FOUR YEAR UNDER GRADUATE PROGRAM (FYUP), CHOICE BASED CRADIT SYSTEM (CBCS) AS PER UGC
Under School of Life Sciences and Biotechnology
Department of Life Sciences and Biotechnology

Syllabus

B.Sc. (Hons) Biological Science

PREAMBLE

The Biological science program at the undergraduate level has been envisioned in order to emphasize the importance of interdisciplinary nature underlying the study of all the aspects of structure and function of living organisms. The course curriculum for U.G. program under choice based for B.Sc. in Biological Science (Hons) presented in this document follows the nationwide exercise undertaken by the UGC as part of curriculum restructuring initiative.

SEMESTER I						
Paper code	**Courses offered (Core course)**	**Course name**	**Credit**		**Marks**	
			Theory	**Practical ***	**Theory**	**Total**
BBS - 1001	CC-1	Cell biology	4		100	600
BBS – 1001P	Practical 1	Cell Biology Practical		2	100	
BBS - 1002	CC-2	General biochemistry - I	4		100	
BBS – 1002P	Practical 2	General biochemistry Practical		2	100	
BBS – 1003 /AECC - 01	Ability Enhancement Compulsory Course	English communication – I	4		100	
BBS – 1004 /GE-01	Generic Elective (elect any one)	101 (A): Developmental biology	4		100	
		101 (B): Plant & animal diversity	4		100	

SEMESTER II						
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical ***	**Theory**	**Total**
BBS - 2001	CC-3	Mammalian physiology	4		100	600
BBS – 2001P	Practical 3	Mammalian physiology Practical		2	100	
BBS - 2002	CC-4	Plant physiology	4		100	
BBS – 2002P	Practical 4	Plant physiology Practical		2	100	
BBS - 2003 /AECC - 02	Ability Enhancement Compulsory Course	English communication –II	4	-	100	
BBS - 2004 /GE-02	Generic Elective (elect any one)	201 (A): Stress biology	4		100	
		201 (B): Bioprocess technology	4		100	

SEMESTER III						
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical ***	**Theory**	**Total**
BBS - 3001	CC-5	Intermediary metabolism	4		100	700
BBS – 3001P	Practical 5	Intermediary metabolism Practical		2	100	
BBS - 3002	CC-6	General microbiology	4		100	
BBS – 3002P	Practical 6	General microbiology Practical		2	100	
BBS - 3003	CC-7	Fundamentals of genetics	4		100	
BBS – 3003P	Practical 7	Fundamentals of genetics Practical		2	100	
BBS – 3004 / SEC -01	Skill Enhancement Course (elect any one)	(A) Fermentation technology	4		100	
		(B) Enzymology	4		100	
SEMESTER IV						
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical ***	**Theory**	**Total**
BBS - 4001	CC-8	Environmental biology	4		100	700
BBS – 4001P	Practical 8	Environmental biology Practical		2	100	
BBS - 4002	CC-9	Biophysical chemistry & techniques	4		100	
BBS – 4002P	Practical 9	Biophysical chemistry & techniques Practical		2	100	
BBS - 4003	CC-10	Biostatistics	4		100	
BBS – 4003P	Practical 10	Biostatistics Practical		2	100	
BBS - 4004 /SEC-02	Skill Enhancement Course (elect any one)	(A) Intellectual property rights (IPR)	4		100	
		(B) Molecular diagnostics	4		100	
SEMESTER V						
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical ***	**Theory**	**Total**
BBS -5001	CC-11	Molecular biology	4		100	600
BBS -5001P	Practical 11	Molecular biology Practical		2	100	
BBS -5002	CC-12	Immunology	4		100	
BBS -5002p	Practical 12	Immunology Practical		2	100	
BBS -5003	Discipline Specific Elective (elect any two) / DSE -01	Bioinformatics	4		100	
BBS -5004		Advanced genetics	4		100	
BBS -5005		Genomics & proteomics	4		100	

SEMESTER VI						
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical**	**Theory**	**Total**
BBS -6001	CC-13	Principles & methods of genetic engineering	4		100	600
BBS -6001P	Practical 13	Principles & methods of genetic engineering Practical		2	100	
BBS -6002	CC-14	Environmental biotechnology	4		100	
BBS -6002P	Practical 14	Environmental biotechnology Practical		2	100	
BBS -6003	Discipline Specific Elective (elect any two)	Fundamentals of food technology	4		100	
BBS -6004		Basics of nanotechnology	4		100	
BBS -6005/DSE-02		Environmental monitoring&toxicology	4		100	
		Total credits	**124**			**3800**
		SEMESTER VII				
Paper code	**Courses offered**	**Course name**	**Theory**	**Practical**	**Theory**	**Total**
In addition complete any three optional subject: BBS – 701 (A)/ (B)/ (C)/ (D)						
BBS- 7001 (A)	CC-15	Applied Biochemistry	4		100	700
BBS- 7001 (A)P		Applied Biochemistry Practical		2	100	
BBS -7001 (B)		Applied Environmental Science	4		100	
BBS -7001 (B)P		Applied Environmental Science Practical		2	100	
BBS -7001 (C)		Applied Microbiology	4		100	
BBS -7001 (C)P		Applied Microbiology Practical		2	100	
BBS -7001 (D)		Applied Food Technology	4		100	
BBS -7001 (D)P		Applied Food Technology Practical		2	100	
BBS -7002	CC-16	Research methodology	4		100	
		SEMESTER VIII				
BBS- 8001	CC-17	Research project		22		700
		Total credit	168			**5200**

Core Courses (17); Ability Enhancement Compulsory Course (02); Skill Enhancement Courses(2) and Discipline Specific Elective (04). Numbers within bracket indicate the total number of courses to be taken up by the student in each category.

SEMESTER- I

BBS-I00I(CC-1): Cell Biology

UNIT I- Cell: Introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell Membrane and Permeability: Chemical components of biological membranes, organization and Fluid Mosaic Model, membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II- Membrane Vacuolar system, cytoskeleton and cell motility: Structure and function of microtubules•, Microfilaments, Intermediate filaments. Endoplasmic reticulum: Structure, function including role in protein segregation. Golgi complex: Structure, biogenesis and functions including role in protein secretion.

UNIT Ill - Lysosorpes: Vacuoles and micro bodies: Structure and functions Ribosomes: Structures and function including role in protein synthesis. Mitochondria: Structure and function, Genomes, biogenesis. Chloroplasts: Structure and function, genomes, biogenesis Nucleus: Structure and function, chromosomes and their structure:·

UNIT IV - Extracellular Matrix: Composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix, macromolecules, regulation of receptor expression and function. Signal transduction. Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecular basis of cancer.

BBS-I00IP: Practicals1: Cell Biology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Study the effect of temperature and organic solvents on semi permeable membrane.
2. Demonstration of dialysis.
3. Study of plasmolysis and de-plasmolysis
4. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source.
5. Study of structure of any Prokaryotic and Eukaryotic cell.
6. Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes.
7. Cell division in onion root tip/ insect gonads.
8. Preparation of Nuclear, Mitochondrial & cytoplasmic fractions

Suggested reading:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition.Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASMPress & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

BBS-1002 (CC-2): General Biochemistry

Unit 1- Biomolecules in their cellular environment: The cellular basis of life. Cellular structures - prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules.

