List of Courses for B.Sc. Biotechnology Honors Degree program (w.e.f. AY 2017-18)

	Course name	Credits	
		Theory	**Practical**
A Discipline Specific Core courses (DSC) – (6 credits each)			
1	BIC101 Biochemistry and metabolism	4	2
2	CBC101 Chemistry I for Biotechnology	4	2
3	ZBC101 Animal Diversity I	4	2
4	BIC102 General Microbiology	4	2
5	CBC102 Chemistry II for Biotechnology	4	2
6	ZBC102 Animal Diversity II	4	2
7	BIC103 Cell Biology	4	2
8	CBC103 Chemistry III for Biotechnology	4	2
9	ZBC103 Mammalian Physiology	4	2
10	BIC104 Plant Physiology	4	2
11	CBC104 Chemistry IV for Biotechnology	4	2
12	ZBC104 Genetics	4	2
13	BIC105 Plant Biotechnology	4	2
14	BIC106 Bio-analytical Tools	4	2
15	BIC107 Molecular Biology	4	2
16	BIC108 Bioprocess Technology	4	2
17	BIC109 Immunology	4	2
18	BIC110 Environmental Biotechnology	4	2
B Discipline specific electives (DSE) – Code: BID; (4 credits each)			
1	BID101 Biostatistics and Bioinformatics	3	1
2	BID102 Food Biotechnology	3	1
3	BID103 Animal Biotechnology	3	1
4	BIP101 Project	4 credits research project	
C Generic elective (GE) – Code: BIG; (4 credits each)			
1	BIG101 Food Science and Nutrition	4	-
2	BIG102 Entrepreneurship Development	4	-
D Skill enhancement courses (SEC) – Code: BIS; (4 credits each)			
1	BIS101 Urban Gardening	3	1
2	BIS102 Basics of Forensic Science	3	1
E Ability Enhancement Compulsory Courses (AECC) – (4 credits each)			
1	AECC 1 English communication (2019-20)/ ENA 201 Spoken English (2020-21)	4	-
2	AECC 2 Environmental Studies	4	-

Course Structure of B.Sc. Biotechnology Honors/General Degree program (w.e.f. AY 2017-18)

Year	Semester	Discipline Specific Core	Discipline Specific Elective	Skill Enhancement course	Generic Elective	Ability Enhancement Compulsory Course
First	**I**	BIC101 CBC101 ZBC101	-	-	BIG101	AECC 1
	II	BIC102 CBC102 ZBC102	-	-	BIG102	AECC 2
Second	**III**	BIC103 CBC103 ZBC103	-	BIS101	-	-
	IV	BIC104 CBC104 ZBC104		BIS102	-	-
Third	**V**	BIC105 BIC106 BIC107	BID101 BID102	-	-	-
	VI	BIC108 BIC109 BIC110	BID103 BIP101	-	-	-

BSc Biotechnology Honors Syllabus (CBCS OC66)

BIC101	Biochemistry and Metabolism	Credit: 6 (Theory-4; Practical-2)

Course objectives

To understand the structure, properties, functions, amino acids, proteins, and carbohydrates
To understand the structure, properties, functions of lipids and nucleic acids.
To understand the classification, properties, functions of enzymes and cofactors.
To understand the reactions of carbohydrate metabolism and its energetics.

THEORY

UNIT I : Introduction to Biochemistry A historical prospective: Urey-Miller's experiment. Amino acids & Proteins: Structure & Function. Structure and properties of Amino acids, Types of proteins and their classification, Forces stabilizing protein structure and shape. Different levels of structural organization of proteins, Protein Purification. Denaturation and renaturation of proteins. Fibrous and globular proteins. Carbohydrates: Structure, Function and properties of Monosaccharides, Disaccharides and Polysaccharides. Homo & Hetero Polysaccharides, Mucopolysaccharides, Bacterial cell wall polysaccharides, Glycoproteins and their biological functions.	**10 H**
UNIT II Lipids Lipids: Structure and functions - Classification, nomenclature and properties of fatty acids, essential fatty acids. Phospholipids, sphingolipids, glycolipids, cerebrosides, gangliosides, Cholesterol. Nucleic acids: Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines & pyrimidines, Biologically important nucleotides, Double helical model of DNA structure and forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA.	**10 H**
UNIT III Enzymes Nomenclature and classification of Enzymes, Holoenzyme, apoenzyme, Cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric &oligomeric enzymes, activation energy and transition state, enzyme activity, specific activity, common features of active sites, enzyme specificity: types & theories, Michaelis-Menten equation. Factors affecting enzyme activity, Role of: NAD+, FMN/FAD, coenzymes A, Thiamine pyrophosphate, Pyridoxal phosphate, Vitamin B12, Tetrahydrofolate	**20 H**
UNIT IV: Carbohydrates Metabolism Reactions, energetics and regulation. Glycolysis: Fate of pyruvate under aerobic and anaerobic conditions. Pentose phosphate pathway and its significance, Gluconeogenesis, Glycogenolysis and glycogen synthesis.TCA cycle, Electron Transport Chain, Oxidative phosphorylation. ß-oxidation of fatty acids.	**20 H**
PRACTICAL	
1. Preparation of solutions of different molarity and normality.	60 H

2. Preparation of buffers. 3. Principles of Colorimetry: (i) Verification of Beer's law (ii) To study relation between absorbance and % transmission 4. Estimation of protein by Biuret method. 5. Estimation of protein by Folin Lowry's method 6. Estimation of reducing sugars by DNSA method. 7. To study the effect of pH on the activity of salivary amylase enzyme. 8. To study the effect of temperature on the activity of salivary amylase enzyme. 9. Determination of Km value and Vmax value of acid phosphatase enzyme activity. 10. To study the effect of inhibitor (Inorganic phosphate) on acid phosphatase enzyme activity. 11. Qualitative tests for Carbohydrates. 12. Qualitative tests for lipids. 13. Qualitative tests for proteins. 14. Estimation of blood glucose by glucose oxidase method. 15. Separation of amino acids by paper chromatography.	

Learning outcome

The student will be able to understand the structure, properties, functions, amino acids, proteins, carbohydrates, lipids and nucleic acids.
To will be able to understand classification, properties, functions of enzymes and cofactors and understand the reactions of carbohydrate metabolism and its energetics.
The student will be able to perform qualitative tests and quantitative estimations of biomolecules.
The student will be able to perform evaluate enzyme kinetics.

Suggested reading

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2019). Biochemistry.IXth Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants.American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (2006) Plant Physiology, 3rd edition, Wadsworth Publishing Co.
6. Victor W. Rodwell, David Bender, Kathleen M. Botham, (2018) Harpers Illustrated Biochemistry. Overruns Publisher

CBC101	Chemistry I For Biotechnology Atomic Structure, Bonding, General Organic	Credit: 6 (Theory-4; Practical-2)

Course objectives

To understand the atomic structure with respect to Bohr's theory, hydrogen atom spectra, Schrödinger equation for hydrogen, discovery of spin quantum numbers and magnetic quantum numbers.
To understand the rules for filling the electrons in various orbitals.
To learn to write the electronic configuration of the atom.
To understand different types of bonds including ionic and covalent bonds.
To understand the basics of organic chemistry including Structure, shape and reactivity of organic molecules.
To identify the different formulas and representations concerning stereochemistry, locate chiral centre, summarize the concept of isomerism and to classify cis-trans, threo-erythro, D / L and E /Z nomenclature.
To recognize the aliphatic compounds and classify them as alkanes, alkenes and alkynes based on the bonding of carbon-carbon bonds. To use alkanes, alkenes or alkynes for carrying out reactions and preparations using the same.

THEORY

Section A: Inorganic Chemistry-1	**30 H**
Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers *ml* and *ms*. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (*ms*). Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.	**14 H**
Chemical Bonding and Molecular Structure *Ionic Bonding:* General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability andsolubilityof ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, dipole moment and percentage ionic character. *Covalent bonding:* VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.MO Approach: Rules for the LCAO method, bonding and anti bonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd Periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO	**16 H**

approaches.	
Section B: Organic Chemistry-1	**30 H**
Fundamentals of Organic Chemistry Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyper conjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.	**8 H**
Stereochemistry Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis- trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=Csystems).	**10 H**
Aliphatic Hydrocarbons Functional group approach for the following reactions (preparations & reactions) to be studiedin context to their structure. **Alkanes:** (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe'ssynthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation. **Alkenes:** (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) andtrans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. **Alkynes**: (Upto 5 Carbons) *Preparation:* Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. *Reactions:* formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. KMnO4.	**12 H**
PRACTICAL	
Section A: Inorganic Chemistry - Volumetric Analysis-(5x6 =30 hours) 1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture. 2. Estimation of oxalic acid by titrating it with KMnO4. 3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4. 4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator. 5. Estimation of Cu (II) ions iodometrically using Na2S2O3. ***Section B: Organic Chemistry*** 1. Detection of chemical type, detection of elememts, group test for any 9 compounds. (containing upto two extra elements) -18 hours Identification of given organic compounds(2 x 6 =12) i) water insoluble solids (acids, bases, phenols and neutral) ii) water soluble solids (acids and neutral) 2. Thin layer chromatographic technique: plate preparation, spotting, separation of mixture by TLC: measure the Rf value in each case (combination of two compounds to be given) Eg. Mixture of o and p-nitroaniline.	**60 H**
Learning outcome To students will have knowledge about the atomic structure and the different types of bonds including	

ionic and covalent bonds.
The student will be able to design the most probable mechanism for a particular reaction by implementing the knowledge of curved arrows.
The student will be able to Identify the comparative strength of organic acids and bases and draw the Newmanns configuration and to solve the problems on R and S configuration.
The student will be able to choose different methods for preparing alkanes, alkenes and alkynes and also distinguish between them.
The student will be able to generate or develop their own reactions with the help of the different methods which are listed above.

Suggested reading

1. J. D. Lee: (2018) fifth edition,*A new Concise Inorganic Chemistry*, E L. B. S. 18
2. F. A. Cotton & G. Wilkinson (2007)sixth edition *Basic Inorganic Chemistry*, John Wiley
3. *Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles ofStructure and Reactivity*, Pearson Publication.
4. T. W. Graham Solomon: (2017) first edition *Organic Chemistry, John Wiley and Sons*.
5. Peter Sykes: (2003) sixth edition*A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
6. E. L. Eliel: (2001)*Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
7. L. Finar: (Vol I sixth edition 2014 and Vol II fifth edition 2018)*Organic Chemistry* (Vol. I & II), E. L. B. S.
8. R. T. Morrison & R. N. Boyd: (2013) seventh edition *Organic Chemistry*, Prentice Hall.
9. ArunBahl and B. S. Bahl: (2018)*Advanced Organic Chemistry,* S. Chand
10. R. L Madan: (2016) first edition *Chemistry For Degree Students*semester I, S. Chand
11. A.I. Vogel, *Vogel's Qualitative Inorganic Analysis,*(1996) Prentice Hall, 7th Edition.
12. A.I. Vogel, (2009) *Vogel's Quantitative Chemical Analysis*, Prentice Hall, 6th Edition.
13. A.I. Vogel (2005) Textbook of Practical Organic Chemistry, , Prentice Hall, 5th edition.
14. F. G. Mann.& B. C. Saunders, Orient Longman, (1960.)Practical Organic Chemistry

ZBC101	Animal Diversity I	Credit: 6 (Theory-4; Practical-2)

Course objectives

To understand various animal classes from primitive animal groups.
To understand the classification of Non- Chordates, Coelomata, Acoelomata, Protozoa and Porifera.
To gain thorough knowledge about phyla Coelenterata, Platyhelminthes, and Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata and Hemichordata.
To gain thorough knowledge of vermicomposting and social interaction of insects

THEORY

UNIT I a) Outline of classification of Non- Chordates upto subclasses. Coelomata, Acoelomata b) Protozoa: Locomotion, Reproduction, General features of*Paramoecium*and *Plasmodium*. Pathogenic protozoans c) Porifera: General characters, outline of Classification; skeleton, Canal System	**15 H**
UNIT II a) Coelenterata: General Characters, Outline of classifications Polymorphism, Various types of stinging cells; Metagenesis, coral reefs and their formation. b) Platyhelminthes- General Characters; Outline of classification; Pathogenic flatworms:Parasitic adaptations. c) Aschelminthes: General features, Outline of classification, Pathogenic roundworms andtheir vectors in relation to man: Parasite adaptation.	**15 H**
UNIT III a) Annelida: - General features, Outline of classification, Coelom: Metameric segmentation,General features of Earthworm, Vermicomposting. b) Arthropoda: General Features, Outline of Classification; Larval forms of crustacean,Respiration in Arthropoda; Metamorphosis in insects; Social insects; Insect vectors of diseases; Apiculture, Sericulture.	**15 H**
UNIT IV a) Mollusca : General features, Outline of classification, Shell Diversity; Torsion in gastropoda, b) Echinodermata: General features, Outline of Classification Larval forms c) Hemichordata: Phylogeny: Affinities of *Balanoglossus*	**15 H**
PRACTICAL	
1. Identification and Classification of Any these of the following – Protozoa-*Amoeba, Paramoecium, Plasmodium* Porifera*: Scypha, , Leucosolenia, Euspongia, Hylonema, EuplectellaCnidaria:Medrepora, Millepora, Physalia, Porpita, Valella, Aurelia, Metridium* Platyhelminthes: *Taenia, Fasciola*, Aschelminthes*: Ascaris, Ancylostoma, Enterobius* Annelida: *Pheretima, Hirudinaria, Chaetopterus, Nereis, Aphrodite* Arthropoda: *Julus,Scolopendra, Peripatus, Carcinus, Limulus, Lepisma, Dragonfly, Musca, Acheta* Mollusca: *Pila, Unio, Mytilus, Loligo, Sepia, Octopus, Solen* Echinodermata: *Asterias, Ophiothrix, Echinus, Holothuria, Astrophyton* Hemichordata: *Balanoglossus* *2.* Identification of slides with two points of identification. Spicules of sponges, Larvae of *Fasciola,*	**60 H**

Seta of Earthworm, Nephridia of Earthworm 3. Ecological Note – On any 2 of the specimens in Exercise No 1 Models of dissection of Earthworm, Cockroach Earthworm: Digestive, Nervous System Cockroach: Digestive Reproductive, Nervous System 4. Mouth parts of Honey bee (Permanent slides/ Microphotographs/digital sources) 5. Mouth parts of House fly, Mouth parts of Cockroach (Permanent slides/ Microphotographs/digital sources) 6. Appendages of Prawn (mounting should be carried out)	

Learning outcome

The students will be able to explain characteristics of Non- Chordates, Coelomata, Acoelomata, Protozoa and Porifera; phyla Coelenterata, Platyhelminthes, and Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata and Hemichordata

Students can describe general features of Earthworm and Vermicomposting.

