
10	Production of glycerols
11	Production of acetone
12	Production of citric acid
13	Production of acetic acid
14	Production of antibiotics (penicillin and tetracycline),
15	Production of streptomycine
16	Production of amino acids (lysine, glutamic acid)

Text Books

1. Glaze AN & Nikaido H. 2007. Microbial Biotechnology: Fundamentals of Applied Microbiology. 2nd Ed. Cambridge University Press.
2. Mohapatra PK. 2006. Text Book of Environmental Biotechnology. International Publishing House Pvt. Ltd.

Reference Books

1. Shetty K, Paliyath G, Pometto A and Leven RE. 2006. Food Biotechnology. 2nd Ed.Taylor & Francis Group.
2. Peppler HJ. and Perlman D. 2004. Microbial Biotechnology. Vol.I & II.2nd Ed. Academic Press.

Course No : **MEBTEL-362** Course Title : **Bio-prospecting of Moleculesand Genes**
Credit : **3 (3+0)** Semester : **VI**

Theory:

UNIT I
Concepts and practices of bioprospecting; Traditional and modern bioprospecting; Gene prospecting; Isolation, synthesis and purification of new bioactive chemicals for laboratory.clinical and field trials; Intellectual property rights, mechanisms and the legal framework; Patenting of new genes and/or bioactive principles with novel antibiotic, insecticidal or anti-tumour properties.

UNIT II
Principles of the Convention on Biological Diversity, biodiversity conservation and biotechnology; Development and management of biological, ecological, taxonomic, and related systematic information on living species and systems.

UNIT III
Bioprospecting of microorganisms and their components; Bioprospecting of biodiversity for new medicines: Identification and collection of material by random and traditional (medicinal) approaches; Screening for particular bio-activities; Elucidation of novel molecular form, process technology; Development of techniques for large scale industrial production of the final bioactive product and its market availability and accessibility to the public.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
Concepts and practices of bioprospecting, Traditional and modern bioprospecting:		
1	What is bioprospecting? Business in bioprospecting	1
2	Biodiversity & its importance	1
3	Indigenous knowledge and biodiversity	1
4	Role of natural products in bioprospecting: Pharmaceutical industry	1
5	Role of natural products in bioprospecting: Agriculture & other industries	1
Gene prospecting:		
6	Gene prospecting in plants and microbes: Overview	3
7	Gene prospecting approaches: Metagenomic approach, transcriptome profiling, insertional mutagenesis, allele mining	3
8	Gene prospecting approaches: Metagenomic approach, transcriptome profiling, insertional mutagenesis, allele mining	4
Isolation, synthesis and purification of new bioactive chemicals for laboratory		
9	Screening for bioactivities	1
10	Isolation of new molecules from microbes	2
11	Isolation of new molecules from plants	2
12	Synthesis of new molecules	1
13	Synthesis of new molecules	2

14	Purification techniques for new bioactive molecules	2
Clinical and Field trials:		
15	Clinical Trials	2
16	Field Trials	3
Intellectual property rights, mechanisms and the legal framework;		
17	Intellectual property rights	1
18	Patenting of Biological material: Plant breeder rights,	2
19	Protection of plant variety	2
20	Legal frameworks, Difficulties and challenges of implementing Legal Frameworks	1
Patenting of new genes and/or bioactive principles with novel antibiotic, insecticidal or anti-tumour properties:		
21	Patenting of novel antibiotic: Case study	3
22	Patenting of novel insecticidal molecule: Case study	4
23	Patenting of novel anti-tumour molecule: Case study	2
Principles of the Convention on Biological Diversity:		
24	United Nations convention on biodiversity	1
24	Issues under convention, International bodies established by convention, parties	1
25	Global strategy for plant conservation	1
26	Cartagena protocol and Nagoya protocol	2
Biodiversity conservation and biotechnology:		
27	Conventional approaches for biodiversity conservation: In situ and Ex situ methods	3
28	Biotechnological approaches for biodiversity conservation	3
29	Tissue culture techniques used for conservation	3
30	Cryogenic techniques for conservation of biodiversity	3
31	Transgenics and biodiversity	3
Bioprospecting of microorganisms and their components:		
32	Bioprospecting for Microbial Endophytes and Their Natural Products: General considerations, rationale for plant selection	3
33	Endophyte-host interaction,	2
34	Bioprospecting for Microbial Endophytes and Their Natural Products:Endophytes and biodiversity, endophytes and phytochemistry, collection and isolation techniques of endophytes	3
35	Bioprospecting for Microbial Endophytes and Their Natural Products: Bioactive molecules from endophytes such as antimicrobial, antitumour, insecticidal, antidiabetic, etc	3
Bioprospecting of biodiversity for new medicines:		
36	Bioprospecting of medicinal plants general considerations	3
37	Medicinal plants, indigenous knowledge and ethnobotany research	2
Identification and collection of material by random and traditional (medicinal) approaches:		
38	Survey, Exploration and collection of medicinal plants with bioactivities	2
39	Bioprospecting of medicinal plants for antioxidant activity	2
40	Chemodiversity	1
Screening for particular bio-activities:		
41	Screening for antibacterial activities: Methods & One case study	2
42	Screening for antifungal activities: Methods & One case study	1
43	Screening for enzyme activities: Methods & One case study	1

44	Screening for enzyme inhibitors: Methods & One case study	1
Elucidation of novel molecular form:		
45	Structural elucidation general approaches	1
46	Techniques used in structural elucidation: FTIR, NMR, Mass spectroscopy, XRD	2
47	Techniques used in structural elucidation: FTIR, NMR, Mass spectroscopy, XRD	2
Market availability and accessibility to the public:		
48	Marketing survey and marketing strategies	4
	Total:	**100**

Text Books:

1. Mohapatra PK. 2006. Text Book of Environmental Biotechnology. International Publishing House Pvt. Ltd.
2. Sharma PD. 2012. Ecology and Environment. 11th Ed. Rastogi Publications
3 Aravind Kumar and Govind Das. 2010. Biodiversity, Biotechnology and Traditional Knowledge: Understanding Intellectual Property Rights
4. Sarah Laird and Rachel Wynberg. 2016. Biodiversity Research, Bioprospecting and Commercialization: Science, Markets and Access and Benefit-sharing (People and Plants International Conservation). Routledge Publ.
5. Singh BD. 2015. Biotechnology Expanding Horizons. Kalyani Publ.