Unit 2- Amino acids and peptides: Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides: Basic chemistry of sugars, optical activity. Disaccharides, trisaccharides and polysaccharides - their distribution and biological role.

Unit 4 Nucleosides, nucleotides and nucleic acids: Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids: Various classes of lipids and their distribution, storage lipids, structural lipids in membranes, lipids as signals, cofactors and pigments.

Unit 6 Vitamins, coenzymes and metal io,ns: Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

Unit 7 Signalling molecules: Second messengers - cAMP, cGMP, IP3, diacyl glycerol, Ca2+, NO. Brief account of their importance and role in signalling and signal transduction.

BBS-1002P: Practical 2: General Biochemistry Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. General safety procedures in a laboratory. Use of auto pipettes. Making solutions and buffer pr paration - acetate and tris buffers.
2. Qualitative tests for biomolecules - carbohydrates, lipids, amino acids, proteins, bases and nucleic acids.
3. Separation of amino acids by paper chromatography.
4. Separation of sugars/bases by TLC and their identification.
5. Estimation of ascorbic acid in fruit juices.

Suggested readings:

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1/ ISBN:10-14641- 0962-1.
2. Textbook of Biochemistry with Clinical Correlations (2011) 7th ed., Devlin, T.M., John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4.

BBS 1003/AECC 01: Ability Enhance Compulsory Course: English Communication – I

Introduction: Theory of Communication, Types and modes of Communication Language of Communication: - Verbal and Non-verbal (Spoken and Written) - Personal, Social and Business - Barriers and Strategies - Intra Personal, Inter Personal and Group Communication

Speaking Skills: Monologue - Dialogue - Group Discussion - Effective Communication/ Mis- Communication - Interview - Public Speech Reading and Understanding - Close Reading - Comprehension - S_ummary Paraphrasing - Analysis and Interpretation - Translation (from Indian language to English and vice-versa) Literary/Knowledge Texts

Applied Grammar: Parts of speech, conjunction, subject verb agreement, words confused and misused, one-word substitution, conditional substances, use of articles.

Suggested reading:

Stream A (For students who have studied English up to Class XII):

1. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brat iBiswas
2. Fluency in English Part II Oxford University Press, 2006 3. Business English, Pearson, 2008.

BBS 1004/ GE 01- Generic Elective (GE): elect any one

101 (A): Developmental Biology

UNIT I- Gametogenesis and Fertilization: Definition, scope & historical perspective of development Biology, Gametogenesis - Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.

UNIT II- Early embryonic development: Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements- epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps in early embryos.

UNIT Ill- Embryonic Differentiation: Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome, transcription and post-translation level Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction and induction of vertebrate lens.

UNIT IV- Organogenesis: Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germlayers Development ,of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated**

through any other material or .medium including videos/virtual labs etc.)

1. Identification of developmental stages of chick and frog embryo using permanent mounts
2. Preparation of a temporary stained mount of chick embryo
3. Study of developmental stages of Anopheles.
4. Study of the developmental stages of Drosophila from stock culture/ photographs.
5. Study of dffferent types of placenta.

Suggested reading:

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, M?ssachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to,Embryology, International Thomson Computer Press.
3. Kalthoff, {2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

101 (B): Plant and animal diversity

Unit-I- Classification of plant phyla: Classification of extant plant phyla (upto 'class' in case of algae, fungi, bryophytes, pteridophytes and gymnosperms and upto =family' in case of angiosperms).

Unit-II- Classification of animal phyla: Classification of extant major phyla (upto 'class' in case of invertebrates and upto =order' in case of vertebrates).

Unit-Ill- Structural and functional specializations in Plants: Insectivorous plants (pitcher plant, Drosera sp., Aldrovanda sp.), parasitic plants (Cuscuta reflexa, Santalum album), orchids, xerophytic plants (Opuntia sp.), mangroves of Sunderbans.

Unit-IV- Structural and functional specializations in animals: Polymorphism in Siphonophora, bioluminescence in firefly, accessory respiratory organ in fishes, electric organ in fishes, neoteny in Axolotl larva, poison gland and biting mechanism in poisonous snakes, echolocation in bat, echolocation in dolphin.

Unit-V- Elements of Human System Physiology I: Basic system biology of human: outline of Alimentary, Circulatory, Nervous and Excretory system.

Unit-VI- Elements of Human System Physiology II: Basic system biology of human: outline of Endorine, Reproductive, Homeostasis and Integrative physiology.

Practical:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Algae, Fungi and Bryophytes.
2. Pteridophytes, Gymnosperms, Morphology of Angiosperms.
3. Taxonomy (Cereals: Rice, Wheat, Corn, Maize, Red gram, Green gram, Black gram, Radish, Onion, Mango, Coconut, Orange, Banana, Lemon, Apple.
4. Anatomy of Angiosperms: Preparation of double-stained temporary slides of cross section of the following: Dicot stem and Dicot root, Monocot stem and Monocot root.
5. Porifera, Coelenterata, Helminthes, An nelida, Arthropoda, Mollusca.
6. Amphibia, Reptilia, Aves, Mammalia.

Suggested reading:

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkin , W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.

SEMESTER- II

BBS-2001{CC-3): Mammalian Physiology

UNIT I- Digestion and Respiration: Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice Respiration: Exchange of gases, Transport of 02 and CO2, Oxygen dissociation curve, Chloride shift.

UNIT II- Circulation: Composition of blood, Plasma proteins & their role, blood cells, Haemopoisis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.

UNIT Ill- Muscle physiology and osmoregulation: Structure of cardiac, smooth & skeletal muscl , threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction. Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation.

UNIT IV- Nervous and endocrine coordination: Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters Mechanism of action of hormones (insulin and steroids) Different endocrine glands- Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

BBS-2001P: Practical 3: Mammalian Physiology Practical

***(Wherever wet lab experiments are f!Ot possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Determination of Haemoglobin

Suggested reading:

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley & sons,ln .

BBS-2002 (CC-4): Plant Physiology

UNIT I- **Plant water relations and micro** & **macro nutrients:** Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing. Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

UNIT II- **Carbon and nitrogen metabolism:** Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

UNIT III- **Growth and development:** Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene) Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism and vernalization

BBS-2002P: Practical 4: Plant Physiology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
2. Demonstration of plasmolysis by Tradescantia leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

Suggested reading:

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, .L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd. 8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

BBS 1003/ AECC 02 - 201: Ability Enhance Compulsory Course (AECC)
English Communication - II

Unit- I: Essay writing
Unit- II: Letter writing, curriculum

vitae **Unit-** III: Story writing,

dialogue writing **Unit - IV:**

Journalistic writing, punctuation

Unit - V: Proverbs and maxims, idioms and phrases

Suggested reading:

Stream A (For students who have studied English up to Class **XII):**

1. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brat iBiswas
2. Fluency in English Part II Oxford University Press, 2006 3. Business English, Pearson, 2008.

BBS 2004/ GE 02- Generic Elective (GE}: elect any one
201 (A}: Stress biology

Unit- I: Defining plant stress: Acclimation and adaptation.

Unit-II: Environmental factors: Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis- rela.ted (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

Unit-III: Stress sensing mechanisms in plants: Role of nitric oxide. Calcium modulation, Phospholipid signaling

Unit-IV: Developmental and physiological mechanisms that protect plants against environmental stress: Adaptation in plants; Changes in root: shoot ratio; Aerenchyna development; osmotic adjustment; Compatible solute production.