Students will be able to describe the economic importance of insects

Suggested reading

1. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W. & J.I., Spicer (2002) TheInvertebrates: A New Synthesis. III Edition.Blackwell Science.
2. Kotpal R.L. (2000) Invertebrates. Rastogi Publi. Meerut
3. Parker A.J., Haswell W. A. A. (2002) Textbook of Zoology Vol. I . Mc millan
4. Ganguly B. B., Sinha A.K. and Adhikari S. (2000) Introduction to biology of Animals. New Central Book Agency, Calcutta
5. Barnes R.D. (2000) Invertebrate Zoology. Saunders College Publishing
6. Ayer Ekabaranath, M. (2000). A Manual of Zoology.Vol. I Part I & II. S. Viswanath, Madras.
7. Dhami, P. S. and Dhami, J. K. (2000). Invertebrate Zoology, S. Chand & Co. Pvt. Ltd. New Delhi.
8. Jorden, E. L. & Verma, P.S. (2000). Invertebrate Zoology. S. Chand & Co. Pvt. Ltd. New Delhi

BIG101	Food Science and Nutrition	Credit: 4 (Theory-4)

Course objectives

To acquire knowledge of various concepts of Food Science – its facts and principles.

To understand the composition of food

THEORY

Unit I: **25 H**

1. Role of nutrition in health– An overview

I. Concept of nutrition

II. Significance & functions of food

2. Introduction to Nutrition and Food Science Facts and Principles, Detailed study of foodstuffs, Composition and nutritive value, Processing, Classification, Digestibility, Storage, their importance in the diet & their recommended daily intake : Milk, Eggs, Meat, Poultry, Fish and shell fish, Vegetables, Fruits, Fats, Oils and nuts

Role of water: Role of water in the body, Water and Electrolyte balance

Unit II: **20 H**

Macro & Micronutrients

3. Macronutrients: Carbohydrate, Proteins & Fats - Their Classification, Functions , Digestion and absorption, Sources , Requirements, Deficiency and related diseases **(08 periods)**

4. Micronutrients – Their Classification, Functions, Digestion and absorption, Sources, Requirements , Deficiency and related diseases, & role of antioxidants **(12 periods)**

I. Minerals: a) Macro: i. Calcium ii. Phosphorus iii. Sodium iv. Potassium

b) Micro: i. Iron ii. Iodine iii. Zinc

II. Vitamins –a) Fat soluble –A, D, E, K

b) Water Soluble - B Complex , Vitamin C

Unit III: **15 H**

5. A brief Introduction to Energy:

I. Balance; underweight, overweight, obesity

II. Factors determining energy requirements

6. Meal Planning **(07 periods)**

I. Factors affecting meal planning

II. Balanced Diet

III. RDA and Dietary guidelines for Indians, ICMR, 2010

IV. Food exchange list, its usage

V. Basic steps in planning a meal.

7. Recent advances in Nutrition **(04 periods)**

I. Nutritional labelling

II. Functional foods-Antioxidants, Probiotics, Nutraceuticals, Phytonutrients

Learning outcome

The student will be able to describe the role of nutrition in health, define different concepts of nutrition and also the significance and functions of food.

The student will be able to apply the knowledge gained through this course in having a balanced and healthy diet with respect to macronutrients and micronutrients.

The student will gain knowledge about the factors determining the daily energy requirement and identify various functional food for maintaining the health.
Suggested reading 1. Chaddha and PulkeetMathur, 2015, Nutrition a lifecycle approach, recent edition 2. B. Srilakshmi, 2018, Food Science, New Age International, recentSixth edition 3. SunetraRodyRodey, 2012, Food Science & Nutrition, Oxford University Press, recentSecond edition.

AECC1	English communication (AY2019-20)	Credit: 4 (Theory-4)

Course objectives

To understand the language of communication : verbal and non-verbal comminucation.
To learn and garner various types of speaking skills.
To enhance the English reading and understanding process.
To improve writing skills in English.

THEORY	**60 H**
1. Introduction: Theory of Communication, Types and modes of Communication	
2. Language of Communication: Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication	
3. Speaking Skills: Monologue Dialogue Group Discussion Effective Communication/ Mis-Communication Interview Public Speech	
4. Reading and Understanding Close Reading Comprehension Summary Paraphrasing Analysis and Interpretation Translation (from Indian language to English and vice-versa) Literary/Knowledge Texts	
5. Writing Skills Documenting Report Writing Making notes Letter writing	

Learning outcome

The student will be able to enhance communication in English language mainly through speaking, writing and reading.

Suggested reading

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr RanjanaKaul, Dr BratiBiswas

AECC1	Spoken English (AY2020-21)	Credit: 4 (Theory-4)

Course objectives

To listen to, understand and convey information
To listen to and respond appropriately to the contributions of others
To understand, order and present facts, ideas and opinions
To articulate experience and express what is thought, felt and imagined
To communicate clearly and fluently
To use grammatically correct language
To use register appropriate to audience and context.

THEORY	**60 H**
(Several components may be covered in every session) Pronunciation and Enunciation: (Vowels and Consonants and their types) Diction, intonation, phrasing, pausing, emphasis, stress, inflection. Grammar, vocabulary and alternatives to slang Conversation skills: e.g. interviews, chat show 'host-guest' situation Presentation skills Discussion skills: leading and participating. Active listening skills Asking and answering questions Requests and explanations Persuasion and Negotiation Expressing opinions Giving and getting advice Cross - cultural communication Skills required for conduct of meetings - Summarizing, Chairing, Explaining, Time Management	

Learning outcome

On completion of the course the student should be able to:
1. Describe a visual or an object
2. Explain and give cause and effect
3. Narrate an experience with descriptive detail
4. Provide relevant information in response to a query
5. Use alternatives to slang
6. Take an active part in group discussion
7. Elicit and show respect for the views of others
8. Disagree, argue and use persuasive speech in appropriate language

Suggested reading

Hancock, Mark. English Pronunciation in Use. Cambridge UP, 2003 onwards
O‟ Connor, J.D. Better English Pronunciation.Cambridge UP, 1967 onwards
Murphy, Raymond. Murphy’s English Grammar. Cambridge UP
Jones, Daniel, et al. Cambridge English Pronouncing Dictionary, 18th edition. Cambridge UP
Online Resource – The homepage of NATE (National Association Of Teaching English) while a national British association, has many resources which are in effect international.
Series: English Writing Frames – Copiable books. Could be used in used in conjunction with any language/Communication skills course. A systematic resource, with step–by-step

practical exercises and photocopiable frames to practice with.
Neild, J. English Writing Frames: Genre. Folens Publishing Limited, 2000.
Neild, J English Writing Frames: Style and PurposeFolens Publishing Limited 2000 -
also book and disk pack ISBN: 1841636983 Published by Folens Publishing Limited, Unit 20, Apex Business Centre, Boscombe Road, Dunstable, Bedfordshire, LU5 4RL ,U.K
www.folens .com
Seely, J & Kitshen, D . Heinemann English Programme. Heinemann -a thematically arranged four part series. Teacher resource files accompany the set.
Authors : ISBN:
0435103520
0435103547
0435103563
0435103466
Publisher: Heinemann, Harcourt Education Ltd, Halley Court, Jordan Hill, Oxford, OX2 8EJ, U.K. www.heinemann.co.uk
Jones, R . Speaking and listening: John Murray, Hodder Murray.
-with accompanying cassette ISBN: 0719546699
Publisher : John Murray, Hodder Murray, 338 Euston Road, London, NW1 3BH UK.
www.johnmurray.co.uk
New Hodder English
This is a series of three books. Teachers can find a variety of accessible material to simulate speaking and listening activities as well as writing.
Hackman, S; Scott, P & Howe, A . New Hodder English Publisher Hodder & Stoughton Education. (edition 2001)
ISBN 034077536X
ISBN 0340775378
ISBN 0340775386
Publisher Hodder & Stoughton Education, Hodder Deadline, 338 Euston Road, London, NW1 3bh, UK
www.hodderheadline.co.uk
Krishna Mohan and N. P. Singh. Speaking English Effectively. Macmillan India Ltd
ISBN: 0333925521
Examples of Questions

BIC102	General Microbiology	Credit: 4 (Theory-4; Practical 2)

Course objectives

To learn the Fundamentals, History and Evolution of Microbiology.

To understand concepts of Microbial taxonomy, molecular approaches, microbial phylogeny and the current classification of bacteria.

To understand microbial diversity distribution, morphology and cell structure of major groups of microorganisms and understand the difference between Prokaryotic and Eukaryotic cells

To understand the Nutritional categories of micro-organisms, synchronous batch and continuous culture and metabolic pathways in microorganisms

To explain the different types of media used for isolation, cultivation, maintenance, purification and preservation of microorganisms.

To understand the Microbial growth curve, define and calculate generation time, bacterial reproduction, sporulation and mechanisms of DNA transfer.To understand methods to control microorganisms and understand the microbiology of water pollution, food fermentation and food borne infections and intoxications.

THEORY	**60 H**
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.	**10 H**
UNIT II Cultivation and Maintenance of microorganisms: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.	**10H**
UNIT III 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.	**20 H**
UNIT IV Control of Microorganisms: By physical, chemical and chemotherapeutic Agents Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage and its disposal. Food Microbiology: Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications,.Fermented Foods.	**20 H**
Practical	**60 H**
1. Isolation of bacteria & their biochemical characterization IMViC. 2. Study of colony characteristics of bacteria. 3. Staining methods: simple staining, 4. Gram staining, 5. Spore staining,	

6. Capsule staining 7. Hanging drop. 8. Preparation of media & sterilization methods. 9. Methods of Isolation of bacteria from different sources. 10. Determination of bacterial cell size by micrometry. 11. Enumeration of microorganism - total & viable count.	

Learning outcome

Describe the Fundamentals, History and Evolution of Microbiology.

To apply concepts of Microbial taxonomy, molecular approaches, microbial phylogeny and the to classify bacteria.

Gain knowledge of the microbial diversity distribution, morphology and cell structure of major groups of microorganisms and understand the difference between Prokaryotic and Eukaryotic cells along with the nutritional categories of micro-organisms, synchronous batch and continuous culture and metabolic pathways in microorganisms

Understand the use of different types of media isolation, cultivation, maintenance, purification and preservation of microorganisms.

To delineate the Microbial growth curve, define and calculate generation time, bacterial reproduction, sporulation and mechanisms of DNA transfer.

To understand methods to control microorganisms and understand the microbiology of water pollution, food fermentation and food borne infections and intoxications.

Suggested reading

Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7 thedition, CBS Publishers and Distributors, Delhi, India.

Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.

Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.

Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.

Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.

Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

B. D. Singh Biotechnology: Expanding Horizons Publisher: Kalyani;,4th edition(2015)

CBC102	Chemistry II For Biotechnology **Chemical Energetics, Equilibria & Functional Organic Chemistry I**	**Credit: 4** **(Theory-4; Practical 2)**

Course objectives

To be able to understand the laws of thermodynamics and chemical equilibrium.

To derive and use the equations and calculate various parameters pertaining to the chemical equilibrium and the bond energies.

Interpret the relationship between equilibrium constants at constant temperature, pressure and mole fraction.

Describe the preparation of buffers and organic various compounds.

Predict and compare the mechanism of reaction, and predict the products, intermediates, reactants and reaction conditions for a given chemical reaction.

