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GROUP-1		
Sl. No.	**Course Code**	**Course Name**
1	16BBT24	Environmental Biotechnology
2	16BBT251	Food Biotechnology
3	16BBT253	Pharmaceutical Biotechnology
4	16BBI254	Metabolic Engineering
5	16BBI422	Health Informatics

GROUP-2		
Sl. No.	**Course Code**	**Course Name**
1	16BBT151	Enzyme Technology
2	16BCE21	Bio-separation and Downstream processing
3	16BBC24	Plant and animal Biotechnology
4	16BBC251	Cell culture techniques
5	168BBT153	Immunotechnology

GROUP-3		
Sl. No.	**Course Code**	**Course Name**
1	16BCE423	Fermentation technology
2	16BCE424	Animal cell culture and tissue engineering
3	16BCE421	Biological waste water treatment
4	16BCE422	Biological thermodynamics
5	16BBT154	Genetic Engineering Techniques

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GROUP-4		
Sl. No.	**Course Code**	**Course Name**
1	16BBT12	Concepts in biotechnology
2	16BBC14	Molecular biology and genetic engineering
3	16BBC152	Computational biology
4	16BBC23	Bioprocess separation and product recovery
5	16BBT21	Industrial Biotechnology

GROUP-5		
Sl. No.	**Course Code**	**Course Name**
1	16BBT13	Principles of biochemical engineering
2	16BBC153	Bioprocess control and instrumentation
3	16BBC22	Bioreactor plant design
4	16BCE14	Bioreactors
5	16BCE13	Bioprocess Engineering

GROUP-6		
Sl. No.	**Course Code**	**Course Name**
1	16BCE24	Safety Management in Bioprocess Industries
2	16BCE41	Bioenergy
3	16BCE23	Chemical biochemical reactions
4	16BBI152	Genomics and Proteomics
5	16BBI251	Protein Engineering & Design

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01	16BBT24	Group-1	ENVIRONMENTAL BIOTECHNOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1 INTRODUCTION TO ENVIRONMENT: Concerns pertaining to Ecological damage, Environmental Pollution Types - Water, Soil, Air, Noise and Thermal pollutions, their sources and ecological effects of pollutants on living and non-living systems.. Acid rain: sources and solutions. Significance of GHGs and carbonfootprint; Biodegradation, of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Microbial desulfurization of coal. Environmental implications of Acid mine drainage and its remediation; Role of Biotechnology in providing solutions to environmental problems

Module -2BOD, COD and TOC – Estimation and correlation; Definition of Waste; Physical, Chemical and Biological characteristics of Industrial waste. Nitrification and Denitrification and their kinetics; Wastewater treatment systems. Waste Management in different industries (food processing, leather tanning, harmaceutical, textile) Solid waste management: landfills, composting, earthworm treatment, recycling and processing of organic residues, Sources and dispersion of atmospheric pollutants and dispersion models. Control methods for air pollutants, noxious pollutants and odor control; Design of air pollution control equipments; Photochemical reactions.

Module -3 WASTE TREATMENT METHODS: Types (Suspended and Attached growth processes), Aerobic and Anaerobic treatment of wastes; Other biological treatment process, Anaerobic digestion – Stoichiometry & Kinetic relationships, design consideration, Process modeling and control, Biological nutrient removal, Biological treatments with Case studies; Bioremediation types and biorestoration of contaminated lands. Handling of hazardous wastes from bioprocess industries and related case studies.

Module -4 ENVIRONMENTAL SENSING TECHNIQUES: Characterization of water contaminants and their measurement, Spectroscopic techniques, AAS, NAA, GCMS, HPLC, Electro analytical techniques, Environmental sensing techniques. Discussions with Case studies.

Module -5 ENVIRONMENTAL POLICIES AND REGULATIONS: Waste minimization and its plan; Conservation of water and energy, Fugitive loss, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development, Environmental Management Systems, ISO and ISO 14000 series: Introduction, Areas covered in the series of standards, Necessity of ISO certification, Environmental Auditing; Other tools for environmental management, Environmental Impact assessment(EIA) and its future and scope. Objectives, Elements of EIA, Baseline studies Methodologies of EIA , , Types of impacts, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India. EIA at various industries

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Bailey & Ollis, Biochemical Engineering Fundamentals, 2 nd Edition, McGraw Hill International Edition, 1986
2. Standard Methods for the Examination of Water and Waste Water, 22ndEdition , AmericanPublic Health Association, American Water Works Association & Water Environment Federation, 2012.
3. Environmental Management, N K Uberoi, 2 nd Edition, Excel Books publication, 2007
4. Environmental Impact Assessment, Canter, 2 nd Edition, McGraw Hill International Edition,1996

TEXT BOOKS

1. Pradipta Kumar Mohapatra, Textbook of Environmental Biotechnology, I K International, 2007
2. Buckingham and Evans, Hazardous Waste Management, LaGrega, 2 nd Edition, McGraw Hill International Edition, 2001.
3. Noel De Nevers Air Pollution Control Engineering, 2 nd Edition, McGraw Hill International Edition, 2000

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02	16BBT251	Group-1	FOOD BIOTECHNOLOGY

Exam Hours:03 **Exam Marks:100**

Module -1 Basic Constitutes of Food: Basic constituents of food, colloidal systems in food, olecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods. Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins.

Module -2 Food Preservation Technology: Food preservation by high and ultra high temperatures- canning, drying. Food dehydration: Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins.

Module -3 Introduction to plant cell culture. Explant selection, sterilization and inoculation; Various media. Food Production Technology: Importance of food industry, specific objectives of food processing, impact of food processing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, probiotic
cheese.Nutritional value, labeling of constituents: Soya foods, organic foods, dietary foods, nutritional food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin),microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.

Module -4 Biotechnology for Improved Processing: Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.

Module -5 Food Quality Assurance and Control: Importance and functions of quality assurance and control. Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws and standards.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. H. Elmer, L James, Marath and Steele. Applied dairy microbiology, CRC press, 2nd edition, 2005.
2. R. Paul Singh., "Introduction to Food Engineering", Academic Press, 3rd Ed., 2004.
3. P. Fellows, "Food Processing Technology: Principles and practice". Woodhead Publishing Ltd., Cambrideg, 2nd Ed., 2005.

TEXT BOOKS

1. James M, Jay. Food Biotechnology CBS Publishers , 2nd edition, 2005.
2. Kalidasshetty Food Biotechnology, CRC Press. 1st ed. 2005
3. T.Britze, R.K Robinson., Advanced Dairy Science and Technology. Wiley- Blackwell publisher. 1st edition. 2008

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03	16BBT253	Group-1	PHARMACEUTICAL BIOTECHNOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1 Introduction: Introduction to pharmaceutical biotechnology, pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles. Quality assurance and control; Concept of GMP, GLP.

Module -2 THERAPEUTICS BASED ON BIOTECHNOLOGY: Hematopoietic growth factor and coagulation factors, interferons and cytokines; Preparation and standardization of hormones-thyroid, insulin and growth hormones; Enzymes-Enzymatic therapy and monographs; antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics (any two); vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diptheria and tetanus; antitoxinsdiptheria and gas-gangrene(any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage.

Module -3 BIOTRANSFORMATION: Introduction, methods used in biotransformation, steroid ransformation, contraceptives, L- Dopa, chemical reactions and mechanisms (hydroxylation, aromatization, synthetic routes, epoxidation and others), production and application of monoclonal antibodies.

Module -4 NUTRACEUTICALS: Antioxidants, flavanoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, deficiency diseases, nutritional status evaluation. Drug delivery systems: Introduction to drug delivery systems and methods, overview of barriers, calculation of drug metabolism and, pharmacodynamics.

Module -5 RECOMBINANT PROTEINS AND PROTEOMICS IN DRUG DEVELOPMENT: Role of proteomics in drug development Application of recombinant proteins in pharmaceutical industry, health care and future prospects.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Manfred E. Wolff Burger's Medicinal Chemistry and Drug Discovery (5th edition) Wiley & Sons, Inc. 2000.
2. Binghe wang, Teruna siahaan, Richard soltero Drug delivery: principles and applications John wiley & sons, 2005
3. Michael D. Coleman Human Drug Metabolism: An Introduction John Wiley & Sons, 2005
4. Ala F. Nassar, Paul F. Hollenberg, and JoAnn Scatina Drug metabolism handbook concepts and applications John wiley & sons 2009.

TEXT BOOKS

1. Walsh G (2003). Biopharmaceuticals: Biochemistry and Biotechnology, Second Edition. John Wiley & Sons Ltd.
2. Pharmaceutical Biotechnology:Fundamentals and Applications, Editors: Crommelin,
Daan J. A., Sindelar, Robert D., Meibohm, Bernd (Eds.) 2013
3. Modern Biopharmaceuticals: Recent Success Stories by Jorg Knablein 2013, Wiley- Blackwell
4. Modern Biopharmaceuticals: Design, Development and Optimization, 4 Volumes Set 2005 by Jorg Knablein2013, Wiley-Blackwell
5. Pharmaceutical biotechnology by Ashutoskar
6. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Second Edition 2012 by Oliver Kayser, Heribert Warzecha wiely publishing house

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04	16BBI254	Group-1	METABOLIC ENGINEERING

Exam Hours:03 **Exam Marks:100**

Module -1 Introduction to Cellular Metabolism: Metabolic engineering and its multidisciplinary nature; Review of cellular metabolism; Models for cellular reactions; Material balances and data consistency-Block box model, elemental balances, heat balance and analysis.

Module -2 Regulation of Metabolic Pathways: Regulation of enzyme activity- Reversible and irreversible inhibition systems, regulation of enzyme concentration- Control of transcription and translation. Global control: Regulation at whole cell level- regulation of metabolic networks.

Module -3 Metabolic Pathway Manipulations:Enhancement of product yield and productivity- Ethanol, Amino acids and Solvents. Extension of substrate- Sucrose utilization and pentose metabolism for ethanol production. Product spectrum and novel products- Antibiotics, Polyketides, Vitamins, Biological pigments. Improvements of cellular properties- Nitrogen metabolism, Oxygen utilization, Overflow metabolism and genetic stability maintenance. Xenobiotics degradation of Polychlorinated Biphenyls (PCBs) and Benzene, Toluene, p-Xylene Mixtures (BTX).

