छत्रपति शाहू जी महाराज विश्वविद्यालय, कानपुर

CHHATRAPATI SHAHU JI MAHRAJ UNIVERSITY, KANPUR

(पूर्ववर्ती कानपुर विश्वविद्यालय कानपुर)

Formerly Kanpur University, Kanpur – 208024

A Documentary Support

For

Metric No. – 1.1.1

Programme Outcomes & Course Outcomes

Under the

Criteria - I

(Curriculum Design and Development)

Key Indicator - 1.1

In

Metric No. – 1.1.1

B.Sc. Bio-Technology

Co-ordinator
Internal Quality Assurance Cell
CSJM University, Kanpur

(Registrar)
C.S.J.M.University
Kanpur

REGISTRAR
C.S.J.M. UNIVERSITY
KANPUR

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR
Department of Life Sciences & Biotechnology

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: B.Sc. (Hons.), SUBJECT: Biotechnology

FOUR YEAR UNDERGRADUATE PROGRAM (FYUP), CHOICE BASED CREDIT SYSTEM (CBCS) AS PER UGC
Under School of Life Sciences and Biotechnology

PREAMBLE

In view of the increasing demand for training manpower in the area of Molecular Biology, Genetic Medicine and Biotechnology, it was consensus of the committee (Faculties & experts) that this course should be broad based and should be able to give a good insight into modern biology and important component of hands-on training to the students. Thus by nature it will be an interdisciplinary course. The course curriculum for U.G program under choice based for B.Sc. in Biotechnology (Hons.) presented in this document follows the nationwide exercise undertaken by the UGC as part of curriculum restructuring initiative.

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SEMESTER-I

Paper code	Courses offered (Core course)	Course Name	Credit		Max Marks
			Theory	Practical*	
BBT – 1001	CC-1	Chemistry	4		100
BBT – 1001P	Practical-1	Chemistry Practical		2	100
BBT – 1002	CC-2	Cell Biology	4		100
BBT – 1001P	Practical-2	Cell Biology Practical		2	100
BBT – 1003/AECC-01	Ability Enhancement Compulsory Course	English Communication-I	4		100
BBT – 1004/GE-01	Generic Elective (elect any one)	1004(A): Biotechnology and Human Welfare	4		100
		1004(B): I.P.R Entrepreneurship Bioethics & Biosafety	4		100
Total				20	600

SEMESTER-II

Paper code	Courses offered (Core course)	Course Name	Theory	Practical*	
BBT – 2001	CC-3	Mammalian Physiology	4		100
BBT – 2001P	Practical-3	Mammalian Physiology Practical		2	100
BBT – 2002	CC-4	Plant Physiology	4		100
BBT – 2001P	Practical-4	Plant Physiology Practical		2	100
BBT – 2003/AECC-01	Ability Enhancement Compulsory Course	Environmental Sciences	4		100
BBT – 2004/GE-02	Generic Elective (elect any one)	2004 (A): Gene Organization, Expression and Regulation	4		100
		2004 (B): Development Biology	4		100
Total				20	600

SEMESTER-III

Paper code	Courses offered (Core course)	Course Name	Theory	Practical*	
BBT – 3001	CC-5	General Biochemistry	4		100
BBT – 3001P	Practical-5	General Biochemistry Practical		2	100
BBT – 3002	CC-6	General Microbiology	4		100
BBT – 3002P	Practical-6	General Microbiology Practical		2	100
BBT – 3003	CC-7	Genetics	4		100
BBT – 3003P	Practical-7	Genetics Practical		2	100
BBT -3004/SEC-01	Skill Enhancement Course	Enzymology	4		100
Total				22	700

SEMESTER-IV

Paper code	Courses offered (Core course)	Course Name	Theory	Practical*	
BBT – 4001	CC-8	Bioanalytical Tools	4		100
BBT – 4001P	Practical-8	Bioanalytical Tools Practical		2	100
BBT – 4002	CC-9	Intermediary Metabolism	4		100
BBT – 4002P	Practical-9	Intermediary Metabolism Practical		2	100
BBT – 4003	CC-10	Immunology	4		100
BBT – 4003P	Practical-10	Immunology Practical		2	100

9/12/22

CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY, KANPUR

STRUCTURE OF SYLLABUS FOR THE

PROGRAM: B.Sc. (Hons.), SUBJECT: _ Biotechnology

BBT -4004/SEC-02	Skill Enhancement Course	Molecular diagnostics	4		100
Total				22	700
SEMESTER-V					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
BBT – 5001	CC-11	Molecular Biology	4		100
BBT – 5001P	Practical-11	Molecular Biology Practical		2	100
BBT – 5002	CC-12	Biostatistics	4		100
BBT – 5002P	Practical-12	Biostatistics Practical		2	100
BBT – 5003	Discipline Specific Elective (elect any two)	Animal Biotechnology	4		100
BBT – 5004		Environmental Biotechnology	4		100
BBT -4005		Microbial Biotechnology	4		100
Total				20	600
SEMESTER-VI					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
BBT – 6001	CC-13	Recombinant DNA Technology	4		100
BBT – 6001P	Practical-13	Recombinant DNA Technology Practical		2	100
BBT – 6002	CC-14	Genomics and Proteomics	4		100
BBT – 6002P	Practical-14	Genomics and Proteomics Practical		2	100
BBT – 6003	Discipline Specific Elective (elect any two)	Plant Biotechnology	4		100
BBT – 6004		Bioinformatics	4		100
BBT - 6005		Bioprocess Technology	4		100
Total				20	600
SEMESTER-VII					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
In addition complete any THREE optional subject: BBT-7001(A)/(B)/(C)/(D)					
BBT – 7001 (A)	CC-15	Applied Biotechnology	4		100
BBT – 7001 (A)P		Practical		2	100
BBT – 7001 (B)		Applied Biochemistry	4		100
BBT – 7001 (B)P		Practical		2	100
BBT – 7001 (C)		Applied Microbiology	4		100
BBT – 7001 (C)P		Practical		2	100
BBT – 7001 (D)		Applied Food Technology	4		100
BBT – 7001 (D)P		Practical		2	100
BBT – 7002	CC-16	Research Methodology	4		100
Total				22	700
SEMESTER VIII					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	**Theory**
Develop the skill required to completed a substantial original research project					
BBT-8001	CC-17	Research Project		20	700
Total				20	700
Grand Total				**166**	**5200**