THEORY	**60 H**
Section A: Physical Chemistry-1	**30 H**
Chemical Energetics Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature –Kirchhoff' sequation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.	**10 H**
Chemical Equilibrium Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between *G* and *G*o, Le Chatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.	**8 H**
Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.	**12 H**
Section B: Organic Chemistry-2	**30 H**
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. **Aromatic hydrocarbons (8 Periods)** *Preparation* (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. *Reactions*: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).	**20 H**

Alkyl and Aryl Halides Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. *Preparation:* from alkenes *and* alcohols. *Reactions:* hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions (Chlorobenzene):* Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.	**8 H**
Alcohols, Phenols and Ethers (Upto 5 Carbons) Alcohols: *Preparation:* Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. *Reactions:* With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO3).Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. **Phenols:** (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer- Tiemann Reaction, Gattermann- Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. **Ethers (aliphatic and aromatic):** Cleavage of ethers with HI. **Aldehydes and ketones (aliphatic and aromatic):** (Formaldehye, acetaldehyde, acetone and benzaldehyde) *Preparation:* from acid chlorides and from nitriles. *Reactions* – Reaction with HCN, ROH, NaHSO3, NH2-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein – Pondorff Verley reduction.	**14 h**
Practical	**60 H**
Section A: Physical Chemistry **Thermochemistry(4x 6 =24)** 1. Determination of heat capacity of calorimeter for different volumes. 2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide. 3. Determination of enthalpy of ionization of acetic acid. 4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl). 5. Determination of enthalpy of hydration of copper sulphate. 6. Study of the solubility of benzoic acid in water and determination of ΔH. **Ionic equilibria** **pH measurements(4 hours)** a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter. b) Preparation of buffer solutions:**(2 hours)** (i) Sodium acetate-acetic acid	

(ii) Ammonium chloride-ammonium hydroxide
Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic solids by recrystallization (from water and alcohol) and determination of melting point.
2. Purification of organic liquids bydistillation (using water and air condenser) and determination of boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallization, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) Oximeof ketone
(d) Nitration of acetanilide from p-nitroacetanilide.

Learning outcome

To study the chemical energetics including the Laws of Thermodynamics and thermochemistry.
To understand concept of standard state and standard enthalpies and calculate bond energy, bond dissociation energy and resonance energy from thermochemical data.
To state variation of enthalpy of a reaction with temperature –Kirchhoff's equation.
To understand chemical equilibrium with respect to the free energy change in a chemical reaction.
To distinguish between *G* and *G*o, Le Chatelier's principle and interrelate between *Kp, Kc* and *Kx* for reactions involving ideal gases.
To delineate the strong, moderate and weak electrolytes, degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect.
To calculate hydrolysis constant, degree of hydrolysis and pH for different salts.
To discuss on solubility and solubility product of sparingly soluble salts – applications of solubility product principle.
To study the functional group approach for the following reactions (preparations & reactions) in context to their structure: a**romatic hydrocarbons**, a**lkyl and aryl halides, Alcohols, Phenols and Ethers, Phenols:** (Phenol case)**, Ethers (aliphatic and aromatic), Aldehydes and ketones (aliphatic and aromatic):** (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Suggested reading

T. W. Graham Solomons: *Organic Chemistry, John Wiley and Sons*.
Peter Sykes: *A Guide Book to Mechanism in Organic Chemistry,* Orient Longman.
I.L. Finar: *Organic Chemistry* (Vol. I & II), E. L. B. S.
R. T. Morrison & R. N. Boyd: *Organic Chemistry,* Prentice Hall.
Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.
G. M. Barrow: *Physical Chemistry* Tata McGraw_Hill (2007).
G. W. Castellan: *Physical Chemistry* 4th Edn. Narosa (2004).
J. C. Kotz, P. M. Treichel& J. R. Townsend: *General Chemistry* CengageLening, India Pvt. Ltd., New Delhi (2009).
B. H. Mahan: *University Chemistry* 3rd Ed. Narosa (1998).
R.H. Petrucci: *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985)
A.I. Vogel: (2005) Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
F. G. Mann & B. C. Saunders, (1960).Practical Organic Chemistry, Orient Longman

B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

ZBC102	**Animal Diversity II**	**Credit: 4** **(Theory-4; Practical 2)**

Course objectives

To gain thorough knowledge about various higher animal classes, Protochordates, Pices and Amphibia.
To gain thorough knowledge about Class Reptilia, Aves, and Mammalia.
The understand integumentary system, skeletal system, respiratory system, circulatory system, heart & aortic arches, and urinogenital system in mammals.
The student understand the nervous systems & its development and development of eye and ear in mammal.

THEORY	**60 H**
UNIT I:Proto-chordates, Pisces and Amphibia Proto-chordates: Outline of classification, General features and important characters of Herdmania, Branchiostoma Origin of Chordates Cyclostomata- General features, Classification Pisces: General features, Migration in Pisces, Outline of classification Amphibia: General features,Classification, Origin, Parental care, Neoteny and Paedogenesis	**20 H**
UNIT II:Reptilia, Aves and Mammalia Reptilia: General features Classification, Origin Aves: General features, Classification, Origin, flight- adaptations, migration, Flightless birds or ratitae, Beak and feet in birds. Mammalia: General features, Classification, Origin, dentition, Aquatic and flying mammals	**20H**
UNIT III:Mammalian Anatomy I Integumentary- Epidermal derivatives and their modifications, Dermal derivatives Skeletal system in mammal- appendicular and axial. Respiratory systems- air ducts, Circulatory system – anatomy of Heart, Aortic arches urinogenital system - anatomy of kidney and nephron	**10 H**
UNIT IV:Mammalian Anatomy II Nervous system – development of brain, Central /nervous System, Peripheral nervous system, Autonomic Nervous system in Mammal Anatomy of Eye and Ear of Mammal	**10 H**
Practical	**60 H**
1. Identification & Classification upto order of the following: a. Proto-chordata: *Salpa, Doliolum, Herdmania, Branchiostoma* Cyclostomata: *Myxine, Petromyzon* b. Chondrichthyes: *Scoliodon, Zygnea, Pristis, Trygon, Raja,* c. Ostiechthyes: *Labeo, Mystus, Catla, Hippocampus, Anabas, Echeneis, Lophius, Polypeterus* d. Amphibia: *Rana, Hyla, Amblystoma, Necturus, Proteus.*	

e. Reptiles: *Hemidactylus, Calotes, Draco, Phyrnosoma, NajaVipera, Bungarus*
f. Aves: *Columba, Alcedo, Passer*
g. Mammalia: *Ornithorhynchus, Macropus, Didelphes, Dasypus*

2. An Ecological Note on any one of the specimens in Experiment 1
3. Identification of the following slides: Slides of Salpa, Doliolum, Spicules of Herdmania, Tadpole of Frog
4. Preparation of a permanent mount of Placoid scales, Cycloid and Ctenoid scales
5. Types of beaks and feet and feathers in birds
6. Identification of venomous and non venemous snakes.

Learning outcome

At the end of this course the student will be able to:

To describe, identify and classify higher animal classes, Protochordates, Pices and Amphibia and also state their general features, classification.

Will be able to observe and state features of Class Reptilia, Aves, and Mammalia and identify venomous and non-venomous snakes

Will be able to understand the parts and functioning of integumentary system, skeletal system, respiratory system, circulatory system, heart & aortic arches, and urinogenital system in mammals.

Will be able to understand the parts and functioning of nervous systems & its development and development of eye and ear in mammal.

Suggested reading

Hall B.K. and Hallgrimsson B. (2008).Strickberger's Evolution.IV Edition. Jones and, Bartlett Publishers Inc. Kardong, K.V. (2005) Vertebrates Comparative Anatomy, Function and evolution.IV Edition.,McGraw-Hill Higher Education. 3. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates.IX Edition.The.McGraw-HillCompanies. 4.Young, J.Z. (2004). The life of vertebrates.III Edition.Oxford university press

BIG102	Entrepreneurship Development	Credit: 4 (Theory-4)

Course objectives

To understand entrepreneurship development and know the needs and importance of entrepreneurship.
To drive a process of promoting entrepreneurship and factors influencing entrepreneurship.
To understand the different forms of organization and discuss the process of project identification, selection of the product, project formulation, assessment of project feasibility.
To define the importance of finance /loans and repayments and classify the characteristics of business finance.
To explain the concept of fixed and working capital management and it's sources.
To discuss the process of raising capital for investing in inventory direct and indirect raw materials and it's management.
To understand marketing management and it's importance and describe concepts of marketing-mix and product management -product line.
To derive a different stages of product life cycle, discuss the importance of marketing research and survey, understand physical distribution and stock management.
To understand international business and analyse the concept of selection of product and the market for international business and define term export finance and list it's sources of supply.

THEORY	**60 H**
UNIT I Introduction Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.	**10 H**
UNIT II Establishing an Enterprise Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.	**12H**
UNIT III Financing the Enterprise Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.	**15 H**
UNIT IV Marketing Management Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management, Costing and Books of Accounts.	**13 H**
UNIT V Entrepreneurship and International Business Meaning of International business, Selection of a product, Selection of a market for International business, Export financing, Institutional support for exports.	**10 H**

Learning outcome

At the end of the course students will be able to:

Define and explain the terms and concepts involved giving examples.
Describe the meaning of the entrepreneur and also delineate the evolution and development of the concept

of the term entrepreneurship.
Delineate the entrepreneurial decision process while establishing an enterprise.
Identify, classify and discuss the sources of finance and it's importance to enterprises.
Appreciate the importance of marketing management in modern business organisations and elaborate the various elements of marketing mix. Also analyse and understand the importance of research and survey needed to know the competitive situation in the market.
Identify the importance of international business and to take an accurate decision with regards to seclection of product and market for his sales. It also important to know the finance raise for exports and institutional support to it.

Suggested reading

Kumar S.A, Poornima S.C, Abraham M.K, Jayshree K. (2003). Entrepreneurship Development. New Age International (P) Ltd, New Delhi.

Sharma S. (2016). Entrepreneurship Development. PHI Leraning Private Limited, Delhi.
Bhamare A.M, Mascarenhas R.S. (2015). Entrepreneurship Development. Vipul Prakashan, Mumbai.

AECC2	Environmental Studies	Credit: 4 (Theory-4)

Course objectives

The course envisages that all the under graduates coming out of our University system are aware of our natural resources, ecosystems and their linkages to society, livelihood, environment and conservation. This theoretical learning shall be supported by the actual field visits.

To understand the scope and importance of environmental studies and create awareness of current environmental status.

To understand Renewable and Non-Renewable resources, describe about equitable use of resources for suitable lifestyle.

To understand role of individual in conservation of natural resources and maintaining the sustainable development.

To understand the different concept of an ecosystem, to describe the ecological succession and food webs and to illustrate the ecological pyramids.

To understand biodiversity conservation- in-situ and ex-situ conservation, value of biodiversity and threats to biodiversity.

To visit local area to document environmental assets**, understand a simple ecosystem, visit a polluted site and write a report on the field visit.**

To understand types of environmental pollution, wastes and waste management, prevention of the pollution, understand past disasters which occurred due to pollutions and various

methods in disaster mitigation and management. To understand the concept of sustainable development, urban problems related to energy and

environmental ethics.

To understand the objectives and scope of Environment (Protection) Act, variation in population of different nations and create welfare programs.

To understand the role of Information Technology in environment and human health.

To understand tourism, describe the aspects of degradation and exploitation and sustainable tourism.

THEORY	**60 H**
SECTION – A Natural Endowments: Status, Issues, concerns and responses	
Unit 1: The Multi-Disciplinary Nature of Environmental Studies Definition, Scope and Importance; need for public awareness.	**2 H**
Unit 2: Natural Resources Renewable and Non-Renewable resources: natural resources and associated problems a) Forest Resources: use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people. b) Water Resources: use and over-exploitation of surface and ground water; floods, droughts, conflicts over water, dams-benefits and problems. c) Mineral Resources: use and exploitation, environmental effects of extracting and using mineral resources; case studies related to mining and its effect on siltation and loss of biodiversity. d) Food Resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity; case studies. e) Energy Resources: growing energy needs, renewable and non-renewable energy sources, use of alternative energy sources, case studies f) Land Resources: land as a resource, land degradation, man-induced landslides, coastal erosion, soil erosion and desertification.	**8 H**