Unit-V: Reactive oxygen species: Production and scavenging mechanisms.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Quantitative estimation of peroxidase activity in the seedlings in the absence and presence of salt stress.
2. Superoxide activity in seedlings in the absence and presence of salt stress.
3. Zymographic an lysis of peroxidase.
4. Zymographic analysis of superoxide dismutase activity.
5. Quantitative estimation and zymograp ic analysis of catalase.
6. Quantitative estimation and zymographic analysis of glutathione reductase.
7. Estimation of superoxide anions.

Suggested reading:

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd. 8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4th edition, Sinauer Associates Inc .MA, USA

201 (B}: Bioprocess technology

Unit I- Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics- Batch, Fedbatch and Continuous culture.

Unit II- Design of bioprocess vessels- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in production processes. Principles of upstream processing - Media preparation, Inocula development and sterilization.

Unit Ill- Introduction to oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa. Bioprocess measurement and control system with special reference to computer aided process control.

Unit IV- Introduction to downstream processing, product recovery and purification. Effluent treatment. Microbial production of ethanol, amylase, lactic acid and Single Cell Proteins.

Practicals:

***{Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Bacterial growth curve.
2. Calculation of thermal death point (TDP) of a microbial sample.
3. Production and analysis of ethanol.
4. Production and analysis of amylase.
5. Production and analysis of lactic acid.
6. Isolation of industrially important microorganism from natural resource.

Suggested reading:

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biot chnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

SEMESTER- III

BBS-3001 (CC-5): Intermediary metabolism

Unit 1- Basic concepts and design of metabolism: The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

Unit 2- Carbohydrate metabolism: Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis. Glycogen metabolism: Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

Unit 3- The citric acid cycle: Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

Unit 4- Oxidative phosphorylation: The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3- phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

Unit 5- Photosynthesis, Calvin cycle and pentose phosphate pathway: The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pa_thway, importance and regulation.

Unit 6- Fatty acid synthesis and degradation: TAG as energy source, oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

Unit 7- Amino acid and nucleotide metabolism: Protein degradation to amino acids, urea cycle. Nitrogen fixation, synthesis of non-essential amino acids. Biosynthesis - de novo and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

BBS-3001P: Practical 5:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Alcohol fermentation by yeast.
2. H25 production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria.

Suggested readings:

1. Biochemistry {2012) 7th ed., Campbell, M.K. and Farrel, 5.0. Brooks/Cole, Cengage Learning (Boston), ISBN: 13:978-1-111-42564-7.

BBS-3002 (CC-6): General microbiology

Unit I- Fundamentals, History and Evolution of Microbiology: Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria. Microbial Diversity: Distribution and characterization Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

Unit II- Cultivation and Maintenance of microorganisms: Nutritional categories of micro- organisms, methods of isolation, Purification and preservation.

Unit Ill- Microbial growth: Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

Unit IV- Control of Microorganisms: By physical, chemical and chemotherapeutic Agents Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal. Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

BBS-3002P: Practical 6: General microbiology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods, Methods of Isolation of bacteria from different sources.
4. Determination of bacterial cell size by micrometry. 5. Enumeration of microorganism - total & viable count.

Suggested reading:

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company

BBS-3003 (CC-7): Fundamentals of genetics

Unit I- Introduction: Historical developments in the field of genetics. Organisms suitable for genetic experimentation and their genetic significance. Cell Cycle: Mitosis and Meiosis: Control points in cell-cycle progression in yeast. Role of meiosis in life cycles of organisms. Mendelian genetics : Mendel's experimental design, monohybrid, di-hybrid and tri hybrid crosses, Law of segregation & Principle of independent assortment. Verification of segregates by test and back crosses, Chromosomal theory of inheritance, Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, pleiotropy, multiple allele, pseudo-allele, essential and lethal genes, penetrance and expressivity.

Unit II- Non allelic interactions: Interaction producing new phenotype complementary genes, epistasis (dominant & recessive), duplicate genes and inhibitory genes. Chromosome and genomic organization: Eukaryotic nuclear genome nucleotide sequence composition -unique & repetitive DNA, satellite DNA. Centromere and telomere DNA sequences, Genetic organization of prokaryotic and viral genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, intrans, genetic code, gene function.

Unit Ill- Chromosome and gene mutations: Definition and types of mutations, causes of mutations, Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression, chromosomal aberrations in human beings, abonormalities- Aneuploidy and Euploidy. Sex determination and sex linkage: Mechanisms of sex determination, Environmental factors and sex determination, sex differentiation, Barr bodies, dosage compensation, genetic balance theory, Fragile-X-syndrome and chromosome, sex influenced dominance, sex limited gene expression, sex linked inheritance.

Unit IV- Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping. Extra chromosomal inheritance: Rules of extra nuclear

inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting

BBS-3003P: Practical 7:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Permanent and temporary mount of mitosis.
2. Permanent and temporary mount of meiosis.
3. Mendelian deviations in dihybrid crosses
4. Demonstration of - Barr Body -Rhoeo translocation.
5. Karyotyping with the help of photographs
6. Pedigree charts of some common characters like blood group, color blindness and PTC tasting.
7. Study of polyploidy in onion root tip by colchicine treatment.

Suggested reading:

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. {2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. {2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. {2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. Ill Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

BBS 3004/SEC 01: Skill Enhancement Course (SEC): Elect any one

(A): Fermentation technology

Unit I- Introduction: Fermentation process, Importance of Fermented products, Isolation and maintenance of PL!re culture, Preparation of substrates/media, inoculums, Rate of microbial growth and death, Fermentation Kinetics,

Unit II- Fermentation Technology: Types of fermentation sub-merged/solid state, Batch/continuous fer_mentation, Fermenter design, operation, measurement and control in fermentation, Recovery of fermentation products and conversion into marketable/storage forms, Aeration and agitation in fermenta tion: Oxygen requirement, sterilization of air and media, Scale up in fermentation.

Unit Ill- Fermented Products: Production of baker's yeast, food yeast, Single Cell Protein, Beer, Wine, Cider, Vinegar, Cheese Lactic acid F rmentation of milk, vegetables, cereals, Mushroom cultivation, IMFL/distilled spirits.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Study of a Bio-fermentor- its design and operation, Downstream Processing and product

recovery.

2. Solid State Fermentation.
3. Fermentation of sugars by yeasts
4. Production of Baker's Yeast.
5. Production of Yogurt using DIV cultures.
6. Development of a fermented food/drink utilizing plant products/animal products or byproducts as substrate.

Suggested reading:

1. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

(B}: Enzymology

Unit I- Isolation, crystallization and purification of enzymes: test of homogeneity of enzyme preparation, methods of enzyme analysis. Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation.

Unit II- Two subst ate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis. Enzyme regulation: Product inhibition, feed backcbntrol, covalent modification.

Unit Ill- Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Negative rnoperativity and half site reactivity. Enzyme - Enzyme interaction, kinetics of allosteric enzymes. lsoenzymes- multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes.