Course No : **MEBTEL-363** Course Title : **Molecular Ecology & Evolution**

Credits : **3 (3+0)** **Semester : VI**

Theory

UNIT I

Molecular Evolution: Concept, molecular divergence and molecular clocks; Speciation and domestication; Evolution of earth and earlier life forms; Primitive organisms,their metabolic strategies and molecular coding; New approaches to taxonomical classification including ribotypeing, Ribosomal RNA sequencing; Molecular tools in phylogeny, classification and identification.

UNIT II

Protein and nucleotide sequence analysis; Origin of new genes and proteins; Gene duplication and divergence; Genome evolution, components of genomes, whole genome duplications, chromosome rearrangements and repetitive sequence evolution.

UNIT III

Application of molecular genetics and genomics to ecology and evolution; Assessment of genetic diversity, phylogeny, inbreeding, quantitative traits using molecular tools; Mutations; Regulations of gene expression.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1	**Concept of molecular evolution** Population dynamics Forces in molecular evolution Gene conversion Genetic drift Selection Genome architecture Repetitive elements Chromosome number and organization Gene content and distribution Organelles The driving forces of evolution	2
2-3	**Molecular divergence** Analysis Usage Divergent species	3
4-5	**Molecular clocks** Early discovery and genetic equidistance Relationship with neutral theory Calibration Non-constant rate of molecular clock Methods Uses	3
6-7	**Speciation and domestication**	3

	Modes of speciation Artificial speciation Types of Speciation and mechanisms of Speciation Speciation via polyploidization Hybrid speciation Gene transposition Rates of speciation	
8	**Evolution of Life on Earth and earlier life forms** The Big Bang theory of the formation of the universe Formation of the solar system Early Earth Conditions Theories regarding evolution of life on earth. RNA World hypothesis	4
9-10	**Primitive organisms, their metabolic strategies and molecular coding** Prokaryotes, Eukaryotes and Archea. Multicellular organisms. The basic theories of the code nature, origin and evolution. Universality of the genetic code and collective evolution	6
11-13	**New approaches of taxonomic classification including ribotypeing** Genotypic Methods Phenotypic Methods Chemotaxonomy DNA-Based Typing Methods DNA-DNA reassociation	5
14	**Ribosomal RNA Sequencing:** Structure of r RNA Importance of rRNA Applications of Ribosomal RNA in species identification and evolution.	3
15	**Molecular tools in Phylogeny** Origins and history of Molecular Phylogenetics Phylogenetic Analysis Tools Understanding Phylogenetic Trees Distance-Matrix Methods UPGMA Method Discrete Data Methods Techniques and application	3
16	**Classification and identification** Systematic Approaches to Phylogeny Classification of phylogeny. Identification of phylogenic levels. Phenetic Cladistic Evolutionary	3
17-19	**Protein and nucleotide sequence analysis** Protein and nucleotide structure. Methods' of sequence analysis of proteins. Method's of sequence analysis of nucleotide.	6

	Sequence Alignment Profile comparison Sequence assembly Gene prediction Protein Structure Prediction Methodology Applications.	
20-22	**Origin of new genes and proteins** Theories regarding origin of new genes and gene families. Theories regarding origin of new proteins and proteins motifs with example. Retrotransposition	6
23-24	**Gene duplication and divergence** Gene Duplication Ectopic Recombination Retrotransposition Aneuploidy Generation of duplicate genes Evolutionary fate of duplicate genes Conservation of gene function	4
25	**Genome evolution** Defination of genome Prokaryotic and eukaryotic genomes Genome size Mechanisms of genome evolution Genome evolution and speciation Composition of nucleotides (GC content) Evolving translation of genetic code	3
26	**Components of genomes** Genome Sequencing and mapping Genome compositions Proportion of non-repetitive DNA Proportion of repetitive DNA Tandem repeats Interspersed repeats Retrotransposons DNA transposons	2
27	**Whole genome duplications** Evolutionary importance, Genome diversity,Evidence of Whole-Genome Duplication Examples of different levels of ploidy, Paleopolyploidy (ancient whole genome duplications), Detecting paleopolyploidy	3
28-30	**Chromosome rearrangements and repetitive sequence evolution** Chromosomal rearrangement Impact of Chromosomal rearrangement on evolution of species. Role of repetitive sequence evolution	6
31-33	**Application of molecular genetics and genomics to ecology and evolution**	8

	Application of Molecular markers Application of **molecular genetics in** Study of genome evolution Application of **molecular genetics in** Study of Population genetics Application of Molecular approaches in study of behavioural ecology Application of **molecular genetics in**Environmental genomics	
34-35	**Assessment of genetic diversity** Significance of Genetic Conservation of Crop Plants Erosion of Genetic Diversity due to Population Size Climate Change and Its Impact on Plant Genetic Resources Assessment of Genetic Diversity in Crop Plants Analyses of Genetic Diversity in Genomic Era Analysis of Genetic Diversity from Molecular Data Assessment of Genetic Diversity in Postgenomic Era	4
36-37	**Phylogeny** Taxonomic system Evidence for specific phylogenies Phenetics versus cladistics Evolution of land plants Animal evolution Application of phylogeny	4
38	**Inbreeding** Defination Measures of inbreeding in different organisms. Genetic disorders Examples Genetic disorders Effects of inbreeding Prevalence of inbreeding Application of inbreeding	2
39-41	**Quantitative traits using molecular tools** Quantitative traits Heritable disease and multifactorial inheritance Examples of Quantitative traits Types of QTL mapping	6
42-44	**Mutations** Defination Causes of mutation Types of mutation Application of mutation	5
45-48	**Regulations of gene expression** Control of gene expression at various stages Regulation of transcription Post-transcriptional regulation Regulation of translation Examples of gene regulation Up-regulation and down-regulation Inducible vs. repressible systems.	6
Total:		**100**

Text Books:

1. Beebee T & Rowe G. 2008. An Introduction to Molecular Ecology. 2nd Ed. Oxford University Press.
2. Brown TA. 2007. Genome 3. Garlan Science Publishing.
3. Carvalho GR. 2002. Advances in Molecular Ecology. IOS Press Netherland.
4. Prakash M. 2008. Molecular Biology of Ecology (Encyclopaedia of Molecular Biology-4) Discovery Publishing House Pvt. Ltd.
5. Schierwater B, Streit B, Wagner GP and Desalle R. 1994. Molecular Ecology and Evolution: Approaches and Applications. Springer.
6. Freeland JR, Petersen SD and Kirk H. 2006. Molecular Ecology 2nd Edition. Wiley Blackwell.