• Role of an individual in conservation of natural resources. • Equitable use of resources for sustainable lifestyles.	
Unit 3: Ecosystems Concept of an ecosystem, structure and functions of ecosystems; producers, consumers and decomposers, energy flow in the ecosystem, ecological succession, food chains, food webs and ecological pyramids. Introduction, types, features, structure and functions of the following ecosystems: forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystem (ponds, streams, lakes, rivers, oceans, coastal zone, estuaries).	**6 H**
Unit 4: Biodiversity and its Conservation Introduction, definition, genetic, species and ecosystem diversity; bio-geographical classification of India; value of biodiversity - consumptive use, productive use, social, ethical, aesthetic and option values; biodiversity at global, national, regional and local levels; India as a mega-diversity nation; hotspots of biodiversity; threats to biodiversity - habitat loss, poaching of wildlife, man-wildlife conflicts, bio-invasion, and over exploitation; endangered and endemic species of India (at least 5 examples of animals and plants each); conservation of biodiversity- in-situ and ex-situ conservation, role of biotechnology in conservation of biodiversity.	**8 H**
Unit 5: Field visit to different ecosystems/Landscapes and to learn biodiversity Visit to a local area to document environmental assets - river/ forest/ grassland/ hill/ mountain; study of common plants, insects, birds; study of simple ecosystems-pond/ river/ hill slopes, etc. A report of field visit(s) to be maintained.	**6 H**
SECTION – B Socio-economic dimensions of Environment	
Unit 6: Environmental Pollution Definition, causes, effects and measures to control air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards; waste – types, causes, effects; waste management –solid, sewage and effluents; measures to control industrial and urban wastes; role of an individual in prevention of pollution; pollution case studies (Bhopal gas tragedy and mining); disaster mitigation and management-floods, droughts, earthquakes, landslides, cyclones, Tsunami.	**7 H**
Unit 7: Social issues and the Environment From unsustainable to sustainable development; urban problems related to energy; water conservation, rainwater harvesting, watershed management; resettlement and rehabilitation of people - problems and concerns, case studies; environmental ethics - issues and concerns; climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies; wasteland reclamation; consumerism and associated waste products; Objectives and scope of Environment (Protection) Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Forest Conservation Act, Wildlife Protection Act, Forest Rights Act and Biodiversity Act; Issues involved in enforcement of environmental legislation; public awareness.	**8 H**
Unit 8: Human Population and the Environment Population growth, variation among nations; population explosion - Family Welfare Programme; environment and human health; human rights; value education; HIV/AIDS; women and child welfare; role of Information Technology in environment and human health; case studies.	**5 H**
Unit 9: Tourism and Environment Definition and typology of tourism; mass tourism and environment - aspects of degradation and exploitation, physical and social impacts; examples at local, regional, national and international	**4 H**

levels. Sustainable tourism.	
Unit 10: Field visit local polluted / waste treatment site(s) Visit to a local polluted site - urban/rural/ industrial/ agricultural and waste treatment plant(s)/sustainable tourism site(s). A report of field visit to be maintained.	**6 H**
Learning outcome ***At the end of the course students will be able to:*** Define the terms involved in Environmental studies and also the scopes and importance of environmental studies. Make awareness of current environmental status. Differentiate the types of Renewable and Non-Renewable resources. Understand the equitable use of resources for suitable lifestyle. Know the different concepts of an ecosystem such as ecological succession and food webs Draw the ecological pyramids. Understand the threats of biodiversity and its in-situ and ex-situ conservation. To identify the local pollution sites.	
Suggested reading Agarwal K.C. (2001): Environmental Biology, Bikaner, Nidi Bharucha E.: The Biodiversity of India, Ahmedabad, Mapin Bharucha E.: Textbook of Environmental Studies. Orient BlackSwan Brunner R.C. (1989): Hazardous Waste Incineration, New York, McGraw-Hill Chatwal G.R. & Sharma H. (2005: A Textbook of Environmental Studies, Mumbai, Himalaya Clark R.S.: Marine Pollution, Oxford, Clanderson Cunningham W.P., Cooper T.H., Gorani E. & Hepworth M.T. (2001): Environmental Encyclopaedia, Mumbai, Jaico.	

BIC103	Cell Biology	Credit: 4 (Theory-4; Practical 2)

Course objectives

To understand classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation.
To describe the structure of cell membrane and chemical components of biological membranes.
To study the Fluid Mosaic Model, cell recognition and membrane transport,
To understand and elucidate the structure of cell wall ultrastructure & function.
To describe the membrane vacuolar system,
To understand and illustrate components of cytoskeleton and cell motility:
To explain the structure, function and biogenesis of Golgi complex.
To understand and describe the structure and functions of lysosomes, Vacuoles and micro bodies, Ribosomes, Mitochondria Chloroplasts, Nucleus, chromosomes.
To understand the stages of Cell cycle and Mitosis & Meiosis in eukaryotic cells
To understand the composition, molecules that mediate cell adhesion, membrane receptors for extra cellular matrix.
To explain macromolecules, regulation of receptor expression and function and Signal transduction.
To study the characteristics and molecular basis of cancer.

THEORY	**60 H**
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, Cell wall Ultrastructure & Function	**12 H**
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.	**13 H**
UNIT III Lysosomes: 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. Cell cycle: Mitosis & Meiosis	**15 H**
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.	**20 H**
Practical	**60 H**
Study the effect of temperature on semi permeable membrane. Study the effect of organic solvents on semi permeable membrane Demonstration of dialysis.	

Study of plasmolysis and de-plasmolysis. Cell fractionation and determination of enzyme activity in organelles using sprouted seed or any other suitable source. Study of structure of a Prokaryotic cell Study of structure of a Eukaryotic cell Microtomy: Fixation, block making, section cutting, double staining of animal tissues like liver, oesophagus, stomach, pancreas, intestine, kidney, ovary, testes. Study of Mitosis & Meiosis using Permanent / Temporary slides Localisation of Mitochondria by Janus Green stain Cytochemical staining of DNA.	

Learning outcome

At the end of the course students will be able to

Classify organisms by cell structure.
Describe the different types of interactions maintaining the stability of lipid bilayer.
Explain recognition and membrane transport in the eukaryotic cell.
List and describe the components of the cytoskeleton of the eukaryotic cell.
Describe the ultrastructures of the cell and sub cellular organelles.
Elucidate the structures of organelles with a labelled diagrams.
Explain the biogenesis, structure and functions of cell organelles.
Elucidate the structures of organelles with a labelled diagrams.
Explain the role of viruses in causing cancer, regulation of receptor expression and function, Signal transduction, membrane receptors and Carcinogenesis.
List and explain all the components of a biological membranes and physical and chemical agents causing carcinogenesis.

Suggested reading

Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley &Sons. Inc.
De Robertis, E.D.P. and De Robertis, E.M.F. 2006.Cell and Molecular Biology.8th edition. Lippincott, Williams and Wilkins, Philadelphia.
Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition.ASM Press &Sunderland, Washington, D.C.; Sinauer Associates, MA.
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.

CBC103	Chemistry III for Biotechnology **Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II**	**Credit: 4** **(Theory-4; Practical 2)**

Course objectives

To understand different aspects of solutions: ideal solutions and Raoult's law, vapour pressure-composition and the theory behind miscibility of liquids.

To understand the principle and theory of phase equilibrium

To understand the principle and theory of conductance, Kohlrausch law of independent migration of ions, to represent transference number and its experimental determination using Hittorf and Moving boundary methods. To understand ionic mobility.

To compare the various conductometric titrations (only acid base).

To understand electrochemistry using reversible and irreversible cells, concept of EMF of a cell and its measurement

To study the Nernst equation and describe the different types of electrodes, standard electrode potential and gradation of EMF in the electrochemical series.

To explain the thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data.

To recognize the concentration cells with and without transference, understand liquid junction potential and usage of salt bridge and pH determination using hydrogen electrode and quinhydrone electrode.

To summarize potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

Functional group approach for the organic reactions (preparations & reactions) to be studied in context to their structure for carboxylic acids and their derivatives (aliphatic and aromatic), Amines and diazonium salts, amino acids, peptides and proteins, alkaloids, Terpenes, Pharmaceutical compounds

THEORY	**60 H**
Section A: Physical Chemistry-2	**30 H**
Solutions Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids-Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.	**6 H**
Phase Equilibrium Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, FeCl3-H2O and Na-K only).	**6 H**
Conductance Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).	**8 H**

Electrochemistry Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).	**10 H**
Section B: Organic Chemistry-3 Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.	**30 H**
Carboxylic acids and their derivatives Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.	**6 H**
Amines and Diazonium Salts Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.	**6 H**
Amino Acids, Peptides and Proteins Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitter ion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test. Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) &Cactivating groups and Merrifield solid-phase synthesis.	**6 H**
Alkaloids Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.	**4 H**
Terpenes Occurrence, classification, isoprene rule; synthesis of Citral, Neral and α-terpineol(only structure).	**4 H**
Pharmaceutical Compounds Structure and Importance, Classification, structure and therapeutic uses of antipyretics: Paracetamol Analgesics: Ibuprofen Antimalarials: Chloroquine. An elementary treatment of	**4 H**

Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).	
Practical	**60 H**
Section A: Physical Chemistry (12 hours) Distribution Study of the equilibrium of one of the following reactions by the distribution method: I2(aq) + I-(aq) ⇌ I3-(aq) Cu2+(aq) + xNH2(aq) ⇌ [Cu(NH3)x]2+ Phase equilibria a) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it. b) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature. Conductance(10 hours) IV. Determination of cell constant V. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. VI. Perform the following conductometric titrations: v. Strong acid vs. strong base vi. Weak acid vs. strong base Potentiometry(8 hours) Perform the following potentiometric titrations: v. Strong acid vs. strong base vi. Weak acid vs. strong base vii. Potassium dichromate vs. Mohr's salt **Section B: Organic Chemistry** I Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines). 9 compounds(9x2=18) II 2. Determination of the concentration of glycine solution by formylation method.(6 hours) **a)** 3. Titration curve of glycine.(6 hours)	

Learning outcome

At the end of the course students will be able to

Assess the thermodynamics of ideal solutions, state Raoult's law and its deviations.

Draw Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions.

Compare the partial miscibility of liquids, identify the critical solution temperature; check the effect of impurity on partial miscibility of liquids.

Explain the Nernst distribution law and its applications, discuss solvent extraction and state the Gibbs Phase Rule and its thermodynamic derivation.

Interpret the thermodynamics of a reversible cell, calculation of thermodynamic properties and calculation of equilibrium constant from EMF data.

Explain what is Liquid junction potential and the use of salt bridge. pH determination using hydrogen electrode and quinhydrone electrode.

Summarize potentiometric titrations -qualitative treatment

Identify carboxylic acids (aliphatic and aromatic)**.**

List examples of the carboxylic acid derivatives (aliphatic): (Upto 5 carbons)Give examples of preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.
Discuss and propose mechanisms of Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.
List uses of ester of carboxylic acid, explain the acetylation of amino group and discuss the reaction of complexation of copper ions and ninhydrin of amino acids.
Distinguish the advantages and disadvantages of Merrifield solid phase synthesis.
Illustrate the reactions -Hoffmann's exhaustive methylation, Emde's modification, Outline the structural elucidation and synthesis of Hygrine and Nicotine.
Define drugs and classify the pharmaceutical compounds,summarize the medicinal uses of different types of drugs,design methods
List out/ classify/ draw structures of terpenes and terpenoids
Explain the importance of haldi, neem, vitamin C and ranitidine and enlist examples of Amines.
Describe and compare electrophilic substitution (case aniline): nitration, bromination, sulphonation

Suggested reading

G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
G. W. Castellan: Physical Chemistry 4th Ed. Narosa (2004).
J. C. Kotz, P. M. Treichel, J. R. Townsend, General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
B. H. Mahan: University Chemistry, 3rd Edn. Narosa (1998).
R. H. Petrucci, General Chemistry, 5th Edn., Macmillan Publishing Co.: New York (1985).
Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
Berg, J. M., Tymoczko, J. L. &Stryer, L. Biochemistry 7th Ed., W. H. Freeman
A.I. Vogel: Textbook of Practical Organic Chemistry, Prentice Hall, 5th Edn.
F. G. Mann & B. C. Saunders: Practical Organic Chemistry, Orient Longman, 1960.
B.D. Khosla: Senior Practical Physical Chemistry, R. Chand & Co.
Ahluwalia, V.K. &Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

ZBC103	**Mammalian Physiology**	**credits: 06** (Theory-04; Practicals-02)

Course objectives:

1. To understand the metabolic activities in mammalian body
2. To understand the processes of digestion, respiration and blood circulation
3. To understand the muscle physiology and learn about the coordination between nervous system and endocrine system

THEORY

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 O_2 and CO_2, Oxygen dissociation curve, Chloride shift.	15 H
UNIT II: Circulation Composition of blood, Plasma proteins & their role, blood cells, Haemopoeisis, Mechanism of coagulation of blood. Mechanism of working of heart: Cardiac output, cardiac cycle, Origin & conduction of heart beat.	10 H
UNIT III: Muscle physiology and osmoregulation Structure of cardiac, smooth & skeletal muscle, 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.	15 H
UNIT IV: Nervous and endocrine coordination Reproduction Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, salutatory conduction, Neurotransmitters Mechanism of action of hormones (insulin and steroids) Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions. Anatomy of human male reproductive system, structural and functional aspects of testis (in brief).Onset of puberty. Anatomy of the female reproductive system in brief, estrous cycle, menstrual cycle in relation to ovarian cycle and menopause. Methods of fertility control-mechanical, chemical and surgical.	20 H
PRACTICAL	60 H

1. Finding the coagulation time of blood
2. Demonstration of action of salivary enzyme
3. Mounting of haemin crystals
4. Separation of lipids by Thin layer Chromatography
5. Estimation of blood cholesterol.
6. Detect the presence of Albumin, sugar, uric acid, ketone/ acetone bodies, chlorides, phosphates, calcium, bilirubin from urine sample. (2)
7. Permanent slides of Transverse section of mammalian gonads
8. Measurement of blood pressure and determination of pulse rate in Man
9. Effect of osmolarity on RBC
10. Determination of ESR
11. Study of ECG using recorded graph

12. Diffusion of glucose through intestine
13. Study of any five clinical conditions associated with hypo/hyper active endocrine glands using photographs (Gigantism, dwarfism, acromegaly, cretinism, myxodema, Graves' disease, cushion's disease) (2)

Learning Outcomes

1. The students will be able to explain the processes of digestion, respiration, circulation
2. The students will be able to describe the physical, chemical & electrical events of mechanism of muscle contraction and overall muscle physiology
3. Students will be able to explain the mechanism of working of nerve cells and nature of endocrine glands and their secretion

Books

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,Inc.

