UNIVERSITY OF MUMBAI

Revised Syllabus for T.Y.B.Sc.
Programme- B.Sc.
Course- Biotechnology (USBT)
(Third Year – Sem. V & VI)

(Credit Based Semester and Grading System with effect from the academic year 2024-2025)

TYBSC Biotechnology Course Structure Semester V

Course code USBT	Title	Theory /Practical	Marks	Credits	Nos of Lectures/ week
501	**Cell biology**	Theory	100	2.5	4
502	**Biochemistry**	Theory	100	2.5	4
503	**Immunology & Stem cell biology**	Theory	100	2.5	4
504	**Industrial Biotechnology**	Theory	100	2.5	4
P 501+502	**Cell biology + Biochemistry**	Practical	100	3.0	8
P 503+504	**Immunology & Stem cell biology + Industrial Biotechnology**	Practical	100	3.0	8
Applied Component	**Computational Statistics and IPR**	Theory	100	2.0	4
Applied Component	**Computational Statistics and IPR**	Practical	100	2.0	4
	TOTAL		**800**	**20**	**40**

Semester VI

Course code USBT	Title	Theory/ Practical	Marks	Credits	Nos of Lectures / week
601	**Plant and Animal Biology**	Theory	100	2.5	4
602	**Genetic engineering and Gene editing**	Theory	100	2.5	4
603	**Basic Pharmacology and Neurobiology**	Theory	100	2.5	4
604	**Marine and environmental Biotechnology**	Theory	100	2.5	4
P 601+ P 602	**Plant and Animal Biotechnology + Genetic Engineering and Gene Editing**	Practical	100	3.0	8
P 603+ P 604	**Basic Pharmacology and Neurobiology + Marine and Environmental Biotechnology**	Practical	100	3.0	8
Applied component	**Agri Biotechnology**	Theory	100	2.0	4
Applied component	**Agri Biotechnology**	Practical	100	2.0	4
	TOTAL		**800**	20.0	40

Teaching pattern:
One (01) Credit would be of thirty- forty (30-40) learning hours; of this more than fifty percent of the time will be spent on classroom instructions including practical as prescribed by the University. Rest of the time spent invested for assignments, projects, journal writing, case studies, library work, industrial visits, attending seminars / workshops, preparations for examinations etc. would be considered as notional hours. The present syllabus considers (60L as classroom teaching and 15 lectures as Notional hours/ paper). Each lecture duration would be for 50 min

The names of the reference books provided in the syllabus are for guidance purpose only. Students and faculty are encouraged to explore additional reference books, online lectures, videos, science journals for latest/ additional information.

Examination pattern for:

Theory:

- The question paper for the Term End Exam would be of **75 marks** consisting of 5 Questions (15M each), of which one question would be common for all units in the syllabus.

- The question paper would be set for 140 marks including internal options.

EVALUATION PATTERN

The performance of the learner shall be evaluated in TWO parts.

The learner's Performance shall be assessed by Internal Assessment of 25 Marks and Semester End Examination (Theory) of 75 marks for each Term. Practical Examination will be conducted at end of each Semester for 200 marks

Internal Assessment- 25 Marks

SR. No.	Particulars	Marks
1.	Class test / Assignment / Presentation	**20 Marks**
2.	Department Activities, Attendance etc.	**5 Marks**
	TOTAL	**25 Marks**

Semester end Exam- 75 marks

SR. No.	Particulars	Marks
All questions are Compulsory Number Questions : 5 (Five) Each Question carries 15 Marks		
1.	Q 1 – Objective Questions based on unit I, II, III and IV (Internal Options)	**15 Marks**
2.	Q 2 – Unit I (a and b OR c and d)	**15 Marks**
3.	Q 3 – Unit II (a and b OR c and d)	**15 Marks**
4.	Q 4 – Unit III (a and b OR c and d)	**15 Marks**
5.	Q 5 – Unit IV (a and b OR c and d)	**15 Marks**
	TOTAL	**75 Marks**

Note:- All questions are compulsory with internal options within the questions.

SEMESTER V

Practical examination – 200 marks

USBT P 501-502	**Practicals of USBT P 501-502**	**100 Marks**
USBT P 503-504	**Practicals of USBT P 503-504**	**100 Marks**

SEMESTER VI

Practical examination – 200 marks

USBT P 601-602	**Practicals of USBT P 601-602**	**100 Marks**
USBT P 603-604	**Practicals of USBT P 603-604**	**50 Marks Project + 50 Marks Practical = 100 Marks**

Semester V

USBT 501	**Cell biology**
Course Objectives:	1. To explore the molecular mechanisms that control cell cycle progression, including the roles of cyclins, cyclin-dependent kinases (CDKs), and checkpoints. 2. To introduce the fundamental concepts of cancer biology, including the hallmarks of cancer, tumor progression, and metastasis.
Learning Outcomes:	1. Learners will be able to analyze the roles of cyclins, cyclin-dependent kinases (CDKs), and checkpoints in maintaining cell cycle fidelity. 2. Learners will be able to evaluate the consequences of cell cycle dysregulation in diseases, particularly cancer.

Course code USBT	**Title**	**Unit**	**Topics**	**Credit**	**No of Lecture s**
501	**Cell biology**	**I: Cell cycles**	Introduction: Prokaryotic and Eukaryotic cell cycle **(3 Lectures)** The Early Embryonic Cell Cycle and the Role of MPF **(4 Lectures**); Cell cycle in Yeasts and the Molecular Genetics of Cell-Cycle Control **(4 Lectures)** Apoptosis, Cell-Division Controls in Multicellular Animals**(4 Lectures)**	2.5	15
		II: Cell signaling	Cell signaling and signal transduction. Introduction General Principles of Cell Signaling - **3 Lectures**; Signaling via G-Protein-linked Cell-Surface Receptors - **3 Lectures;** Signaling via Enzyme-linked Cell-Surface Receptors - **3 Lectures**; Target-Cell Adaptation, The Logic of Intracellular - **3 Lectures;** Signaling: Lessons from Computer-based "Neural Networks"- **3 Lectures**		15

		III: Developmental Biology	Overview of how the modern era of developmental biology emerged through multidisciplinary approaches - **5 Lectures**; Stages of development- zygote, blastula, gastrula, neurula cell fate & commitment – potency- concept of embryonic stem cells, differential gene expression, terminal differentiation ,lineages of three germ layers, fate map - **6 Lectures**; Mechanisms of differentiation- cytoplasmic determinants, embryonic induction, concept of morphogen, mosaic and regulative development Pattern formation- axis specification, positional identification (regional specification), Morphogenetic movements, Model organisms in Developmental biology - **4 Lectures**		15
		IV: Cancer Biology	Cancer: Introduction, Cancer as a Microevolutionary Process - **4 Lectures**; The Molecular Genetics of Cancer - **6 Lectures**; Cancer and Viral Cancer diagnosis and chemotherapy - **5 Lectures**		15
		Total			60