Course No : **MEBTEL-364** Course Title: **Molecular Pharming and Biopharmacetuticals**
Credits : **3 (2+1)** Semester: **VI**

Theory

UNIT I

Concept of molecular pharming and production of biopharmaceuticals; Mammalian cell culture manufacturing and microbial fermentation; Fermentation and cell culture processing; Protein purification and processing; Industrial fermentation: batch and continuous cultures, production of biopharmaceuticals, immobilization techniques.

UNIT II

Biopharmaceutical analytical techniques; Biopharma drug discovery and development; production of specific vaccines and therapeutic proteins.

Practical

Isolation & purification of proteins from microbes and plants; Production of recombinant proteins in prokaryotes; Analysis of proteins by one and two dimensional gel electrophoresis; Affinity chromatography;Immunoblotting; Cell culture and immobilization techniques. Visit to biopharmaceutical industry.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1	Overview of molecular farming & A Top-down View of Molecular Farming from the Pharmaceutical Industry: Requirements and Expectations	2
2	Plant based expression system	5
3-4	Approaches for Increasing Heterologous Protein Accumulation in Plants	3
5	Foreign Protein Expression Using Plant Cell Suspension and Hairy Root Cultures	4
6	Production of Pharmaceutical Proteins in Plants and Plant Cell Suspension Cultures	4
7	Chloroplast Derived Antibodies, Biopharmaceuticals and Edible Vaccines	4
8	Tobacco, a platform for the production of Recombinant proteins	2
9	Edible vaccines	3
10	Biosafety Aspects of Molecular Farming in Plants	3
11	Overview, biopharmaceuticals from microbial fermentation	2
12	Inoculum development, small scale liquid fermentations, Selection of raw material for industrial scale applications	3
13	Overproduction of Metabolites of Industrial Microorganisms	4
14	Bioreactor design and Modes of operation of bioreactor	4
15	Production of Antibiotics	4
16	Production of Vaccines	4
17	Methods of immobilization of cells	4
18-19	Upstream processing: General considerations	1

	Upstream processing: Prokaryotic and eukaryotic systems for biopharmaceutical production	2
20	Downstream processing	2
21	Cell disruption and Centrifugation	2
22	Membrane filtration	2
23	Protein purification: Salting out	2
24	Protein purification: Chromatography	2
25	Protein purification: Chromatography, ion exchange, gel filtration and affinity chromatography	3
26	Production of biopharmaceutical: vaccine	2
27	Production of biopharmaceutical: therapeutic protein	2
28	Immunoassays	5
29	Chromatography, GC & HPLC	5
30	Mass spectroscopy	5
31	Discovery process of biopharmaceutical, different stages and economics	5
32	Role of regulatory authorities in drug development	5
Total:		**100**

Practical Exercises

Exercise No.	Title
1.	General Instructions
2.	Laboratory organization & Important instruments used in Biotechnology laboratory
3.	Methods of sterilization & Preparation of buffers and solution
4-5.	Production of recombinant proteins using bioreactor
6.	Immobilization techniques
7.	Isolation of proteins using cell disruption & Centrifugation techniques
8.	Purification of proteins using ammonium sulphate: Salting out
9.	Buffer exchange using dialysis and membrane filtration
10-11	Affinity chromatography for purification of proteins
12.	Analysis of proteins by one and two dimensional gel electrophoresis
13-16.	Visit to Biopharmaceutical Industry

Text Books:

1. Brown TA. 2001. Gene Cloning and DNA Analysis and Introduction. Blackwell Publ.
2. Sambamurthy K. & Kar A. 2006. Pharmaceutical Biotechnology. New Age International Pvt Ltd Publishers.
3 Crommelin DJA,Sindelar RD and Meibohm B. 2013. Pharmaceutical Biotechnology: Fundamentals and Applications. Springer Publ.
4. Kokare CR. 2013. Pharmaceutical Biotechnology: Fundamentals And Applications. Nirali Publ.
5. Debnath M. 2005. Tools and Techniques of Biotechnology. Pointer Publ
6. Primrose SB & Twyman RM. 2013. Principles of Gene Manipulation and Genomics. John Wiley & Sons.

Course No : **MEBTEL-365** Course Title : **Food Biotechnology**
Credit : **3(2+1)** Semester **: VI**

Theory

UNIT I

Food Biotechnology: Introduction, history and importance; Applications of biotechnology in food processing: Recent developments, risk factors and safety regulations; Food spoilage and preservation process; Food and beverage fermentation: Alcoholic and non alcoholic beverages, food additives and supplements.

UNIT II

Industrial use of micro organisms; Commercially exploited microbes: *Saccharomyces, Lactobacillus, Penecillium, Acetobactor, Bifidobacterium, Lactococcus*and *Streptococcus*; Dairy fermentation and fermented products; Prebiotics and probiotics; Genetic engineering for food quality and shelf life improvement; Bioactive peptides; Labelling of GM foods.

Practical

Isolation, culture and maintenance of biotechnologically important micro-organisms; Use of laboratory and industrial scale shakers; Batch and continuous cultures; Use of fermentors; Detection of pathogens in food and feed; Detection of GM food; Visit to food processing industry**.**

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic to be covered	Weightage (%)
1	Food Biotechnology: Introduction,	2
2	History and importance of food biotechnology	2
3	Applications of biotechnology in food processing: Risk factors and safety regulations	2
4	Factors affecting accumulation of reducing sugars in potatoes	2
5	Sucrose metabolism in potatoes	2
6	Role of membrane in shelf life of tomatoes	2
7	Cell wall metabolism and fruit softening	4
8	Applications of biotechnology in food processing: Recent developments	4
9	Enzymes in fruit juices and brewing industries	4
10	Genes of pectin degrading enzymes	2
11	Biotechnological tools for improving processing qualities of fruits and vegetables	4
12	Food and beverage fermentation: non alcoholic beverages	2
13	Food and beverage fermentation: alcoholic beverages	4
14	Genetic engineering of wine grapes	4
15	Genetic engineering of yeast for fermentation	4
16	Biotechnology of wine yeast	4
17	Food additives and supplements	4
18	Industrial use of micro organisms	4
19	Pectinases of *Aspergillus*	2