SEC: BIS101	**Urban Gardening**	**credits: 04** (Theory-03; Practical-01)

Course objectives:

1. To understand the potential and status of Urban Gardening in India and Goa.
2. To learn about various plants of human benefits.
3. To study about water holding capacity, the plant spacing and planting methods.
4. To learn the application and uses of Panchagavya, Sanjivani, Beej Amrut solutions.
5. To learn the innovations like vertical gardening, sub-surface irrigation, hydroponics

THEORY

UNIT I Introduction to Urban Farming, its status and potential in India and Goa	3 H
UNIT II Study different kinds of plants and their role in our lives, Uses of plants for creating an ambience, adding colour, beauty; providing shade/cooling; protecting from dust; removing odours, toxins ; yielding flowers, fruits, nuts, berries, tubers, spices, flavours, etc; preventive and therapeutic medicinal value of plants, their root systems, their requirement for nutrition, water and light. Study of specific vegetable, fruit & flowering plants, their light and water requirements, maturity indices, harvesting and post-harvest treatment	12 H
UNIT III Study of plant spacing and planting methods, Water holding capacity of different soils, Saturation, Field Capacity and Wilting Point. Improvement of WHC.	10 H
UNIT IV Panchagavya, Sanjivani, Beej Amrut solutions, their efficacy, application and uses, Advantages of organic or jaivik agriculture for better quality/flavour of food, longer shelf life of fruits, vegetables, herbs and flowers and for human	20 H

health and well-being, Sources of seeds, plants and garden inputs including tools and equipment, Beneficial and Effective Micro-organisms [E.M.] solutions, their efficacy, dilutions, application and uses, Innovations like vertical gardening, sub-surface irrigation, hydroponics.	
Practical	30 H
1. Study of plants with respect to requirement of water [including xerophytes, cacti and succulents, epiphytes], preparation of pot with appropriate soil mix or other media. 2. Study of plants with respect to requirement of light or shade [including orchids, anthurium, fruit/ vegetable plants, cacti and succulents] including selection of appropriate light filters like shade-nets, curtains, etc 3. Study of plants with respect to nutrient requirement [including orchids, anthurium, fruit/ vegetable plants, cacti and succulents] and preparation of pot with appropriate mix of manures, PSB, Rhizobium, VAM, etc. 4. Study of specific vegetable crops, their light and water requirements, harvesting and PHT [Okra/Bhendi, Legumes, Solanaceous crops, Cucurbits etc] 5. Study of specific fruit plants, their light and water requirements, harvesting and PHT [Banana, Mango, Guava, etc] 6. Study of specific flowering plants, their light and water requirements, harvesting and PHT [Gladioli, Anthurium, Orchids, Chrysanthemums, Roses, etc] 7. Preparation of Effective Micro-organisms [E.M.] solutions and their dilution without plasmolysis. 8. Preparation of Panchagavya, Sanjivani, Beej Amrut, etc 9. Determination of available soil moisture at Field Capacity in different soils. Improvement of WHC using compost, coco-peat or clay 10. Study of shelf life in conventionally grown and organically grown fruits and vegetables/ herbs in different kinds of packaging [polythene, butter paper, brown paper, newsprint bags, etc] and different storage conditions [ambient, refrigeration, etc] 11. Study of shelf life in conventionally grown and organically grown flowers in different kinds of packaging [polythene, butter paper, brown paper, newsprint bags, etc] and different storage conditions [ambient, refrigeration, etc]. Extension of vase-life of flowers with additives 12. Using plants for creating an ambience, adding colour, beauty; providing shade/cooling, removing odors, toxins as specimen plants and by massing or clusters. Study of plants in a local garden 13. Transect walk across the campus to evaluate and understand the role of plants therein; Discussion based on the observations. 14. Calculation of space requirement for plants based on recommended spacing, design and layout for home garden 15. Field visit to a nursery, KVK or institute	
Learning Outcomes	
1. Students will be able to identify the different kinds of plants in their surrounding and their role in day today life based on the various utilities. 2. Students will be able to imply the different methods and techniques to improve the quality of plants. 3. Students will be able to prepare the Panchagavya and EM solutions and also its application in enhancing the growth of various plants. 4. Students will be able to apply the knowledge in developing innovations like hydroponics,	

bottle gardening and vertical gardening.

Books:

1. Braganza, Miguel, 2015. **Growing Organically.**Botanical Society of Goa, Panaji-Goa. Pp 60
2. Kumar N. (2014). **Introductory Horticulture**. Rajalaxmi Publications, Pune-Maharashtra
3. Natrajan , K. 2009 Panchagavya. Organic Farming Association of India, Mapusa-Goa
4. Chadha K. L. (2008) **Handbook of Horticulture** I.C.A.R., Delhi.
5. Figueiredo , Nelson. 2000. **Integrated Pest Management**. Agriculture Officers' Association. Panaji-Goa. Pp 159
6. Singh, Ranjit.1992. **Fruits.** National Book Trust. New Delhi. Pg 221
7. Alvares, Claude (Ed.) 2009. Organic Farming Source Book . Other India Press. Mapusa-Goa.

BIC 104	**Plant Physiology and Metabolism**	**credits: 06** **(**Theory-04; Practicals-02)

Course objectives:

To understand the nutrient uptake and transport mechanisms.

To understand the physiological role and mechanism of action of the phytohormones.

To understand Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

To understand the machinery and mechanism of photosynthesis and photorespiration.

To understand Nitrogen metabolism.

Theory

UNIT I: Plant-water relations Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement	8 H
UNIT II: Mineral nutrition Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents.	6 H
UNIT III: Nutrient Uptake Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport.	8 H
UNIT IV: Translocation in the phloem Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.	8 H
UNIT V: Plant growth regulators Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and	6 H

Jasmonic acid.	
UNIT VI: Physiology of flowering Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.	6 H
UNIT VII: Phytochrome, crytochromes and phototropins Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR), mode of action.	6 H
UNIT VIII: Photosynthesis Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.	8 H
UNIT IX: Nitrogen metabolism Biological nitrogen fixation; Nitrate and ammonia assimilation.	4 H
Practical	60 H
1. Determination of osmotic potential of plant cell sap by plasmolytic method. 2. Determination of water potential of given tissue (potato tuber) by weight method. 3. Study of the effect of wind velocity and light on the rate of transpiration in excised twig/leaf. 4. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte. 5. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and xerophyte (both surfaces). 6. To study the phenomenon of seed germination (effect of light). 7. To study the effect of different concentrations of IAA on Zea mays coleoptile elongation (IAA Bioassay). 8. To study the induction of amylase activity in germinating wheat grains. 9. Demonstration of Hill reaction. 10. To study the effect of light intensity and bicarbonate concentration on O_2 evolution in photosynthesis. 11. Comparison of the rate of respiration in any two parts of a plant. 12. To demonstrate suction due to transpiration. 13. Fruit ripening/Rooting from cuttings (Demonstration) 14. Bolting experiment/ Auxin bioassay (demonstration). 15. Demonstration of Respiration in roots	
Learning Outcomes: 1. Students will be able to explain the water transport processes. 2. Students will be able to describe the absorption of water and transport of water through tracheids. 3. Students will be able to explain the components and mechanism of photosynthesis. 4. Students will be able to describe biological nitrogen fixation and reduction of N_2 into ammonia. 5. Students will be able to explain the physiological role and mechanism of action of the phytohormones.	

CBC104	**Chemistry IV for**	**credits: 06 (**Theory-04,

	Biotechnology	Practicals-02)

Course Objectives:

1. To understand the Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept
2. To understand the chemical properties, bonding, structure and preparation of compound of various elements of s and p block
3. To learn about the noble gases, organic polymers and bioinorganic chemistry
4. To understand the kinetic theory of gases, liquids, solids and chemical kinetics.

Theory

Section A: Inorganic chemistry **Acids and Bases:** Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.	6 H
Chemistry of s and p Block Elements Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudohalogens and basic properties of halogens.	10 H
Noble Gases Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).	6 H
Inorganic Polymers Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.	4 H
Bio-Inorganic Chemistry A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na+, K+ and Mg2+ ions: Na/K pump; Role of Mg2+ ions in energy production and chlorophyll. Role of Ca2+ in blood clotting, stabilization of protein structures and structural role (bones).	4 H
Section B: Physical Chemistry **Kinetic Theory of Gases** Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Vander Waals equation of state for real gases. Boyle temperature	10 H

(derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO2.Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).	
Liquids Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)	4 H
Solids Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only).Defects in crystals. Glasses and liquid crystals.	6 H
Chemical Kinetics The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates.Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).	10 H
PRACTICAL	60H
Section A: Inorganic Chemistry Semi-micro qualitative analysis using H2S of mixtures- not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following: Cations : NH4+, Pb2+, Ag+, Bi3+, Cu2+, Cd2+, Sn2+, Fe3+, Al3+, Co2+, Cr3+, Ni2+, Mn2+, Zn2+, Ba2+, Sr2+, Ca2+, K+ Anions : CO32– , S2–, SO2–, S2O32–, NO3–, CH3COO–, Cl–, Br–, I–, NO3–,SO42-, PO43-, BO33- ,C2O42-,F- (Spot tests should be carried out wherever feasible) Preparation of Aluminium potassium sulphate KAl(SO4)2.12H2O (Potash alum) or Chrome alum. Section B: Physical Chemistry 1. Surface tension measurement (use of organic solvents) a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer. b) Study of the variation of surface tension of a detergent solution with concentration. 2. Viscosity measurement (use of organic solvents). a) Determination of the relative viscosity of a liquid using an Ostwald's viscometer. b) Study of the variation of viscosity of an aqueous solution with concentration of solute.	

3. Chemical Kinetics
a) Initial rate method: Iodide-persulphate reaction
b) Integrated rate method
c) Acid hydrolysis of methyl acetate with hydrochloric acid.
d) Saponification of ethyl acetate.
e) Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis of methyl acetate

Learning Outcomes:

1. Students will be able to draw the structures of inorganic polymers, structures related to boranes, diboranes, silanes, phosphorous, chlorine, and Bioinorganic molecules.
2. Students will be able to state the Kinetic theory of gases.
3. Students will be able to discuss various theories of acids and bases.
4. Students will be able to interpret the structures of the noble gas compounds.
5. Students will be able to draw PV isotherms of real gases.
6. Students will be able to state the Kinetic theory of gases.
7. Students will be able to derive and use the equations to solve the numericals.
8. Students will be able to explain the methods of determining order of reactions.
9. Students will be able to solve the problems based on Chemical Kinetics, gaseous state, viscosity, Solid state.
10. Students will be able to interpret the graphs for the zero, first, second, third order reactions.

Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw---Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004).
3. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi (2009).
4. B. H. Mahan: University Chemistry 3rd Ed. Narosa (1998).
5. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
7. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
8. D. F. Shriver and P. W. Atkins: Inorganic Chemistry, Oxford University Press.
9. Gary Wulfsberg: Inorganic Chemistry, Viva Books Pvt. Ltd.

ZBC104	**Genetics**	**credits: 06 (**Theory-04, Practicals-02)

Course Objectives:
To understand the basics of Mendelian genetics, its modifications.
To understand Sex determination and linkage
To learn Chromosomal structure,
To understand Linkage and crossing over.
To understand types of gene mutations.

To learn human genetics, evolution and population genetics	
THEORY	
UNIT I **Overview of Mendelian genetics, its modifications, Sex determination and linkage** Introduction: Historical developments in the field of genetics. 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. Epistasis and Hypostasis- Multiple alleles with example, Multiple genes with example Sex determination and sex linkage - Sex determination in Drosophila, Insects, Honeybee, Bonelia, Turtle, Birds and Man. Barr bodies, dosage compensation, genetic balance theory, sex influenced dominance, sex limited gene expression, sex linked inheritance.	**15 H**
UNIT II **Chromosomal structure, Linkage and crossing over** 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, repetitive transposed sequences, repetitive multiple copy genes, noncoding DNA. Genetic organization of prokaryotic genome. Structure and characteristics of bacterial andneukaryotic 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, introns, genetic code, gene function.	**15 H**
UNIT III Gene mutations Types of gene mutations (Classification), Types of chromosomal aberrations (Classification, figures and with one suitable example of each), spontaneous mutation and induced mutation, Types of mutagens- physical, Chemical and Biological. Ames test for mutagenic agents, screening procedures for isolation of mutants and uses of mutants, Chromosomal aberrations in human beings, abnormalities– Aneuploidy and Euploidy, Chromosome and gene mutations: Definition and types of mutations, causes of mutations, s, variations in chromosomes structure - deletion, duplication, inversion and translocation (reciprocal and Robertsonian), position effects of gene expression	**15 H**
UNIT IV Human genetics Eugenics, Pedigree construction and analysis (Inheritance pattern of sex linked, autosomal dominant and recessive traits), Inheritance of human traits- Brown eyes, polydactyl, Diabetes insipidus, sickle cell anaemia.Study of Human chromosomal disorders: Down's syndrome, Klinefelter's syndrome, Turner's syndrome, Philadelphia syndrome. In breeding and out breeding, applications and evolutionary	**15 H**

significance. Evolution and population genetics: Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.	
PRACTICAL	**60 H**
1. Problems in Genetics through beads / seeds mixtures. Monohybrid and Dihybrid ratios. 2. Problems in Genetics on multiple alleles and Quantitative inheritance (multiple genes). 3. Study of ABO blood group and Rh factor in Humans. 4. Chromosome mapping using point test cross data 5. Study of polyploidy in onion root tip by colchicine treatment. 6. Study of phenotypic characters in Drosophila (Body colour, Wing pattern and Eye colour). 7. Determination of sex by Barr body method. 8. Karyotyping Analysis in Humans from Printed material: a. Normal male or female a. Klinefelter's Syndrome b. Turner's Syndrome c. Down's Syndrome d. Philadelphia 9. Determination of allelic frequency of the following Mendelian Human traits- Tongue Rolling, Ear lobes, Widow's peak, Clasping of hand, Thumb crossing pattern, Folding of arms, Hitch-hiker's thumb. 10. Pedigree charts of some common characters like blood group, color blindness and PTC tasting. 11. Preparation of Polytene chromosome slide	

Learning Outcomes:

1. Students will be able to describe different laws of genetics and calculate monohybrid, di-hybrid and tri hybrid crosses
2. Students will be able to explain the concepts of allelic interactions, dominance, recessiveness, epistasis and hypostasis, cistron, exons, introns, genetic code, gene function, types of mutations.
3. Students will be able to describe the sex determination in *Drosophila* , Bonelia, Turtle, Birds and Man.
4. Students will be able to describe with examples various chromosomal aberrations in human beings
5. Students will be able to do Pedigree construction and analysis and explain population genetics and laws of evolution.