References:

1. Molecular Cell Biology. 7th Edition, (2012) Lodish H., Berk A, Kaiser C., K Reiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P. Scott M.P., W.H. Freeman and Co., USA
2. Molecular Biology of the Cell, 5th Edition (2007) Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Garland Science, USA
3. Cell Biology, 6th edition, (2010) Gerald Karp. John Wiley & Sons., USA
4. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper, Robert E. Hausman, Sinauer Associates, Inc. USA
5. Developmental Biology; Scott Gilbert; 9th Edition
6. Developmental biology :Veerbala Rastogi
7. Concept of Developmental biology: Dr.Amrita Singh,Mangalam Publication
8. NPTEL :: Biotechnology - NOC:Cell Biology: Cellular organization, division and processes
   NPTEL :: Biotechnology - NOC:Introduction to Developmental Biology

USBT 502	**Biochemistry**
Course Objectives:	**1. To understand the structure,function and interactions of biomolecules such as proteins,carbohydrates** **2. To understand basic concepts of nutrition including macro and micro nutrients , their metabolism, functions,sources and daily requirements** **3. Study the impact of overnutrition and undernutrition on health.**
Learning Outcomes:	**1. Learners will be able to explain protein structures, functions, mechanisms of interactions, principles and mechanisms of protein folding , factors affecting protein stability and methods of purification** **2. Learners will acquire basic nutritional knowledge involving vitamins and minerals and understand the impact of malnutrition on health.**

Course code USBT	**Title**	**Unit**	**Topics**	**Credit**	**No of Lectures**
502	**Biochemistry**	**I: Protein Chemistry**	Protein structure-Tertiary and Quaternary structures **(2 lectures)** Protein Denaturation and Folding- **(3 lectures)** Protein Function- Reversible binding of a protein to a ligand, Oxygen binding proteins **(2 lectures)** Complementary Interactions between proteins and ligands, Immunoglobulins **(1 lecture)** Protein interactions modulated by Chemical Energy: Actin, Myosin and Molecular Motors **(3 lectures)** Protein purification **(4 lectures)**		15
		II: Metabolism	Carbohydrate biosynthesis and its regulation: Peptidoglycan in Bacteria **(2 Lectures)**; Starch and sucrose in Plants **(4 Lectures)** ; Glycogen in Animals **(4 Lectures)** Biosynthesis and regulation of Cholesterol FASC		15

			(5 Lectures)		
		III: **Endocrinology**	Basic of Group I and II hormones- **2 Lecture**; Structure, storage, release, transport, biochemical functions and disorders associated with hormones secreted by Hypothalamus -**1 Lecture**; Anterior Pituitary gland - GH, stimulating hormones) -**1 Lecture**; Posterior Pituitary gland – oxytocin and vasopressin -1 Lecture; Thyroid gland – Thyroxine, calcitonin - **2 Lectures**; Parathyroid gland – PTH -**1 Lecture**; Adrenal medulla – epinephrine and norepinephrine -**1 Lecture**; Adrenal cortex – Glucocorticoids - **1 Lecture**; Pancreas – insulin and glucagon - **2 Lectures**; Female Gonads ?– estrogen and progesterone - **2 Lectures**; Male gonads? – testosterone- **1 Lecture**; Placenta – HcG - **1 Lecture**		15
		IV: Nutrition	Introduction and Functions of Nutrients **1 lecture)** Concept of RDA, BMR **(1 lecture)** Minerals and Vitamins Dietary sources, bioactive form, functions and disorders associated with fat soluble vitamins (A D E, K) and water soluble vitamins (B groups I, II & III, Vit C)- (**6 Lectures)** Minerals - classification, physiological and biochemical functions of principal and trace elements. - (**6 Lectures)** Malnutrition – Over nutrition (obesity) and PEM (Kwashiorkor and Marasmus)- (**1 Lecture)**		15
		Total			60

References:

1. Lehninger, principles of biochemistry, 4th edition (2005), David Nelson and Michael Cox W.H. Freeman and Company, New York.
2. Biochemistry , 4th edition (2010), Voet and Voet, John Wiley and sons, USA
3. Harper's Illustrated Biochemistry, 27th edition, RK Murray, DK Granner, PA Mayes and VW Rodwell, McGraw Hills publication.
4. Biochemistry, 4nd edition (2017), Satyanarayana and Chakrapani, Books & Allied (P)Ltd
5. Nutrition and Dietetics (with Indian Case Studies), 3rd Edition, Shubhangini A.Joshi, Tata McGraw Hill Education Private Limited
6. A Handbook of Food and Nutrition, 5th Edition, Swaminathan N, Bangalore printing and publishing Co.Ltd.
7. Vitamins & Minerals Demystified, Steve Blake, McGraw Hill
8. https://onlinecourses.nptel.ac.in/noc20_cy10/preview

PRACTICALS

USBT P 501-502 3 credits 120 hrs

1. Estimation of Starch by Anthrone method.
2. Estimation of Glycogen by Phenol sulfuric acid method.
3. Determination of Protein stability and viscosity.
4. Estimation of vitamin C by DCPIP method.
5. Analysis of protein purity using PAGE.
6. Determination of Calcium in milk by Complexometric titration (EDTA titration)
7. Total Cholesterol estimation.
8. Vitamin B12 bioassay
9. Cancer Biology: (Field visit / ACTREC web page visit and assignment writing in the journal)
   ACTREC home page:
   https://www.actrec.gov.in/home
   Assignment draft:
   https://docs.google.com/document/d/13Pzz928dI5Dn7NkgdrWks58ZoJXA-zDwAwVAT2HX_LE/edit?usp=sharing

USBT 503	**Immunology & Stem cell biology**
Course Objectives:	1. To provide a comprehensive understanding of the biological functions and regulatory mechanisms of cytokines. 2. To categorize and understand the different types of hypersensitivity reactions (Type I-IV), and their implications in allergic and autoimmune conditions. 3. To explore the concept of the stem cell and their types.
Learning Outcomes:	Learners will be able to translate basic immunological and stem cell biology principles into potential clinical applications and therapeutic strategies.