Module -4 Metabolic Flux Analysis:Methods for determination of metabolic fluxes by isotope labeling- Fractional label enrichment, complete enumeration of TCA cycle metabolite isotopomers from labeled pyruvate and acetate. Applications of metabolic flux analysis: Amino acid production by Glutamic acid bacteria and mammalian cell cultures. Flux analysis of metabolic networks- Bottomup Approach, Top-Down Approach.

Module -5 Metabolic Control Analysis (MCA): MCA theorems, determination of flux control coefficient. MCA of linear and branched pathways. Theory of large deviations.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT /REFERENCE BOOKS

1. Gregory N. Stephanopoulos, Aristos A. Aristidou and Jens Nielsen. Metabolic engineering –Principles and Methodologies. Academic press, USA 1998.
2. Nestor V. Torres and Eberhard O. Voit, Pathway analysis and optimization in metabolic,Cambridge University Press, 2002.
3. Shuler M.L. and F. Kargi. Bioprocess engineering basic concepts, 2ndEdn, Prentice Hall, 2001.
4. Cortassa s., Aon, M.A., Lglesias, A.A., and L LyodD. An introduction and metabolic and cellular Engineering. World scientific publications Pvt ltd. Singapore. 2002.

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05	16BBI422	Group-1	HEALTH INFORMATICS
Exam Hours:03		**Exam Marks:100**	

Module -1An introduction to Health care informatics: An interaction between health care and information systems. Acquisition, storage, retrieval, and use of information in health and biomedicine. Tools and techniques. Information systems in Medicine, Dentistry, Nursing, surgery and diagnosis. Future prospects.

Module -2Building blocks of Health care informatics: Standards, types of standards. Modeling –principles of modeling for healthcare. Architecture of Health care system – models, subsystems, packages and components. Modeling framework for health care. generic health care information model. Unified modeling language. Modeling methodologies in healthcare systems. Databases, types, and applications. Database Architecture; ANSI/SPARC three tier architecture. Data warehousing; architecture.

Module -3 Tools and techniques in Health Informatics: Introduction, conditions for telemedicine development, applications, access techniques in telecare and Internet technologies in medical systems: Requirement of Medical systems in the internet environment, internet medical architectures, and internet based telemedical services, next generation point of care information systems, internet access technologies in Telecare Wireless communication technologies. Electronic Health records (HER): Challenges in clinical care, characteristics of good EHR, Generic EHR representation, EHR Standards and Scope of the HER.

Module -4 Decision support systems and Telematic networks in Medicine: Decision support systems, knowledge based and Expert based. Probabilistic and Logical decision systems. Transport layer in telematics networks, health digital data standards, E-health networks services.

Module -5 Applications of IT in hearing and chronic problems: Methodology of hearing screening, computer aided adjustment of hearing aids, diagnosis, tinnitus treatment. Application of IT to diagnose chronic conditions patient-centered symptom monitoring. Computer aided techniques in Medicine: Laproscopic surgery navigation, Introoperative imaging, multimodel imaging, Biosignal processing and algorithms. Biosignal databases.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS/REFERENCE BOOKS

1 Naakesh A. Dewan, John Luo, Nancy M. Lorenz. Information Technology Essentials for Behavioral Health Clinicians, 2010.
2. Krzysztof Zielinski, MariuszDuplaga. Technology Solutions for Healthcare, 2006.
3. Moya Conrick, Health Informatics, 2006.
4. Frank Sullivan, Jeremy Wyatt. ABC of Health Informatics, 2009

01	16BBT151	Group-2	ENZYME TECHNOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1 Introduction, current and potential uses of enzyme technology. Enzymes as biocatalysts: advantages and disadvantages over chemical catalysts and characteristics. Extraction and Purification of Enzymes: xtraction of enzymes: Extraction of soluble enzymes and membrane bound enzymes, nature of extraction medium and conditions of extraction. Purification of enzymes: preliminary and secondary purification rocedures, degree of purification and criteria of purity of enzymes. Determination of molecular mass of nzymes.

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Module -2 Enzymatic Techniques: Principles of enzymatic analysis. End-point and kinetic methods, mmunoassays, spectro photometric, electrochemical and radiochemical. Test strips methods, automation in enzymatic analysis: fixed time, fixed and continuous concentration. Handling of enzymes and coenzymes. Applications of enzymes in medicine and diagnostic kits; therapeutic enzymes.

Module -3 Industrial Applications of Enzyme Technology: Textile industry, detergents, pulp and paper, eather, wood, animal feed, food and dairy industry - amylases, proteases, lipases, pectinases. Immobilization of Enzymes: Introduction, immobilization techniques and carriers. Immobilization techniques for soluble and insoluble (bound) enzymes. Immobilization of cells and organelles. Activity and kinetics of immobilized enzymes.

Module -4 Immobilized Enzyme Reactors: Types of bioreactors: Batch stirred tank, plug-flow tubular, continuous stirred tank, fixed (packed) bed, fluidized bed and membrane. Applications Of Immobilized Enzymes: Enzyme sensors for clinical analysis, therapeutic medicine (intracorporeal and extracorporeal applications). Production of highfructose corn syrup, L-aspartic acid, L- alanine and acrylamide. nvironmental applications. Economic aspects of immobilized enzymes, microorganisms, mammalian cells and plant cells. Safety aspects.

Module -5 Enzyme Engineering: Glucose isomerase, subtilisin, redesigned lactate dehydrogenase. Synthetic enzymes peroxidase. Catalytic antibodies.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Price N. C. and L Stevens. Fundaments of Enzymology: 3rd edn. Oxford University Press. 2003.
2. Trovor Palmer. Enzyme- Biochemistry, Biotechnology, Clinical chemistry. East West Press Pvt Ltd. 2004.
3. Bommanius A.S. and R. Riebel. Biocatalysis. Wiley-VCH. 2004.
4. Octave Levenspiel. Chemical Reaction Engineering. 3rd Edition. John Wiley and Sons. 1999.

TEXT BOOKS

1. Klaus Buchholz, Volker Kasche and Uwe Theo Bornscheuer. Biocatalisys and Enzyme Technology. 1st edn. Wiley-VCH, 2005.
2. Wolfgang Aehle. Enzymes in industry-production and applications. 3rd edn. Wiley- VCH, 2007.
3. Chaplin M.F. and C. Bucke. Enzyme Technology. CUP. Cambridge. 1990.

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02	16BCE21	Group-2	BIOSEPARATION AND DOWNSTREAM PROCESSING

Exam Hours:03 **Exam Marks:100**

Module -1 INTRODUCTION Role and importance of downstream processing in biotechnological processes. Problems and requirements of byproduct purification. Economics of downstream processing in Biotechnology. Cost cutting strategies, Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes.

Module -2PRIMARY SEPARATION TECHNIQUES Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; flocculation and sedimentation, Centrifugation (ultra and differential) and filtration methods. Solid-liquid separation with theory of batch filtration, Theories of Centrifugal force, equipments and centrifugal filtrations, numericals.

Module -3 ISOLATION AND PRODUCT PURIFICATION: Extraction: Principles of extraction, batch and staged extraction, differential extraction. Adsorption: Chemistry of adsorption, batch and continuous adsorption. Precipitation: Precipitation methods with salts, organic solvents, and polymers. Electrophoresis: Principle and Applications of Electrophoresis - their types, Iso-electric focusing.

Module -4MEMBRANE SEPARATION PROCESSES Membrane – based separations theory; Design and configuration of membrane separation equipment; Applications: Use of membrane diffusion as a tool for separating and characterizing naturally occurring polymers; enzyme processing using ultra filtration membranes; separation by solvent membranes; reverse osmosis.

Module -5FINISHING OPERATIONS AND FORMULATIONS Finishing operations: crystallization: Basic concepts, crystal size distributions, batch and recrystallization. Drying: basic concepts, drying equipments, lyophilization, principle of lyophilization, working and applications of lyophilization and formulations

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Verrall, M.S. Downstream processing of natural products: A practical handbook: John Wiley & Sons Ltd., England, UK. 1996.
2. Elliott Goldberg, Handbook of downstream processing, Blackie Academic and Professional, 1997.
3. Mulder, M. Basic principles of Membrane Technology: Kluwer Acadamic Publishers, Netherlands. 1996
4. Product Recovery in Bioprocess Technology - BIOTOL Series,VCH,1990.
5. Asenjo J and Dekker M, **Separation Process in Biotechnology**, Marcell Dekker Publications,1993

TEXT BOOK

1. Belter PA, Cussier E and Wei Shan Hu, **Bioseparation –Downstream processing for biotechnology,** John Wiley & Sons, New York.1988.
2. Roger G Harrison,**Bioseparataions**: Science and Engineering, Oxford Publications, 2006**.**

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03	16BBC24	Group-2	PLANT AND ANIMAL BIOTECHNOLOGY

Exam Hours:03 **Exam Marks:100**

Module -1 INTRODUCTION TO PLANT TISSUE CULTURE: Tissue culture media (composition and preparation) Sterlization methods; Culture media and growth regulators; Various types of culture and single cell isolation techniques; callus, suspension, Totipotency; Organogenesis, somatic embryogenesis. Embyo culture. Androgenesis and gynogenesis. Endosperm culture. Protoplast culture, selection of cybrids and asymmetric hybrids. Cryopreservation.

Module -2 INTRODUCTIONS TO PLANT GENETIC ENGINEERING: Gene isolation – General strategies for cloning genes from plants. Types of plant vectors; Ti and Ri-plasmids: structure and functions, Ti plasmid based vectors, advantages. Gene transfer techniques in plants; Vector mediated (Agrobacteriumand Virus mediated gene transfer), Direct gene transfer (Physical and Chemical methods). Screening and selection of transformants – Marker g enes (Reporter genes and selectable markers). Molecular markers and Marker-Assisted selection- Non-PCR based approaches (RFLP) and PCR based techniques- RAPD, AFLP, SSRs, STS.