Books:

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.III 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.

SEC: BIS102	**Basics of forensic Sciences**	**credits: 04 (**Theory-03, Practical-01)

Course Objectives:
To learn the principles of forensic science and setup of a forensic science lab.
To learn about the various branches and techniques in forensic sciences.
To explain the different types of injuries and deaths.
To understand the classification of the fire arms and explosives.
To explain the examination and comparison of handwriting and analysis of ink samples
To explain fingerprinting and DNA profiling.
To learn the basics of cyber security.

THEORY

Unit I Introduction and principles of forensic science, forensic science laboratory and its organization and service, tools and techniques in forensic science, branches of forensic science, causes of crime, role of modus operandi in criminal investigation. Classification of injuries and their medico-legal aspects, method of assessing various types of deaths	15 H
Unit II Classification of fire arms and explosives, introduction to internal, external and terminal ballistics. Chemical evidence for explosives. General and individual characteristics of handwriting, examination and comparison of handwritings and analysis of ink various samples.	13H
Unit III Role of the toxicologist, significance of toxicological findings, Fundamental principles of fingerprinting, classification of fingerprints, development of finger print as science for personal identification	8 H
Unit IV Principle of DNA fingerprinting, application of DNA profiling in forensic medicine, Investigation Tools, eDiscovery, Evidence Preservation, Search and Seizure of Computers, Introduction to Cyber security.	9 H
PRACTICAL	30 H

1. Documentation of crime scene by photography, sketching and field notes.
2. a. Simulation of a crime scene for training.
b. To lift footprints from crime scene.
3. Case studies to depict different types of injuries and death.
4. Separation of nitro compounds (explosives)/ ink samples by thin layer chromatography.
5. Investigate method for developing fingerprints by Iodine crystals.
6. PCR amplification on target DNA and DNA profiling,
7. E-Mail Investigation, E-Mail Recovery, Recovering, deleted evidences,

Learning Outcomes:
1. Students will be able to explain the principles and different techniques involved in forensic science.

2. Students will be able to explain different types of deaths and classify the injuries. 3. Students will be able to interpret DNA profiles. 4. Students will be able to imply various cyber tools and techniques in cyber security.
Books: 1. Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington. 2. B.B. Nanda and R.K. Tiwari, Forensic Science in India: A Vision for the Twenty First Century, Select Publishers, New Delhi (2001). _ 3. M.K. Bhasin and S. Nath, Role of Forensic Science in the New Millennium, University of Delhi, Delhi (2002). _ 4. S.H. James and J.J. Nordby, Forensic Science: An Introduction to Scientific and Investigative Techniques, 2nd Edition, CRC Press, Boca Raton (2005). _ 5. W.G. Eckert and R.K. Wright in Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (ED.), CRC Press, Boca Raton (1997). _ 6. R. Saferstein, Criminalistics, 8th Edition, Prentice Hall, New Jersey (2004). _ 7. W.J. Tilstone, M.L. Hastrup and C. Hald, Fisher's Techniques of Crime Scene _Investigation, CRC Press, Boca Raton (2013).

BIC105	**Plant Biotechnology**	**credits: 06 (**Theory-04, Practicals-02)
Course Objectives: 1. To learn the design of the PTC laboratory, various equipments required for conducting tissue culture experiments and the sterilization methods. 2. To learn the composition, preparation and sterilization of different media and ideal conditions used for culturing. 3. To understand the concepts of subculture, regeneration and hardening. 4. To learn about different types of culture like Callus, Seed, Embryo, Organs, single cell culture, anther culture, microspore culture etc. 5. To explain and discuss the Significance and use of haploids. 6. To describe androgenesis and gynogenesis and the factors affecting it. 7. To learn protoplast culture, protoplast fusion and somatic hybridization. 8. To understand the process of gene transfer using the Ti plasmid vectors and the selection of transformants 9. To understand different methods of tissue culture used for the production of secondary metabolites 10. To describe somaclonal variation, its application and disadvantages. **11.** To understand the role of Plant Growth Promoting bacteria 12. To understand the application of transgenic plants to develop insect resistance, drought and salt tolerance, herbicide resistance, nutritive quality of crop plants and development of edible vaccines		
THEORY		
UNIT I Introduction &history of plant tissue culture. Importance of plant tissue culture. In vitro culture techniques: Sterilization methods, Culture media – composition,		20 H

types of media and role of hormones in in-vitro culture. Inoculation, Incubation and Acclimatization. Cryo and organogenic differentiation, Types of culture: Callus, Seed, Embryo, Organs, single cell and suspension Protoplast culture. Micro propagation Axillary bud proliferation, Meristem and shoot tip culture, bud culture, organogenesis, embryogenesis, advantages and disadvantages of micro propagation.	
UNIT II In vitro haploid production: Androgenic methods: Anther culture, Microspore culture androgenesis Significance and use of haploids, Ploidy level and chromosome doubling, diploidization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.	10 H
UNIT III Protoplast Isolation and fusion: Methods of protoplast isolation, Protoplast development, Somatic hybridization, identification and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation-Nomenclature, methods, application and disadvantages. Plant transformation using *Agrobacterium tumefaciens*, Production of secondary metabolites using plant tissue culture	20 H
UNIT IV Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria. Applications of Plant Biotechnology-Improved crop varieties- High yield, Insect resistance, drought and salt tolerance, edible vaccines	10 H
PRACTICAL	60 H
1. Preparation of simple growth nutrient (Knop's medium), full strength, half strength, solid and liquid. 2. Preparation of complex nutrient medium (Murashige & Skoog's medium) 3. To select, sterilize and prepare an explant for culture. 4. Effect of growth hormones in callus induction. 5. To demonstrate various steps of Micropropagation. 6. Protoplast isolation. 7. To set up single cell suspension culture and to check cell viability.	
Learning Outcomes: 1. Students will be able to design the PTC laboratory. 2. Students will be able to prepare and sterlize different types of PTC media. Students will be able to select the explants and choose the appropriate surface sterilizing agent. 3. Students will be able to explain different methods of in vitro haploid prodiction. 4. Students will be able to perform callus induction 5. Students will be able to perform protoplast isolation, evaluate protoplast viability, and also explain the different methods for protoplast fusion, hybrid selection and culturing. 6. Students will be able to explain micropropagation, and how tissue culture can be used in making gene banks and its importance in forestry. 7. Classify the secondary metabolites produced in plants and compare the different methods of culture used for secondary metabolite production.	

8. Students will be able to discuss the role of plant biotechnology to get improved crop varieties.
Books: 1. Kalyan Kumar De: Plant Tissue Culture; (2008). New Central Book Agency; 1st edition Calcutta. 2. S.P. Misra: Plant Tissue Culture; 2009. Ane Books Pvt.Ltd., New Delhi. 3. Chawla H.S.; Introduction to Plant Biotechnology; (2002)2009.CRC press, 3rd Edition 4. K.G.Ramawat: Plant Biotechnology; S.Chand & Company Ltd., NewDelhi, 2008 2004 5. Jha & Ghosh: Plant Tissue Culture; (2016) Platinum Publishers; 2nd Edition 6. Prakash and Arora: Cell and Tissue Culture; 5thed 2005Anmol Publications Pvt. Ltd., New Delhi 7. Kumar U; Methods in Plant Tissue Culture. Agrobios; 01 edition (2012) 2011. 8. S.S. Purohit, Practical Plant Biotechnology,7th ed,2009. Student Edition. 9. B.D. Singh, Plant Biotechnology; 2015, Kalyani Publishers; 3rd edition

BIC106	**Bio-analytical tools**	**Credits: 06** **(**Theory-04, Practicals-02)
Course Objectives: 1. To understand the principle, working and applications of Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy and mass spectrometry. 2. To understand the principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared) 3. To understand the principles of centrifugation (centrifugal force and sedimentation rate). 4. To learn the principle and technique of Differential centrifugation, Density gradient centrifugation and cell fractionation techniques. **5.** To learn the working principle, methodology and applications of Chromatographic techniques like Paper Chromatography, TLC, Gel filtration chromatography, Ion Exchange chromatography, Affinity chromatography, HPLC, GLC 6. To understand the principle, procedures and applications of Starch gel, Agarose gel electrophoresis, PAGE-SDS, PAGE-Native, pulse field gel electrophoresis, immuno-electrophoresis, Isoelectric focusing Southern blotting, Northern blotting and Western blotting.		
THEORY		
UNIT I Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy. Introduction to mass spectrometry.		10 H
UNIT II Principle and law of absorption fluorimetry, colorimetry, spectrophotometry (visible, UV, infrared), centrifugation: principle of centrifugation, centrifugal force and sedimentation rate, differential and density gradient centrifugation, cell fractionation techniques, isolation of sub-cellular organelles and particles.		15 H
UNIT III		15 H

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 SDS-PAGE), agarose-gel electrophoresis, pulse field gel electrophoresis, immuno-electrophoresis, isoelectric focusing, Southern Blotting, Northern Blotting and Western blotting. Introduction to Biosensors and Nanotechnology and their applications**.**	20 H
PRACTICAL	60 H

1. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.
2. Quantitative and qualitative analysis of DNA using UV spectroscopy.
3. Florimetry demonstration video.
4. Demonstration of Column Chromatography
5. Separation of amino acids by paper chromatography
6. Separation of plant pigments by paper chromatography
7. To identify lipids in a given sample by TLC.
8. Isolation of nuclei from liver tissue using density gradient centrifugation.
9. Native gel electrophoresis of proteins
10. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
11. Immunoelectrophoresis
12. Southern and Western Blotting (Video or Demonstration) (2)
13. DNA elution from Agarose gel.
14. Visit to a R&D section of pharmaceutical industry for demonstration of new analytical instruments

Learning Outcomes:

1. The students will be able to explain the principle, working and applications of Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy and mass spectrometry.
2. Students will be able to isolate of sub-cellular organelles and particles.
3. Students will be able to perform Differential and Density gradient centrifugation.
4. Student will be able to perform paper chromatography and thin layer chromatography of different compounds.
5. Students will be able to explain and perform the separation of nucleic acids using agarose gel electrophoresis and separation of proteins by SDS-PAGE, Native-PAGE
6. Students will be able to state the principle and applications of PAGE, agarose gel electrophoresis, Isoelectric focusing and Immuno-electrophoresis and pulse-field electrophoresis
7. Students will be able to explain the principle, technique and applications of Northern blotting, Southern Blotting and Western Blotting

Books:

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.
5. Wilson, K. and Walker J. 2010. Principles and Techniques of Biochemistry and Molecular Biology.7th Edition.Cambridge University Press.
6. Wilson, K. and Walker J. 2000. Practical Biochemistry Principles and Techniques 5th Edition.Cambridge University Press.
7. Singh B.D., Biotechnology: Expanding horizons (2010), Kalyani publishers

BIC107	**Molecular Biology**	**Credits: 06 (**Theory-04, Practicals-02**)**

Course Objectives:

1. To understand the structure of DNA and its types.
2. To understand the process of Replication of DNA in prokaryotes and eukaryotes:
3. To understand the concepts of DNA damage and learn about DNA repair mechanisms and homologous recombination
4. To understand the structure of DNA and its types.
5. To understand about RNA transcription, splicing and processing.
6. To understand the regulation of gene expression and protein translation.
7. To learn about various Molecular tools such as restriction enzymes, ligases, polymerases, alkaline phosphatase.
8. To undestand the process of Gene Recombination and Gene transfer which includes techniques such as Transformation, Episomes, Plasmids and other cloning vectors, Microinjection, Electroporation, Ultrasonication,
9. To understand the principle and applications of Polymerase chain reaction, primer-design, and RT- PCR.
10. To learn about restriction and modification system, restriction mapping, preparation of Genomic and cDNA library, screening of recombinants

THEORY

UNIT I: DNA structure and replication DNA as genetic material, Structure of DNA, Types of DNA, Replication of DNA in prokaryotes and eukaryotes: Semi conservative 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	15 H
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.	10 H
UNIT III: Transcription and RNA processing RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic	10 H

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, aminoacyltRNAsynthetases, Mechanism of initiation, elongation and termination of polypeptide	15 H
UNIT V: Recombinant DNA technology 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. Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants	10 H
PRACTICAL	60 H
1. Preparation of solutions for Molecular Biology experiments. 2. Isolation of chromosomal DNA from plant cells 3. Isolation of chromosomal DNA from bacterial cells. 4. Isolation of nuclei and chromatin. 5. Plasmid DNA isolation by alkaline lysis 6. Restriction digestion of DNA 7. Making competent cells 8. Transformation of competent cells. 9. Demonstration of Ames test or reverse mutation for carcinogenicity 10. UV survival curve for E. coli 11.Preparation of Polytene chromosomes from Drosophila larva 10. Titration of phages P1 and λ, studying plaque morphology 12. Chemical mutagenesis and isolation of auxotrophic mutants. 13. Isolation of RNA from bacterial cells 14. Isolation of RNA from plant cells 15. Estimation of RNA by orcinol method.	
Learning Outcomes: 1. Students will be able to explain the process of DNA replication, transcription, translation and gene regulation with role of various proteins involved in same. 2. Students will be able to explain different methods of gene recombination and gene transfer. 3. Students will be able explain and perform DNA isolation form plant and bacterial cells. 4. Students will be able to explain and perform RNA isolation from plant and bacterial	

cells.
5. Students will be able to carry out DNA transfer in bacterial cells and also isolate the plasmid DNA from bacterial cells.
6. Students will be able to discuss about different Molecular tools and applications of recombinant DNA technology.