Course Code USBT	**Title**	**Unit**	**Topics**	**Credit**	**No of Lectures**
		I: Innate immune reactions & hypersensitivity	Innate immune response: overview Inflammation , Antiviral defense Microbial Evasion of Innate Immunity, Regulation of Innate Immune Responses Role of innate immunity in stimulating adaptive immune responses **5 lectures** Introduction to hypersensitivity - **1 lecture** types and treatment/ therapy : Type I Hypersensitivity Reactions (Allergy) **3 lectures** Antibody-Mediated (Type II) Hypersensitivity reactions **2 lectures** Immune Complex-Mediated (Type III) Hypersensitivity **2 lectures** Delayed-Type (Type IV) Hypersensitivity (DTH) **2 lectures**		
		II: Cytokines & Adaptive immunity	Cytokines - history , properties , functional categories of cytokines (overview) ,cytokine receptors, role of cytokines and cytokine receptors in disease **9 lectures** T-Cell Differentiation **1 lecture** B-Cell Differentiation **1 lecture** antibody related immune responses: Properties of antibodies that determine effector function **2 lectures** Functions of antibodies at special anatomic sites **2 lectures**		15

503	**Immunology & Stem cell biology**	**II: Tolerance & autoimmunity**	Tolerance **-4 lectures** Possible Mechanisms for the Induction of Autoimmunity & factors responsible for autoimmunity **- 3 lectures** Autoimmune Diseases which target Specific Organs: Hashimoto's Thyroiditis, Type 1 Diabetes Mellitus, Myasthenia Gravis- **3 lectures** Systemic Autoimmune Diseases: Systemic Lupus Erythematosus (SLE), Multiple Sclerosis, Rheumatoid Arthritis - **4 lectures.** Treatment/ therapy **1 lecture**	2.5	15
		IV: Stem cell biology	Stem Cell Origin and Types of Stem Cells (**(4 lectures)** **Human Embryonic Stem Cells (hESCs)** Isolation of hESCs, Culture of hESCs, Characterization of hESCs, Differentiation of ESCs **(4 lectures)** Pluripotency, Pluripotent Stem Cells, Types of Pluripotent Stem Cells **(4 lectures)** Applications of Human Embryonic Stem Cells Regenerative Medicine **(3 lectures)**		15
		Total			60

References:

1. Kuby IMMUNOLOGY, Eighth Edition, ISBN: 978-1-319-26722-3
2. Kuby IMMUNOLOGY, Seventh Edition
3. Basic Immunology: Functions and Disorders of the Immune System 7th Edition Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai
4. Cellular and Molecular Immunology 7th Edition Abul K. Abbas , Andrew H. Lichtman , Shiv Pillai
5. IMMUNOLOGY A Short Course 7th Edition Richard Coico, Geoffrey Sunshine
6. Introductory Immunology Basic Concepts for Interdisciplinary Applications 1st Edition Jeffrey K. Actor
7. Regenerative Medicine and Stem Cell Biology, Nagwa El-Badri , ISBN 978-3-030-55359-3 (eBook) https://doi.org/10.1007/978-3-030-55359-3

USBT 504	Industrial Biotechnology
Course Objectives:	1. To gain information about microflora of milk, factors affecting bacteriological quality**,** Microbiological examination of milk and dairy technology preservation methods. 2. To study about the production of fermented dairy products and the functional dairy foods for the health benefits 3. To make the students understand the fermentation process, using these tools and its combination of bioprocess engineering. 4. In addition, this provides broad understanding and experience of technological processes involved in biotechnological industries. 5. This course updates students' knowledge of new developments in biology of industrial relevance. 6. To provide a comprehensive understanding of the critical importance and underlying principles specific to QA/QC
Learning Outcomes:	1. Gain information about spoilage of milk and its products and its antimicrobial properties. 2. Learn various techniques for microbiological examination of milk and the importance of dairy technology preservation methods. 3. Students will be able to acquire knowledge on the types of fermentation process, bioprocess and the preparation of media and anaerobic digesters, current themes and insights, informed by the forefront of the Biotechnology industry and its related disciplines, 4. understand and apply scale-up methods for designing bioreactors. 5. Become familiar with principles of recovery and purification techniques of bioprocess. 6. Learners will be able to distinguish between concepts of quality assurance and quality control

Course Code USBT	Title	Unit	Topics	Credit	No. of Lectures
	Industrial Biotechnology	**I: Dairy technology**	Types of microorganisms present in milk: acid and gas producing, protein and fat splitting, pathogenic and inert organisms **-1 lecture;** Biochemical changes during storage and abnormal fermentation- **1 lecture;** Factors affecting bacteriological quality **- 1 lecture;** Microbiological examination of milk - **2 lectures** ;Dairy technology Preservation methods - **2 lectures**; Starter Cultures - **1 lecture;** Fermented products-Production process and spoilage of Cheese: Swiss and Cheddar - **2 lectures;** Butter - **1 lecture** Yogurt - **1 lecture** and Buttermilk - **1 lecture;**		15

504			Milk borne diseases: bacterial, Viral and other diseases**- 2 lectures.**	2.5	
		II: Fermentation processes	The fundamental concept of fermentation & bioprocess technology-**1 lectures;** Introduction to Inoculum development - **2 lectures;** Bacterial and fungal inoculum development with one example each - **3 lectures**, Concept of scale up, scale down challenges- **2 lectures;** Bioprocess monitoring and control, automated control vs manual control-**2 lectures**; Commercial production of various bioprocess based products (Bioethanol, Citric acid)-**2 lectures;** Single cell protein-**1 lecture** Microbial polysaccharides and their applications in food processing industries ; **-2 lectures**		15
		III: Down-stream Processing (DSP)	Downstream processing; definition, criteria, and typical steps involved in DSP(with examples) -**2 lectures;** Target application of product Vs cost - **1 lecture;** separation of cells and whole broth -**2 lectures;** Methods of cell breakage for harvesting intracellular products-**2 lectures;** Typical unit operation- Filtration-**1 lecture;** Centrifugation- **1 lecture;** Solvent recovery-**1 lecture;** Membrane processes - **1 lecture;** Drying - **1 lecture**; Crystallization- **1 lecture** Types and nature of waste generated in bioprocess- **2 lectures**		15
		IV: QA QC	Concept of GMP- **1 Lectures**; Requirements of GMP implementation - **2 Lectures;** Documentation of GMP practices - **2 Lectures**; Regulatory certification of GMP - **2 Lectures**; Quality Control (QC): Concept of QC - **2 Lectures;** Requirements for implementing QC - **2 Lectures**; QA concepts: Concept of QA - **2 Lectures**; Requirements for implementing - **2 Lectures**.		15
	Total				60