C: Core Course; **GE:** Generic Elective; **AECC:** Ability Enhancement Compulsory Course; **SEC:** Skill Enhancement Courses; **DSE:** Discipline Specific Elective

9/12/23 9/12/23

SEMESTER-I					
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			Theory	**Practical***	
BBT – 1001	CC-1	Chemistry	4		100
BBT – 1001P	Practical-1	Chemistry Practical		2	100
BBT – 1002	CC-2	Cell Biology	4		100
BBT – 1001P	Practical-2	Cell Biology Practical		2	100
BBT – 1003/AECC-01	Ability Enhancement Compulsory Course	English Communication-I	4		100
BBT – 1004/GE-01	Generic Elective (elect any one)	1004(A): Biotechnology and Human Welfare	4		100
		1004(B): I.P.R Entrepreneurship Bioethics & Biosafety	4		100
Total			20		600
SEMESTER-II					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
BBT – 2001	CC-3	Mammalian Physiology	4		100
BBT – 2001P	Practical-3	Mammalian Physiology Practical		2	100
BBT – 2002	CC-4	Plant Physiology	4		100
BBT – 2001P	Practical-4	Plant Physiology Practical		2	100
BBT – 2003/AECC-01	Ability Enhancement Compulsory Course	Environmental Sciences	4		100
BBT – 2004/GE-02	Generic Elective (elect any one)	2004 (A): Gene Organization, Expression and Regulation	4		100
		2004 (B): Development Biology	4		100
Total			20		600
SEMESTER-III					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
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BBT – 3001P	Practical-5	General Biochemistry Practical		2	100
BBT – 3002	CC-6	General Microbiology	4		100
BBT – 3002P	Practical-6	General Microbiology Practical		2	100
BBT – 3003	CC-7	Genetics	4		100
BBT – 3003P	Practical-7	Genetics Practical		2	100
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Total			22		700
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Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
BBT – 4001	CC-8	Bioanalytical Tools	4		100
BBT – 4001P	Practical-8	Bioanalytical Tools Practical		2	100
BBT – 4002	CC-9	Intermediary Metabolism	4		100
BBT – 4002P	Practical-9	Intermediary Metabolism Practical		2	100
BBT – 4003	CC-10	Immunology	4		100
BBT – 4003P	Practical-10	Immunology Practical		2	100
BBT - 4004/SEC-02	Skill Enhancement Course	Molecular diagnostics	4		100
Total			22		700
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Paper code	Courses offered (Core course)	Course Name	Theory	Practical*	
BBT – 5001	CC-11	Molecular Biology	4		100
BBT – 5001P	Practical-11	Molecular Biology Practical		2	100
BBT – 5002	CC-12	Biostatistics	4		100
BBT – 5002P	Practical-12	Biostatistics Practical		2	100
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BBT – 5004		Environmental Biotechnology	4		100
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BBT – 6001P	Practical-13	Recombinant DNA Technology Practical		2	100
BBT – 6002	CC-14	Genomics and Proteomics	4		100
BBT – 6002P	Practical-14	Genomics and Proteomics Practical		2	100
BBT – 6003	Discipline Specific Elective (elect any two)	Plant Biotechnology	4		100
BBT – 6004		Bioinformatics	4		100
BBT - 6005		Bioprocess Technology	4		100
Total			20		600
SEMESTER-VII					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	
In addition complete any THREE optional subject: BBT-7001(A)/(B)/(C)/(D)					
BBT – 7001 (A)	CC-15	Applied Biotechnology	4		100
BBT – 7001 (A)P		Practical		2	100
BBT – 7001 (B)		Applied Biochemistry	4		100
BBT – 7001 (B)P		Practical		2	100
BBT – 7001 (C)		Applied Microbiology	4		100
BBT – 7001 (C)P		Practical		2	100
BBT – 7001 (D)		Applied Food Technology	4		100
BBT – 7001 (D)P		Practical		2	100
BBT – 7002	CC-16	Research Methodology	4		100
Total			22		700
SEMESTER VIII					
Paper code	**Courses offered (Core course)**	**Course Name**	**Theory**	**Practical***	**Theory**
Develop the skill required to completed a substantial original research project					
BBT-8001	CC-17	Research Project		20	700
Total				20	700
Grand Total			**166**		**5200**

C: Core Course; **GE:** Generic Elective; **AECC:** Ability Enhancement Compulsory Course; **SEC:** Skill Enhancement Courses; **DSE:** Discipline Specific Elective

PROGRAMME OUTCOMES (PO's)

PO1: Graduate Attributes

A graduate student shall be able to develop skill and acquire knowledge in fundamentals of Chemistry, Biology and will develop disciplinary theory and practical knowledge in the diversified areas of Biochemistry. The students are given fundamentals in each course and they are encouraged to become unique by allowing them to perform experiments in the areas of their interest. This will enable the students to equip themselves with the basic practical training in different areas of Biochemistry having various Biomolecules, nature and their structure and function. To take up further specialized Master level courses in these areas or to take up suitable assignments/jobs in Biotech/Biochemical industries. The students shall enjoy the academic freedom which will bring out the best from each student. These attributes are elaborated as under:

PO2: Disciplinary Knowledge:

a) Ability to understand fundamental concepts of biology, chemistry and biochemistry.
b) Ability to apply basic principles of chemistry to biological systems and molecular biology.
c) Ability to relate various interrelated physiological and metabolic events.
d) A general awareness of current developments at the forefront in biotechnology, biochemistry and allied subjects.
e) Ability to critically evaluate a problem and resolve to challenge blindly accepted concepts.
f) Zeal and ability to work safely and effectively in a laboratory.
g) Good experimental and quantitative skills encompassing preparation of laboratory reagents, conducting experiments, satisfactory analyses of data and interpretation of results.
h) Awareness of resources, and their conservation.
i) Ability to think laterally and in an integrating manner and develop interdisciplinary approach.
j) Overall knowledge of the avenues for research and higher academic achievements in the field of Biotechnology and allied subjects.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1: Communication Skills:

a) Ability to speak and write clearly in English
b) Ability to listen to and follow scientific viewpoints and engage with them.