Unit IV- Enzyme Technology: Methods for large scale production of enzymes. Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes. Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering- selected examples, Delivery system

for protein pharmaceuticals, structure function relationship in enzymes, structural motifs and enzyme evolution.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Purification of an enzyme from any natural resource
2. Quantitative estimation of proteins by Bradford/Lawry's method.
3. Perform assay for the purified enzyme.
4. Calculation of kinetic parameters such as Km, Vmax, Keat

Suggested reading:

1. Biochemistry, Lubert Stryer, 6th Edition, WH Freeman, 2006.
2. Harper's illustrated Biochemistry by Robert K. Murray, David A Bender, Kathleen M.Botham, Peter J. Kennelly, Victor W. Rodwell, P. Anthony Weil. 28th Edition, McGrawHill, 2009.
3. Biochemistry, Donald Voet and Judith Voet, 2nd Edition, Publisher: John Wiley andSons, 1995.
4. Biochemistry by Mary K.Campbell & Shawn O.Farrell, 5th Edition, Cenage Learning,2005.
5. Fundamentals of Enzymology Nicholas Price and Lewis Stevens Oxford University Press 1999
6. Fundamentals of Enzyme Kinetics Athel Cornish-Bowden Portland Press 2004
7. Practical Enzymology Hans Bisswanger Wiley-VCH 2004
8. The Organic Chemistry of Enzyme-catalyzed Reactions Richard B. Silverman Academic Press 2002

SEMESTER- IV

BBS-4001 (CC-8): Environmental Biology

Unit 1- Introduction to environmental studies: Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.

Unit 2- Ecosystems: What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chains, food webs and ecological succession. Case studies of the following ecosystems: a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 3- Natural Resources: Renewable and Non-renewable Resources, Land resources and landuse change; Land degradation, soil erosion and desertification. Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations. Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources : Renewable and non renewable energy sources, use of alternate energy sources, growing energy needs, case studies.

Unit 4- Biodiversity and Conservation: Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global

biodiversity hot spots, India as a mega-biodiversity nationi Endangered and endemic species of India, Threats to biodiversity : Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5- Environmental Pollution: Environmental pollution : types, causes, effects and controls; Air, water, soil and noise pollution, Nuclear hazards and human health risks, Solid waste management : Control measures of urban and industrial waste. Pollution case studies.

Unit 6- Environmental Policies & Practices: Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture 2/2, Environment Laws: Environment Protection Act; Air (Prevention & Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act. International agreements: Montreal and Kyoto protocols and Convention on Biological Diversity {CBD). Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Unit 7- Human Communities and the Environment: Human population growth: Impacts on environment, human health and welfare. Resettlement and rehabilitation of project affected persons; case studies. Disaster management: floods, earthquake, cyclones and landslides. Environmental movements: Chipko, Silent valley, Bishnois of Rajasthan. Environmental ethics: Role of Indian and other religions and cultures in environmental conservation. Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi).

BBS-4001P: Practical 8 – Environmental Biology

Field work:

Visit to an area to document environmental assets: river/ forest/ flora/fauna,

etc. Visit to a local p lluted site-Urban/Rural/Industrial/Agricultural.

Study of common plants, insects, birds and basic principles of identification.

Study of simple ecosystems-pond, river, Delhi Ridge, etc.

Suggested Readings:

l. Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.

2. Gadgil, M., & Guha, R. 1993. This Fissured Land: An Ecological History of India. Univ. of California Press.

3. Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.

4. Gleick, P. **H.** 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.

5. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.
6. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats
7. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
8. Sodlii,- N.S., Gibson, **L.** & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.

BBS-4002 (CC-9): Biophysical chemistry & techniques

Unit I- Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM}, pH meter, absorption and emission spectroscopy

Unit II- Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared}, centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.

Unit Ill- Introduction to the principle of chromatography. Paper chromatography, thin layer chromatography, column chromatography: silica and gel filtration, affinity and ion exchange chromatography, gas chromatography, HPLC.

UNIT IV- Introduction to electrophoresis. Starch-gel, polyacrylamide gel (native and SOS-PAGE}, agarose-gel electrophoresis, pulse field gel electrophoresis, immuno-electrophoresis, isoelectric focusing, Western blotting. Introduction to Biosensors and Nanotechnology and their applications.

BBS-4002 P:Practical 9: Biophysical chemistry & techniques Practicals

***(Wherever we lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of thf sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.

Suggested reading:

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley& Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009 The World of the Cell.7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

BBS-4003 (CC-10): Biostatistics

Unit I- Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

Unit II- Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

Unit Ill- Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)

Unit IV- Correlation and Regression. Emphasis on examples from Biological Sciences.

BBS-4003 P: Practical 10: Biostatistics Practicals

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Based on graphical Representation
2. Based on measures of Central Tendency & Dispersion
3. Based on Distributions Binomial Poisson Normal
4. Based on t, f, z and Chi-square

Suggested reading:

l. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA

2. Glaser AN (2001_) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.

BBS 4004/ SEC 02: Skill Enhancement Course (SEC}: Elect any one

(A): Intellectual Property Rights (IPR)

Unit I- Introduction to Indian Patent Law. World Trade Organization and its related intellectual property provisions. Intellectual/Industrial property and its legal protection in research, design and development. Patenting in Biotechnology, economic, ethical and depository considerations.

Unit II- Entrepreneurship: Selection of a product, line, design and development processes, economics on material and energy requirement, stock the product and release the same for making etc. The basic regulations of excise: Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations export potential etc.

Unit Ill- Bioethics - Necessity of Bioethics, different paradigms of Bioethics - National & International. Ethical issues against the molecular technologies.

Unit IV- Biosafety- Introduction to biosafety and health hazards concerning biotechnology. Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP).

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Proxy filing of Indian Product patent
2. Proxy filing of Indian Process patent
3. Planning of establishing a hypothetical biotechnology industry in India
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence.
7. Case study on handling and disposal of radioactive waste

Suggested reading:

1. Entrepreneurship: New Venture Creation : David H. Holt
2. Patterns of Entrepreneurship : Jack M. Kaplan
3. Entrepreneurship and Small Business Management: C.B. Gupta, S.S. Khanka, Sultan Chand & Sons.
4. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd. 5. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

(B): Molecular diagnostics

Unit I- Enzyme Immunoassays: Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays. Enzyme immunoassays after immune blotting. Enzyme immuno histochemical techniques. Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology

Unit II- Molecular methods in clinical microbiology: Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology Laboratory tests in chemotherapy: Susceptibility tests: Micro-dilution and macro- dilution broth procedures. Susceptibility tests:Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

Unit Ill- Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies. Concepts and methods in idiotypes. Antiidiotypes and molecular mimicry and receptors. Epitope design and applications. Immunodiagnostic tests. Immune florescence. Radioimmunoassay.

Unit IV- GLC, HPLC, Electron microscopy, flowcytometry and cell sorting. Transgenic animals

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Perform/demonstrate RFLP and its analysis
2. Kirby-Bauyer method (disc-diffusion method) to study antibiotic sensitivity of a bacterial culture
3. A kit-basd detection of a microbial infection (Widal test)
4. Study of Electron micrographs (any four). 5. Perform any one immuno diagnostic test (Typhoid, Malaria, Dengue)

Suggested reading:

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van lmpe,Kluwer Academic
4. Ananthanarayan Rand Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ}. University Press Publication.
5. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
6. Goering R, Dockrell H, Zuckerman M anc;l Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. AppletonCentuary-Crofts publication.

SEMESTER-V

BBS-5001 (CC-11): Molecular biology

Unit I- DNA structure and replication: DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and euk13ryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases, The replication complex: Pre-primming proteins, primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication.