Module -3 TRANSGENICS: for long shelf life of fruits , Stress Resistance, Herbicide resistance - phosphoinothricin, glyphosate, atrazine; Insect resistance, Transgenics for increased nutritional quality (Golden Rice), male sterile lines- barstar and barnase systems, Molecular farming for the production of lipids, fatty acids, biodegradable polymers, industrial enzymes, antibodies and edible vaccines.

Module -4BIOLOGY OF CULTURED CELLS: Animal Cell culture media- Physiochemical properties, Balanced salt solutions, complete media, Serum containing and Serum- free media. Primary culture- Types, Primary explants and method of tissue disaggregation, Chick embryo cell culture, Mouse embryo cell culture, Human biopsy materials. Subculture and Propagation of cell cultures. Quantitation and Cytotoxicity assays - hemocytometer, Electronic counting, Dye exclusion and inclusion tests, clonogenic assay, Metabolic assays, MTT based assay. Cell lines – Properties of finite and continuous cell lines, characterization, authentication, routine maintenance and preservation of cell lines. Contamination - Detection and Prevention of contaminants. Scale-up of animal cell cultures- Scale-up in suspension and monolayer. Immortalization of cell lines.

Module -5*Invitro* fertilization and embryo culture., Embryo preservation, Artificial insemination, preparation of foster mother, embryo transfer, Cloning - concept of nuclear transfer, nuclear reprogramming and creation of Dolly; Stem cells - embryonic and adult stem cells, plasticity and concept of regenerative medicine; Genetherapy (ex vivo and in vivo), Tansgenic animals: Methods of transgenesis and applications (biopharming, disease

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. R Ian Freshney, Culture of Animal Cells, Wiley-Liss Publications, 2011
2. HS Chawla, Biotechnology in Crop Improvement, Intl Book Distributing Company. 1998
3. Butler M, Animal Cell Technology: Principles and Practices, Oxford Press. 2005
4. R.E. Spier and J.B. Griffiths, Animal Cell biotechnology, Academic press. 1992.

TEXT BOOKS

1. R.A. Dixon & Gonzales Plant Cell Culture: A Practical Approach, IRL Press. 1994.
2. Murray Moo-Young, Animal Biotechnology, Pergamon Press, 1989
3. S.S. Bhojwani and M K Razdan, Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam. 1996
4. William G Hopkins, Plant Biotechnology, Infobase Publishing, 2007.

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04	16BBC251	Group-2	CELL CULTURE TECHNQIUES
Exam Hours:03		**Exam Marks:100**	

Module -1 INTRODUCTION TO PLANT CELL AND TISSUE CULTURE: Definition and technologies; Design of typical plant tissue culture laboratory and its management. Sterilization methods and principles; Plant tissue culture (PTC): Media composition, phytohormones and their selective usage, Concept of Cellular Totipotency. Callus & suspension cultures. Plant propagation: Regeneration through meristem and callus cultures; Somatic embryogenesis: production, preservation and use of somatic embryos as propagules; Artificial Seeds and Automation of Somatic Embryo Production. Embryo culture; Haploid plant production; Protoplast culture; Somatic hybridization; Induction & utilization of somatic variants; Cryopreservation: Storage of germplasm.

Module -2PLANT TISSUE CULTURE AND BIOSYNTHESIS OF SECONDARY PRODUCTS:
Principles and the technology, pharmaceutical, pigments, other natural products and beverage production; Kinetics, scale up and Characterization: optimization of physiochemical parameters. Plant secondary metabolites manipulation of different pathways (Metabolic engineering), genetic stability of production. Large scale production of secondary metabolites: Different types of reactors and their design; Biotransformation: Principle and applications; Commercialization of tissue culture technology: Concept of commercialization.

Module -3 ANIMAL CELL CULTURE TECHNIQUES, LABORATORY
DESIGN & EQUIPMENTS: Sterilization of different materials used in animal cell culture; Aseptic concepts; Maintenance of sterility; Cell culture vessels. Media and reagents: Types of cell culture media; Ingredients of media; Physiochemical properties of the culture media; Balance salt solutions; Natural and artificial media, Serum and its importance, Serum free media, chemically defined media, Protein free media; Preparation and sterilization of cell culture media, serum and other reagents.

Module -4PRIMARY CULTURE TECHNIQUES AND CELL LINES: selection, isolation and preparation of tissue (mouse and chick embryo isolation); isolation of cells by tissue disaggregation; enzymatic & mechanical methods. Viability tests and Quantitation. Criteria for Sub culture. Secondary culture. Characterization and maintenance of cell lines. Continuous cell lines, Organotypic culture, preservation of cell lines. Common cell culture contaminants. Biology of cultured cells. Stem cells; Types, identification, culture and applications. Scale up studies. Concepts of tissue engineering and case studies.

Module -5MICROBIAL CELL CULTURE TECHNIQUES: Sterilization, media preparation and Culture maintenance. Isolation of pure-colonies. Bacterial titre estimation. Growth kinetics. Culture characterization. Auxotroph culture isolation. Biochemical characterization. Antibiotic sensitivity. Bacterial recombination, Replica plating technique, Preservation methods. Screening and isolation of microorganisms, Primary and secondary screening, Metabolic screening, Enrichment and specific screening for the desired product. Strain improvement for the selected organism: strategies of strain improvement for primary, secondary metabolites with relevant examples. Use of UV/Chemicals, recombinant DNA technology, protoplast fusion techniques for strain improvement of primary and secondary metabolites. Selection of improved Strain/Cell line.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. John R. W. Masters. Animal Cell Culture:. A Practical Approach. 5 th edn. Oxford University Press. 2000
2. M M Ranga. Animal Biotechnology: 3rd Edition. Agrobios (India) 2007.
3. M. Prescott Microbiology. Lansing. WCB/McGraw-Hill. 1999.

TEXT BOOKS

1. Bhojwani SS. Plant Tissue Culture:. Theory and Practice. Elsevier. 1983
2. Chawla H S. Introduction to Plant Biotechnology:. (2^{nd} edn).Science Publishers Inc. 2002

3. Roberta H. Smith Plant Tissue Culture: Second Edition: Academic Press. 2000
4. Freshney I., Culture of Animal Cells : 5th Edition, Wiley-Liss. 2005.
4. Stanbury P.F., and Whitaker A Principles of Fermentation Technology, Pergamon Press,

05	16BBT153	Group-2	IMMUNOTECHNOLOGY

Exam Hours:03 **Exam Marks:100**

Module -1 THE IMMUNE SYSTEM: Introduction: Phylogeny of Immune system, Immunity, Clonal nature of immune response. Organisation and structure of lymphoid organs and cells. Nature and Biology of antigens and antibodies classes, subclasses and determinants.

Module -2 LYMPHOCYTE MEDIATED IMMUNITY B-lymphocytes and their activation; Genetic control of antibody production, production of monoclonal and polyclonal antibodies. MHC Complex, antigen presenting cells (APC), mechanisms of T cell activation, Cell mediated cytotoxicity: mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity and macrophage mediated cytotoxicity Antigen processing and presentation.

Module -3 IMMUNE REGULATION AND THERAPY Complement activation**,** cytokines, Hypersensitivity, Autoimmunity, Immuno-deficiency, production of recombinant-DNA vaccines. Catalytic antibodies, application of PCR technology to produce humanized antibodies, immunotherapy with genetically engineered antibodies,

Module -4TRANSPLANTATION IMMUNOLOGY Immunological basis of graft, types of transplantation, mechanism of graft rejection, role of HLA in graft rejection, tissue typing, immuno-suppression and immunosuppressive drugs, immuno-tolerance, tumor specific antigens, mechanism of AIDS

Module -5IMMUNODIAGNOSIS Antigen antibody interaction – Precipitation reactions, Agglutination reactions, Blood typing, A, B, ABO & Rh, principles and applications of ELISA, Radio Immuno Assay (RIA), western blot analysis, immunoelectrophoresis, surface Plasmon resonance (SPR)based immunoassay, immuno-fluorescence, chemiluminescence assay, FACS.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books

1. Janeway C. and Travers P., "Immunobiology", Garland Publ. (2001).
2. Abbas A., Litchman A. H., and Pober J., "Cellular and Molecular Immunology" W B Saunders & Co.(2000)

Text Books

1. Sharon J.,"Basic Immunology" Williams and Wilkins. (1998).
2. Roitt I., Brostoff, J and Male, D., "Immunology", Mosby Publ. (2002).
3. Kuby J., "Immunology", W.H. Freeman & Co. (2006).

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

01	16BCE423	Group-3	FERMENTATION TECHNOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1INTRODUCTION TO FERMENTATION PROCESSES: The range of fermentation Processes: Microbial Biomass, Enzymes, Metabolites and Transformation Processes; Development of fermentation Industry; Components of Fermentation Process;
Microbial Growth Kinetics – A Review: Batch Culture; Continuous Culture; Fed-batch Culture; Applications.

Module -2 ISOLATION, PRESERVATION AND IMPROVEMENT OF INDUSTRIAL MICROORGANISMS: Isolation Methods utilizing the selection of desired characteristics; Isolation Methods not utilizing the selection of desired characteristics; Preservation Methods: At Low temperature, Dehydration, and their quality control; The selection and Isolation of induced mutants improving yields of secondary metabolites; Use of recombinant systems for the improvement of industrial microorganisms.

Module -3MEDIA FOR INDUSTRIAL FERMENTATIONS: Typical Media and formulation; Sources of Energy, Carbon, Nitrogen, Minerals, vitamins, precursors, Oxygen and others. **S**
terilization of Media: Medium Sterilization; Design of Batch and Continuous Sterilization; Sterilization of Fermenter, Feed, Air; Filtration of Air and Design of Filters**;**
Development of Inocula For Industrial Fermentations: The development of Inocula for yeast, bacterial, fungal and streptomycete processes; Aseptic inoculation of plant Fermenters.

Module -4INSTRUMENTATION AND CONTROL: Control Systems: Manual, automatic and their combination; Methods of measurement of for Process Variables: Temperature, Flow of gases and liquids, Pressure, Safety valves, Shaft Power, Rate of stirring, Foam, Weight, DO, Exit gas, pH, Redox etc.; On-line analysis of other chemical factors; Application of computers in fermentation industry.