PSO2: Critical Thinking:

a) Ability to substantiate critical readings of scientific texts in order to persuade others.
b) Ability to place scientific statements and themes in contexts and also evaluate them in terms of generic conventions.

PSO3: Problem Solving:

a) Ability to closely observe the situation, and apply lateral thinking and analytical skills. Analytical

PSO4: Reasoning:

a) Ability to evaluate the strengths and weaknesses in scholarly texts spotting flaws in their arguments.
b) Ability to use critics and theorists to create a framework and to substantiate one's argument in one's reading of scientific texts.

PSO4: Research-Related Skills:

a) Ability to problematize; to formulate hypothesis and research questions, and to identify and consult relevant sources to find answers.
b) Ability to plan and write a research paper.

PSO5: Teamwork and Time Management:

a) Ability to participate constructively in class room discussions.
b) Ability to contribute to group work.
c) Ability to meet a deadline.

PSO6: Scientific Reasoning:

a) Ability to analyze texts, evaluating ideas and scientific strategies.
b) Ability to formulate logical and convincing arguments. Reflective Thinking: Ability to locate oneself and see the influence of location—regional, national, global— on critical thinking.

SYLLABUS

SEMESTER-1

C1 CHEMISTRY
Paper Code (BBT 1001)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- To educate the students to develop the knowledge of the fundamental principles of chemistry
- To enable understanding of the nomenclature, structural, isomerism, stereochemistry of organic compounds.

Course Outcome(s):

- Students will learn different fundamentals of basic chemistry of different chemistry branches like organic chemistry, Inorganic, Physical etc.

- Studies includes chemical bonding i.e. formation of different molecules types of bonds, hybridization, in thermodynamic studies free energy required for chemical and biochemical reactions and chemical kinetics rates of chemical reaction.
- In stereo chemistry how different molecules/ bio-molecules are presented by different methods along with their stereo aspects like chirality, etc.
- They will also learn electrochemical aspects during their course.
- They will also perform experimental verification of some parts of theory.

THEORY

Unit 1: Chemical Energetics (10 Lectures)

A Review of the Laws of Thermodynamics Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, 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's equation Statement of the Third Law of Thermodynamics and calculation of the absolute entropies of substances

Unit 2: Chemical Equilibrium and Ionic Equilibrium (10 Lectures)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^o , Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

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.

Unit 3: Stereochemistry (10 Lectures)

Writing of Fischer projection, Newmann and Sawhorse projection and Wedge formulae. Interconversion of one type of structural representation into another type. **Conformations:** Restricted rotation about single bonds, Various conformations of ethane, butane, ethane-1,2-diol and cyclohexane. Relative stability of different conformations in terms of energy difference is to be discussed for all these compounds. **Geometrical Isomerism:** Requirements for a molecule to show geometrical isomerism, CisTrans and E/ Z notation along with CIP rules for geometrical isomers. **Optical Isomerism:** Optical activity, specific and molar rotation, chirality, enantiomerism, diastereoisomers, racemic mixtures and their resolution by salt formation method. Relative and absolute configuration: D / L nomenclature system for configuration of carbohydrates

(difference between d/l and D/L notations). Threo and Erythro designation. Rand S- configuration (upto two chiral centres).

Unit 5: Substitution Reactions and Spectroscopy (10 Lectures)

Free radical substitution reactions: Halogenation of alkanes, allylic compounds and alkyl benzenes. 34**Nucleophilic substitution reactions:** Mechanism of SN1 and SN2 reactions (stereochemistry, nature of substrate, nucleophile and leaving group), Electrophilic Substitution Reactions (aromatic compounds): General mechanism of electrophilic substitution reactions (nitration, halogenation, sulphonation, Friedel Crafts alkylation and acylation), directive influence of substituents.

Introduction to spectroscopy: Electromagnetic radiation, fundamental definitions, electromagnetic spectrum, introduction to concepts of absorption and emission spectroscopy, Beer-Lambert law. **IR Spectroscopy:** Fundamental and non-fundamental molecular vibrations, IR spectrum, Study of hydrogen bonding. Electronic Spectroscopy: Electronic transitions, singlet and triplet states, dissociation and predissociation. **Laws of photochemistry:** Fluorescence and phosphorescence. Primary and secondary processes in photochemical reactions. Photochemical and thermal reactions.

PRACTICALS

Organic preparations: Carry out the following preparations using 0.5 - 1 g of starting compound. Recrystallize the product and determine the melting point of the recrystallized sample.

1. To prepare acetanilide by the acetylation of aniline.
2. To prepare p-bromoacetanilide.
3. Benzolyation of aniline or β-naphthol by Schotten-Baumann reaction
4. Hydrolysis of benzamide or ethyl bezoate.

Thermochemistry:

1. Determination of heat capacity of a calorimeter for different volumes.
2. Determination of the enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of integral enthalpy of solution of salts (endothermic and exothermic).

pH-metric and potentiometric measurements:

1. Preparation of sodium acetate-acetic acid buffer solutions and measurement of their pH.
2. Potentiometric titrations of (i) strong acid vs strong base (ii) weak acid vs strong base
3. Determination of dissociation constant of a weak acid.

RECOMMENDED TEXTS

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 9th Ed., Oxford University Press (2011).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Chang, R. Physical Chemistry for the Biosciences. University Science Books (2005).
6. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
7. R. T. Morrison & R. N. Boyd: Organic Chemistry, Pearson Education

C2 CELL BIOLOGY

Paper Code (BBT 1002)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 60

Course Objective(s):

- This course introduces the students to the basics of cell and its components.
- This gives them a strong foundation on the basic unit of life.
- The present course has been devised to familiarize students with the structural and functional aspects of cell, the basic unit of life, and its different organelles. Knowing the components of cells and how they work is fundamental to all biological sciences.

Course Outcome(s):

- Understanding of the structure of cell and various cellular events.
- Understanding of the function of various subcellular organelles.
- Students will learn about cell theory and techniques for fractionation of sub-cellular organelles.
- They will be acquainted to various microscopic techniques to visualize subcellular organelles.
- Students will have an understanding of the composition of cytoskeleton and extracellular matrix.

- Students will acquire knowledge of cell cycle, cell division and cell death mechanisms.