Unit II- DNA damage, repair and homologous recombination: DNA damage and repair: causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, translesion synthesis, recombinational repair, nonhomologous end joining. Homologous recombination: models and mechanism.

Unit Ill- Transcription and RNA processing: RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation

and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5' cap

formation, polyadenylation, splicing, rRNA and tRNA splicing.

Unit IV- Regulation of gene expression and translation: Regulation of gene expression in prokaryotes: Operon concept (inducible and repressible system), Genetic code and its characteristics, Prokaryotic and eukaryotic translation: ribosome structure and assembly, Charging of tRNA, aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides, Fidelity of translation, Inhibitors of translation.,Posttranslational modifications of proteins.

BBS-5001P: Practical 11: Molecular biology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples

Suggested reading:

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

BBS-5002 (CC-12): Immunology

Unit I- **Immune Response:** An overview, co.mponents of mammalian immune system, molecular structure of Immuno-globulins or Antibodies, Humoral & Cellular immune responses, T lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells), T-cell receptors, genome rearrangements during B-lymphocyte differentiation, Antibody affinity maturation class switching, assembly of T-cell .receptor genes by somatic recombination.

Unit II- **R gulation of immunoglobulin gene expression:** Clonal selection theory, allotypes & idiotypes, allelic exclusion, immunologic memory, heavy chain gene transcription, genetic basis of antibody diversity, hypotheses (germ line & somatic mutation), antibody diversity.

Unit Ill- **Major Histocompatibility complexes:** class I & class II MHC antigens, antigen processing. Immunity to infection - immunity to different organi ms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS.

Unit IV- Vaccines & **Vaccination:** Adjuvants, cytokines, DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines, vaccines to other infectious agents, passive & active immunization. Introduction to immunodiagnostics - RIA, ELISA.

BBS-5002 P:Practical 12: Immunology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Differential leucocytes count
2. Total leucocytes count
3. Total RBC count
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.

Suggested reading:

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and

Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.

Discipline Specific Elective (DSE 01): Elect any two

BBS 5003: Bioinformatics

Unit I- History of Bioinformatics. The notion of Homology. Sequence Information Sources, EMBL, GENBANK, Entrez, Unigene, Understanding the structure of each source and using it on the web.

Unit II- Protein Information Sources, PDB, SWISSPROT, TREMBL, Understanding the structure of each source and using it on the web. Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry.

Unit Ill- Sequence and Phylogeny analysis, Detecting Open Reading Frames, Outline of sequence Assembly, Mutation/Substitution Matrices, Pairwise Alignments, Introduction to BLAST, using it on the web, Interpreting results, Multiple Sequence Alignment, Phylogenetic Analysis.

Unit IV- Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identificati_on tools.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Sequence information resource
2. Understanding and use of various web resources: EMBL, Genbank, Entrez, Unigene, Protein information resource (PIR)
3. Understanding and using: PDB, Swissprot, TREMBL
4. Using various BLAST and interpretation of results.
5. Retrieval of information from nucleotide databases.
6. Sequence alignment using BLAST. 7. Multiple sequence alignment using Clustal W.

Suggested reading:

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.

BBS5004: Advanced genetics

Unit I- **Polygeny:** Introduction, multiple factor inheritance, human skin color, medical examples, variable gene pools.

Unit II- **Genetic control of development and differentiation:** emphasizes critical periods of development,

triggers (inducers), canalization, threshold effects, phenocopies.

Unit Ill- Genetics of Domestication: Genetically determined behavior of domesticated mammals, evolution of biochemical, physical and behavioral traits (cats, dogs, horses, Siberian foxes, mice).

Unit IV- Human genome analysis: Conception, mapping, cloning and sequencing, Outcome- Generation of 'OMICS' era, significant leads. Genetic variation in health and disease: Human genetic diversity- Methods of study - Biochemical/molecular genetic markers; some examples. Tracing human migrations with autosomal, Y-chromosomal and mitochondrial markers.

Unit V- Diseases and disorders: Ch omosomal disorders: Structural and numerical; Autosomal/sex chromosomal/sex reversal; Mechanisms - mitotic/meiotic non-disjunction/ chromosomal rearrangements; Some examples (Syndromes/Cancer/Infertility); Single gene and disease: Inborn errors of metabolism, Haemoglobinopathies; Multifactorial disorders: Introduction; Methods of study (Epidemiological, Twin/ adoption and Family studies); Etiology - genetic arid non-genetic determinants; Common examples.

Unit VI- Epigenetics and disease: Mechanisms (lmprinting/methylation; chromatin remodeling); Current understanding; examples. Mitochondrial myopathies. Ethical, legal and social issues in Human genetics: Prenatal/adult (individual/family/population) screening of mutation/risk factor for genetic diseases; Confidentiality/privacy, Discrimination, Ethical dilemma, Human rights,

Surrogate mothers; Human cloning and eugenics; Organ banking and transplantation; Research ethics; Medical ethics in India.

Practicals:

***{Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Study of Linkage, recombination, gene mapping using marker based data from *Drosophila.*
2. Study of *Phlox/ Allium* Karyotype (normal and abnormal).
3. PTC testing in a population and calculation of allele and genotype frequencies.
4. Study of abnormal human karyotype and pedigrees (dry lab)
5. Isolation of plasmid DNA from *E.coli.* and restriction
6. Restriction enzyme digestion plasmid DNA.
7. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
8. Construction of Restriction digestion maps from data provided.
9. Demonstration of DNA fingerprinting

Suggested reading:

1. Genes IX by Be·njamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S. . Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.

4. Russell, P. J. (2009), iGenetics- A Molecular Approach. Ill Edition. Benjamin Cummings.
5. Molecular Cloning: A Laboratory Manua.I (3rd Edition) Sambrook and Russell Vol. I to Ill, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
7. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.

BBS 5005: Genomics and proteomics

Unit I- Introduction to Genomics, DNA sequencing methods: manual & automated: Maxam & Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods, Computer tools for sequencing projects: Genome sequence assembly software.

Unit II- Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

Unit Ill- Introduction to protein structure, Chemical properties of proteins. Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions. Determination of sizes(Sedimentation analysis, gel filteration, SDS-PAGE); Native PAGE, Determination of covalent structures - Edman degradation.

Unit IV- Introduction to Proteomics, Analysis of proteomes. 2D-PAGE. Sample preparation, solubilization, reduction, resolution. Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. De nova sequencing using mass spectrometric data.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database
5. Softwares for Protein localization.
6. Native PAGE
7. SDS-PAGE

Suggested reading:

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotec nology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Russell, P. J. (2009). iGenetics- A Molecular Approach. Ill Edition. Benjamin Cummings.
5. Molecular Cloning: A Laboratory Manua·I (3rd Edition) Sambrook and Russell Vol. I to Ill, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
7. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
8. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.

9. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington. 6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Son

SEMESTER- VI

BBS-6001 (CC-13): Principles and methods of genetic engineering

Unit I- Molecular tools and applications-, restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors {Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction {PCR), primer-design, and RT- {Reverse transcription) PCR.

Unit II- Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic engineering in animals: Production and applications of transgenic mice.

Unit Ill- Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).

Unit IV- Genetic engineering in plants: Use of Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors.