Books:

1. LewinB.Genes XI.2007. Jones and Bartlett Publishers
2. Nelson D.L. and Cox M.M. 2000. Lehninger Principles of Biochemistry (3rdEdition). Worth Publishers, New York, USA.
3. Gerald Karp, Harris D. Cell and Molecular Biology –Concepts and Experiments. 2008. John Wiley& SonsInc, New York.
4. Robertis E.D.P.,Robertis E.M.F., Cell Biology and Molecular Biology, 8th edition, 1998. SauderCollege.
5. Watson J.D., Hopkins N.H. etal. Molecular Biology of the Gene. (2008).Garland Publishing (Taylor&FrancisGroup),New York &London.

BID101	**Biostatistics and Bioinformatics**	**credits: 04 (**Theory-03, Practicals-01)

Course Objectives:
1. To understand different types of data and methods of collection of data.
2. To learn different methods of representation of data.
3. To solve problems on mean, median, mode and standard deviation.
4. To understand the concepts of skewness and kurtosis.
5. To understand probability and get basic idea of Binomial, Poisson and Normal distribution.
6. To solve problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA), Correlation and Regression on examples from Biological Sciences.
7. To learn about various Sequence Information Sources: EMBL, GENBANK, Entrez, Unigene, Protein Information Sources: PDB, SWISSPROT, TREMBL.
8. To learn about protein visualization tools and use them to visualize protein-protein and protein-ligand interactions.
9. To use BLAST on the web, Interpreting results, Multiple Sequence Alignment and Phylogenetic Analysis.
10. To learn about different gene identification tools, entrez databases, SNP databases and other mutation database.

THEORY

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. Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions	10 H
UNIT II	10 H

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), Correlation and Regression. Emphasis on examples from Biological Sciences	
UNIT III History of Bioinformatics.The notion of Homology. Sequence Information Sources: EMBL, GENBANK, Entrez, Unigene, Protein Information Sources: PDB, SWISSPROT, TREMBL, Introduction of Data Generating Techniques and Bioinformatics problem posed by them- Restriction Digestion, Chromatograms, Blots, PCR, Microarrays, Mass Spectrometry. Introduction to protein structure. Protein Data Bank (PDB) data format and visualization of protein structure. Protein-Protein and Protein-Ligand interaction visualization	15 H
UNIT IV 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. Searching Databases: SRS, Entrez, Sequence Similarity Searches-BLAST, FASTA, Data Submission. Genome Annotation: Pattern and repeat finding, Gene identification tools. SNP (Single Nucleotide Polymorphism) and other mutation databases.	10 H
PRACTICAL	30 H
1. Based on graphical Representation 2. Based on measures of Central Tendency 3. Based on measures of Dispersion 4. Based on Distributions Binomial Poisson Normal 5. Based on t test 6. Based on z - test 7. Based on Chi-square test 8. Based on Regression and Correlation 9. Sequence information resource 10. Understanding and use of various web resources: EMBL, Genbank, Entrez 11. Understanding structural data: Exploring Protein Data Bank (PDB), Visualizing protein structures with RasMol or PyMOL. 12. Understanding and use of various web resources: Unigene, Protein information resource (PIR) 13. Understanding and using: PDB, Swissprot (UniProt), TREMBL 14. Using various BLAST options and interpretation of results.	
Learning Outcomes: 1. Students will be able to collect data using the different methods of sampling 2. Students will be able to plot and interpret graphical representation of biological data. 3. Students will be able to use measures of central tendency and Dispersion in data analysis. 4. Students will be able to solve problems on probability and explain classical & axiomatic definition of probability,	

5. Students will be able to describe the different types of biological databases- literature, protein and structure databases.
6. Students will be able to explain the PDB data format and visualize the protein structure.
7. Students will be able to detect Open Reading Frames, describe the use of SRS, Entrez for searching databases.
8. Students will be able to explain the working and salient features of BLAST and FASTA.

Books:

1. Rastogi S.C., Mendiratta N. & Rastogi P., Bioinformatics: Concepts, Skills and Applications 2 edition (1st December 2009)
2. David W. Mount, Bioinformatics - sequence and Genome analysis; (2004), CBS Publishers and Distributers.
3. Ignacimuthu S., Basic Bioinformatics. 2005. Narosa Publishing House, NewDelhi.
4. Chikhale N.J., Gomase V.S., Bioinformatics: Theory and Practice, 2007, Himalaya Publishing House, NewDelhi.
5. Xiong, Jin, Essential Bioinformatics, 2006, Cambridge University Press.

BID102	**Food Biotechnology**	**credits: 04 (**Theory-03, Practicals-01)

Course Objectives:

1. To understand the role and significance of microorganisms in foods.
2. To learn about the intrinsic and extrinsic factors responsible for food spoilage
3. To understand food poisoning caused by bacterial and fungal toxins
4. To learn about the causative agents, symptoms, diagnosis and treatment for food borne infections such as Gastroenteritis and Salmonellosis.

5. To learn about the causative agent symptoms, diagnosis and treatment for milk borne diseases such as Listeriosis and Scarlet fever
6. To understand the principle and determine the quality of the milk using dye reduction test – MBRT and Resazurin.
7. To understand the principle of SPC, Breeds smear and also selective and differential media for identification of spoilage organisms.
8. To understand the principle of Preservation by Drying, High temperature and low temperature, Pasteurization process, canning and Hurdle technology, and use of additives and radiation for preservation of food.
9. To understand the process, microbiology involved and changes during fermentation of saurkraut and yogurt
10. To learn about the Nutritive value and use of Mushroom and Spirulllina.
11. To learn about the pros and cons of GM foods.

THEORY

UNIT I: Microbiology of food	3 H

• History of Microorganisms in food • Role and significance of microorganisms in foods.	
UNIT II:Food Technology and Diseases • Intrinsic and extrinsic factors responsible for food spoilage • Microorganisms involved in food spoilage: fruits, vegetables, meat, eggs, bread • Food Borne diseases. 1. Food poisoning: (Bacterial Toxin Botulism and Staphylococcal toxin) Fungal Toxins: Aflatoxin. 2. Food borne Infections: Gastroenteritis and Salmonellosis	10 H
UNIT III: Milk technology and Diseases • Sources of contamination • Different microorganisms implicated in spoilage • Milk borne diseases: Listeriosis and Scarlet fever • Grading of milk by dye reduction test - MBRT and Resazurin	5 H
UNIT IV: Detection of food spoilage • Methods of detection of food spoilage: 1. Traditional approaches: SCP, Breeds smear, identification of specific organisms by using selective and differential media. 2. New approaches: use of gene probes, RDT, Bioluminescence.	7 H
UNIT V: Food preservation 12 periods • Preservation by Drying: Solar drying, mechanical drying, salting, smoking). • Preservation at High temperature: concept of TDP and TDT. Pasteurization (LTHT, HTST,UHT processes; efficiency of pasteurization phosphatase test, canning, Hurdle Technology. • Preservation at low temperature: Freezing, • Preservation by use of additives: Acids, Salts, Sugars, Antibiotics, Ethylene oxide, Antioxidants. • Preservation by radiation: UV, ionizing radiations, gamma and cathode rays, microwave processing. • Other methods: Hydrostatic pressure cooking, modified atmosphere. Fermentation technology • Fermented Food: Process, microbiology involved and changes during fermentation of - Fermented food: sauerkraut Milk products: yogurt	12 H
UNIT VI: Microorganisms as source of food and enzymes • Nutritive value and use of -Mushroom (production done in industrial) -SCP eg. Spirulllina •. Enzymes and its application in food industry	3 H
UNIT VII: Food quality assurance • Food safety: HACCP System to food protection, Responsibility for food safety. Pros and Cons of GM foods	5 H
PRACTICAL	30 H
1. Dye reduction tests (MBRT) 2. Dye reduction tests (Resazurin) 3. SPC 4. Breed's smear 5. Plating on selective media 6. Efficiency of pasteurization: Phosphatase test 7. Determination of TDP and TDT 8. Microbiology of food: Microbial examination of spoilt food on selective media. 9. MIC of preservatives (Sugar, NaCl, Na-benzoate and K – metabisulfite) 10. Estimation of shelf-life of packaged food stuff 11. Mushroom production 12. Field trip to a dairy industry	
Learning Outcomes: 1. Students will be able to explain the role of various microorganisms in food.	

2. Students will be able to describe the causative agent symptoms, diagnosis and treatment for various food borne Infections and diseases.
3. Students will be able to discuss the use of various approaches to identify food spoilage organisms.
4. Students will be able to explain the various food preservation methods.
5. Students will be able to explain the process of pasteurization and also check the efficiency of pasteurization.
6. Students will be able to explain the nutritive value of Mushroom and Spirullina.
7. Students will be able to discuss the pros and cons of GM foods.

Books:

1. Jay, James M., Loessner, Martin J., Golden, David A. Modern Food Microbiology, 2005
2. M. R. Adams, M. O. Moss, Food Microbiology, Royal Society of Chemistry; 1st revision of 4th New edition edition (2015)
3. Frazier, Food Microbiology, McGraw Hill Education; Fifth edition (2017) 1950
4. Bibek Ray, Arun Bhunia, Fundamental Food Microbiology, CRC Press; 4 edition (2007)
5. Banwart, George, Basic Food Microbiology, CBS; 2 edition (2004)

BIC108	**Bioprocess Technology**	**credits: 06 (**Theory-04, Practicals-02)

Course Objectives:

1. To understand basic principle components of fermentation technology.
2. To list types of microbial cultures and their growth kinetics– Batch, Fedbatch and Continuous culture.
3. To understand the Design of bioprocess vessels- and Significance of its parts.
4. To understand the principles of upstream processing.
5. To understand oxygen requirement in bioprocess; mass transfer coefficient; factors affecting KLa.
6. To learn about the bioprocess measurement and control system with special reference to computer aided process control.
7. To understand the types and working of various types of downstream processes and their significance.
8. To learn about the microbial production of penicillin/ streptomycin, ethanol/ wine, amylase, lactic acid and Single Cell Proteins**.**

THEORY

UNIT I Introduction to bioprocess technology. Range of bioprocess technology and its chronological development.(Historical contributions), Basic principle components of fermentation technology.Types of microbial Culture and its growth kinetics– Batch, Fedbatch and Continuous culture.	10 H
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	20 H

preparation, Inocula development and sterilization.	
UNIT III 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.	15 H
UNIT IV Introduction to downstream processing, product recovery and purification. Microbial production of penicillin/ streptomycin, ethanol/ wine, amylase, lactic acid and Single Cell Proteins.Effluent treatment.	15 H
PRACTICAL	60 H
1. Bacterial growth curve. (Batch Fermentation) 2. Bacterial growth curve. (Fed Batch Fermentation) 3. Calculation of thermal death point (TDP) of a microbial sample. 4. Production and analysis of ethanol. 5. Production and analysis of amylase. 6. Production and analysis of lactic acid. 7. Isolation of industrially important microorganism from natural resource. 8. Bioassay of Penicillin 9. MIC: penicillin 10. MIC: streptomycin 11. Industrial visit to a Bioprocess facility.	