20	Applications of microbes for Ore leaching	
21	Commercially exploited microbes: *Saccharomyces, Lactobacillus, Penicillium,* and *Acetobactor*	4
22	Commercially exploited microbes: *Bifidobacterium, Lactococcus* and *Streptococcus*;	6
23	Dairy fermentation and fermented products	4
24	Plasmid biology of dairy starter cultures	2
25	Tools for genetic manipulation of dairy starter cultures	4
26	Genomics of dairy cultures	4
27	Prebiotics	2
28	Probiotics	4
29	Genetic engineering for food quality	2
30	Genetic engineering for shelf life improvement	4
31	Bioactive peptides	4
32	GM foods and its applications	2
Total:		**100**

Practical Exercises

Exercise No.	Title
1	Isolation of biotechnologically important micro-organisms
2	Culture and maintenance of biotechnologically important micro-organisms
3	Inoculum development and maintenance
4	Sterilization
5	Strain improvement by biotechnologically applications
6	Scale up of the process
7	Study of laboratory and industrial scale shakers
8	Study of bioreactors by using batch and continuous cultures
9	Study of fermentation medias
10	Study of types of fermenters
11	Study of downstream processing
12	Production of secondary metabolites
13	Study of biocontrol agents
14	Detection of pathogens in food and feed
15	Detection of GM food
16	Visit to food processing industry like distilleries and breweries

Text Books

1. Hui YH & Khachatourians GG. 1995. Food Biotechnology: Microorganisms. Wiley-VCH.
2. Shetty K, Paliyath G, Pometto A & Levin RE. 2006. Food Biotechnology. 2nd Ed. CRC Press.

Reference Books

1. Singh BD. 2011. Biotechnology Expanding Horizons. Kalyani Publishers, New Delhi.
2. Pelczar MJ Jr., Chan ECS &Krieg NR. 2007. Microbiology, Tata McGraw Hill Publish.

Course No : **MEBTEL-366** Course Title : **Green Biotechnology**
Credit : **3 (2+1)** Semester : **VI**

Theory

UNIT I

Green biotechnology: Definition, concept and implication; Bio-fertilizers and bio-pesticides; Plant growth promoting rhizobacteria; Production of biofuels, biodiesel and bioethanol; Biomass enhancement through biotechnological interventions; Generation of alternate fuels in plants; Identification and manipulation of micro-organisms for biodegradation of plastics and polymers; GMOs for bioremediation andphytoremediation, their roles; Strategies for detection and control of soil, air and water pollutants.

UNIT II

Carbon sequestration; Methanogenic microbes for methane reduction; Microbes for phytic acid degaradation; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Marker-free transgenic development strategies; Development of disease resistant and pest resistant crops through biotechnological tools.

Practical

Identification and efficiency assays of micro-organisms for biodegradation and bioremediation;Isolation of *Bacillus thurigenesis* and plant growth promoting rhizobacteria; Production of biofertilizers, biopesticides and biofuel; Assays for removal of oil spillage**.**

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1	• Green Biotechnology: Definition, Introduction • What is green biotechnology? • History of green biotechnology	4
2	• Concept and implication of Green Biotechnology, Aims, and • Future with green biotechnology	4
3	• Agriculturally important beneficial microorganism • Bio-fertilizers and their types its importance and applications	4
4	• Bio-pesticides their types and its importance and applications • Different plant growth promoting rhizobacteria- Mechanisms of action, Pathogenic roles, Biocontrol agent, Nitrogen fixation, Symbiotic relationships	4
5	• Introduction of biofuels, biodiesel and bioethanol • Procedure for production biofuels, biodiesel and bioethanol • Engineering of plant cell walls for enhanced biofuel production	4
6	• Applications and current status of biofuels, biodiesel and bioethanol	4

	• Biotechnological approaches for production of biofuels, biodiesel and bioethanol • Current Worldwide status of transgenic research in production of biofuels, biodiesel and bioethanol	
7	Biotechnological Approach to Enhance the Growth and Biomass	6
8	Application of Biotechnology for the Production of Biomass-Based Fuels	4
9	Production of Fuels, Chemicals, and Materials from Biomass	2
10	Anaerobic biotechnological approaches for production of liquid energy carriers from biomass	2
11	Generation of alternate fuels from -Algae-based fuels, Biodiesel from plant source, Alcohol fuels from plant source, Recycling organic waste, etc.	2
12	Identification and Screening of micro-organisms for biodegradation of plastics and polymers	2
13	Manipulation of Plastic Degrading Microbes	2
14	Genetic Engineering (GMOs) approaches to control environmental pollution.	4
15	Genetic Engineering approach forbioremediation and phytoremediation	2
16	Biotech Plants for Bioremediation	2
17	Risk mitigation of genetically modified bacteria and plants designed for bioremediation	4
18	Carbon sequestration- Biosequestration- carbon sequestration through biological processes	4
19	Methods of carbon sequestration in Ocean	2
20	Methanogenic microbes for methane reduction	2
21	Biochemistry of methanogenesis, Natural occurrence of methanogenesis	2
22	Role of methanogenesis in global warming	2
23	Microbes for phytic acid degradation in agriculture and industry	4
24	Genetic Engineering approaches to increasing crop productivity by manipulation of photosynthesis process genes	4
25	Nitrogen fixation and its improvement through genetic engineering approach	4
26-27	Concept of C_3 and C_4 carbon fixation cycle in plant	4
28-29	Marker-free transgenic concept and application	4
30	Controversy and disadvantage of use of markers in transgenic development	4

31	Strategies for Generating Marker-Free Transgenic Plants	4
32	Biotechnological approaches for disease and pest resistant crops	4
	Total:	**100**