BBS-6001P: Practical 13: Principles and methods of genetic engineering practical

***{Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from E.coli
3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Making competent cells
7. Transformation of competent cells.
8. Demonstration of PCR

Suggested reading:

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Clark' DP and Pazdernik NJ. {2009). Biotechnology-Applying the Genetic Revolution. Elsevier

Academic Press, USA.
3. Glick, B.R., Pasternak, J.J. {2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
4. Primrose SB and Twyman RM. {2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
5. Sambrook J, Fritsch EF and Maniatis T. {2001}. Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.

BBS-6002 (CC-14): Environmental biotechnology

Unit I- Conventional fuels and their environmental impact. Firewood, Plant, Animal, Water, Coal and Gas. Modern fuels and their environmental impact - Methanogenic bacteria, Biogas, Microbial hydrogen Production, Conversion of sugar to alcohol Gasohol

Unit II- Bioremediation of soil & water contaminated with oil spills, heavy metals and detergents. Degradation of lignin and cellulose using microbes. Phyto-remediation. Degradation of pesticides and other toxic chemicals by micro-organisms- degradation aromatic and chlorinates hydrocarbons and petroleum products.

Unit Ill- Treatment of municipal waste and Industrial effluents. Bio-fertilizers Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Algal and fungal biofertilizers (VAM)

Unit IV- Bioleaching, Enrichment of ores y microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

BBS-6002P: Practical 14: Environmental biotechnology Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Calculation of Total Dissolved Solids {TDS) of water sample.
2. Calculation of BOD of water sample.
3. Calculation of COD of water sample.
4. Bacterial Examination of Water by MPN Method.

Suggested reading:

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mohapatra
3. Environmental Biotechnology - Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology: Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright 8. Principles of Environmental Engineering, Gilbert Masters 9. Wastewater Engineering - Metcalf & Edd

Discipline Specific Elective (DSE 02): Elect any two

BBS 6003 : Fundamentals of food technology

Unit I- Introduction: History and evolution of food processing technology

Unit II- Compositional, Nutritional and Technological aspects of Plant foods **A. Cereals and Millets:** Structure and composition of cereals and millets; Wheat- structure and composition, types (hard, soft/ strong, weak) Diagrammatic representation of longitudinal structure of wheat grain; Malting, gelatinization of starch, types of browning- Maillard & caramelization; Rice- structure and composition, parboiling of rice- advantages and disadvantages. **B. Pulses:** Structure and composition of pulses, toxic constituents in pulses, processing of pulses- soaking, germination, decortication, cooking and fermentation. **C. Fats and Oils:** Classification of lipids, types of fatty acids - saturated fatty acids, unsaturated fatty acids, essential fatty acids, trans fatty acids. o Refining of oils,methods of refining- their advantages and limitations, hydrogenation. **D. Fruits and Vegetables** : Classification of fruits and vegetables, general composition, enzymatic browning, names and sources of pigments, Dietary fibre; Post harvest changes in fruits and vegetables - Climacteric rise, horticultural maturity, physiological maturity, physiological changes, physical changes, chemical changes, Pathological changes during the storage of fruits and vegetables.

Unit-Ill- Compositional, Nutritional and Technological aspects of Animal foods: A. Flesh Foods - Meat, Fish, Poultry; Meat - Definition of carcass, concept of red meat and white meat, composition of meat, marbling, post-mortem changes in meat- rigor mortis, tenderization of meat, ageing of meat; Fish - Classification of fish, aquaculture, composition of fish, characteristics of fresh fish, spoilage of fish- microbiological, physiological, biochemical; Poultry - Structure of hen's egg, composition and nutritive value, egg proteins, characteristics of fresh egg, deterioration of egg quality, difference between broiler and layers. **B. Milk and Milk Products:** Definition of milk, chemical composition of milk, its constituents, processing of milk, pasteurization, homogenization, an overview of types of market milk and milk products.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.}**

1. Estimation of reducing sugar by Fehlings procedure.
2. Determination of acidity of water
3. Demonstration of the Soxhlet method for determination of fat content
4. Estimation of gluten content of flour.
5. Demonstration of the Kjeldahl's method for estimation of protein content
6. Determination of pH of different foods using pH meter.

Suggested readings:

1. WimJongen- Fruit and vegetable processing improving quality, Woodhead Publishing Limited.
2. A. Ch.akraverty- Post harvest Technology of cereals, pulses and oilseeds, Oxford & IBH Publishers
3. SukumarDey- Outlines of Dairy Technology, Oxford Publishers.
4. William J. Stadelman, V. M. Olson, G. A. Shemwell, S. Pasch- Egg and Poultry-Meat Processing, VCH Publishers.

BBS 6004: Basics of Nanotechnology

Unit-I: introduction of Nanoscience and Nanotechnology, bio molecules {nucleic acids and proteins),Nanoscle material, implication for physics, chemistry, engineering and biology, and motivation for nanotechnology study, history and development of nanoscience and nanotechnology.Applications of nanotechnology in life sciences

Unit-II: Nanostructures: one dimensional (ID), two dimensional (2D), three dimensional (3D) nanostructural materials.

Unit-Ill: Nanomaterials and properties: carbo_n nanotubes (CNT), metals, (Au, Ag), metal oxides ($Ti0_2$, $Ce0_2$, ZnO) semiconductors {Si, Ge, CdS, ZnSe); biological system, DNA and RNA, lipids, size development properties, mechanical, physical and chemical properties.

Unit-IV: Application of nanomaterials: molecular electronics and nanoelectronics, quantum electronic devices, CNT based transistor and field emission display, biological application, biological sensor, membrane based water purification.

Practicals:

***{Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Determination of molecular weight of polymer by viscosity average methods
2. Determination of Band gap of semiconductor
3. Determination of dielectric content-LCR bridge
4. Separation of a mixture of two amino acids by paper chromatography

Suggested readings:

1. Molecular Cell Biology,Harvey Lodish, Published by W.H. Freeman & Company
2. 2. Biomaterials: A Nano Approach,S Ramakrishna, M Ramalingam, T.S. Sampath Kumar, Winston 0. Soboyejo,Published by CRC Press
3. Bionanotechnology: Lessons from Nature, D S. Goodsell, by John Wiley & Sons, Inc.
4. 4. Nanobiotechnology: Concepts, Applications and Perspectives,(edited by C. M. Niemeyer and C. A. Mirkin), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim,
5. 5. Nanobiotechnology: Concepts, Applications and Perspectives,Edited by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH, 2004,ISBN 3527306587, 9783527306589

BBS 6005: Environmental Monitoring and Toxicology

Unit I- Air pollution monitoring: Introduction, sampling methods, air quality standards and criteria. Instruments, Control of gases and particulate matter,

Unit II- Water pollution monitoring: Introduction, sampling methods, water quality standards and criteria. Instruments pertaining wastewater treatments, episode and case study, Ganga Action plan.

Unit Ill- Soil pollution monitoring: Introduction, sampling methods, control of soil pollution.

Unit IV- Toxicology: Definition, principle, importance and scope of toxicology,nature of toxicity (acute, chronic and sub-chronic), mutagenecity,teratogenecity and carcinogenicity.

Unit V- Translocation of xenobiotics: Diffusion, distribution, metabolism, biotransformation, accumulation and execration. Impact of different xenobiotics (heavy metals, food additive, pesticides) on biota.