References:

1. Applied Dairy Microbiology Elmer H Marth and James L Steele Mercel Dekker Inc New York, 2nd edition
2. Sugumar D. (1997). Outlines of dairy technology, Oxford University press. 1997.
3. Dairy technology by Yadav and Grower
4. Microbial Technology Peppler,H.J and Perlman,D 2nd Academic Press Practicals
5. Industrial Microbiology Prescott and Dunn CBS publishers
6. Fermentation technology by Stanbury and Whittkar
7. Glazer, A.N. and Nikaido, H. (2008). Microbial Biotechnology. Cambridge University Press. 576 pp.
8. Pharmaceutical Microbiology by Russel and Hugo

PRACTICALS

USBT P 503-504 3 credits 120 hrs

1. Poster making on any of the following topics:
   i. Stem cell-based regenerative medicine
   ii. Autoimmunity
   iii. Cytokines
2. Anti globulin testing (Coomb's Test)
3. Analysis of Immunoglobulins by Serum electrophoresis
4. Detection of antigen-antibody complexes by Rocket immunoelectrophoresis.
5. Determination of fat content of paneer using gerber method
6. Determination of moisture content of paneer
7. Estimation of Milk protein-Pynes method
8. Microbial analysis of Milk by MBRT and RRT.
9. Phosphatase test in Milk
10. DMC of milk sample
11. Isolation of Normal flora from Milk and curd
12. Visit a Dairy plant to observe the preparation of Concentrated & dried milk and other dairy products.

Applied component	Computational Statistics and IPR
Course Objectives:	● Get insights of computational statistics using MS excel and R. ● Get introduced to the concepts of intellectual properties and IPR protection for biotech inventions. ● Understand the basics of patents like patent drafting, licensing and infringement.
Learning Outcomes:	● The learner will be able to analyze the data using MS Excel and R. ● The learner will understand different concepts of IP. ● The learner will know the drafting process in patenting.

Course	Title	Unit	Topics	Credits	Lectures
Applied component	**Computational Statistics and IPR**	**I: Computational Statistics using Ms Excel**	Loading of Data Analysis Toolpak in Excel. **1 lecture** Computation of Analysis of Variance, Correlation, Covariance, Descriptive Statistics, Exponential Smoothing **3 lectures** Random number generation from different distributions, Regression, Sampling, t-test, Z-test **5 lectures** Optimization using Solver **1 lecture** Computation of Determinants of matrix, Inverses of a matrix, Rank of a matrix, Solutions of matrix equations, Characteristic roots and vectors of a matrix **5 lectures**	2.0	15
		II: Computational Statistics using R	Starting and exiting R, getting help, setting, listing and deleting variables, creating vector, defining variables, creating sequences, performing vector arithmetic. **5 lectures** Entering data from key-board, reading tabular data files, reading from and writing to CSV-files, reading data from HTML tables, Initializing a matrix in R, performing Matrix		15

			operations. **5 lectures** Statistical Graphics in R: Basic Graphs- Bar, Pie, line, histograms, Box-plot, Scatter plot, QQ Plot. Descriptive Statistics **5 lectures**		
		III: Introduction to IPR	Introduction to patents, trademarks, trade secrets, copyright & related IPR rights, industrial design, traditional knowledge.geographical indications: **6 lectures** Biodiversity importance and legislation: **3 lectures** International convention and treaties:**3 lectures** Plant variety protection and farmers rights act: **3 lectures**		15
		IV: Patents	Basics of patents: eligibility criteria, classification of Patents, categories: **4 Lectures** patenting biological products. Patentable and non-patentable inventions in India: **4 lectures** Process of Patenting: Patent Search and Inventor's homework, drafting patent applications, Rights of the patent holder, assignment and licensing of patents and patent Infringement: **6 lectures** Patent Agent: **1 Lecture**		15
		Total			**60**

References:

1. Kshitij Kumar Singh (auth.) - Biotechnology and Intellectual Property Rights_ Legal and Social Implications-Springer India (2015)
2. Goel, D., & Parashar, S. (2013). IPR, Biosafety and Bioethics. Pearson Education India.
3. Gardener M. (2010) Beginning R : The STATistical Programming Language, Wiley India Pvt. Ltd., New Delhi
4. Teetor, Paul (2011) R Cookbook, O'Really
5. Bhattacharjee, D. (2010). Practical Statistics using Microsoft Excel, Asian Books, New Delhi
6. Levine, D. M., Stephan, D., Krehbiel, T.C. and Berenson, M.L. (2006). Statistics for Managers Using Microsoft Excel, Prentice Hall of India Pvt. Ltd., New Delhi.
7. Albright, S.C., Winston, W. L. and Zappe C. J. (2009) Decision Making Using Microsoft Excel, Cengage Learning, New Delhi.
8. Braun, W. J. and Murdoch, D. J. (2007) A First Course on Statistical Programming with R, Cambridge University Press.
9. Quirk, Thomas J.*, Rhiney, Eric.* (2020) Excel 2019 for Advertising Statistics*. A* Guide to Solving Practical Problems*, Springer*

PRACTICALS

Applied Component- Computational Statistics and IPR

2 Credits 4 LECTURES PER WEEK

1. To study a patent and to develop a patent application for a product or process.
2. Case Studies based on Patent.
3. Assignment on geographical indications
4. Computation of Analysis of Variance (ANOVA), Correlation and Covariance & Descriptive Statistics in Excel
5. Random Number Generation from Different Distributions in Excel
6. Simple Linear Regression in Excel
7. t-test and Z-test in Excel
8. Applications Basic R Commands, Vector Operations, Data Input and Output
9. Statistical Graphics - Create basic graphs: bar, pie, line, histograms, box plot, scatter plot, QQ plot.
10. Descriptive Statistics - Calculate descriptive statistics for one & two variables.
11. One-Way ANOVA - Perform a one-way & two-way ANOVA test.
12. Correlation Analysis - Calculate correlation coefficients between variables.
13. Regression Analysis - Perform linear regression analysis.
14. Hypothesis Testing - Conduct common tests of significance (t-test, chi-square test).
15. Data Visualization & Data Manipulation using R

Semester VI

USBT 601	**Plant and Animal Biotechnology**
Course Objectives:	1. Master the fundamental techniques of plant tissue culture, including media preparation, sterilization, 2. Analyze the physiological and molecular mechanisms by which plants respond to various abiotic stresses. 3. Understand the criteria for selecting appropriate model organisms for biological research.
Learning Outcomes:	1. Learners will develop a thorough understanding and gain practical skills of plant tissue culture, and animal cell culture, and model systems in biology.