THEORY

UNIT I (10 Periods)

Cell: introduction and classification of organisms by cell structure, cytosol, compartmentalization of eukaryotic cells, cell fractionation. Cell Membrane and Permeability: Chemical Components of Biological Membranes, Organization and Fluid Mosaic Model, Membrane as a dynamic entity, cell recognition and membrane transport.

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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.

UNIT IV (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

AECC1 ENGLISH

Paper Code (BBT 1003)

(Credits 4: Theory-4)

Lectures: THEORY: 20

Course Objective(s):

- This course is designed to develop communication and vocabulary skills in the students.

Course Outcome(s):

- Analyze and restate the meaning of a text in English
- Demonstrate the skill to write in English without grammatical error
- Practice listening effectively to communication in English
- Develop the ability to speak English language with the right way of pronunciation
- Express the viewpoints with confidence in English
- Express values and skills gained through effective communication to other disciplines
- Compose articles and compositions in English
- Discuss and socialize effectively in English

THEORY

Introduction:

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

Speaking Skills:

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

Writing Skills:
Documenting - Report Writing - Making notes - Letter Writing

SUGGESTED READING

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

GE1 BIOTECHNOLOGY AND HUMAN WELFARE

Paper Code (BBT 1004 [A])

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s):

- To introduce methods and strategies commonly used in protein engineering, polysaccharide production.
- To acquire knowledge and application of beneficial microbes in the agriculture sector.
- To study and understand the impact of development on environment safety and its significance for sustainable ways of development.
- To provide knowledge of the basics about implications of biotechnology in Human Health and Forensic Sciences.

Course Outcome(s):

- Recognize the importance of various molecular techniques used in biotechnological industry and the importance of modern agriculture and its application.
- Understand the importance of biotechnology in relation to environment and pollution.
- Learn about various applications-based techniques in biotechnology like forensic science and the related activities currently going on and that will lay the foundations for the future work in relation to crime.

- Comprehend the application of biotechnology in therapeutic drug and vaccine development, gene therapy and diagnostics

THEORY

UNIT I (10 Periods)

Industry: protein engineering; enzyme and polysaccharide synthesis, activity and secretion, alcohol and antibiotic formation.

UNIT II (10 Periods)

Agriculture: N2 fixation: transfer of pest resistance genes to plants; interaction between plants and microbes; qualitative improvement of livestock.

UNIT III (10 Periods)

Environments: e.g. chlorinated and non-chlorinated organ pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB.

UNIT IV (05 Periods)

Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing.

UNIT V (05 Periods)

Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal in E.coli, human genome project.

PRACTICALS

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

1. Perform of ethanolic fermentation using Baker's yeast
2. Study of a plant part infected with a microbe
3. To perform quantitative estimation of residual chlorine in water samples
4. Isolation and analysis of DNA from minimal available biological samples
5. Case studies on Bioethics (any two)

SUGGESTED READING

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
2. Shree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

GE2 I.P.R. ENTREPRENEURSHIP BIOETIHCS & BIOSAFETY
Paper Code (BBT 1004 [B])

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 60

Course Objective(s):

- To develop the understanding of Intellectual property, Entrepreneurship, IPR, Biosafety, GMO and bioethics.

Course Outcome(s):

- Teachings like good laboratory procedure and practices, standard operating procedures for biotechnology research, legal and institutional framework for biosafety, international agreements and protocols for biosafety.
- Learn about the Intellectual property rights and their usages to protect work created by human mind that has commercial value.
- Makes students aware about different national and international IPR issues including patents, trademarks, copyrights etc. and various international agreements and treaties.
- The course makes student understand the Regulatory bodies for Bioethics in India and International considerations.
- Students will become aware of Institutional Ethical Committee and International laws on Biosafety. Students will analyse and imbibe the Objectives and role of WIPO which will also help in interpreting impact of Intellectual property and its legal protection in research.
- The course is designed to have applications of research in innovation and entrepreneurship by involving the significance of patents and copyrights to have sustenance at global level.

THEORY

UNIT-I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

SEMESTER-2

C3 MAMMALIAN PHYSIOLOGY

Paper Code (BBT 2001)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s):

- To understand the basic concept of mammalian digestion, respiration, circulation, muscular system and nervous system.

Course Outcome(s):

- Illustrate the integration of individual functions of all cells, tissues and organs into functional whole-human body.
- Detect gross organs in the body
- Identify various bones of the skeletal system
- Find various blood indices
- Determine the blood groups
- Measure blood pressure
- Integrate the knowledge of whole body organs and their mechanisms.
- Compare various health conditions and their effects.

THEORY

UNIT I: Digestion and Respiration (10 Periods)

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.

UNIT II: Circulation (10 Periods)

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

UNIT III: Muscle physiology and osmoregulation (10 Periods)

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.

UNIT IV: Nervous and endocrine coordination (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

C4 PLANT ANATOMY AND PHYSIOLOGY
Paper Code (BBT 2002)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s):

- To develop the understanding of plant anatomy, growth and development.
- To develop understanding of nutrients requirement of plants.

Course Outcome(s):

- Understand the basics of plant physiology and physiological mechanisms governing plant growth and development
- Learn the basics of transport in plants and movement of solutes and water
- Remember the basics of photosynthesis, respiration and hormonal signalling as it impacts plant growth and development
- Comprehend and increase the awareness and appreciation for plants in environment, as well as to understand their diverse physiological functions.

THEORY

UNIT I: Anatomy (10 Periods)

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

UNIT II: Plant water relations and micro &macro nutrients (10 Periods)

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

UNIT III: Carbon and nitrogen metabolism (10 Periods)

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

UNIT IV: Growth and development (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

AECC2 ENVIRONMENTAL SCIENCES
Paper Code (BBT 2003)

(Credits 4: Theory-4)
Lectures: THEORY: 20

Course Objective(s)

- To provide Knowledge about the importance of conserving biodiversity and to acquire a broad base of knowledge of environmental systems
- It enables the students to understand the fundamental and applied aspects of environmental biotechnology
- To understand the pros and cons of the usage of bioscience in various aspects of environment and its applications

Course Outcome(s):

- Student understood the concept of environmental pollution, types of pollutants and related hazards.
- Acquire knowledge on environment protection acts and understand the need to conserve environment by implementing policies with the help of different organizations.
- Students will understand the structure, growth and the interactions of populations in the environment. Build awareness on disaster management, environmental movements and ethics.
- Field visit enhance the skill techniques among the students to document assets, study local polluted site and ecosystem structure and environmental impact.