Module -5 RECOVERY AND PURIFICATION OF FERMENTATION PRODUCTS: A REVIEW: Filtration, Centrifugation, Cell Disruption, Extraction, Chromatography, Ultra filtration, Drying, Crystallization and Whole broth processing;
Effluent Treatment: Strength of fermentation effluents; Disposal Methods; Treatment processes: Aerobic and Anaerobic; Byproducts;

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. Shuler M. L. and Kargi F, **Bioprocess Engineering**, 2nd Edition, Prentice Hall, 2002.
2. Mitchell DA. Krieger N, Berovic, "Solid State Fermentation Bioreactors", Springer Press, Germany, 2005.

TEXT BOOK

1. Peter F. Stanbury, Alan Whitaker and Hope, Principles of Fermentation Technology, Pergamon Press, 2nd Edition, Reprint 2010

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

02	16BCE424	Group-3	ANIMAL CELL CULTURE & TISSUE ENGINEERING

Exam Hours:03 **Exam Marks:100**

Module -1 Characteristics of animal cell, metabolism, regulation and nutritional requirement. Effects of shear force and kinetics of cell growth and product formation. Product and substrate transportation.

Module -2 Hybridoma technology; genetic engineering in animal cell culture; scale-up and large scale operation; Perfusion bioreactors, hollow fiber bioreactor, operational strategies of mass cell culture.

Module -3 Disaggregation (enzymatic and mechanical) of tissue and primary culture; Cultured cells and evolution of cell lines; Maintenance of cultures – cell lines; Cloning of cell lines; Large scale cell cultures in biotechnology ; Somatic cell fusion.

Module -4 Culture media (Preparation and sterilization), Harvesting, selection and expansion. Differentiation, Change of phenotype. Cryopreservation. Tissue, organ and organotypic cultures. Mass transport and nutrition gradients in tissue engineering (O2) as model. Cryopreservation of organs and ECMFreezing and vitrification. Most common Bioreactors in Tissue Engineering, Cell Seeding in Bioreactors, Bioreactor Applications in Functional Tissues, Design Considerations, Challenges in Bioreactor Technologies.

Module -5 Tissue Engineering of Skin, Bone, tendon, Adipose Tissue Engineering Introduction, FDA Regulation, Regulation of Pharmaceutical / Medical Human Tissue Products in Europe/USA, Other considerations Relevant to Engineered Tissues.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1.Methods of Tissue Engineering by Anthony Atala & P Lanza, Academic Press Elsevier 2006.
2. Biocatalytic Membrane Reactor by Drioli, Taylor & Francis, 2005
3. Translational approaches in Tissue Engineering and regenerative medicine.

TEXT BOOKS

1. Ruiereis, Introduction to tissue engineering, 2006
2. Tissue Engineering by Clemens Van Blitterswijk
3. Tissue Engineering by John P. Fisher, A G Mikos & Joseph D. Bronzino, CRC Press, 2007.

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

03	16BCE421	Group-3	BIOLOGICAL WASTE WATER TREATMENT

Exam Hours:03 **Exam Marks:100**

Module -1INTRODUCTION: Objectives of wastewater treatment. Flow measurements and Composition. Characterization -Properties and analysis of wastewater, Problems on wastewater characterizations. Waste-water treatability studies-a bench scale and pilot scale. Effluent standards for discharge to water bodies and land applications-state and central.

Module -2 Physical and Chemical treatment of wastewater: Screens, Comminutes, Grit chambers, Flow equalizations, Sedimentation, Flotation, Granular medium filtration Chemical treatment: chemical precipitation, Adsorption, Disinfection with chlorine, ozone, Ultraviolet light etc.

Treatment disposal of sludge – Sludge characteristics, concentration. Aerobic/Anaerobic sludge digestion, sludge conditioning, Dewatering and drying. Incineration and wet oxidation.

Module -3 Microbiology of waste treatment – Growth and inhibition of bacteria. Kinetic of Biological growth, Batch culture substrate limited growth, Cell growth and substrate utilization, Effects of endogenous metabolism. Monods and Michaels Menton kinetics and their applications. Determination of kinetic coefficients. Fundamentals of process analysis, Mass balance analysis, Reactors and their hydraulic characteristics, Reaction kinetics and Reactor selection. (Batch, Plug flow, Completely stirred tank reactor and packed and fluidized bed reactor).

Module -4 Biological treatment processes: Aerobic/Anaerobic attached and suspended growth treatment processes-Activated sludge process: Process analysis : Completely mix with recycle, Sequential Batch Reactor (SBR), Rotating biological contactor/disc (RBC), Trickling filter, UASB digester, aerated lagoon, stabilization ponds.– Standard type and modifications. Aerators/diffusers. With applicable numerical.

Module -5 Biological Nutrient Removal: Nitrogen removal with and without phosphorous removal, Nitrogen and Phosphorous removal, Phosphorous removal with or without nitrifications, Removal of ammonia by biological nitrifications, Removal of Nitrogen by biological nitrification/denitrifications. Combined removal of Nitrogen and Phosphorus by Biological, Physical and Chemical methods.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. H.E. Babbilt and R.Baumann, Sewage and Sewage Treatment, 1986.
2. Webber WJ, Physicochemical processes for water quality
3. Fasir GM , Geyer JG and Okun- Waste water engineering
4. RonandDroste, Theory and practice of water and wastewater treatment, John Wiley and sons, Canada, 2005.
5. George Tchobanoglous and Franlin L. Burton, Wastewater Engineering- Treatment, Disposal and Reuse, Tata McGraw Hill Publishing Co. Ltd, 1990.

TEXT BOOKS:

1. Eckenfelder and O'Conner, Biological Waste Treatment, 2001
2. Metcalf and Eddy, Wastewater Engineering -Treatment, Disposal & Reuse, Tata McGraw Hill, 1991

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

04	16BCE422	Group-3	BIOLOGICAL THERMODYNAMICS

Exam Hours:03 | **Exam Marks:100**

Module -1

FRONTIER OF BIOLOGICAL THERMODYNAMICS: Energy conservation in living organism, Irreversibility and life, third law and biology, entropy and protein stability, Energy, information processing and life, second law and evolution, Gibbs free energy, Equilibrium concepts for biological thermodynamics.

Module -2FUNDAMENTAL CONCEPTS OF THERMODYNAMICS: System and Surroundings, First law of thermodynamics -Internal energy, enthalpy, Heat capacity, applied examples from biochemistry.

Module -3

ENTROPY: Second law – Entropy and universe, Concept of heat engines, protein stability and calorimetric measurements. Fundamentals of Differential scanning calorimeter and Isothermal calorimeter n biological property measurements, Third law of thermodynamics, Maxwell equations, Gibbs-Duhem Equation and the Phase Rule, Legendre Transforms.

Module -4

GIBBS FREE ENERGY AND ITS APPLICATIONS: Gibbs free energy and equilibrium, Chemical potential, ionic solutions, Equilibrium constant, standard state in biochemistry, Acid and bases, chemical coupling and redox reactions, Gibbs free energy in photosynthesis, glycolysis citric acid cycle, Oxidative phosphorylation and ATP hydrolysis, substrate cycling, Membrane transport, Enzyme substrate interaction, Haemoglobin, Protien solubility, stability and dynamics.

Module -5

REACTION KINETICS: Rate of a reaction, rate constant and order of the reaction, effect of temperature, collision and transition state theory, Electron transfer kinetics, Enzyme kinetics and inhibition, Reaction mechanism of lysozyme, protein folding and pathological misfolding, polymerisation, muscle contraction and the molecular motors.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOK

1. Robert A. Alberty, Thermodynamics of Biochemical Reactions, John willy publications, 2003

TEXT BOOK

1. Donald T. Haynie, Biological Thermodynamics, Cambridge press, 2008.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

05	16BBT154	Group-3	GENETIC ENGINEERING TECHNIQUES
Exam Hours:03		**Exam Marks:100**	

Module -1 DNA REPLICATION: Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes DNA Repair: Mismatch correction, Mechanisms in thymine-dimer repair: Photoreactivation, Nucleotide excision repair, SOS repair DNA Recombination: Homologous and non-homologous recombination; Holliday Model; Site specific recombination: General mechanism, Examples: SSR in Bacteriabacteriophage, FLP/FRT and Cre/Lox recombination. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors

Module -2 GENETIC CODE AND ITS PROPERTIES: Wobble hypothesis. Translation: Role of Ribosomes & tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypepetide; Posttranslational modifications; Transport of proteins and molecular chaperones. Transcriptional regulation in Prokaryotes: General mechanism of positive and negative control; Operon concept: lac, trp, and gal operons; Transcriptional control in Eukaryotes: Chromatin remodeling: Acetylation and deacetylation of histone proteins; Regulatory proteins: DNA binding transactivators, coactivators; Homeotic gene and their role in gene regulation.

Module -3 Plasmids, Phage Vectors, Phagemids, Cosmids, YACs and BACs; Cloning & Expression vectors. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction: General mechanism and applications; Variants of PCR; In vitro mutagenesis.

Module -4 Microprojectile bombardment; Agrobacterium transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, mechanism of T- DNA transfer; Chloroplast transformation; Transgenic science in plant improvement: resistance to biotic and abiotic stresses, biopharming – plant s as bioreactors. Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones.

Module -5 Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Brown TA, Genomes, 3rd edition. Garland Science 2006.
2. T. A. Brown. Gene Cloning: An Introduction, Stanley Thornes Publishers Limited, 1995.
3. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001

TEXT BOOKS

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell, 4th edition, New York: Garland Science; 2002.
2. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. Molecular Cell Biology, 4th edition, New York: W. H. Freeman; 2000.
3. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

01	16BBT12/16BBC12	Group-4	CONCEPTS IN BIOTECHNOLOGY

Exam Hours:03 **Exam Marks:100**

Module -1 Introduction to Biology; Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: DNA & RNA; storage and transfer of genetic information; Lipids: membranes, structure & function; Carbohydrate chemistry, energy storage, building blocks.