Practical Exercises

Lecture No.	Title
1	Do's and Dont's in Laboratory
2	Microbiology laboratory specifications and organization of equipments and their use
3	Different Sterilization techniques to reduce cross contamination in culture
4	Preparation of culture media and their composition for growth of microorganism
5	Isolation, propagation and storage of *Bacillus thurigenesis*
6	Method of Long and Short Term Storage of *Bacillus thurigenesis*
7	Isolation, propagation and storage of plant growth promoting rhizobacteria
8	Methods of production of biofertilizers
9	Types of biofertilizers formulation
10	Principle of strain selection of *Rizobium*&*Azotobacter*
11	Methods of production of biopesticides
12	Methods of production of biofuel
13	Isolation and Identification of Endosulfan-Degrading Bacteria
14	Isolation and identification of petroleum hydrocarbon degrading microorganisms from oil contaminated environment
15	Indole acetic acid assay
16	Siderophore production assay

Text Books:

1. Kirkosyan A & Kaufman PB. 2009. Recent Advances in Plant Biotechnology. Springer.
2. Kumar A. 2004. Environmental Biotechnology. Daya Publishing House.
3. Murray DC. 2011. Green Biotechnology. Dominant Publishers and Distributors.
4. Kirkosyan A & Kaufman PB. 2009. Recent Advances in Plant Biotechnology. Springer.
5. Kumar A. 2004. Environmental Biotechnology. Daya Publishing House.
6. Murray DC. 2011. Green Biotechnology. Dominant Publishers and Distributors.
7. Pooja. 2010. Textbook of Green Biotechnology. Discovery Publishing House Pvt. Ltd.
8. Murray DC. 1993. Green Biotechnology. Dominant Publishers and Distributors.

ELECTIVE IV: BIOINFORMATICS

Course No : **BIFEL-361** Course Title : **Programming for Bioinformatics**
Credit : **4 (2+2)** Semester : **VI**

Theory

UNIT I

Introduction: Operating systems, programming concepts, algorithms, flow chart, programming languages, compiler and interpreter; Computer number format: Decimal, Binary, Octal and Hexadecimal.

UNIT II

C-Language: History, constant, variables and identifiers, character set, logical and relational operators, data input and output concepts; Decision making: if statement, if-else statement, for loop, while loop and do-while loop; Arrays and functions, file handling; Programs related to arithmetic operations, arrays and file handling in C.

Practical

UNIT I

PERL-Language: Introduction, variables, arrays, string, hash, subroutines, file handling, conditional blocks, loops string operators and manipulators, pattern matching and regular expressions in PERL; Sequence handling in PERL demonstrating string, array and hash.

UNIT II

Shell Programming: Concepts and types of UNIX shell, Linux variables, if statements, control and iteration, arithmetic operations, concepts of awk, grep and sed; Sequence manipulations using shell scripting.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1	Introduction to Operating System	4
2	Chronological events in the development of operating system	
3	Operating System Overview: Definitions of Memory, device, processor and file management	6
4-5	Operating System types and Services	4
6-7	Operating System properties and Processes	4
8	Introductory programming concepts	6
9-10	Introduction to algorithms and flow charts	6
11-12	Introduction to programming languages	6
13-14	Compiler and interpreter	6
15-16	Computer number format: Decimal, Binary, Octal and Hexadecimal. Problems on interconversion of number system	8
17	C-Language: History	4
18-19	Constant, variables and identifiers	4
20-21	Character set, logical and relational operators	6
22	Data input and output concepts	4

23-24	Decision making: if statement, if-else statement	6
25-26	For loop, While loop and Do-while loop	6
27-28	Arrays and Functions	6
29	File handling	6
30-31	Programs related to arithmetic operations,	4
32	Arrays and file handling in C	4
	Total:	**100**

Practical Exercises

Exercise No.	Title
1-2	Programs using simple scalar and array variables: • To transcribe DNA sequence to RNA • To concatenate sequences • To make reverse complement of sequence • To reverse transcribe RNA to DNA sequence
3-7	Programs based on conditional statements and loops: • To searchmotifs in DNA or protein • To count nucleotides from given DNA and RNA sequences • To report percentage of hydrophobic amino acid in given protein • To write PERL script to report GC content of sequence • To search a motif in DNA and Protein sequence using regular expression and print it on screen (use special variables '$&' if required) • To focus using following PERL features for above mentioned programs: (1) Open and unless calls (2) do-until loop (3) foreach loop (4) Perl built in functions like Split, Pop, Shift etc.
8-10	Programs based on Subroutines: • To write a subroutine and calling it- Scoping a subroutine- Passing arguements to subroutine- Using Pass by value and Pass by reference- • To demonstrate the Perl Debuggers Programs like starting a debugger, setting breakpoints. Usage of 'use warnings' and 'use strict' utilities.
11	Programs based on concept of randomization: • To write a program to simulate DNA mutation • To write programs calculating percent identity between pairs of random DNA sequence
12-13	Introduction to hash datatype: • To write a program to manage Genetic code and redundancy in genetic code • To write program that translate DNA into protein • To write a program that Read FASTA file and extract the sequence data • To read DNA sequence from FASTA file, translate to protein and report the formatted output • To work with reading frames. (Example: Writing programs that translate DNA in all six reading frames)
14-15	Working with Restriction Maps and Regular Expressions: • To make programs for parsing REBASE datafile and creating a subroutine • To make restriction map from user input on names of restriction enzymes

16	Working with GenBank files • To program for separating Annotation from sequences from GenBankflatfile • To programs for parsing annotation using arrays • To program for parsing FEATURE table data
17-19	Working with PDB files: • To program to extract sequence from PDB file • To program for extracting secondary structure information from PDB file. (Examples: HELIX, SHEET, TURN record types of PDB file)
20	Working with BLAST output: • Parsing BLAST output. (Example : Extract annotation and Alignment) • To use BIOPERL module
21-23	Getting Started with Shell Programming: • How to write shell script, • Variables in shell, • How to define User defined variables (UDV) • Rules for Naming variable name (Both UDV and System Variable) • How to print or access value of UDV (User defined variables) • echo Command • Shell Arithmetic • More about Quotes • Exit Status- The read Statement- • Wild cards (Filename Shorthand or meta Characters) • More commands on one command line • Command Line Processing • Why Command Line arguments required • Redirection of Standard output/input i.e. Input - Output redirection • Pipes- Filter- • What is Processes- Why Process required- • Linux Command(s) related with Process
24-26	Shells (bash) structured Language Constructs: • Decision making in shell script (i.e. if command) • test command or [expr] • if...else...fi- Nested ifs- Multilevel if-then-else- • Loops in Shell Scripts • for loop- Nested for loop- While loop- • The case Statement • How to de-bug the shell script?
27-30	awk Revisited: • Getting Starting with awk • Predefined variables of awk • Doing arithmetic with awk • User Defined variables in awk • Use of printf statement • Use of Format Specification Code • if condition in awk • Loops in awk