Learning Outcomes:

1. Students will be able to explain bioprocess technology, its range and basic principle components of fermentation technology.
2. Students will be able to describe Batch, Fed-batch and Continuous culture.
3. Students will be able to explain the design, working and uses of Airlift; Cyclone Column; Packed Tower
4. Students will be able to explain the significance of Impeller, Baffles, Sparger.
5. Students will be able to explain the processes of media preparation, Inocula development and sterilization.
6. Students will be able to explain the need for oxygen requirement in bioprocess, mass transfer coefficient and factors affecting KLa.
7. Students will be able to explain bioprocess measurement and control system with special reference to computer aided process control.
8. Students will be able to describe the principle and process of downstream processing, product recovery, purification and effluent treatment.
9. Students will be able to describe the microbial production of penicillin/ streptomycin, ethanol/ wine, amylase, lactic acid and Single Cell Proteins**.**
10. Students will be able to carry out ethanol and lactic acid production and analysis in lab set up.

Books:

1. Casida LE. (1968). 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. (2016). Industrial Microbiology.2nd edition, Trinity Press. New Delhi
4. Stanbury PF, Whitaker A and Hall SJ.(2006). Principles of Fermentation Technology. 2nd

edition, Elsevier Science Ltd.
5. S.C Prescott, C.G. Dunn, Agrobios(2009). Industrial Microbiology. 1st Edition. Agrobios

BIC109	**Immunology**	**credits: 06 (**Theory-04, Practicals-02)

Course Objectives:

1. To learn about components (innate and acquired) of mammalian immune system.
2. To understand molecular structure of Immuno-globulins or Antibodies, regulation of immunoglobulin gene expression, process of antibody affinity maturation, class switching and antibody diversity.
3. To learn about different types of T lymphocytes (cytotoxic T-cell, helper T-cell, suppressor T-cells), & immune response carried out by them.
4. To understand the assembly of T-cell receptor genes by somatic recombination.
5. To understand the terms allotypes & idiotypes, allelic exclusion and immunologic memory.
6. To learn about class I & class II MHC antigens, mechanism and significance of antigen processing.
7. To discuss the mechanisms for immunity to different organisms pathogen, defense strategies and avoidance of recognition.
8. To learn about Autoimmune diseases and AIDS.
9. To learn about vaccination, methods of generation and mechanism of action of DNA vaccines, recombinant vaccines, bacterial vaccines, viral vaccines.
10. To explain and compare passive & active immunization.
11. To understand the principle, procedure and applications of immunodiagnostic techniques like RIA and ELISA.

THEORY

UNIT I Immune Response - An overview, components 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	20 H
UNIT II Regulation 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	15 H
UNIT III Major Histocompatibility complexes – class I & class II MHC antigens, antigen processing. Immunity to infection – immunity to different organisms, pathogen defense strategies, avoidance of recognition. Autoimmune diseases, Immunodeficiency-AIDS. Types of Hypersensitivity	15 H

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.	10 H
PRACTICAL	60 H

1. Blood Grouping
2. Preparation of serum
3. Differential leucocytes count
4. Total leucocytes count
5. Total RBC count
6. Haemagglutination inhibition assay
7. Simple Immunodiffusion
8. Double immunodiffusion test using specific antibody and antigen.
9. Demonstration of ELISA
10. Pregnancy test
11. WIDAL test (Qualitative)
12. Countercurrent Electrophoresis
13. Haemoglobin estimation by Sahli's haemometer

Learning Outcomes:

1. Students will be able to describe innate immunity, acquired immunity, active immunization and passive immunization
2. Students will be able to Compare Humoral & Cellular immune responses
3. Students will be able to explain the molecular steps involved in maturation of B cells and T cells
4. Students will be able to describe the molecular steps involved in antibody affinity maturation and class switching
5. Students will be able to explain the regulation of immunoglobulin gene expression
6. Students will be able to explain the Major Histocompatibility complexes and the steps of antigen processing and its significance.
7. Students will be able to discuss the mechanisms for immunity against bacterial and viral infections
8. Students will be able to explain Autoimmune and Immunodeficiency diseases
9. Students will be able to elaborate on the methods of generation and mode of action of different types of vaccines
10. Students will be able to explain the principle, procedure and applications of immunodiagnostic techniques like RIA and ELISA
11. Students will be able to carry out serum preparation, total leukocyte count, differential leukocyte count, total RBC count, heamoglobin estimation and countercurrent electrophoresis.

Books:

1. Roitt and Roitt, Essential Immunology. Wiley-Blackwell; 12th edition (18 April 2011) Blackwell science, Oxford Blackwell Scientific Publications.
2. Kuby J.,Immunology, 5thEdition ,2018. W.H. Freeman and Company, New York.
3. Rastogi V.B., Genetics. 2018. S. Chand Publishers, New Delhi. 48

4. Weir D.M. Handbook of Experimental Immunology- Vol I&II. Wiley-Blackwell; Volume I edition (1997)

BIC110	**Environmental Biotechnology**	**Credits: 06 (**Theory-04, Practicals-02**)**

Course Objectives:

1. To understand global environmental problems such as ozone depletion, UV-B, greenhouse effect and acid rain and the impact of anthropogenic activities on environment and biotechnological approaches for management.
2. To learn about types of pollution, sources of pollution, measurement of pollution, Bioconcentration and bio/geomagnification.
3. To understand various Aerobic and anaerobic processes of waste water treatment and learn about treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.
4. To learn about Organic and inorganic xenobiotic compounds and methods of Bioremediation of xenobiotics in environment.
5. To understand the concepts and applications of Biopesticides, bioreactors, bioleaching, biomining, biosensors.
6**.** To learn about Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis,
7. To learn about WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics, Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report 75 (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.
8. To understand the National Legislations, Policies for Pollution Management
9. To learn about various Environmental movements such as Gandhamardan, Chilika and Narmada Bachao Andolan, Chipko and Silent valley Movement and public participation**.**

THEORY	
Unit 1: Environment Basic concepts and issues, global environmental problems - ozone depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management.	4 H
Unit 2: Environmental problems Environmental pollution - types of pollution, sources of pollution, measurement of pollution, methods of measurement of pollution, fate of pollutants in the environment, Bioconcentration, bio/geomagnification.	6 H
Unit 3: Microbiology of waste water treatment Aerobic process - activated sludge, oxidation ponds, trickling filter, towers, rotating discs, rotating drums, oxidation ditch. Anaerobic process - anaerobic digestion, anaerobic filters, upflow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industries.	8 H

Unit 4: Xenobiotic compounds Organic (chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants) and inorganic (metals, radionuclides, phosphates, nitrates).Bioremediation of xenobiotics in environment - ecological consideration, decay behavior and degradative plasmids, molecular techniques in bioremediation.	10 H
Unit 5: Role of immobilized cells/enzymes in treatment of toxic compounds Biopesticides, bioreactors, bioleaching, biomining, biosensors, biotechniques for air pollution abatement and odour control.	6 H
Unit 6: Sustainable Development Economics and Environment: Economic growth, Gross National Productivity and the quality of life, Tragedy of Commons, Economics of Pollution control, Cost-benefit and cost effectiveness analysis, WTO and Environment, Corporate Social Responsibility, Environmental awareness and Education; Environmental Ethics.	8 H
Unit 7: International Legislations, Policies for Environmental Protection Stockholm Conference (1972) and its declaration, WCED (1983) and Brundtland Report 75 (1987), Rio Earth Summit-UNCED (1992) and its declaration, Montreal Protocol - 1987, Basel Convention (1989), Kyoto Protocol- 1997, Ramsar Convention 1971.	6 H
Unit 8: National Legislations, Policies for Pollution Management Salient features of Wild life protection act 1972, Water Pollution (Prevention and Control) Act-1974, Forest conservation act 1980, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy -2006, Central and State Pollution Control Boards: Constitution and power.	6 H
Unit 9: Public Participation for Environmental Protection Environmental movement and people's participation with special references to Gandhamardan, Chilika and Narmada BachaoAndolan, Chipko and Silent valley Movement; Women and Environmental Protection, Role of NGO in bringing environmental awareness and education in the society.	6 H
PRACTICAL	60 H
1. Determination of Total Suspended Solids (TSS) of water sample. 2. Determination of Total Dissolved Solids (TDS) of water sample. 3. Determination of DO of Water Sample 4. Calculation of BOD of water sample. 5. Calculation of COD of water sample. 6. Determination of Presence of coliforms in water 7. Bacterial Examination of Water by MPN Method. 8. Determination of total alkalinity of water. 9. Detection of chlorine in water. 10. Isolation of xenobiotic degrading bacteria 11. Determination of acidity of water.	

12. Determination of salinity of water 13. Determination of nitrates in water 14. Determination of calcium in water 15. Determination of phosphorus in water	

Learning Outcomes:

1. Students will be able to state applications of various techniques studied for pollution control.
2. Students will be able to explain various bioremediation techniques.
3. Students will be able to explain various water pollution, air pollution and soil pollution control measures.
4. Students will be able to explain different methods of waste water treatment.
5. Students will be able to explain about Biopesticides, bioreactors, bioleaching, biomining, biosensors.
6. Students will be able to discuss about national legislations and policies of pollution management.
7. Students will be able to elaborate on various environmental movements and public participation.

Books:

1. Chatteiji A.K., Introduction to Environmental Biotechnology.3rd ed,(2011).Prentice Hall India Pvt.Ltd., New Delhi.
2. Jogdand B.N., Environmental Biotechnology (IndustrialPollutionManagement).(2010). Himalaya Publishing House, Mumbai.
3. Agarwal S.K.,Environmental Biotechnology.(2009). APH Publishing Corporation New Delhi.
4. Indu Shekar Thakur, Environmental Biotechnology: Basic concepts and applications. (2011).1.K.International Pvt. Ltd. New Delhi.
5. SinghB.D., Biotechnology. 4th ed, (2010). Kalyani Publishers.
6. Murugesan A; G.,Rajakumari C., Environmental science and Biotechnology: theory and techniques.(2006).M J P publishers, Chennai.
7. Santra S.C., Environmental Science.2011. New central book agency (P) ltd. Calcutta.
8. Anjaneyula Y., Introduction to environmental Science. (2005). BS publications.

BID103	**Animal Biotechnology**	**credits: 04 (**Theory-03, Practicals-01)

Course Objectives:

1. To learn about the requirements for animal cell culture technology (washing room, media prep, sterilization room, inoculation and culture room, equipment, culture vessels)

2. To understand the concept of Culturing of cells and Cell growth.

3. To understand Gene transfer methods in Animals

4. To gain basic understanding of transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect.

5. To study various animal diseases that need help of Biotechnology. 6. To understand animal propagation via Artificial insemination, Animal Clones. 7. To learn about Stem Cell Technology and its applications. 8. To understand the techniques of gene therapy its types, vectors and molecular engineering, 9. To understand the problems and ethics associated with human genetic engineering.	
THEORY	
UNIT I History and Scope of animal tissue culture, Requirements for animal cell culture technology (washing room, media prep, sterilization room, inoculation and culture room, equipment, culture vessels) Culturing of cells (basic techniques, cell lines and maintenance, types of culture, transformed and normal cells) ,Cell growth (cell cycle, synchronization, apoptosis)	10 H
UNIT II Gene transfer methods in Animals Introduction to transgenesis. Transgenic Animals – Mice, Cow, Pig, Sheep, Goat, Bird, Insect. Animal diseases need help of Biotechnology – Foot-and mouth disease, Coccidiosis,Trypanosomiasis, Theileriosis.	10 H
UNIT III Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications.	15 H
UNIT IV Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.	10 H
PRACTICAL	30 H
1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization 2. Sources of contamination and decontamination measures 3. Preparation of serum from animal blood for cell culture. 4. Preparation of Hanks Balanced salt solution 5. Preparation of Minimal Essential Growth medium 6. Isolation of lymphocytes for culturing (demonstration) 7. Establishing primary culture (monolayer) 8. Sub culturing of monolayer culture. 9. DNA isolation from animal tissue 10. Quantification of isolated DNA. 11. Viability study of cell using trypan blue.	
Learning Outcomes: 1. Students will be able to give significance of washing room, media prep, sterilization room, inoculation and culture room, equipment, culture vessels for	

cell culture.

2. Students will be able to explain basic techniques of cell culture, cell lines and maintenance, types of culture, transformed and normal cells, and cell growth (cell cycle, synchronization, apoptosis).
3. Students will be able to explain gene transfer methods in animals.
4. Students will be able to explain transgenesis and uses of transgenic animals.
5. Students will be able to describe Animal diseases such as Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis. that need help of Biotechnology
6. Students will be able to explain the concept of artificial propagation in animals
7. Students will be able to state the applications of stem cell technology.
8. Students will be able to describe the techniques used in gene therapy its types, vectors, molecular engineering, human genetic engineering
9. Students will be able to discuss the benefits and challenges of human genetic engineering.
10. Students will be able to prepare and sterilize different media used to culture animal cells.
11. Students will be able to set up primary culture and do sub-culturing.

Books:

1. Mathur Shivangi, Animal cell & tissue culture, (2009), Agrobios (India),
2. Masters John., Animal cell culture- A practical approach. (2000). Oxford publishers
3. Butterworth-Heinemann., Invitro cultivation of animal cells, (2007)
4. DasH.K., Text book of Biotechnology, (2007). Wiley India, New Delhi
5. Sudha Gangal, Principles and practicle of animal tissue culture. (2007).
6. Freshney Ian., Animal Cell Biotechnology (5^{th} Edition) (2005). Wiley, John & sons
7. GuptaP.K., Elements of Biotechnology- (1^{st} Edition-2000). Rastogi Publications.