Module -2 Cell Structure: Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis. Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and organization, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.

Module -3 Scope and History of microbiology, Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate. Immune System, Innate and adaptive immunity, antigens and antibodies; types of immune response, hypersensitivity. Humoral immunity: B-lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (Tcells), Antigen presenting cells (APC); Immunity to infection, Cytokines.

Module -4 Scope of agricultural biotechnology, Role of Micorbes in agriculture, Biopesticides, Bio fertilizers (Nitrogen fixing microbes), GM crops. Plant metabolic engineering and industrial products: Molecular farming for the production of industrial enzymes, biodegradable plastics, antibodies, edible vaccines. Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc. Basic aspects of Food & Nutrition.

Module -5 Industrially important Microorganisms, Preservation techniques, Different media for fermentation, basic structure of fermentor and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics) Biological treatment of waste water, primary, secondary and tertiary treatments. Bio indicators, Bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Bio-sorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Gardner, Simmonns and Snustad, Principles of Genetics, 8th edition, 2005.
2. P S Verma, V R Agarwal, Cell Biology, Genetics, Evolution and Ecology, New Publisher Delhi, 2007.
3. K. Lindsey and M.G.K. Jones, Plant biotechnology in Agriculture, Prentice hall, New Jersey. 1989.
4. Munnecke DM, Johnson LM and others, Biodegradation and Detoxification of Environmental Pollutants CRC Press, 1982

TEXT BOOKS

1. De Robertis EDP and De Robertis Jr. EMF, Cell and Molecular Biology, Wippincott Williams and Wiilkins publisher, 2001.
2. Strickburger M W, Principles of Genetics, 3rd edition, Prentice Hall Publication, India, 2011.
3. Prescott and Dunn, Industrial Microbiology, Macmillian, 1982.
4. Ashim K Chakravarthy, Immunology & Immunotechnology, Oxford University Press, 2006.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

02	16BBC14	Group-4	MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Exam Hours:03 | **Exam Marks:100**

Module -1 DNA REPLICATION: Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes DNA Repair: Mismatch correction, Mechanisms in thymine-dimer repair: Photoreactivation, Nucleotide excision repair, SOS repair DNA Recombination: Homologous and non-homologous recombination; Holliday Model; Site specific recombination: General mechanism, Examples: SSR in Bacteriabacteriophage, FLP/FRT and Cre/Lox recombination. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors

Module -2 GENETIC CODE AND ITS PROPERTIES: Wobble hypothesis. Translation: Role of Ribosomes & tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypepetide; Post-translational modifications; Transport of proteins and molecular chaperones. Transcriptional regulation in Prokaryotes: General mechanism of positive and negative control; Operon concept: lac, trp, and gal operons; Transcriptional control in Eukaryotes: Chromatin remodeling: Acetylation and deacetylation of histone proteins; Regulatory proteins: DNA binding transactivators,

Module -3 VECTORS: Plasmids, Phage Vectors, Phagemids, Cosmids, YACs and BACs; Cloning & Expression vectors. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering:
Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction**:** General mechanism and applications; Variants of PCR; In vitro mutagenesis.

Module -4 GENE TRANSFER TECHNIQUES INTO PLANTS: Microprojectile bombardment; *Agrobacterium* transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, mechanism of TDNA transfer; Chloroplast transformation; Transgenic science in plant improvement: resistance to biotic and abiotic stresses, biopharming – plant s as bioreactors.

Module -5 Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1. Brown TA, Genomes, 3rd edition. Garland Science 2006.
2. T. A. Brown. Gene Cloning: An Introduction, Stanley Thornes Publishers Limited, 1995
3. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001

Text Books:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell, 4th edition, New York: Garland Science; 2002.
2. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. Molecular Cell Biology, 4th edition, New York: W. H. Freeman; 2000.
3. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

03	16BBC152	Group-4	COMPUTATIONAL BIOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1 Sequence databases Formats, querying and retrieval, Nucleic acid & Protein sequence databases, Genome Databases, NCBI, EBI, TIGR, SANGER ; Various file formats for bio-molecular sequences: Similarity matrices; Pair-wise alignment; BLAST; Statistical significance of alignment; Sequence assembly; multiple sequence alignment; Tools and techniques. Phylogenetics: distance based and character based approaches. Discussions with Case studies.

Module -2 SEQUENCE PATTERNS AND PROFILES: Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; trees Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding. Profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches. Discussions with Case studies.

Module -3 DATABASES: PDB, NDB, Chemical Structure database. Pubchem, Gene Expression database: GEO, SAGE, InterPro, Prosite, Pfam, ProDom, Gene Ontology Structure classification database: CATH, SCOP, FSSP, Protein-Protein interaction databases. Representation of molecular structures (DNA, mRNA, protein), secondary structures, domains and motifs; Protein structure classification, evolution; structural quality assessment; structure comparison and alignment; Visualization software (Pymol, Rasmol etc.); 3-D structure comparison and concepts, CE, VAST and DALI, concept of coordinate transformation, RMSD, Z-score for structural comparison. Discussions with Case studies.

Module -4 STRUCTURE PREDICTION: Chou Fasman, GOR methods; analysis of results and measuring the accuracy of predictions. Prediction of membrane helices, solvent accessibility; RNA structure prediction; Mfold; Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative modelling, fold recognition, threading approaches, and *ab initio* structure rediction methods. Force fields, backbone conformer generation by Monte Carloapproaches, sidechain packing; Energy minimization; Structure analysis and validation**:** Pdbsum, Whatcheck, Procheck, Verify3D and ProsaII; Rosetta; Discussions with Case studies.

Module -5COMPUTATIONAL BIOLOGY IN DRUG DESIGN: Target identification, validation and Identification and Analysis of Binding sites; virtual screening, lead optimization. Ligand based drug design: QSARs and QSPRs, In silico prediction ADMET properties for Drug Molecules. Pharmacophore identification. Protein-ligand docking; Rigid and Semi Flexible Molecular Docking. Studying Protein-Protein interactions via computational biology tools. Computational Biology applications for proteomics, Comparative genomics**,** Transcriptomics, Microarray technology, expression profiles data analysis; SAGE; MS Data analysis, Probabilistic Models of Evolution, Protein arrays; Metabolomics, Gene Mapping, SNP analysis, Systems Biology. Discussions with case studies.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Reference Books:

1.Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids, Durbin et al Cambridge University Press. 2007.
2.Thomas E. Creighton Proteins: structures and molecular properties, New York Freeman, 1992
3. Johann Gasteiger and Thomas Engel Chemoinformatics Wiley, 2003
4. Tsai, C Stan, Biomacromolecules Introduction to Structure, function and Informatics, Wiley& Sons, 2007Robert A. Meyers. Systems Biology Wiley Blackwell. 2012.

TEXT BOOKS

1. David W. Mount. Sequence and Genome Analysis, CSHL Press, 2nd Edition, 2004.
2. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical, guide to the analysis of genes and proteins, 2nd Edition, JohnWiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, Wiley-Liss, 1 st Edition, 2003.

4. Philip E. Bourne & Helge Weissig Tsai, Structural Bioinformatics, Wiley, 2003.

04	16BBC23	Group-4	BIOSEPARATIONS AND PRODUCT RECOVERY

Exam Hours:03 | **Exam Marks:100**

Module -1 INTRODUCTION TO DOWNSTREAM PROCESSES Role and importance of downstream processing in biotechnological processes. Problems and requirements of bio product purification. Economics of downstream processing in biotechnology; cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of by-products (high volume, low valve products and low volume, high valve products). Discussion of case studies.

Module -2 PRIMARY SEPARATION AND RECOVERY PROCESS: Cell disruption methods for intracellular products, removal of insoluble (particulate debris), centrifugation and filtration methods. Membrane based separations (dialysis, micro and ultra-filtration, reverse osmosis), theory design and configuration of membrane separation equipment application. Enrichment operations; precipitation methods (with salts, organic solvents and polymer extractive separations aqueous two phase extraction). Discussion of case studies.

Module -3 ELECTROPHORETIC TECHNIQUES; Theory of Electrophoresis; Classification; Applications : Moving boundary electrophoresis, Zone Electrophoresis, Gel Electrophoresis, Continuous Gel Electrophoresis, Disc gel Electrophoresis, Agarose Gel Electrophoresis, Cellulose Acetate, Starch Gel and page (Polyacrylamide gel electrophoresis) and SDS - Polyacrylamide, High voltage electrophoresis, Isoelectric focusing, Immunoelectrophoresis. Capillary electrophoresis. PFGE. Discussion of case studies..

Module -4 4INTRODUCTION TO MOLECULAR INERACTION AND CHROMATOGRAPHY:
Adsorption and absorption, Kinds of adsorption interactions. Adsorption characteristics, molecular orientation, adsorption isotherms: quantitative Relationships; adsorption from solutions, and the importance of Adsorption phenomena. Principle and classification of chromatography, important terms of chromatography, Partition chromatography – Single dimensional (Both Ascending and Descending) and two dimensional chromatography; Paper chromatography, Thin layer chromatography, Adsorption Chromatography. Discussion of case studies

Module -5 ADVANCED PURIFICATION TECHNIQUES: Ion Exchange Chromatography, Gel Filtration Chromatography, Affinity Chromatography. Principle of HPLC, theory and calculations,
Instrumentation both analytical and preparative, Types of Columns, Detectors; Sampling Methods; Applications of HPLC, LCMS, GCMS. FPLC, HPTLC. Drying techniques, Crystallization, lyophilisation, Pervaporation, super liquid extraction, foam based separations, in situ product removal, Single step purification, Super critical extraction, online membrane separation, Discussion of case studies.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Wang D.I.C., Cooney C.L., Demain A.L., Dunnil.P., Humphery A.E. and Lilly M.D. Fermentation and Enzyme Technology John Wiley and Sons. 1979.
2. Engelbert Buxbaum, Biophysical chemistry of proteins, Spinger, 2011
3. David Freifelder Physical Biochemistry W H Freeman, 1982

TEXT BOOKS:

1. Bailey and Ollis, Biochemical Engineering Fundamentals, Prentice Hall, 1992
2. Atkinson, B. & Maviuna, F. Biochemical Engg. and Biotechnology Handbook, Mc-Graw hill (2 nd Edition), 1993)
3. W.R.Vieth et al., Design and Analysis of Immobilised Enzyme Flow Reactors. 1993.
4. M. L. Schuler & F. Kargi, Basic concepts Bioprocess Engineering - by Entice Hall 1992

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

05	16BBT21	Group-4	INDUSTRIAL BIOTECHNOLOGY
Exam Hours:03		**Exam Marks:100**	

Module -1
INTRODUCTION: The era of the discovery of Microbes, Pasteur and fermentation, The discovery of Antibiotics, Production strains, screening techniques, Growth of Industrial Fermentations, Screening techniques, Strain Development, Preservation of Micro organisms and Preparation of Inoculum.