THEORY

Unit 1: Introduction to environmental studies (2 lectures)

Multidisciplinary nature of environmental studies; Scope and importance; Concept of sustainability and sustainable development.

Unit 2: Ecosystems (6 lectures)

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

Unit 3: Natural Resources (8 lectures)

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

Unit 4: Biodiversity and Conservation (8 lectures)

Levels of biological diversity : genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots, India as a mega-biodiversity nation; Endangered and endemic species of India, Threats to biodiversity : Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity : In-situ and Ex-situ conservation of biodiversity. Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 5: Environmental Pollution (8 lectures)

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

Unit 6: Environmental Policies & Practices (7 lectures)

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

Unit 7: Human Communities and the Environment (6 lectures)

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

Unit 8: Field work (Equal to 5 lectures)

Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc.
Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.

Study of common plants, insects, birds and basic principles of identification.
Study of simple ecosystems-pond, river, Delhi Ridge, etc.

SUGGESTED READINGS:

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

GE2 GENE ORGANIZATION, EXPRESSION AND REGULATION
Paper Code (BBT 2004 [A])

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s):

- To develop the understanding of genes, chromosomes, transcription and translation.

Course Outcome(s):

- Define the roles of DNA and proteins in cell development and metabolism
- Determine the amino acid sequence of a protein given the nucleotide sequence of a gene.

- Describe the roles that the promoter, coding region, and, termination sequence of a gene play in gene expression.
- Recognize the differences between the structure of proteins, amino acids, genes, and nucleotides
- Draw the process of gene expression and include the following in your drawing. Gene, RNA polymerase, promoter, coding region, termination sequence, intron, cell, nucleus, cytoplasm, RNA, tRNA, ribosome, anticodon, codon, amino acid, protein, peptide bond.

THEORY

Unit 1 Structure of genes and chromosomes (Lectures : 6)

Definition of a gene, chromosomal organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA.

Unit 2 Replication of genomes (Lectures: 6)

General features of DNA replication, properties of prokaryotic and eukaryotic DNA polymerases. Replication of DNA and telomeres in linear chromosomes. Replication of RNA genomes.

Unit 3 Recombination of DNA (Lectures: 4)

Homologous genetic recombination, Holliday model, proteins and enzymes mediating recombination.

Unit 4 Gene mutations and repair (Lectures: 6)

Molecular basis of mutations, multiple repair systems, mismatch repair, base excision repair, nucleotide excision repair, direct repair and translation DNA synthesis.

Unit 5 Transcription of genes (Lectures: 6)

General features of gene transcription, prokaryotic and eukaryotic RNA polymerases, stages of transcription, initiation, elongation and termination. Inhibitors of transcription.

Unit 6 RNA processing (Lectures: 3)

Processing of eukaryotic mRNA, splicing of introns, alternate splicing and editing, ribosomal and tRNA processing.

Unit 7 Protein synthesis (Lectures: 5)

Features of the genetic code, amino acylation of tRNAs, structure and assembly of ribosomes; three stages of protein synthesis - initiation, elongation and termination. Inhibitors of protein synthesis.

Unit 8 Regulation of gene expression (Lectures: 4)

Regulation of transcription in prokaryotes, concept of operons. Lac operon - control by negative and positive regulatory proteins, Trp operon - control by attenuation. Regulation of transcription

in eukaryotes, regulatory sequences - enhancers, silencers response elements, nucleosome alterations, DNA-protein interactions and RNA interference.

PRACTICALS

1. Quantitative determination of DNA and RNA by absorbance at 260 nm and using A260/A280 ratio to distinguish between them.
2. To study the viscosity of DNA solutions.
3. Isolation of chromosomal DNA from E. coli.
4. Isolation of total RNA from yeast cells.

SUGGESTED READINGS

1. Lehninger: Principles of Biochemistry (2013) 6th ed., Nelson, D.L. and Cox, M.M., W.H. Freeman and Company (New York), ISBN:13; 978-1-4641-0962-1 / ISBN:10-14641- 0962-1.

GE2 DEVELOPMENTAL BIOLOGY

Paper Code (BBT 2004 [B])

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s):

- Describe the events in the developmental process,
- Predict the results of genetic or embryological manipulations, based on their knowledge of the developmental process,
- Make hypotheses about the mechanisms involved in the process based on experimental results
- Design experiments to test hypotheses about the developmental process.

Course Outcome(s):

- Name, describe and order the main stages of development common to most multicellular organisms.
- Describe the main anatomical changes that occur during development.
- Identify the cellular behaviors that lead to morphological change during development.
- Describe the hierarchy of gene activation that occurs in early Drosophila development.
- Understand how gene activation plays a role in differentiation and development.

- Describe the unique characteristics of the Hox genes and explain how they act as master regulators of development in multicellular organisms.
- Describe the main signaling pathways that play important roles in development.
- Explain how embryonic stem cells and their alternatives can be used in medical treatments

THEORY

UNIT I: Gametogenesis and Fertilization (10 Periods)

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

UNIT II: Early embryonic development (20 Periods)

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

UNIT III: Embryonic Differentiation (20 Periods)

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

UNIT IV: Organogenesis (10 Periods)

Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germ layers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals.

PRACTICALS

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

SUGGESTED READING

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.

3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

SEMESTER-3
C5 GENERAL BIOCHEMISTRY
Paper Code (BBT 3001)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- Understand the basics of biomolecules and surrounding interaction.
- Understand basic details of amino acid & protein molecules, carbohydrate, Nucleic Acid, Lipid, vitamin molecules and their classification
- Understand the basics of macromolecules involved in the Cellular Signaling

Course Outcome(s):

- As Biochemistry is the branch of science concerned with the chemical and physico-chemical processes and substances that occur within living organisms, therefore students will be able to understand how biomolecules relate to a particular process (metabolism) within a living cell.
- Students will be acquainted with the knowledge of structures, functions, and interactions of proteins, nucleic acids, carbohydrates and lipids.
- The course will help the students to understand the abnormalities in the metabolism their relationship to various diseases. In addition to, it will help to understand the mechanism underlying correct disorders with dietary modifications or genetic modifications.
- Students will learn about enzyme kinetics and types of inhibition as enzymes are important in catalyzing various reactions in the body

THEORY

Unit 1 Biomolecules in their cellular environment (05 lectures)

The cellular basis of life. Cellular structures – prokaryotes and eukaryotes. Chemical principles in biomolecular structure. Major classes of biomolecules. Role of water in design of biomolecules.