	• Real life examples in awk • awkmiscellaneous • sed - Quick Introduction • Redirecting the output of sed command • How to write sed scripts? • More examples of sed-
31-32	Sequence manipulations using shell scripting-

Text Books:

1. Balagurusamy. 2008. *Programming in ANSI C*. Tata McGraw-Hill Education.
2. James Tisdall. 2003. *Mastering Perl for Bioinformatics*. O'Reilly Media.
3. Tom Christiansen, Brian D Foy, Larry Wall & Jon Orwant. 2012. *Programming Perl*.4th Ed. O'Reilly Media.
4. KanetkarYashavant. 2013. *Let Us C*. BPB Publications.

Course No : **BIFEL-462** Course Title: **Bioinformatics Tools and Biological Databases**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

Introduction: Biological data types, collection, classification schema of biological databases; Biological databases retrieval systems; Sequence and molecular file formats.

UNIT II

Biological databases: Nucleotide database, protein database, structural database, genome databases, metabolic pathway database, literature database, chemical database, gene expression database, crop database with special reference to BTISNET databases.

UNIT III

Bioinformatics Tools: Concept of alignment, scoring matrices, alignment algorithms, heuristic methods, multiple sequence alignment, phylogenetic analysis, molecular visualization tools.

Practical

NCBI; Expasy: SwissProt; EBI; Search engines: ENTREZ and SRS; Perform local alignment using all BLAST variants; Multilple sequence alignment using ClustalW; T Coffee; phylogenetic analysis by PHYLIP; MEGA.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
UNIT I		
1	Introduction: Biological data types	5
2-3	Collection, classification scheme of biological databases; primary and secondary databases, Nucleotide, protein, molecular etc.	5
4-5	Biological databases retrieval systems; Entrez, SRS	5
6-7	Sequence and molecular file formats :Genbank, EMBL, Fasta, PDB, Flat file, ASN.1, XML	5
UNIT II		
8-10	Biological Databases : Primary databases: Nucleotide sequence databases (GenBank, EMBL),	07
11-12	Protein sequence databases; Secondary databases: SwissProt/TrEMBL, conserved domain database, Pfam;	07
13-15	Structural databases: Protein Data Bank (PDB), MMDB, SCOP, CATH;	07
16-17	Genome databases : Model plant database Arabidopsis and Rice metabolic pathway database : KEGG, MetaCyc, PMN	05
18-19	Literature database: chemical database,crop database with special reference to BTISNET databases.	05
UNIT III		
20-21	Bioinformatics Tools: Concept of alignmentsequence alignment and its applications: Pair wise and multiple sequence alignment,	7
22	Concept of local and global alignment	7

23-25	Alignment Algorithms: Dot Matrix method, dynamic programming methods (Needleman–Wunsch and Smith–Waterman); heuristic methods	10
26-27	Multiple sequence alignment: Tools of MSA: ClustalW, TCoffee;	07
28-29	Phylogenetic analysis: Phylogeny and methods of phylogenetic analysis	10
30-32	Molecular visualization tools : Rasmol, Friend, Jmol	08
	Total:	**100**

Practical Exercises

Exercise No.	Practical Exercise
1	To access information from NCBI database
2	To access information from EBI database
3-4	To retrieve information using search engines: ENTREZ
5-6	To retrieve information using search engines: SRS
7-8	To study protein database : Expasy:
9-10	To study protein database : SwissProt
11	To perform Blast analysis: Blast program.
12	Multilple sequence alignment using ClustalW
13-14	Multilple sequence alignment using T Coffee
15	Phylogenetic analysis by PHYLIP
16	Sequence analysis and graphic viewer : MEGA

Text Books:

1. Baxevanis AD. & Ouellette BFF. 2001. *Bioinformatics: A practical guide to the analysis of genes and proteins.*John Wiley and Sons.
2. Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor.
3. Xiong J. 2006. *Essential Bioinformatics.*Cambridge University Press

Course No : **BIFEL-463** Course Title : **Structural Bioinformatics**
Credit : **3(2+1)** Semester **: VI**

Theory

UNIT I

Introduction to structural databases of macromolecules, natural and synthetic small molecules; Structure of amino acids; Protein structure classification, Ramachandran plot; Experimental structure determination methods; Motifs, domain, profiles, fingerprint and protein family databases.

UNIT II

Structural features of RNA, RNA secondary structure predictions; RNA folding; Small RNA prediction.

UNIT III

Structure prediction: Basics of protein folding, protein folding problem, molecular chaperons; Secondary structure prediction methods and algorithms: Homology, *ab initio* and folding based tertiary structure prediction; Structure validation tools, energy minimization techniques; Introduction to molecular dynamics and simulation, Monte-Carlo methods, Markov chain and HMM; Structure visualization and comparison methods.

Practical

Protein structural classification databases, 3D-Structural databases searching and retrieval, Ramchandran Plot, Structural visualization tools, Tools for protein secondary and tertiary structure prediction; RASMOL, Cn3D, CHIMERA, SWISSPDBviewer, CPH, MODELLER, SWISS Model, EasyModeler, Procheck; GROMAC; SANJIVNI; BHAGIRATH.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1-2	Introduction to structural databases of macromolecules, natural and synthetic small molecules	4
3	Structure and physico-chemical properties of amino acids	4
4-5	Protein structure classification (Primary, secondary, super secondary, tertiary and quaternary structure of protein)	6
6-7	Dihedral angles or Tortional angles and Ramachandran plot	6
8-9	Experimental structure determination methods: NMR and X-crystallography	6
10-11	Concept and definition of Motifs, domain, profiles and fingerprint.	6
12-13	Introduction and need of protein family databases or derived databases	6
13-14	Structural features of RNA and types of RNA	6
15-16	RNA secondary structure predictions	6
17	RNA folding	6
18-19	Small RNA prediction	6
20-21	Structure prediction: Basics of protein folding, protein folding problem, molecular chaperons	6
22-23	Secondary structure prediction methods and algorithms structure	6