Practicals:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Water quality monitoring: pH, Conductivity, DO, BOD, COD, Total Hardness, Alkalinity, Chloride, TS, TSS & TDS.
2. Blood diag osis (Hb%, RBC, WBC, PCV, ESR, platelet).
3. LC_{50} calculation by probit analysis with data provided.
4. Air quality monitoring; Noise Level monitoring.
5. Biochemical analysis of plant and animal.

Suggested reading

1. Carson, R. 2002. Silent Spring. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R. 1993. This Fissured Land: An Ecological History of India. Univ. of California Press. 3. Gleeson, B. and Low, N. (eds.) 1999. Global Ethics and Environment, London, Routledge.
3. Gleick, P. H. 1993. Water in Crisis. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
4. Groom, Martha J., Gary K. Meffe, and Carl Ronald Carroll. Principles of Conservation Biology. Sunderland: Sinauer Associates, 2006.
5. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats
6. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
7. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. Conservation Biology: Voices from the Tropics. John Wiley & Sons.

SEMESTER- VII

CC - 15: In addition complete any three optional subject

BBS-7001 (A): Applied Biochemistry

Unit I- **Experimental systems in biochemical studies:** in vivo and in vitro models. Cell cultures. Microbial cultures. Cel count techniques. Basic principles of FACS analysis and applications of flow cytofluorimetry. UV-VIS spectroscopy: first elements, applications and instrumentation. Spectrofluorimetry: first elements, applications and instrumentation. Sedimentation and centrifugation: physical laws, preparative and analytical applications. Preparation and fractionation of cell and tissue homogenates. Assay methods for protein measuring.

Unit II- **Aminoacid composition and primary structure of proteins:** analysis methods. Protein fragmentation and peptide production: first elements of mass spectrometry in the proteome analysis. Electrophoresis: first elements and physical laws. Electrophoresis in liquid and semisolid media: agarose gels and polyacrilamide gels. SOS-PAGE and molecular mass determination of proteins. Native PAGE. Gradiente gels. lsoelectrofocusing and protein pl. Detection, evaluation and recovery of. protein from gel. Western and South-Western blotting. Agarose and polyacrilamide gel electrophoresis of nucleic acids. Pulsed field gel electrophoresis (PFGE) DNA sequencing: Sanger and Maxam-Gilbert methods. Chromatography: first elements and theoretical principles. TLC chromatography. Column low pressure chromatography. High performance liquid _chromatography (HPLC, FPLC). Adsorption chromatography. Partition chromatography. Normal phase and reversed phase (RPC) chromatography. Ion pair RPC. Hydrophobic interaction chromatography (HIC). Ion exchange chromatography (IEX). Gel filtration chromatography. Affinity chromatography. Working out of protein purification protocols.

Unit Ill- **Radiochemistry:** nuclear reactions, radioisotopes, radioactive decay. Matter-radiation interactions: safety elements in radioprotection. Detection and measuring of radioactivity: autoradiography, gas ionization methods, scintillation methods. Practical aspects in radioactivity counting and data analysis. Uses of radioisotopic

tracers in biochemical, biomolecular and biomedical analyses.

Unit IV- Immunochemistry: monoclonal (mAb) and polyclonal (pAb) antibodies production. In vivo and in vitro radiolabeling of proteins and nucleic acids. Purification and fragmentation of immunoglobulins. Immunoprecipitation. Antibody labeling.

Unit V- Immunoassays: RIA, IRMA, ELISA. Nucleic acids analysis:Northern and Southern analyses, restriction enzymes, modification enzyme and their applications. Polymerase chain reaction (PCR). Ser:isitivity and general applications of PCR. Cloning vectors and molecular cloning. Production of recombinant proteins.

BBS-7001 (A)P Applied Biochemistry Practical

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Differential leucocytes count
2. Total leucocytes count
3. Blotting
4. Haemagglutination assay
5. Haemagglutination inhibition assay
6. Separation of serum from blood
7. Double immunodiffusion test using specific antibody and antigen.
8. ELISA.
9.

Suggested reading

1. Wilson, Keith & Walker, John -Principles and Techniques of Biochemistry and Molecular Biology - 6th ed. Cambridge University Press, 2005 (Italian edition: WILSON Keith & WALKER, John - Biochimica e Biologia Molecolare: Principi e Tecniche - Raffaello Cortina ed. (ISBN 88- 6030-066-5))

BBS-7001 (B): Applied Microbiology

Unit 1- Agriculture Microbiology: Role of microorganisms in soil fertility. Interactions between microbes and plan"ts - rhizosphere, phyllosphere, mycorrhizae. Biofertilizer for sustainable agriculture Rhizobium, Azospirillium, Azotobacter, Azolla, BGA - mass production methods - applications methods of biofertilizers - significance of biofertilizers. Microorganisms used as biocontrol agents against microbial plant pathogens (Trichoderma sp. and Pseudomonas fluorescens), Bacterial, fungal and viral bio-insecticides and bio-herbicides

Unit 2- Food Microbiology: Factors influencing microbial growth in foods - extrinsic and intrinsic. Principles of food preservation - preservation methods - irradations - drying, heat processing, chilling and freezing, and chemical preservatives. Microbial production of Dairy Cheese, Yogurt, Butter, Buttermilk. prebiotics, probiotics-health benefits and types of microorganisms used. Cultural and rapid detection of food borne pathogens.

Unit 3- Industrial Microbiology: Introduction to fermentation. Industrially important organisms - Isolation, preservation and strain improvement. Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch and continuous fermentations. Components of a typical bio-reactor, types of bioreactors, downstream processing. Microbial productions: Wine and ethyl alcohol, citric acid, glutamic acid, penicillin Recombinant products: vaccine.

Unit 4- Medical and Pharmaceutical Microbiology: History and Importance of Medical Microbiology, Significance of Microbiome: Normal microflora, True pathogen Opportunistic Pathogens. Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis. Antimicrobial Chemotherapy: General Characteristics and model of action of different classes of Antibiotics, Antiviral, Antifungal and Anti protozoa! Agents.

Unit 5- Microbiology of waste management: Determination of water quality: BOD, COD, bacteriological examination of water (Presumptive, confirmed, completed test, SPC, MPN, Membrane filter technique). Waste treatment: Types of wastes, Effluent treatment - Primary, secondary (aerobic and anaerobic) and tertiary Methods, Disinfection, Biagas production. Solid waste management - Composting, vermicomposting, and Mushroom cultivation.

Unit 6- Microbial Applications and ethical issues: Bioremediation strategies (environment modification, microbial application), Enhanced metal recovery; Transgenic plants (BT crops, golden rice), transgenic animals, advantages, social and environmental aspects. Advances and trends, ethical issues, quality control, legislation, FDA & FPO, (India), safety and security at workplace

BBS-7001 (B) P: Applied Microbiology Practical:

***(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)**

1. Screening of antibiotics producing microbes from soil.
2. Isolation of rhizobia from root nodules.
3. Ascertaining microbial quality of milk by MBRT
4. General techniques for bacterial isolation - MPN test, Total coliform
5. Passive monitoring of microbial air quality
6. Determination of resistance/sensitivity of bacteria using disc diffusion method
7. Detection of biological oxygen demand of given water sample.

Suggested readings:

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Pres.s Publication.
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Bare. Act, 2007.lndian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.

4. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
5. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.
6. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
7. Goel D & Prashar S (2013).IPR, Biosafety and Bioethics. Pearson.
8. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.