Unit 2 Amino acids and peptides (05 lectures)

Types of amino acids and their chemistry, derivatives of amino acids and their biological role. Introduction to biologically important peptides.

Unit 3 Sugars and polysaccharides (05 lectures)

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

Unit 4 Nucleosides, nucleotides and nucleic acids (05 lectures)

Structures and chemistry, DNA structures and their importance, different types of RNA. Unusual DNA structures, other functions of nucleotides.

Unit 5 Lipids (10 lectures)

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

Unit 6 Vitamins, coenzymes and metal ions (05 lectures)

Occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomolecules - heme, porphyrins and cyanocobalamin; their biological significance.

Unit 7 Signalling molecules (05 lectures)

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

PRACTICALS

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

SUGGESTED READINGS

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

C6 GENERAL MICROBIOLOGY

Paper Code (BBT 3002)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- 1. To make the students to understand the basic concepts of the biology of microorganisms

- 2. To learn the general principles for microbial the growth, evolution and classification
- 3. To make the students to understand the role of microbes in human life.

Course Outcome(s):

- To become aware with the contributions of Louis Pasteur, Edward Jenner and Robert Koch in microbiology and immunology.
- To get acquainted with the discovery of antibiotics and their targets, drug/antibiotic resistance, preventive and therapeutic approaches of infectious diseases, hospital acquired infections.
- Understanding the importance of microorganisms as model systems in genetics and biochemistry.
- To know the contribution of gut microbiome in human health.
- Exposure to the basic concepts of metabolic engineering and synthetic biology.
- To understand the concepts of fight against major killer diseases – tuberculosis, HIV and malaria.

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

Control of Microorganisms: By physical, chemical and chemotherapeutic Agents Water Microbiology: Bacterial pollutants of water, coliforms and non coliforms. Sewage composition and its disposal. Food Microbiology: Important microorganism in food Microbiology: Moulds,

Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods. Fermented Foods.

PRACTICALS

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

SUGGESTED READING

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology. 2nd edition. Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008) Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

C7 GENETICS
Paper Code (BBT 3003)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s):

- To make the students to understand the principles and theories of inheritance.
- To learn the concepts of chromosome morphology.
- To make the students to understand the gene expression and regulation.

Course Outcome(s):

- Students are able to understand the basic concept of transmission of genetics.
- Students enrich with the knowledge of Mendelian and Non-Mendelian genetics.
- Understanding the concepts of gene interactions and its applications in knowing genetic disorders.
- They learn about chromosomal aberrations and structure of chromosomes.

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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, middle repetitive sequences- VNTRs & dinucleotide repeats, repetitive transposed sequences- SINEs & LINEs, middle repetitive multiple copy genes, noncoding DNA. Genetic organization of prokaryotic and viral genome. Structure and characteristics of bacterial and eukaryotic chromosome, chromosome morphology, concept of euchromatin and heterochromatin. packaging of DNA molecule into chromosomes, chromosome banding pattern, karyotype, giant chromosomes, one gene one polypeptide hypothesis, concept of cistron, exons, introns, genetic code, gene function.

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

Genetic linkage, crossing over and chromosome mapping: Linkage and Recombination of genes in a chromosome crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Crossing over at four strand stage, Multiple crossing overs Genetic mapping. Extra chromosomal inheritance: Rules of extra nuclear inheritance, maternal effects, maternal inheritance, cytoplasmic inheritance, organelle heredity, genomic imprinting. Evolution and population genetics: In breeding and out breeding, Hardy Weinberg law (prediction, derivation), allelic and genotype frequencies, changes in allelic frequencies, systems of mating, evolutionary genetics, natural selection.

PRACTICALS

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

SUGGESTED READING

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006). Principles of Genetics. VIII Edition John Wiley & Sons.
2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. 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.

SEC1 ENZYMOLOGY
Paper Code (BBT 3004)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s):

- To understand the theories of enzyme catalysis and the mechanisms of enzyme regulation

- To solve enzyme kinetics related exercise and estimate important parameter
- To understand the kinetic of enzyme inhibition and regulation
- To understand the methods for protein sequencing, analysis of secondary and tertiary structures of enzymes and Protein folding in vitro & in vivo.

Course Outcome(s):

- The subject is of relevance to students from a wide range of disciplines such as health, environment and medical sciences.
- Students will be able to proceed towards various concepts in biotechnology, the knowledge on enzyme and enzyme reactions.
- Enzyme kinetics will provide the importance and utility of enzyme kinetics in research.
- Students will learn critical analysis of scientific phenomena involving enzymes and will be able to competently work with enzyme systems in both academia and industry.
- Students will get an understanding of procedures involved in purification of enzymes, enzymes assays and quantitative evaluation of the influencing parameters such as concentrations of substrate / enzyme, pH, temperature and effects of inhibitors on enzyme activity.

THEORY

UNIT - I (10 Periods)

Isolation, crystallization and purification of enzymes, test of homogeneity of enzyme preparation, methods of enzyme analysis. Enzyme classification (rationale, overview and specific examples) Zymogens and their activation (Proteases and Prothrombin). Enzyme substrate complex: concept of E-S complex, binding sites, active site, specificity, Kinetics of enzyme activity, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax and their physiological significance, factors affecting initial rate, E, S, temp. & pH. Collision and transition state theories, Significance of activation energy and free energy.

UNIT – II (10 Periods)

Two substrate reactions (Random, ordered and ping-pong mechanism) Enzyme inhibition types of inhibition, determination of Ki, suicide inhibitor. Mechanism of enzyme action: General mechanistic principle, factors associated with catalytic efficiency: proximity, orientation, distortion of strain, acid-base, nucleophilic and covalent catalysis. Techniques for studying mechanisms of action, chemical modification of active site groups, specific examples-: chymotrypsin, Iysozyme, GPDH, aldolase, RNase, Carboxypeptidase and alcohol dehydrogenase. Enzyme regulation: Product inhibition, feed backcontrol, covalent modification.