Module -2
MICROBIAL TRANSFORMATION AND PRODUCTION MEDIA: Characteristics of an Ideal Production Media, Raw materials for production, Screening for production Media, Principles of Sterilization, Sterilization equipment, Sterilization of production Media, Sterilization of Air.

Module -3
PRINCIPAL TYPES OF FERMENTOR IN INDUSTRIES: Introduction to Fermentors, Factors involved in fermentor Design, Fermentor configurations, Principal operating characteristics of fermentors, Computer control of Fermentation process, Computer application in fermentation technology, Justification and Planning.

Module -4 MICROBIOLOGICAL ASSAY: Introduction and History of Assay, Microbiological assay of: Vitamins and Amino Acids, Antibiotics, Trace elements. Advantages and Disadvantages of Microbiological Assay, Automation of Microbiological Assay.

Module -5 INDUSTRIAL APPLICATIONS OF MICROBES: Pharmaceutical sector, Food and Enzymes Industries. Fermented foods. Sewage and Sewage disposal, Objectives of Sewage treatment, Collection of Sewage, Sewage treatment Methods.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. The Air Spora: A manual for catching and identifying airborne biological particles. Maureen E. Lacey and Jonathan S. West. Springer.
2. Soil Microbiology by NS Subba Rao, Oxford and IBH.
3. Palynology and its applications By Shripad N. Agashe, Oxfor and IBH publishing Pvt. Ltd.
4. Text Book of Microbiology by Anantahnarayan and Jayaram Panicker, Universities Press.

TEXT BOOKS

1. Microbiology by Michael J Pelczar Jr Chan ECS, Noel R Krieg, Tata McGraw Hill Publishing co ltd.
2. Microbiology by Prescott, Harley, Klein, McGraw Hill.
3. Industrial Microbiology by Samuel C Prescott, Cecil G Dunn, Agro bios (India)
4. Palynology and its applications By Shripad N.Agashe, Oxfor and IBH publishing Pvt. Ltd.
5. Biotechnological Applications of Microbes by Edite-Ajit Verma, IK Intl. Pub House.
6. Alcamos Fundamentals of Microbiology by Jeffery C Pommerville, Jones and Bartlett Publishers.
7. Microbiology, an Introduction, Gerard J. Tortora, Berdell R. Funke, Christine L. Case, 2012. Pearson
8. Principles of Microbiology: Ronald M Atlas, 1995.McGraw-Hill Inc., US (addition)
9. Microbiology: Principles and Explorations, Jacquelyn G. Black, 8thEdition, John Wiley & Sons,2012.

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

01	16BBT13/16BBC13	Group-5	PRINCIPLES OF BIOCHEMICAL ENGINEERING

Exam Hours:03 **Exam Marks:100**

Module -1 Energy and Material Balances: Material Balance: Law conservation of mass, Material balance with and without reactions. Energy Balance: Law of conversation of energy, Energy balance with and without chemical reactions. Introduction to Momentum Transfer: Types of fluids: Newtonian and Non Newtonian fluids. Measurement of viscosity, Laminar and Turbulent flow, eddy viscosity, flow of a fluid past a solid surface (Cells and immobilized systems), motion of particles in fluid(centrifugation & sedimentation), flow of fluid through granular bed (packed column), fluidization and bubble column.

Module -2 Concepts of Heat and Mass Transfer: Heat Transfer: Thermal conductivity and mechanism of energy transport, design principles of heat exchangers, measurement of heat transfer coefficient, principles, construction and application of evaporators and dryers. Mass transfer: Diffusion and its types, measurement of diffusivities, theoretical estimation of diffusitivities, interfacial diffusion (Mass transfer), convective mass transfer, measurement of mass transfer coefficient, Mass transfer process (Principle, construction and application of Distillation, adsorption, extraction and crystallization).

Module -3Thermodynamics and Bioenergetics Thermodynamics: First and Second law of thermodynamics, application of first and second law in Biomolecular structure, PVT behaviour, PVT diagram of pure fluids, thermodynamics models used in process industries (Peng-Robinson model, EOS, NRTL,SRK etc). Properties of solution, phase equilibrium. Chemical potential and activity of molecules, statistical thermodynamics, Bioenergetics: Energetic of metabolic pathways, energy coupling, thermodynamic efficiency of growth and yield co-efficients.

Module -4Reaction Engineering: Kinetics of enzyme catalyzed reactions, kinetics of microbial growth, substrate utilization and product formation. Batch and continuous reactors, energy and mass balance in biological reactions. Heterogeneous reaction: Shell balance (Immobilized system), effect of mass transfer on reaction, Thiele modulus, solid liquid mass transfer correlations, minimizing mass transfer effects.

Module -5 Drying &RTD in reactors: Drying; moisture content and its types, wet and dry moisture contents, drying curve, drying equipments, RTD curves-its interpretation, RTD for CSTR and PFR calculations.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. O. Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley, 1999.
2. Bailey J.E. and Ollis D.F. Biochemical Engineering Fundamentals 2nd Edition, McGraw- Hill Book CO., Singapore, (1986).
3. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, PHI, 2002.
4. Pauline Doran, Bioprocess Engineering Principles,1st Edition, Academic Press, 1995.

TEXT BOOKS

1. Bhatt B. I and S.M. Vora Stoichiometry Tata McGraw Hill, 4th Edition, 2004.
2. McCAbe RL & J.C Smith "Unit operations of Chemical Engineering" McGraw Hill International Editions, 2001.
3. Mass Transfer Operations by Robert E. Treybal. McGraw-Hill Education.
4. Introduction to Chemical Engineering thermodynamics by Smith & Vanness, MGH.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

02	16BBC153	Group-5	BIOPROCESS CONTROL AND INSTRUMENTATION
Exam Hours:03		**Exam Marks:100**	

Module -1AIMS AND OBJECTIVES OF CONTROL SYSTEMS: Closed loop control and open loop control systems-Examples, Elements of control system, process variables, process parameters, Representation of control systems in terms of block diagrams and its explanation, Laplace transforms. Z transforms.

Module -2 FUNDAMENTALS OF STATIC AND DYNAMIC CHARACTERISTICS: Indicators and recorders. Pressure measurement- Bourdon, diaphragm and bellow type gages. Vacuum measurements. Temperature measurement- Bimetal and resistance thermometers, thermocouples and pyrometers, Flow measurement, Level measurement devices, pH and DO analyzers, on-line and off-line analysis of biomass estimation.

Module -3INTRODUCTION TO CONTROLLER: Mode of action of controllers and the Transfer function, Response of the controller to Step, Pulse, Linear changes to error signals, qualities of good controller, proportional Band. Transmitters, Measurements systems. Measurement of process variables, Actuators, Positioners, Control valves, Valve body, valve Plug, Variable Displacement pumps, and constant output pumps, PLC. Sequential control, Logic and security systems.

Module -4 Block diagram Deduction, Analysis of typical control system-Closed loop analysis -Servo and Regulatory problems for First and second order systems, Closed and loop transfer functions, P-controller for set point change, off-set,P-controller for load change, Pi controller with set point change. Stability. Process identification, Root locus, Routh Array, Bode and Nyquist diagrams. Stability margins. Robustness, Steady state errors. Frequency domain response.

Module -5 Elements of tuning and closed loop dynamics Industrial controllers. Design methodology. Control specifications. PID tuning. Rule and model based tunning. Autotunners. Common control loops. Process design and operability. Control structures. Cascade. Feed forward. Ratio. Examples. Interactive systems. Multivariable processes. RGA. Decoupling control. Design, scale up and optimization of various equipment and biosystems used for biotechnological process industries (equipment used in upstream, downstream and fermentation processes).

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Luyben, Process modeling, simulation and control for chemical engineers. McGraw Hill, 1990.
2. McMillan, Tuning and Control loop performance. ISA 1990.
3. D E Seborg, T F Edger, Process dynamics and control, John Wiley, 1999

TEXT BOOKS

1. Smith & CorrIpio, Principles and practice of automatic process control. John Wiley, 1985.
2. LuybenW.L., Luyben M.L., Essentials of process control, Mc Graw-Hill, 1997
3. Ogunnake B.A., Ray W.H., Process dynamics, modeling and control, Oxford University Press, 1994

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

03	16BBC22	Group-5	BIOREACTOR PLANT DESIGN
Exam Hours:03		**Exam Marks:100**	

Module -1INTRODUCTION TO BIOPROCESS: Objectives, Material and energy balance involved, Energy based calculation involved in bioprocess technology (Upstream and Downstream process Both steady state and Unsteady state), Process Flow diagrams development, validation (introduction, structure and resources for validation) of systems and processes including SIP and CIP, cGMP guidelines. Seed culture and inoculum development, culture cell banks, Operational models of reactors (Batch, continuous, Fed Batch, repetitive batch, recycle and continuous cultivation), Novel bioreactors (Stirred tank, Air lift & Loop reactors, fluidized bed reactor, Packed bed and Hollow fiber membrane bioreactors, immobilized Bioreactor), Bioreactors for waste treatment processes; SSF bioreactors, Selection of bioprocess equipment (upstream and downstream), heat transfer and mass transfer equipment's.