Course Code USBT	**Title**	**Unit**	**Topics**	**Credits**	**Lectures**
601	**Plant and Animal Biotechnology**	**I: Plant Tissue Culture**	History of Plant tissue culture **1 lecture**, media preparation- Significance of Macronutrients, micronutrients, PGR, Trace elements, Carbon source, Fe- EDTA **2 lectures**, Different types of medium- MS medium, Gamborg medium, B5 Medium (Basal Media)-**2 lectures** Techniques in PTC with applications- Totipotency- **1 lecture**, Callus culture, Cell suspension culture- **2 lectures**, Protoplast culture- **1 lecture** ,Micropropagation- **2 lectures** , Somaclonal variations- **2 lectures**, Somatic hybridization and somatic embryogenesis- **1 lecture**, Cryopreservation- **1 lecture**.		15
		II: Plant stress Biology	Abiotic stress – Physiological and molecular responses of plants to water stress, salinity stress, temperature stress – heat and cold, Photooxidative stress, stress perception and stress signaling pathways,		15

			Ionic and osmotic homeostasis, reactive oxygen species scavenging- **4 lectures**. Biotic stress - plant interaction with bacterial-, viral and fungal pathogens- **4 lectures**, plant responses to pathogen–biochemical and molecular basis of host-plant resistance- **2 lectures** , toxins of fungi and bacteria-**1 lectures** , systemic and induced resistance –pathogen derived resistance- **2 lectures**, signaling- **2 lectures**.		
		III: **Animal Cell Culture**	Media used in Animal cell culture- **2 lectures**, Physicochemical Properties of Media, Components of Media, Types of Culture Medium- **3 lectures**, Cell culture Types and Their Properties-**2 lectures;** Morphological Differences in Mammalian Cell culture system, Subculture- **2 lecture**, Growth Conditions and Characteristics-**1 lectures**, Techniques for Detachment of Cells- **2 lectures**, Maintenance of Cell Line **2 lectures**. Applications of Animal Cell Culture Technology-**1 lecture**		15
		IV: **Model systems in Biology**	Concept of Animal Models, Approaches To Animal Care, Model Selection, Selection Criteria, Types of Models, Production Models **(5 lecture)** Commonly Used Animal Models- Mouse, Rat, Rabbit, Sheep, Guinea Pigs, Hamsters, **(8 lecture)** “Animal Rights” ethical Issues, Alternatives to Animal Research. **(1 lecture)** Model Plant: Arabidopsis **(1 lecture)**		15
		Total			60

References:

1. Introduction to PlantBiotechnology –H.S. Chawla- 3 rd Edition
2. Plant Tissue culture-M.K. Razdaan- 2nd edition
3. Introduction to Plant Physiology -Hopkins
4. Biotic interactions in plant-pathogen association-M. J. Jeger
5. Molecular plant pathology-Dickinson
6. Comprehensive and Molecular Phytopathology- Yuri Dyakov
7. Animal Cell Culture: Principles and Practice, Shalini Mani, Manisha Singh, Anil Kumar ISBN 978-3-031-19484-9, https://doi.org/10.1007/978-3-031-19485-6
8. Freshney, R. Ian. Culture of animal cells : a manual of basic technique and specialized applications, / R. Ian Freshney. – 6th ed. ISBN 978-0-470-52812-9
9. Textbook of Animal Biotechnology: B.Singh, S.K. Gautam, M.H. Chauhan; ISBN 978-81-7993-327-5, 2015.
10. Principles of Animal Research for Graduate and Undergraduate Students, Mark A. Suckow and Kay L. Stewart ISBN: 978-0-12-802151-4
11. "Handbook of Animal Models and its Uses in Cancer Research, Surajit Pathak Antara Banerjee Atil Bisgin, ISBN 978-981-19-3824-5 (eBook) https://doi.org/10.1007/978-981-19-3824-5"
12. "Using Animal Models in Biomedical Research, P. Chow, R. Ng, B. Ogden ISBN: 10 981-270-663-1"
13. Model Organisms in Plant Genetics, Ibrokhim Y. Abdurakhmonov ISBN 978-1-83969-751-7

USBT 602	**Genetic Engineering and Gene Editing**
Course Objectives:	The objective of this unit is to provide a comprehensive understanding of genetic engineering techniques applied to plants and animals, along with the use of advanced molecular biology tools and gene editing technologies. Students will gain theoretical and practical knowledge to apply these techniques in various biotechnological contexts. The Students will acquire knowledge on various recombinant DNA techniques to produce genetically modified organisms with novel traits. or On taking this course the student will be able to acquire knowledge on molecular techniques that are required to be a successful genetic engineer of plants, animals and microorganisms.
Learning Outcomes:	Students will be able to explain genetic engineering methodologies for plants and animals, utilize molecular biology tools for cloning and gene transfer, and apply advanced gene sequencing and editing technologies like CRISPR/Cas. They will also understand the implications of genetic modifications in health and disease. Students will be able to: 1. Demonstrate the basic principles that govern the genetic engineering techniques. 2. A good understanding of r-DNA technology, methods of gene transfer and the specificity of vectors for cloning and advantages. 3. Analyze and detect nucleic acid components from different sources using advanced molecular techniques 4. Exhibit knowledge in sequencing technologies and protein engineering techniques. 5. Explore the strategies for Gene cloning and its application in research, medicine and agriculture.

Course Code USBT	Title	Unit	Topics	Credit	No. of Lectures
602	**Genetic Engineering and Gene Editing**	**I: Genetic engineering of plants**	Genetic engineering of plants; Methodology. - **4 -Lectures** Plant transformation with the Ti plasmid of *A. tumefaciens*, Ti plasmid derived vector system; Transgenic plants: Physical methods of transferring genes to plants: electroporation, microprojectile bombardment, liposome mediated, protoplast fusion; **5 -Lectures** Vectors for plant cells; **4 Lectures** Improvement of seed quality protein **2 -Lectures**	2.5	15
		II: Transgenic Animals	Transgenic mice- methodology- retroviral method, **5 Lectures** DNA microinjection, ES method; genetic manipulation with cre-loxP; Vectors for animal cells - **3 Lectures**; Transgenic animals recombination system; **2 -Lectures** Cloning livestock by nuclear transfer - **2 Lectures** ; Green Fluorescent Protein. **2 lectures** Transgenic fish. - **1 -Lecture**		15
		III: Tools in Molecular Biology	**Cloning vectors: 5 -Lectures** Plasmids (pUC series) Cosmids Phagemids M13 Shuttle vectors YAC vectors Expression vectors: pET **Gene cloning: 4 -Lectures** Isolation and purification of DNA Isolation of gene of interest: Restriction digestion Electrophoresis Blotting Cutting and joining DNA		15