UNIT – III (10 Periods)

Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Qualitative description of concerted and sequential models. Negative cooperativity and half site reactivity. Enzyme - Enzyme interaction, Protein ligand binding, measurements analysis of binding isotherm, cooperativity, Hill and scatchard plots, kinetics of allosteric enzymes. Isoenzymes– multiple forms of enzymes with special reference to lactate dehydrogenase. Multienzyme complexes. Ribozymes. Multifunctional enzyme-eg Fatty Acid synthase.

UNIT – IV (10 Periods)

Enzyme Technology: Methods for large scale production of enzymes. Immobilized enzyme and their comparison with soluble enzymes, Methods for immobilization of enzymes. Immobilized enzyme reactors. Application of Immobilized and soluble enzyme in health and industry. Application to fundamental studies of biochemistry. Enzyme electrodes. Thermal stability and catalytic efficiency of enzyme, site directed mutagenesis and enzyme engineering– selected examples, Delivery system for protein pharmaceuticals, and structure function relationship in enzymes, structural motifs and enzyme evolution. Methods for protein sequencing. Methods for analysis of secondary and tertiary structures of enzymes. Protein folding in vitro & in vivo.

PRACTICALS

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

SUGGESTED READING

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

SEMESTER-4
C8 BIOANALYTICAL TOOLS
Paper Code (BBT 4001)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- To learn the principle and application of different tools utilized in biotechnology.

Course Outcome(s):

- Develop competence in handing various chromatographic techniques and apply them in isolating and characterizing different biological molecules.
- Understanding the applications of centrifugation and chromatography in biological investigations.
- Purify proteins by affinity chromatography using epitope tags such as histidine tag, GST tag, Flag tag etc.
- Understanding the principles of Electrophoresis, Spectrophotometry and ELISA and their applications in biological investigations/experiments.

THEORY

UNIT I (10 Periods)

Simple microscopy, phase contrast microscopy, florescence and electron microscopy (TEM and SEM), pH meter, absorption and emission spectroscopy

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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 (10 Periods)

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

PRACTICAL

1. Native gel electrophoresis of proteins
2. SDS-polyacrylamide slab gel electrophoresis of proteins under reducing conditions.
3. Preparation of the sub-cellular fractions of rat liver cells.
4. Preparation of protoplasts from leaves.
5. Separation of amino acids by paper chromatography.
6. To identify lipids in a given sample by TLC.
7. To verify the validity of Beer's law and determine the molar extinction coefficient of NADH.

SUGGESTED READING

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

C9 INTERMEDIARY METABOLISM

Paper Code (BBT 4002)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 60

Course Objective(s)

- To learn the basic concept of different metabolic pathways.
- Students will be taught the metabolic pathways of carbohydrate, amino acid, lipid and coenzymes and their regulation.

Course Outcome(s):

- To understand the relevance, basic concepts and theories of chemistry as relevant to a biological system.
- To understand the properties of biomolecules and their nature of existence in the living system.
- To understand the relevance and basic concepts of experimental biochemistry.

- To understand the nature and commonly used types of biochemical experiments.
- To understand integration of metabolism with the help of different cycles.

THEORY

Unit 1 Basic concepts and design of metabolism (05 Periods)
The nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency.

Unit 2: Glycolysis and gluconeogenesis (05 Periods)
Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis.

Unit 3: The citric acid cycle (05 Periods)
Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway.

Unit 4: Oxidative phosphorylation (05 Periods)
The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

Unit 5: Photosynthesis, Calvin cycle and pentose phosphate pathway (06 Periods)
The light reaction, chlorophyll, accessory pigments, reaction centres, two photo systems, generation of proton gradient and NADPH, Calvin cycle, synthesis of glucose, starch, sucrose, regulation, C4 pathway. Pentose phosphate pathway, importance and regulation.

Unit 6: Glycogen metabolism (02 Periods)
Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis.

Unit 7: Fatty acid synthesis and degradation (02 Periods)
TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Biosynthesis of fatty acids - elongation and unsaturation of fatty acids. Regulation of fatty acid oxidation and synthesis.

Unit 8: Amino acid catabolism and anabolism (03 Periods)
Protein degradation to amino acids, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation, synthesis of non-essential amino acids.

Unit 9: Nucleotide metabolism (03 Periods)
Biosynthesis - de novo and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion.

Unit 10: Integration of metabolism (04 Periods)
Brief role of hormones - catecholamines, insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, role of cortisol in signaling stress - increase in gluconeogenesis and muscle protein breakdown.

PRACTICALS

1. Alcohol fermentation by yeast.
2. H_2S production, indole production and ammonia production by bacteria.
3. Urea estimation.
4. Uric acid estimation.
5. Nitrogen fixation by cyanobacteria.

SUGGESTED READINGS

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

C10 IMMUNOLOGY
Paper Code (BBT 4003)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objectives

- Understand the basics of Immunology and types of Immunity. Antigens as haptens, epitopes and Factors influencing immunogenicity, and Antibodies as their Structure, types, production and functions of immunoglobulins also about Clonal selection theory and Antigen Antibody reactions as Precipitation, Haem-agglutination and ELISA.

- Understand of Major Histocompatibility complexes, structure of MHC, Hypersensitivity, Autoimmunity and Immunodeficiency.
- Understand Passive and Active immunization, Types of Vaccines: Inactivated, Attenuated, Recombinant and Sub Unit Vaccines, Peptide and DNA Vaccines.

Course Outcomes:

- Understanding of the overview of immune system including cells, organs and receptors.
- To learn structure and functions of different classes of immunoglobulins, the genetic basis of antibody diversity and the importance of humoral, cell-mediated and innate immune responses in combating pathogens.
- To understand mechanisms involved in different types of hypersensitivity, and the importance of conventional vs recombinant vaccines.
- To get acquainted with the importance of antigen-antibody interaction in disease diagnosis.
- To understand the principles of tolerance, autoimmunity and the role of immunity in protection against pathogens.

THEORY

UNIT I (10 Periods)

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.

UNIT II (10 Periods)

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.

UNIT III (10 Periods)

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.