Module -2 BASIC DESIGN AND CONSTRUCTION OF FERMENTERS AND ITS UXILIARIES:
Material of construction, Vessels for Bioprocess (Vessel geometry and vessel design), bearing assemblies, Motor drives, Aseptic seals, Flow measuring and control devices, Agitator and Sparger Design, piping, valves, Pressure relief system, Conveyor and elevator, sensors and instrumentation, control system and stability of control system**.**

Module -3REACTOR CONFIGURATION: Facility design aspects and Utility supply aspects, Equipment cleaning aspects, Design considerations for maintaining sterility of process streams and process equipment, Materials of construction for bioprocess plants.Medium requirements and formulation for fermentation processes (examples of simple and complex media), design and usage of commercial media for industrial fermentations, Batch and continuous heat sterilization of liquid media, Filter sterilization of liquids, Air sterilization-Techniques involved, sterility test and integrity test, Inoculation process, sampling process, cell harvesting, Cooling of fermenter system, water system for bioprocess industry (production of triple distilled water), Primary packing and secondary packing, waste disposable technology, environmental aspects.

Module -4 Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes, Oxygen uptake rates and determination of oxygen transfer coefficients (kLa), role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Numerical using Reynold's, Prandtl's, Chil ton & Colburn analogies. Scale up and scale down, effect of scale up on oxygenation issues, mixing, sterilization, pH, temperature, nutrient availability and supply; Bioreactor scale up based on constant power consumption per volume, mixing time, impeller tip speed(Shear), mass transfer coefficients. Scale up of downstream processes: Adsorption; (LUB method); Extractors (geometry based c rules); Filtration (cross flow Chromatography constant resolution etc. Centrifugation (equivalent times etc.). Scale-down related aspects.

Module -5 CONCEPTS OF CAED: Detailed process and mechanical design of the following equipments via CAED – Agitated and jacketed vessels, fermenter vessels, shell and tube heat exchanger and double pipe heat exchanger. Types of joints (welded), pipe and pipe fittings.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCES BOOKS:

1. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press 1995.
2. H. C. Vogel & C. L. Todaro, Fermentation & Biochemical Engineering Hand Book (1983), Principles, Process Design and Equipment.
3. Butterworth-Heiemann, A compendium of Good Practices in Biotechnology, BIOTOL Series, 1993.

TEXT BOOKS:

1. Bailey and Ollis, Biochemical Engineering Fundamentals, Prentice Hall, 1992
2. Atkinson, B. & Maviuna, F. Biochemical Engg. and Biotechnology Handbook, Mc-Graw hill(2nd Edition), 1993)
3. W.R.Vieth et al., Design and Analysis of Immobilised Enzyme Flow Reactors. 1993.
4. M. L. Schuler & F. Kargi, Basic concepts Bioprocess Engineering - by Entice Hall 1992

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

4	16BCE14	Group-5	BIOREACTORS

Exam Hours:03 **Exam Marks:100**

Module -1INTRODUCTION TO BIOREACTORS: Overview of biological reactors: submerged liquid fermentation, solid state fermentation, Understanding of bioreactors: Definition of bioreactor, development of bioreactors, Purpose and importance of bioreactor, Classification of bioreactors, bioreactor for animal cell, plant cell cultivation/culture.

Module -2 TRANSPORT PHENOMENA IN BIOPROCESS SYSTEMS: Gas liquid mass transfer in Cellular Systems. Determination of O2 transfer rates. Mass transfer of freely rising or falling bodies. Forced Convection Mass Transfer: Overall Kla Estimates, and power requirements (review) for sparged and agitated vessels. Other factors affecting Kla, Models, Power Consumption and Mass transfer for Non Newtonian fluids.

Module -3BIOREACTOR OPERATIONS: Common operations of bioreactor, selection and identifications of factors for smooth operations of bioreactors, spectrum of basic bioreactor operations, bioreactor operations for immobilizes systems, plant and animal cell bioreactors peration

Module -4CONTROLS IN BIOREACTORS Control task in bioreactor system, instrumentation in bioreactors, control variables and measurement devices, advanced control technique, consistency checks on measurement, adaptive online optimizations. Online and off line measurements and analytical methods.

Module -5 STERLISATION AND SCALE UP OF BIOREACTORS: Sterilization of Reactors, Batch Sterilization, Continuous Sterilization, filter and air sterilization. Scale up problems in bioreactors, criteria of scale up, similarity criteria; scale up methods, generalized approaches to scale up.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOK

1. Michael L. Shuler and FikretKargi, Bioprocess Engineering: Basic concepts, 2nd Edition, Prentice Hall, 2002.
2. Pauline M. Doran **Bioprocess Engineering -**, 2nd edition, Academic Press, 2012.

TEXT BOOK:

1. Tapabrata Panda, **Bioreactors Analysis and Design**, Tata McGraw Hill Education Pvt. Ltd, August, 2011
2. James E.Bailey and David F.Ollis **Biochemical Engineering Fundamentals** by. Mc- Graw Hill International Edition, Sixth edition, 2005

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

05	16BCE13	Group-5	BIOPROCESS ENGINEERING
]		**Exam Marks:100**	

Module -1INTRODUCTION: Bioprocess development an interdisciplinary challenge, introduction to engineering calculations, presentation of analysis of data, regulatory constraints for bioprocess engineering. Bioprocess engineering and technology. Role of a Chemical engineer in a bioprocess industry. Classification of micro-organisms, Taxonomy, Environmental and Industrial microbiology.

Module -2 ENZYMES: Introduction, definition and enzyme classification, enzyme kinetics, various models, Experimentally determining rate parameters for MM Kinetics, complex enzyme kinetics, effect of pH and temperatures, insoluble substrates,
IMMOBILISED ENZYME SYSTEMS: methods and limitation of immobilization, Effects of diffusion and reaction on kinetics of immobilized enzymes, Effect of other environmental parameters like pH and temperature.

Module -3GROWTH KINETICS OF MICROORGANISMS: Growth Kinetics of Microorganisms: Transient growth kinetics (Different phases of batch cultivation). Quantification of growth kinetics: Substrate limited growth, Models with growth inhibitors, Logistic equation, Filamentous cell growth model. Continuous culture: optimum dilution rate in an ideal Chemostat. Introduction to fed-batch reactors. Immobilized Cells: Formulations, Characterization and Applications

Module -4MIXED CULTURES: Introduction to mixed cultures, Major Classes of Interactions: Simple Models, Competition between two species, Prey-Predator system, Lotka-Volterra Model Web Interaction, Population dynamics in models of mass action form.

Module -5 INDUSTRIAL BIOPROCESS: Anaerobic process: Ethanol, lactic acid, acetone-butanol production. Aerobic Processes: Citric Acid, Baker's Yeast, Penicillin, High fructose corn syrup production.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. James E.Bailey and David F.Ollis **Biochemical Engineering Fundamentals** by. Mc-Graw Hill International Edition, Sixth edition, 2005
2. James Lee, **Biochemical Engineering** –Prentice Hall - 1992.
3. Pelczar **Microbiology Concept and Application -**,5th Edition, McGraw Hill, 2001

TEXT BOOK:

1. Shuler M. L. and Kargi F **Bioprocess Engineering**., 2nd Edition, Prentice Hall,2002.
2. Pauline M. Doran **Bioprocess Engineering -**, 2nd edition, Academic Press, 2012.

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

01	16BCE24	Group-6	SAFETY MANAGEMENT IN BIOPROCESS INDUSTRIES

Exam Hours:03 **Exam Marks:100**

Module -1. BIOTECHNOLOGY AND SOCIETY Introduction to science, technology and society, biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

Module -2BIO-SAFETY CONCEPTS AND ISSUES Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management: Key to the environmentally responsible use of biotechnology. Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

Module -3BIO-SAFETY IN THE LABORATORY Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution.

Module -4REGULATIONS Good manufacturing practice and Good lab practices (GMP and GLP). GMOs: Concerns and Challenges, Regulatory mechanism for GMO, Case studies in IPR (Turmeric and Neem Patent Case) and Biosafety (Bt Bringal and Bt cotton, Golden Rice).

Module -5FOOD SAFETY The GM-food debate and biosafety assessment procedures for biotech foods & related products, case studies of relevance. Environmental aspects of biotech applications.

AGRI AND PHARMA SECTOR Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Recombinant organisms and transgenic crops, case studies of relevance. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE

1. Fleming DA and Hunt DL., Biological Safety principles and practices, ASM Press 2000.
2. Lees F.P, Loss Prevention in Process Industries, 2nd Edition, Butterworth Heinemann, 1996.
3. Patterson D, Techniques of safety managements, McGraw Hill, 1978.
4. Handley W., Industrial Safety hand book, 2nd Edition, McGraw Hill, 1977.
5. Levine S.P and Martin, Protecting personnel at hazardous waste sites, Butterworth, 1985

TEXT BOOK

1. Deepa Goel & Shomini Prasar, IPR, Biosafety, and Bioethics, Pearson Press, New Delhi 2013.
2. Thomas JA and Fuch RI (2002) Biotechnology and safety assessment, Academic press 2002.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

02	16BCE41	Group-6	BIOENERGY
Exam Hours:03		**Exam Marks:100**	

Module -1BIOENERGY RESOURCES: Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels, Structural properties, Physical properties, properties of microbial biomass, Biomass resource assessment. Energy plantations -Preparation of woody biomass: Size reduction, Briquetting of loose biomass, Drying, Storage and Handling of Biomass, hydrogen production and biological fuel cell.

Module -2ETHANOL: Biomass constituent to liquid fuels, liquid fuel alcohol from sugar cane molasses, sweet sorghum, and other sources like corn and lignocelluloses. Lignocelluloses ethanol production technologies, conversion. Corn ethanol production technologies, chemistry of ethanol fermentation, by products from fermentation process.

Module -3BIODESIEL: Defination and properties of biodiesel Properties of Biodiesel, Catalyst used for biodiesel production. Biofuels from vegetable oil: production of vegetable oil, composition, process of extraction of vegetable oil, applications. Trans-Esterification of Oils to produce Bio- Diesel. Biofuels from algae: Microalgae growth, algae harvesting, extraction and utilization of liquid biofuels.

Module -4BIOGAS TECHNOLOGY: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues-. Microbial and biochemical aspects- Operating parameters for biogas production Kinetics and mechanism - Dry and wet fermentation. Digesters for rural application-High rate digesters for industrial waste water treatment.