			Methods of gene transfer in prokaryotes and eukaryotes **Recombinant selection and screening methods: 3 Lectures** Genetic Immunochemical Southern and Western analysis Nucleic acid hybridization HART, HRT Factors affecting the expression of cloned genes. **Cloning strategies: 3 Lectures** Genomic DNA libraries cDNA libraries Chromosome walking and jumping		
		IV: Gene Sequencing and Editing	Maxam Gilbert's method, Sanger's dideoxy method, Automated DNA sequencing, Pyrosequencing; **6 -Lectures** Human genome mapping and its implications in health and disease; **3 -Lectures** RNAi, ZNF (Zinc finger nucleases), TALENS (Transcription Activator Like Effector Nucleases), CRISPR/Cas system (Clustered Regularly Interspersed Repeats) - **6 -Lectures**		15
		Total			60

References:

1. iGenetics A Molecular Approach 3rd Edition Peter J. Russell.
2. Molecular Biotechnology-Principles and Applications of Recombinant DNA Technology 3rd Edition Glick B.R., Pasternak J.J., Patten C.L.
3. Principles of Gene Manipulation 7th Edition Primrose S.B., Twyman R.M.
4. Biotechnology 3rd Edition S.S. Purohit.
5. Genomes 3rd Edition T.A. Brown.
6. Biotechnology B.D. Singh.
7. Gene Cloning and DNA Analysis 6th Edition T.A. Brown.
8. Genomics Cantor C.R., and Smith C.L. John Wiley & Sons. (1999)

PRACTICALS

USBT P 601-602 **3 credits** **120 hrs**

1. Surface sterilization of explant.
2. Study of the effect of abiotic stress on plants.
3. Estimation of antioxidant enzyme- Catalase activity in presence of abiotic stress.
4. Estimation of antioxidant enzyme- Peroxidase activity in presence of abiotic stress.
5. Estimation of antioxidant- Ascorbate in presence of abiotic stress.
6. Trypsinization of the animal tissue.
7. Determination of the percentage viability of cells by Trypan Blue.
8. Genomic DNA Extraction: Animal cells.
9. Transformation in *E. coli*.
10. Vector mapping by restriction endonuclease

USBT 603	**Basic Pharmacology and Neurobiology**
Course Objectives:	1. To understand the scope of pharmaceutical biotechnology in the field of pharma development. 2. Enhancing the basic pharmacological principles within the array of pharmacokinetics and dynamics. 3. Understand the toxic effects of certain misused drugs like alcohol, pesticides,etc 4. To study the anatomy of the nervous system, propagation of the impulse and the mode of action of different neurotransmitters, their agonists and antagonists, neurotoxins.
Learning Outcomes:	1. Learners may acquire the knowledge on the study of drugs and routes of administration. 2. Analyze drug distribution between the compartments of the body and understand the factors affecting the pharmacokinetics of drug in its therapeutic regimen. 3. Acquire knowledge on biochemical aspects of drug actions, receptors, drug receptors interactions, factors modifying drugs effects and the toxic effects of abused drugs. 4. Apply this knowledge in drug discovery.. 5. Understand the role of neurotransmitters and neurotoxins in drug discovery .

Course Code USBT	**Title**	**Unit**	**Topics**	**Credits**	**No of Lectures**
		I: General principles of pharmacology: Drug absorption and distribution	Definition and scope of pharmaceutical Biotechnology-**1 lecture;** Mode of action of pharmacological agents -**2 lectures;** Route of administration- **1 lecture;** Absorption-**2 lectures**, and Bioavailability of drugs factors influencing drug distribution -**2 lectures;** dose-response relationship: therapeutic index-**2 lectures;** ED, LD- **2 lecture**s, Potency and Intrinsic Activity- **2 lecture**s **;** Physiological barriers to drug distribution- **1 lecture**.		15

603	**Basic Pharmacology and Neurobiology**	**II: Pharmacokinetics and pharmacovigilance**	Pharmacokinetics: Drug Concentration–Time Profiles And Basic Pharmacokinetic Parameters- **3 lectures** Additional Pharmacokinetic Parameters - **4 lectures**; Pharmacokinetics Of Single Versus Multiple Dosing- **2 lectures**; Nonlinear Pharmacokinetics-**1 lecture**. Pharmacovigilance: Origins and definition of pharmacovigilance- **2 lectures**, Main lessons learned from Thalidomide tragedy- **1 lecture**, Scope and purpose of pharmacovigilance- **1 lectur**e, Development of pharmacovigilance, Major lessons to be learned from recent safety issues- **1 lecture**.	2.5	15
		III: Basic toxicology and regulatory toxicology	Background Definitions **1 lecture**; Causation: degrees of certainty Classification- **1 lecture** ; Causes Allergy in response to drugs Effects of prolonged administration: chronic organ toxicity - **2 lectures**; Adverse effects on reproduction - **1 lecture** Poisons: Deliberate and accidental self-poisoning Principles of treatment Poison-specific measures General measures- **1 lecture**; Specific poisonings: cyanide, methanol, ethylene glycol, hydrocarbons, volatile solvents, heavy metals- **3 lectures** ; herbicides and pesticides- **1 lecture**, ; biological substances (overdose of medicinal drugs is dealt with under individual agents)- **1 lecture**; Incapacitating agents: drugs used for torture ; Nonmedical use of drugs-**1 lecture** . Introduction to Pharmacopoeia- Introduction to Pharmacopoeia, Monographs- **2 lectures**, National Formulary of India (NFI);Types of Pharmacopoeia and a short description- **1 lecture**		15
		IV: Neurobiology	Anatomy and functioning of the brain- **3 lectures**,; Neuronal pathways-**2 lectures** ; Propagation of nerve impulses- **2 lectures**; Neuronal excitation and inhibition-**3 lectures** ;		15

			Synapses and gap junctions- **2 lectures** ; Action of Neurotoxins and neurotransmitters- **3 lecture**		
		Total			60

Reference:

1. Textbook of Medical Physiology Guyton, A.C and Hall 11th edition J.E Saunders
2. Modern Pharmacology with clinical Applications Craig,C.R, Stitzel,R.E 5th edition
3. Biochemistry Metzler, D.E Elsevier
4. Santoskar R.S. Nirmala N. Rege and Bhandarkar S.D, Pharmacology and Pharmacotherapeutics (Revised 23 rd Edition), Popular Prakashan, Mumbai.
5. Tripathy K. D, Essentials of Medical Pharmacology (6th edition), Jaypee publishers
6. Shoba rani R Hiremath, Textbook of industrial pharmacy, orient longman Pvt ltd 2008.
7. Pharmaceutical Biotechnology: Fundamentals and Applications, CRC Press, 2007.
8. Crommelin Daan J. A., Sindelar D. Robert (3rd edition)
9. Pharmaceutical Biotechnology: Fundamentals and Applications, Springer.
10. Patrick Waller and Mira Harrison‐ Woolrych An Introduction to Pharmacovigilance, Second Edition, ISBN 9781119289753
11. Clinical Pharmacology Bennet,PN,Brown,M.J, Sharma,P 11th edition; Elsevier
12. Indian Pharmacopeia Vol 1 2010 (Online)- only for introduction. Page nos.xvii-xxiii
13. https://www.ipc.gov.in/mandates/national-formulary-of-india-nfi/about-iprs.html
14. Textbook of Medical Physiology Guyton, A.C and Hall 11th edition J.E Saunders
15. Biochemistry Metzler, D.E Elsevier; 2nd edition vol 1-2

USBT 604	**Marine and Environmental Biotechnology**
Course Objectives:	**1. To explore the potential of marine organisms for biotechnological applications** **2. To understand types and sources of waste, management strategies** **3. To explore various waste treatment methods, including physical, chemical, biological and thermal processes.** **4. To learn about the management of hazardous waste and to stay updated on the latest technologies in waste management.**
Learning Outcomes:	**1. The learners will learn to assess and validate marine bioproducts for applications in biomedicine, cosmetics, and agri-food sectors.** **2. The learners will be able to identify and classify different types of wastes, their sources and characteristics.** **3. The learners will be able to describe various waste treatment technologies and will be able to assess the suitability of different treatments for specific types of waste.** **4. The learners will gain experience through laboratory experiments and field trips.**

Course Code USBT	**Title**	**Unit**	**Topics**	**Credits**	**No of Lectures**
	Marine and Environmental Biotechnology	**I: Introduction to bioprospecting, Marine drugs and enzymes**	Introduction to Marine Biotechnology, The marine ecosystem and its functioning: intertidal, estuarine, salt marsh, mangrove, coral reef, coastal & deep sea ecosystems. Hydrothermal vents- **4 lectures**; Bioprospecting, Marine Microbial Habitats and Their Biotechnologically relevant Microorganisms - **2 lectures**; Methods for Microbial Bioprospecting in Marine Environments - **1 lecture**; Approved Marine Drugs as Pharmaceuticals - **2 lectures;** Marine Extremozymes and Their Significance, Current Use of Marine Microbial Enzymes - **6 lectures.**		15

604		**II: Marine nutraceuticals, Functional foods and cosmetics**	Marine Nutraceuticals : Marine Bioactives as Potential Nutraceuticals, Functional Carbohydrates, Polyunsaturated Fatty Acids- **3 lectures;** Carotenoids, Soluble Calcium, Fish Collagen and Gelatin, Marine Probiotics -**2 lectures**. Marine Functional Foods: Marine-Derived Ingredients with Biological Properties- **2 lectures**; Functional Foods Incorporating Marine-Derived Ingredients -**1 lecture;** Cosmetics from Marine Sources: Cosmetics: Definition and Regulations, Cosmeceuticals , Target Organs and Cosmetics Delivery Systems , Components of Cosmetics, Major Functions of Some Marine Components in Cosmetics and Cosmeceuticals , Treatments Based on Marine Resources , Products Based on Marine Resources - **7 lectures**.	2.5	15
		III Management and Treatment of Waste-I	Types of waste - Solid wastes, Liquid wastes Gaseous wastes **1 lecture** **Management of solid waste-** Waste reduction and reuse, Waste collection, strategies of solid waste disposal, types of treatment - Thermal treatment, Thermochemical conversion methods, Biological waste treatment **5 lectures** **Treatment of wastewater** Objectives, characteristics of liquid effluent Primary, secondary and tertiary treatment Types of Biological Treatment – Aerobic, Anaerobic and Anoxic, Microorganisms involved **(2 lectures)** **Bioreactors for waste treatment (7 lectures)** Aerobic biological filters, Activated sludge, RBC,FBR, EBR, Anaerobic-UASB, Contact Digesters, PBR, SBR Process parameters		15

		IV Management and Treatment of Waste-II	**Wastewater monitoring** Estimation of BOD, COD, TSS, TVS, TDS, ash content, lignin, cellulose, hemicellulose Bacteriological examination of wastewater: Multiple tube fermentation method, MPN, other methods (nucleic acid based, biosensor based, Immunological-based methods etc.) **3 lectures** **Industrial Effluent Treatment** Steps involved in aerobic and anaerobic treatment **(1 lecture)** Treatment of effluent from dairy industry, distillery industry, vegetable oil industry (**3** lectures) **Bioremediation and Biodegradation** Types of Biodegradation, Role of microorganisms **(1 lecture)** Types of Bioremediation- In situ, Ex situ Advantages and limitations Bioventing, Bioaugmentation and Biosparging Reactors for Bioremediation **(4 Lectures)** Bioremediation of hydrocarbons, Use of mixture of Bacteria, Use of genetically engineered bacterial strains. Bioremediation of dyes, heavy metals , xenobiotics (**2 lectures**) Phytoremediation-Concept, types, limitations and applications **(1 lecture)**		15
		Total			60

References:

1. Kim, S.K. Springer Handbook of Marine Biotechnology; Springer: Berlin, Germany; Heidelberg, Germany, 2015.
2. Nollet, Leo M. L- Marine microorganisms- extraction and analysis of bioactive compounds-CRC Press_Taylor& Francis (2017)
3. R. S. K. Barnes, R. N. Hughes(auth.)-An Introduction to Marine Ecology, Third Edition-Wiley-Blackwell (1999)
4. Blanca Hernández-Ledesma, Miguel Herrero-Bioactive Compounds from Marine Foods-Plant and Animal Sources-Wiley-Blackwell (2013)
5. Fabio Rindi, Anna Soler-Vila, Michael D. Guiry (auth.), Maria Hayes (eds.)-Marine
6. Bioactive Compounds_ Sources, Characterization and Applications-Springer US (2012) W. Evans-Trease and Evans Pharmacognosy 15 th ed.-Saunders (2010)
7. Textbook of Environmental Biotechnology, Pramod Kumar, Vipin Kumar, Woodhead Publishing India PVT Ltd.
8. Environmental Biotechnology Alan Scragg Oxford University press
9. Environmental Biotechnology (Basic concepts and applications) Indu Shekhar Thakur IK International
10. Environmental Biotechnology (Industrial pollution management) S.D. Jogdand, Himalaya Publishing House
11. Environmental Biotechnology, Bimal C. Bhattacharya, Rintu Banerjee, Oxford University Press