BBS-7001 (C): Applied Environmental Science

Unite I- Ecology: Ecological Concepts: Subdivisions and development phases of ecology; Ecological features on the basis of factors such as climatic, edaphic, and biotic; Autecology - definition, distribution, Synecology : definition, subdivision, food chains, food webs and trophic levels, ecological indicator.

Unit II- Ecosystem, Structure, Function of ecosystem, type of ecosystem

Unite Ill- Ecological restoration: domestic waste water treatment, industrial wastewater treatment, bioremediation, biodegradable plastic, bio-pesticides, biodiesel, human and environmental interaction.

Unite IV- Climate change: Introduction of climate change, global warming and its effect, greenhouse substances, sources and effect,·role of IPCC in climate change monitoring, Kyoto protocol, Montreal protocol, Earth Summit and UN Conventional on climate change, remote sensing and GIS.

Unit V- Green chemistry: Concept and application of green chemistry e. g., use of CO HO TiO_2; Chitin;, the twelve principles of green chemistry; sustainable development-principles, characteristics and-sustainable development indicators, Area highlighted by Agenda-21

Unite VI- Alternative energy resources: Solar energy, tidal energy, nuclear energy, energy from biomass, bio-fuels, energy from bio-waste.

Unite VII- Enviro11mental challenges in India: Introduction, population, poverty and environmental degradation, water crisis, water depletion, land degradation, energy crisis. Threats to biodiversity, and Conservation of biodiversity, Effort to meet environmental challenges in India: Sustaining life support system, urbanization and industrialization, global issue.

Unite VIII- Introduction to Bio-molecules: Chemistry and Classification of Carbohydrate, Protein, Lipid, nucleic acids and enzymes.

BBS-7001 (C) P: Applied Environmental Science Practical

1. Estimation of water parameters - TDS, pH, DO, BOD, COD, Alkalinity, Hardness, Acidity, Chloride.
2. Estimation of Carbohydrate, Protein, and Chlorophyll from plant material
3. Wind speed, direction, Humidity, Atmospheric pressure.
4. Soil porosity, Bulk density, particle density, Organic carbon, calcium plus magnesium

5. Biodiversity of flora and fauna and indices study

Suggested reading:

1. Environmental Science, S.C. Santra
2. Environmental Biotechnology, Pradipta Kumar Mahapatra
3. Environmental Biotechnology - Concepts and Applications, Hans-Joachim Jordening and Jesef Winter
4. Waste Water Engineering, Metcalf and Eddy, Tata McGraw hill
5. Agricultural Biotechnology, S.S. Purohit
6. Environmental Microbiology: Methods and Protocols, Alicia L. Ragout De Spencer, John F.T. Spencer
7. Introduction to Environmental Biotechnology, Milton Wainwright 8. Principles of Environmental Engineering, Gilbert Masters 9. Wastewater Engineering - Metcalf & Edd

BBS-7001 (D): Applied Food technology

Unit I- Low temperature storage: Freezing and chilling, requirements of refrigerated storage - controlled low temperature, air circulation and humidity, changes in food during refrigerated storage, progressive freezing, changes during freezing -concentration effect and ice crystal damage, freezer burn and types of freezers.

Unit II- Thermal processing: Introduction, classification of thermal Processes, Principles of thermal processing, Thermal resistance of microorganisms, Thermal Death Time, Thermal process Calculations, Drying curve , effect of food properties on dehydration , change in food during drying ,drying methods and equipments used for drying and dehydration.

Unit Ill- Food irradiation and microwave •heating: Ionizing radiation and sources, unit of radiations, direct ·and indirect radiation effects, safety and wholesomeness of irradiated food. Microwave heating and application, Infra-red and ultrasonic radiation for processing and their mechanism.

Unit IV- Advanced t chnologies: Extrusion: Theory and applications, extrusion cookers and cold extrusion, single and twin screw extruders, design considerations, Supercritical gas extraction, Non thermal Processing: High pressure processing, Pulsed electric processing and Ohmic heating.

Unit V- Packaging of foods: Packaging: Properties of packaging material, factors determining the packaging requirements of various foods, brief introduction of various packaging materials used in food sector, Advanced packaging techniques- MAP, CAP, Smart packaging.

BBS-7001 (D) P: Applied Food technology Practical

1. Estimation of reducing sugar by Fehlings procedure.
2. Determination of acidity of water
3. Demonstration of the Soxhlet method for determination of fat content
4. Estimation of gluten content of flour.
5. Demonstration of the Kjeldahl's method for estimation of protein content
6. Determination of pH of different foods using pH meter.

Suggested readings:

1. Wim Jongen- Fruit and vegetable processing improving quality, Woodhead Publishing Limited.
2. A. Chakraverty- Post harvest Technology of cereals, pulses and oilseeds, Oxford & IBH Publishers
3. Sukumar Dey- Outlines of Dairy Technology, Oxford Publishers.
4. William J. Stadelman, V. M. Olson, G. A. Shemwell, S. Pasch- Egg and Poultry-Meat Processing, VCH Publishers.

BBS-7002 (CC - 16): Research methodology

Unit I- Objectives of research: Definition, objectives, types of research, classification, various phases of research.

Unit II- Research proposals and literature survey: Research proposal and aspects, Review of literature using appropriate sources - reviews, patents, research papers, books.

Unit Ill- Basic principles of research design: Types of research designs - exploratory, descriptive, and experimental, survey and case study.

Unit IV- Experimental, sampling design and data collection: Sample - types, criteria, characteristics and steps; Tools and techniques to execute experiments; Observation, questionnaire, interview

Unit V- Interpretation, report writing and the art of oral presentation: Report writing, format of publications in research journals, how to present papers and research findings

Unit VI- Bioethics and Plagiarism in Research: Biosafety and Ethics - compliance and concerns; Plagiarism; Citation and acknowledgement

Based on the teaching above, each student will undertake the following exercises.

1. A teacher (adviser) who would guide the student will discuss with student and identify a topic of mutual interest.
2. The student will collect the literature, collate the information and write the same in the form of a term paper with proper incorporation of references using appropriate software such as EndNote.
3. The student will identify scope of research on the topic and will frame objectives to be addressed in the project through a work plan.
4. The student will write standard operating protocols (SOPs) and identify requirement for equipment and reagents.
5. Each student will be asked to make presentation about the project including literature available, objective sought and work plan including methodologies as described above.

Suggested readings

1. Research in Education (1992) 6th ed., Best, J.W. and Kahn, J.V., Prentice Hall of India Pvt. Ltd.
2. At the Bench: A Laboratory Navigator (2005) Barker, K., Cold Spring Harbor Laboratory Press (New York), ISBN: 978-087969708-2. 51
3. Research Methodology - Methods and Techniques (2004) 2nd ed., Kothari C.R., New Age International Publishers.
4. Research Methodology: A Step by Step Guide for Beginners (2005) 2nd ed., Kumar R., Pearson Education.
5. Biostatistics: A Foundation for Analysis in the Health Sciences (2009) 9th ed., Daniel W.W., John Wiley and Sons Inc.
6. Statistics at the Bench: A Step-by-Step Handbook for Biologists (2010) Bremer, M. and Doerge, R.W., Cold Spring Harbor Laboratory Press (New York), ISBN: 978-0-879698- 57-7.

SEMESTER- VIII

BBS-8001 (CC-17): Research Project/ dissertation