Module -5PYROLYSIS AND GASIFICATION OF BIOMASS: Biomass conversion routes, biomass densification technologies, biomass combustion of woody biomass. Biomass pyrolysis, cogeneration in biomass Processing Industries. Guidelines for designing downdraft gasifiers. Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained. Thermo-chemical gasification principles: Effect of pressure, temperature and of introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, Biofuels Engineering Process Technology , Mc Graw Hill Publishers, New York, 2008.
2. Jonathan R.M, Biofuels – Methods and Protocols (Methods in Molecular Biology Series), Humana Press, New York, 2009.
3. Lisbeth Olsson (Ed.), Biofuels (Advances in Biochemical Engineering/Biotechnology Series, Springer-Verlag Publishers, Berlin, 2007.
4. G D Rai, Nonconventional Energy Sources, Khanna Publications, 4th Edition, 2010.

TEXT BOOK

1. Sunggyu Lee and Y T Shah, Biofuels and Bioenergy- Process and Technology, CRC Press, 2014.
2. VV N Kishore, Renewable energy engineering and technology –principles and practice, TERI Press, New Delhi, 2010.

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Biotechnology)

As per 2017 Regulation

03	16BCE23	Group-6	CHEMICAL AND BIOCHEMICAL REACTIONS

Exam Hours:03 | **Exam Marks:100**

Module -1

KINETICS OF HETEROGENEOUS REACTIONS: Catalytic Reactions, Rate controlling steps, Langmuir - Hinshelwood model, Rideal - Eiley Mechanism, Steady State approximation, Non catalytic fluid - solid reactions, Shrinking and unreacted core model.

Module -2

POPULATION BALANCE MODELS: Mixing concepts, Residence Time Distribution, Response measurements, Segregated flow model, Dispersion model, Series of stirred tanks model, Recycle reactor model, Analysis of non-ideal reactors.

Module -3

EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, Modelling diffusion with and without reaction.

Module -4

INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS:

Intra pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.

Module -5

DESIGN OF HETEROGENEOUS CATALYTIC REACTORS: Isothermal and adiabatic fixed bed reactors, Non-isothermal and non adiabatic fixed bed reactors. Two phase fluidized bed model, slurryreactor model, Trickle bed reactor model.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS:

1. Levenspiel, O., Chemical Reaction Engineering, (Third Edtion), 2005.
2. Smith J.M, Chemical Engineering Kinetics, 3rd Edition, McGraw-Hill, 1984.

TEXT BOOKS:

1. Fogler H.S, Elements of Chemical Reaction Engineering, Prentice Hall, 1991.
2. John Villadsen, Jens Nielsen, Gunnar Lidén, Bioreaction Engineering Principles, Springer Science & Business Media, 2011
3. Bischoff and Froment, Chemical Reactor Design and Analysis, Addision Wesley, 1982.

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PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

04	16BBI152	Group-6	Genomics and Proteomics
Exam Hours:03		**Exam Marks:100**	

Module -1 Introduction: Introduction to Genomics & Proteomics. Structure, Organization and features of Prokaryotic & Eukaryotic genomes. C-values of eukaryotic genomes - coding, noncoding and repetitive sequences. Organisation of genome within nucleus, mitochondria and chloroplast. Genome mapping: Genetic and physical mapping. Polymorphisms. Molecular markers – RFLP, AFLP, RAPD, SCAR, SNP, ISSR, and Protein markers – Allozymes and Isozymes, Telomerase. FISH – DNA amplification markers and Cancer biomarkers.

Module -2 Genome sequences databases and Genome annotation: Extrinsic, Intrinsic (Signals and Content), Conservative information used in gene prediction. Frameworks for Information integration – Exon chaining. Generative models: Hidden MorkovModels, Discriminative learning and Combiners. Evaluation of Gene prediction methods – Basic tools, Systematic evaluation and Community experiments (GASP, EGASP and NGASP). And Gene ntology.Functional annotation of Proteins: Introduction, Protein sequence databases, UniProt.

Module -3 UniProtKB – Sequence curation, Sequence annotation, Functional annotation, annotation of protein structure, post-translational modification, protein-protein interactions and pathways, annotation of human sequences and diseases in UniProt and UniProtKB. Protein family classification for functional annotation – Protein signature methods and Databases, InterPro,InterProScan for sequence classification and functional annotation. Annotation from Genes and Protein to Genome and Proteome.

Module -4 Genome Sequencing: Recent developments and next generation sequencing, ultra-highthroughput DNA Sequencing using Microarray technology. Genome sequencing projects on H. Influenzae, E. coli, Orizasativumand Neem. Human-genome project. Raw genome sequence data, Gene variation and associated diseases, diagnostic genes and drug targets. Genotyping-DNA Chips. Comparative and Functional Genomics: Studies with model systems such as Yeast, Drosophila, C. elegans, Arabidopsis. Approaches to analyze global gene expression – transcriptome, Serial Analysis of Gene Expression (SAGE), Expressed Sequence Tags (ESTs), Massively Parallel Signature Sequencing (MPSS), microarray and its applications, gene tagging.

Module -5 Proteomics: Scope, Experimental methods for studying proteomics, methods of protein isolation, purification and quantification. Methods for large scale synthesis of proteins. Applications of peptides in biology. Analysis of proteome – High throughput screening – Yeast two hybrid system and Protein chips, engineering novel proteins, Mass Spectroscopy based protein expression and posttranslational modification analysis. Bioinformatics analysis – clustering methods. Analysis of proteome functional information.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

REFERENCE BOOKS

1. Bioinformatics Genomics, and Proteomics by Ann Batiza, Ann Finney Batiza, Published by Chelsea House Publishers, 2005.
2. Plant Genomics and Proteomics by: Christopher A. Cullis, Wiley-Liss 2004.
3. Stephen R. Pennington, Michael J. Dunn. Proteomics: From Protein Sequence to Function. Garland Science, 2001
4. Darius M. Dziuda. Data Mining for Genomics and Proteomics: Analysis of Gene and ProteinExpression Data. John Wiley & Sons, 2010.
5. Christopher A. Cullis. Plant Genomics & Proteomics, John Wiley & Sons, 2004.
6. Ann Finney Batiza Bioinformatics, Genomics, and Proteomics: Getting the Big Picture, Infobase Publishing, 2006.

TEXT BOOKS

1. Pharmacogenomics by Werner Kalow, Urs A. Meyer, Rachel F. Tyndale, Informa Healthcare,2005.
2. Statistical and Computational Pharmacogenomics (Interdisciplinary Statistics) byRongling Wu, Min Linen, Chapman & Hall/CRC, 2008.
3. Genes VIII by Benjamin Lewis, Jones and Bartlett Publisher, 2006.
4. Genomics and Proteomics by SándorSuhai, Springer, 2000.
5. Modern genome annotation: the BioSapiens Network by DmitrijFrishman, Alfonso Valencia,Springer, 2008.
6. Discovering genomics, proteomics and bioinformatics by A. Malcolm Campbell, Laurie J. Heyer, Published by Pearson/Benjamin Cummings, 2006.

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Biotechnology)
As per 2017 Regulation

05	16BBI251	Group-6	PROTEIN ENGINEERING & DESIGN

Exam Hours:03 **Exam Marks:100**

Module -1. Amino acids (the students should be thorough with three and single letter codes) and their molecular properties (size, solubility, charge, pKa), Chemical reactivity in relation to posttranslational modification (involving amino, carboxyl, hydroxyl, thiol, imidazole groups) and peptide synthesis. Primary structure: peptide mapping, peptide sequencing - automated Edman method and Mass Spectrometry.

Module -2 High-throughput protein sequencing setup Secondary structure: Alpha, beta and loop structures and methods to determine Super-secondary structure: Alpha-turnalpha, beta-turn beta(hairpin), beta-sheets, alpha-betaalpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds. Sites Tertiary structure: Domains, denaturation and renaturation, protein folding pathways, overview of methods to determine 3D structures, Interaction with electromagnetic radiation (radio, micro, infrared, visible, ultraviolet, X-ray) and elucidation of protein structure. Quaternary associations: Modular nature, formation of complexes.

Module -3 Overview of protein structure, PDB, structure based classification, databases, visualization tools, structure alignment, domain architecture databases, protein-ligand interactions. Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander walls interactions in protein structure. Bioinformatics Approaches: Secondary structure prediction and determination of motifs, profiles, patterns, fingerprints, super secondary structures, prediction of substrate binding sites, tertiary structure, quaternary structure, methods to determine tertiary and quaternary structure, posttranslational modification.

Module -4 Methods of protein isolation, purification and quantification; large scale synthesis of engineered proteins, design and synthesis of peptides; methods of detection and analysis of proteins. Protein database analysis, methods to alter primary structure of proteins, examples of engineered proteins, protein design, principles and examples. Advantages and purpose, overview of methods, underlying principles with specific examples: thermal stability T4-lysozyme, recombinant insulin to reduce aggregation and inactivation, de novo protein design.

Module -5 DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, Eukaryotic transcription factors, Zn fingers, helix-turn helix motifs inhomeodomain, Leucine zippers, Membrane proteins: General characteristics, Transmembrane segments, prediction, bacteriorhodopsin and Photosynthetic reaction center. Immunoglobulins: IgG Light chain and heavy chain**.**

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT /REFERENCE BOOKS

1. Moody P.C.E and A.J Wilkinson. Protein Engineering, IRL Press, Oxford University Press.
2. Protein Science by Arthur M Lesk, Oxford University Press.
3. Protein Structure by Creighton, Oxford University Press.
4. Introduction of protein structure by Branden C and Tooze R., Garland.
5. The molecular modeling perspective in drug design by N Claude Cohen, Academic Press.
6. Bioinformatics Methods & Applications: Genomics, Proteomics & Drug Discovery, S C Rastogi, N Mendiratta& P Rastogi, PHI.
7. Young D. C., Computational Drug Design: A Guide for Computational and Medicinal Chemists, John Wiley & Sons, 2009.
8. Jeffrey L. Cleland, Charles S. Craik. Protein engineering: principles and practice,