PRACTICALS

USBT P 603-604 **3 credits** **120 hrs**

1. Visit to nearby coastal areas or marine research centers.
2. Study of any 2 marine bacteria or algae (Macro and micro)
3. DPPH assay for antioxidant extracted from marine algae
4. Extraction of carotenoids from marine algae / Bacteria / Fungi
5. Extraction and estimation of Gelatin from Fish.
6. Extraction of Collagen from Fish and estimation of Collagen by Bradford method.
7. Extraction of alkaloids from marine organisms and their separation by TLC.
8. LD 50, ED 50 evaluation using suitable models.
9. Study the effect of heavy metals on the growth of bacteria.
10. Determination of Total Solids from an effluent sample.
11. Study of physico-chemical (pH, color, turbidity, BOD, COD) parameters of any one industrial effluent sample
12. Visit to ETP/ CETP

Applied Component	**Agri Biotechnology**
Course Objectives:	1. To learn how to identify and utilize molecular markers for selecting desirable traits in crops, improving yield, disease resistance, and environmental adaptability. 2. To guide learners in creating comprehensive business plans for agricultural enterprises, encompassing production, marketing, financial planning, and risk management.
Learning Outcomes:	1. Learners will be able to develop innovative solutions to agricultural problems using modern techniques and technologies, ensuring improved crop performance and resource efficiency. 2. Learners will be able to demonstrate entrepreneurial skills and marketing acumen by developing viable agribusiness plans and strategies tailored to the agricultural sector.

Course	Title	Unit	Topics	Credit	No. of Lectures
Applied Component	**Agri Biotechnology**	**I: Precision Agriculture and Agriculture systems**	Introduction to Agriculture and Agriculture systems- **1 Lecture**; Green house Technology-- Types of green house, importance, functions and features of greenhouse, Design criteria and calculation **-3 Lectures**; Construction material, covering material and its characteristics, growing media, greenhouse irrigation system. nutrient management **-4 Lectures**; Greenhouse heating, cooling and shedding and ventilation system, Computer controlled environment **- 3 Lectures;** Phytotrons, fertigation and roof system **-2 Lecture**; Precision Cultivation- tools, sensors for information acquisition **-2 Lectures.**	2	15

		II: Molecular Markers in Plant Breeding	Genetic markers in plant breeding– Classical markers, DNA markers (RFLP, RAPD, AFLP, SSR, SNP)- **6 Lectures**; Application of Molecular Markers to Plant Breeding [quantitative trait locus (QTL) mapping] - **4 Lectures**; Plant DNA Barcoding- Barcoding Markers (matK, rbcl, ITS, tmH-psbA), steps, recent advances, Benefits, Limitations - **5 Lectures**.		15
		III: Biofertilizers and Biopesticides	Biofertilizer: Nitrogen-fixing Rhizobacteria - Symbiotic Nitrogen Fixers **-2 Lectures;** Nonsymbiotic Nitrogen Fixers Plant Growth Promoting Microorganisms-Phosphate-Solubilizing Microbes (PSM), Phytohormones and Cytokinins, Induced Systemic Resistance- **5 Lectures;** Plant Growth Promotion by Fungi--Mycorrhizae Arbuscular Mycorrhizae Ectomycorrhizae -**2 Lectures;** Microbial Inoculants -- Inocula, Carriers, and Applications, Monoculture and Co-culture Inoculant Formulations Biocontrol, Polymicrobial Inoculant Formulations-**3 Lectures**; Biopesticides – types, *Bacillus thuringiensis*, insect viruses and entomopathogenic fungi (characteristics, physiology, mechanism of action and application) **-3 Lectures.**		15
		IV: Entrepreneurship and Marketing	Concept of Entrepreneur; Entrepreneurship; Need and Importance; Factors Influencing Entrepreneurship; Essentials of a Successful Entrepreneur Marketing Plan for an Entrepreneur; **5 lectures** Strategic Alliances, Advertising and Sales Promotion; Market Assessment, Need for International Market Research, Domestic vs. International		

			Market Research, Cost and Methodology of Market Research, Desk and Field Research **10 lectures**		15

References:

1. Intelligent Environmental Sensing Henry Leung, Subhas Chandra Mukhopadhyay (eds.)
2. QTL mapping and its applications in crop plants, B M Prasanna
3. Advances in Applied Microbiology, Sima Sariaslani and Geoffrey M. Gadd
4. Biotechnology for Sustainable AgricultureRam Lakhan Singh, Sukanta Mondal
5. Microbial Biopesticides, Opender Koul, G. S. Dhaliwal
6. M. Ajmal Ali, G. Gyulai, F. Al-Hemaid -Plant DNA Barcoding and Phylogenetics, LAP Lambert Academic Publishing (2015)
7. P. Parvatha Reddy (auth.)-Sustainable Crop Protection under Protected Cultivation, Springer Singapore (2016)
8. S.B. Anderson (ed.), Plant Breeding from Laboratories to Fields, InTech,2013
9. Henry Leung, Subhas Chandra Mukhopadhyay (eds.) - Intelligent Environmental Sensing (2015, Springer International Publishing)
10. Travis R. Glare, Maria E. Moran-Diez - Microbial-Based Biopesticides_ Methods and Protocols (2016, Humana Press)
11. Altieri, Miguel A.Farrell, John G-Agroecology- The Science Of Sustainable Agriculture, Second Edition-CRC Press (2018)
12. Arie Altman, Paul Michael Hasegawa-Plant Biotechnology and Agriculture_ Prospects for the 21st Century-Academic Press (2011)

PRACTICALS

Applied component-Agri-Biotechnology

USBT P 605 **2 credits** **4 LECTURES PER WEEK**

1. RAPD / AFLP / RFLP analysis. (Demonstration experiment)
2. Isolation of Rhizobium
3. Isolation of Azotobacter
4. Isolation of Phosphate solubilising bacteria
5. Compost Analysis- C, NO_3, NO_2, Ca.
6. Soil analysis- pH, Moisture, Water content.
7. Visit the greenhouse facility and submit a field visit report.
8. Submission and presentation of business proposal for any Biotechnological product / enterprise.