24-25	Homology, *ab initio* and folding based tertiary structure prediction	6
26	Structure validation tools	4
27-28	Energy minimization techniques	6
29-30	Introduction to molecular dynamics and simulation, Monte-Carlo methods, Markov Chain and HMM	6
31-32	Visualization and Comparison methods	4
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	To study protein structural classification databases (CATH and SCOP)
2	To study 3D-structural databases searching and retrieval (e.g. PDB + Nucleic acid databank, PMDB)

3
4
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9
	To study Structural visualization tools (SPDBV) or RASMOL, SWISSPDB viewer, Cn3D
	• To perform following tasks on a molecule using DeepView
	  • Selecting and Displaying
	  • Colouring
	  • Measuring and labeling
	• To apply crystallographic symmetries:
	• To build a full multimer from a pdb file containing only a monomer (subunit) of a protein by applying non-crystallographic symmetries.
	• To study the interactions in the subunit interface.
	• To compare Conformations of Proteins: (example: Deoxyhemoglobin and Oxyhemoglobin)
	• To use Ramachandran Plot
	• To examine Electron Density Maps
	• To perform *in silico* mutagenesis and analyze Side chain conformations
	• To alter the model (PDBID 1HEW) by changing an isoleucine residue to glutamine.
	• To investigate whether the new residue might form an additional H-bond to inhibitor tri-NAG.

10- 11	Protein secondary structure prediction(First generation, second generation and Third generation methods) using online servers
12- 14	Protein tertiary structure prediction methods: (CPH, MODELLER, SWISS Model, EasyModeler).
15- 16	Estimation of Predicted Models: ProCheck, ERRAT, Verify3D, Prove, Prosa etc.

Text Books:

1. A.Malcolm Campbell & Laurie J.Heyer. 2007. *Discovering Genomics, Proteomics and Bioinformatics.* Benjamin Cummings.
2. Allan Hinchkliffe. 2008. *Modeling for Beginners.* Wiley.
3. Creighton TE. 1993. *Proteins: Structures and Molecular Properties*. W.H. Freeman
4. Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor.

Reference Book:

1. Setubal Joao &Meidanis Joao. 1997. *Introduction to Computational Molecular Biology.*PWS Publishing Company

Course No : **BIFEL-463** Course Title : **Pharmacogenomics**
Credit : **3(2+1)** Semester : **VI**

Theory

UNIT I

Basic concepts of pharmacogenomics, clinical application and challenges in pharmacogenomics; Human Genome Project, genetic diseases, personalized medicine and pharmacogenomics necessity in drug designing; Prediction of structural changes among sequence variants and genetic analysis; Microsatellites for studying genetic variations; Drug databanks; Gene therapy.

UNIT II

Drug Design: Study of important drug targets and their variations; Pharmacophore designing, prediction of ADME properties; Computational tool for toxicity prediction; SAR and QSAR techniques in drug designing; Drug receptor interactions; Structural based drug design; Lipinski's rule in drug design.

Practical

Receptor-Ligand interactions, Pharmacophore development; OSDD; DrugBank; PubChem; molecular representation using SMILES; Chemsketch: 2D and 3D structure; Structure analyses using Chimera/VMD; Detection of active site of proteins using various software; bioavailability using Mol inspiration; Docking using HEX and AUTODOCK.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1-2	Basic concepts of pharmacogenomics: Definition and History of medical concepts in pharmacogenomics	6
3-4	Clinical application and challenges in pharmacogenomics	6
5, 6, 7	Human Genome Project, Genetic diseases, Personalized medicine and Molecular basis of personalized medicine	8
8	Pharmacogenomics necessity in drug designing	4
9-11	Prediction of structural changes among sequence variants and genetic analysis	8
12-13	Microsatellites for studying genetic variations.	6
14-15	Drug databanks:	6
16	Gene therapy:	6
17-18	Study of important drug targets and their variations:	6
19-20	Pharmacophore modelling- • Pharmocophore: Definition and classes (HBA, HBD, Aromatic etc.) • Identification of pharmacophore features	6
21-22	Prediction of ADME properties	6
23-24	Computational tools for toxicity prediction	6
25-26	SAR and QSAR techniques in drug designing	8
27-28	Drug receptor interactions:	6
29-30	Structural based drug design	6
31-32	Lipinski's rule in drug design	6
	Total:	**100**

Practical Exercises

Exercise No.	Title
1-3	Molecular Docking Using HEX and AUTODOCK: Docking Studies: • Approaches in Target identification • Methods of Active site analysis • Ligand preparation and conformational analysis • Rigid and flexible docking • Structure based design of lead compounds • Library docking • Molecular vizualition of docked complexes • Interaction analysis • Preparing Publication quality molecular graphics and illustrations
4 5 6	Using Chemsketch: • Chemical Structure representation: 1D, 2D and 3D structures • Molecular file formats (SMILES, WLN, SDF, MOL,PDBetc). • Compound library formatting and filtering (Physicochemical and substructure filters)
7-8	Browsing and searching by DrugBank and PubChem:
9-10	Open Source Drug Discovery (OSDD): Assignment on Community Developed Resources
11	Molecular representation using SMILES
12	Structure analyses using Chimera/VMD
13-14	Detection of active site of proteins using various softwares
15-16	Bioavailability using MolInspiration

Text Books:

1. Allan Hinchkliffe. 2008. *Modeling for Beginners*. Wiley- Blackwell Publishing.
2. GerdFolkers, Wolfgang Sippl, Didier Rognan& Hans Dieter. 2003. *Molecular Modeling: Basic Principles and applications*. Science.
3. Gupta S.P. 1996. *Quantum Biology*.New Age.
4. Lisa B. *Combinatorial Library Methods and Protocols*

Course No : **BIFEL-465** Course Title : **Metabolomics and System Biology**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

Metabolomics overview, major metabolic pathways: Glycolysis, Kreb's cycle, oxidative phosphorylation, amino acid, fatty acid and nucleotide metabolism, their control and integration; Metabolic flux and metabolic profiling; Catalytic mechanisms and enzyme kinetics, Michaelis-Menton kinetics; Conformational change, allosteric regulations, regulation of metabolic pathways; Signal transduction: Inter and intra cellular communications; Receptor ligand interaction; Structural components of signal pathways: G-protein, Jak-stat, receptor tyrosine kinase.

UNIT II

Signal Flow: Pathway to networks, small scale system biology experiments; System analysis of complex diseases, system pharmacology; Assembling large data sets in genomics and proteomics, computational analysis of large data sets, building networks; Mathematical representation of cell biological system, time and space.

Practical

Metabolic pathway databases KEGG, BRENDA, Biosilico, Protein-protein interaction databases, Swiss 2D PAGE, E-PCR; Creating networks using Cytoscape, DAVID, MAS3; in silico functional annotation using GO, AGRIGO, PANTHER, BLAST2GO.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topics	Weightage (%)
1	Introduction, Definition and Overview of Metabolomics	4
2-3	Major metabolic pathways: Glycolysis, Kreb's cycle,	4
4	Oxidative phosphorylation, their control and integration.	4
5-6	Major metabolic pathways: Amino acid, Fatty acid and Nucleotide metabolism, their control and integration.	8
7	Metabolic flux and metabolic profiling	4
8-9	Catalytic mechanisms and enzyme kinetics includingMichaelis-Menton kinetics	6
10-11	Regulation of metabolic pathways by Conformational change and allosteric regulations.	6
12-13	Introduction to Signal transduction, general steps involved in Inter and intra cellular communications and classification of cell signaling based on distance travelled by the molecule.	6
14	Structural components of signal pathways: GPCR Pathway.	5
15-16	Structural components of signal pathways: RTKPathway and Jak-Stat.	5
17	Receptor-ligand interaction and receptor mediated endocytosis	4
18	Signal Flow: Pathway to networks,	5
19	Signal Flow: small scale system biology experiments	5
20-21	System analysis of complex diseases	5
22-23	System pharmacology	5
24-26	Assembling large data sets in genomics and proteomics	8

27-29	computational analysis of large data sets, building networks	8
30-31	Mathematical representation of cell biological system, time and space-I	4
32	Mathematical representation of cell biological system, time and space-II	4
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	Metabolic pathway mapping by KEGG
2	Text based queries by BRENDA
3	Structure based queries by BRENDA
4	Search and analysis of metabolic pathways by BIOSILICO
5	MIPS (Mammalian Protein-Protein Interaction Database)
6	Protein-Protein interaction databases searching
7	Swiss 2D PAGE searching and maps
8-9	E-PCR searching for sub-sequences that closely match the PCR primers and have the correct order, orientation and spacing.
10	Creating networks using Cytoscape
11-12	Database for Annotation, Visualization andIntegrated Discovery (DAVID) for functional annotation.
13	Molecule annotation system (MAS) 3.0 and GO terms
14-15	*In silico* functional annotation using AGRIGO, PANTHER,
16	*In silico* functional annotation using BLAST2GO.

Text Books:

1. Berg JM, Tymoczko JL &Stryer L. 2002.*Biochemistry*.5th Ed. W.H. Freeman and Company.
2. Fersht A. 1999. *Structure and Mechanism of protein science*. W.H. Freeman and Company.
3. Klipp E, Herwig R, Kowald A, Wierling C, Lehrach H. 2006. *Systems Biology in practice.Concepts, implementation and Application*.Wiley VCH.

Reference Books:

1. Vaidynathan S, Harrigan GG, Royston Goodacre. 2005. *Metabolome analysis: Strategies for system biology*. Springer.
2. Voet D &Voet J. 2002.*Biochemistry*3rd Ed. John Wiley and Sons.

Course No : **BIFEL-466** Course Title : **Computational Methods for Data Analysis**
Credits : **3(2+1)** Semester : **VI**

Theory

UNIT I

Introduction to UNIX/LINUX operating system; Knowledge discovery and data mining techniques; Machine learning and pattern recognitions, hidden markov models; Artificial neural networks, Support vector machines.

UNIT II

Principal component analysis, ANOVA; AMOVA and different clustering methods; Gene Prediction algorithms and Phylogeny algorithms; Basics of R statistical package.

Practical

Gene prediction: FGENESH; R statistical package installation and configuration, GUI for R: R-commander, R-studio, RKWard; Analysis of gene expression using R; GNU PSPP, Scilab, QtiPlot.

Teaching Schedule- Theory with weightage (%)

Lecture No.	Topic	Weightage
1	Introduction to UNIX/LINUX operating system:	4
2	Introduction to structure of UNIX/LINUX, Concepts-	
3	UNIX/LINUX operating system: Commands and special features.	6
4	Processes and UNIX/LINUX file system-	
5	Knowledge discovery -	8
6-7	data mining techniques-	
8-10	Machine learning and pattern recognitions	8
11-12	Introduction to Hidden Markov models	6
13-14	Artificial neural networks	6
15-16	Support vector machines	4
17-18	Principal component analysis: Principle Component analysis procedure, How do we find the coefficients?, Interpretation of the principle component	6
19-20	Analysis of Variance (ANOVA): One way ANOVA, Two way ANOVA	6
21	Analysis of Molecular Variance (AMOVA):	4
22	Clustering methods: Sequence and character based methods UPGMA , Neighbor joining	6
24-25	Gene Prediction algorithms: Gene prediction in Eukaryotes by Neural networks and pattern discrimination method.	6
26-27	Gene Prediction in Prokaryotes by the scoring Matrix method and Reliability of Matrix Method-	6
28-29	Phylogeny algorithms: Distance, Maximum likelihood and Maximum Parsimony method-	6
29-30	Basics of R statistical package: Introduction, Objects and Arithmatic, Summaries and subscripting-	6
31	Matrices, attaching to objects, the apply function-	6
32	Statistical Computation and Simulation, Graphics, Writing Functions-	6
	Total:	**100**

Practical Exercises

Exercise No.	Title
1	Eukaryotic Gene Prediction
2	Prokaryotic Gene Prediction
3	R statistical package installation and configuration
4-5	GUI for R
6	R Data Import/ Export
7	R-Commander
8	R-Studio
9	RKWard
10-11	Analysis of Gene Expression using R
12-13	GNU PSPP
14	Scilab
15-16	QtiPlot

Text Books:

1. Gareth James, Daniela Witten, Trevor Hastie & Robert Tibshirani. 2013. An Introduction to Statistical Learning: with Applications in R. Springer
2. Mathur K Sunil. 2010. Statistical Bioinformatics with R. Elsevier.