UNIT IV (10 Periods)

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.

PRACTICALS

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

SUGGESTED READING

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6 th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology. 11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway'sImmunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009). Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology. 6th edition. Wiley Blackwell Publication.

SEC2 MOLECULAR DIAGNOSTICS

Paper Code (BBT 4004)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- Recall the basics of molecular diagnostics.
- Explain potential applications of molecular diagnostics.
- Compare existing and new concepts, methodologies and research results and apply them in and academic or industrial research environment.

Course Outcome(s):

- Demonstrate various diagnostic lab techniques such as identification of causative agent of disease using DNA or protein-based methods, microscopic analysis, and rapid immunoassay
- Perform molecular techniques which include the isolation of DNA and genetic manipulation, Rapid immunoassay, DNA fingerprinting analysis
- Appraise the significance of sensitive and accurate diagnosis in the detection of disease

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

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

1. Perform/demonstrate RFLP and its analysis
2. Kirby-Bauyer method (disc-diffusion method) to study antibiotic sensitivity of a bacterial culture
3. A kit-basd detection of a microbial infection (Widal test)

4. Study of Electron micrographs (any four). 5. Perform any one immuno diagnostic test (Typhoid, Malaria, Dengue)

SUGGESTED READING

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker
2. Bioinstrumentation, Webster
3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic
4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
5. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
6. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition. AppletonCentuary-Crofts publication.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education. 9. Microscopic Techniques in Biotechnology, Michael Hoppert

SEMESTER-5
C11 MOLECULAR BIOLOGY
Paper Code (BBT 5001)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- To teach the dynamic properties of chromatin and it's folding.
- To teach topological properties of DNA, transposable elements and genetic code.
- To provide students with a deep insight and mechanism of the various cellular processes such as DNA Replication, Transcription and Translation

Course Outcome(s):

- Study the discovery of DNA as genetic material, DNA replication, transcription, DNA repair and translation.
- Analyse coding and non-coding regions of eukaryotic genome and their importance.
- Exposure with the importance of E. coli lac operon, PCR, expression vectors and their importance in Biotechnology.
- To produce insulin using recombinant DNA technology.
- Acquaintance with the merits and demerits of transgenic crops.
- Exposure to the concepts of genomics, proteomics, metabolomics and their importance in human health.

THEORY

UNIT I: DNA structure and replication (10 Periods)

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

UNIT II: DNA damage, repair and homologous recombination (10 Periods)

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

UNIT III: Transcription and RNA processing (10 Periods)

RNA structure and types of RNA, Transcription in prokaryotes: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains Transcription in eukaryotes: Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing: processing of pre-mRNA: 5’ cap formation, polyadenylation, splicing, rRNA and tRNA splicing.

UNIT IV: Regulation of gene expression and translation (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. VIII Edition. Lippincott Williams and Wilkins, Philadelphia.
3. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.
4. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., (2008) Molecular Biology of the Gene (VI Edition.). Cold Spring Harbour Lab. Press, Pearson Pub.

C12 BIOSTATISTICS
Paper Code (BBT 5002)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

To provide training to students because there are more and more career fields that need workers who are statistically literate, especially in our growing data-driven economies, such as medicine and healthcare, data science, communications and public relations, government and public policy, journalism, marketing, business, and finance.

Course Outcome(s):

- The students will understand the principles of collection of data in biological experiments, proper statistical analysis of the data and its presentation.
- Students will understand the importance of sample size and various variables that affect data.
- Students will know the importance of mean, standard error, standard deviation, significance in presenting the data.

- Knowing statistical methods will help students in improving their analytical and interpretation skill.
- Students will acquire hands-on practical training to plan biological experiments with requisite sample size.
- After completion of experiments based on different sample sizes students will be able to perform proper statistical analysis of the data using mean, median, mode, variance and standard deviations.
- Students will be able to apply the principles of biological data management in real life situations.
- Statistical training will improve computational, mathematical and computer skills of the students by learning the use of ANOVA, AMOVA and student t-test.
- Students will be able to formulate a hypothesis, relevance to type of sample collected and sample size.

THEORY

UNIT I (10 Periods)
Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis.

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

UNIT III (10 Periods)
Methods of sampling, confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)

UNIT IV (10 Periods)
Correlation and Regression. Emphasis on examples from Biological Sciences.

PRACTICALS

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

SUGGESTED READING

1. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
2. Glaser AN (2001) High Yield Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.

DSE1 ANIMAL BIOTECHNOLOGY

Paper Code (BBT 5003)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- Explain the methods of gene manipulations in animal cells and embryonic stem cells
- Develop breeding and conservation approaches in animals
- Appraise the legal and ethical issues related to animal maintenance

Course Outcome(s):

- Students will understand the basic concepts and terminology used in animal tissue culture.
- Students will understand and evaluate cell cultures constraints and possibilities as an in vitro model.
- This course demonstrates knowledge of basic cell culture techniques
- Students will get the knowledge of how to establish a cell lines and its maintenance.
- This course demonstrates knowledge on design and how to use the cell culture facilities.
- Students will know the advantages and limitations of primary cell culture compared to immortalized or transformed cell lines.

THEORY

UNIT I (10 Periods)

Gene transfer methods in Animals – Microinjection, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer.

UNIT II (10 Periods)

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.

UNIT III (10 Periods)

Animal propagation – Artificial insemination, Animal Clones. Conservation Biology – Embryo transfer techniques. Introduction to Stem Cell Technology and its applications.

UNIT IV (10 Periods)

Genetic modification in Medicine - gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.

PRACTICALS

1. Sterilization techniques: Theory and Practical: Glass ware sterilization, Media sterilization, Laboratory sterilization
2. Sources of contamination and decontamination measures.
3. Preparation of Hanks Balanced salt solution
4. Preparation of Minimal Essential Growth medium
5. Isolation of lymphocytes for culturing
6. DNA isolation from animal tissue
7. Quantification of isolated DNA.
8. Resolving DNA on Agarose Gel.

SUGGESTED READING

1. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. II Edition. Academic Press, California,USA.
2. Butler, M. (2004). Animal cell culture and technology: The basics. II Edition. Bios scientific publishers.
3. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
4. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA.
5. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNAgenes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.

DSE2 ENVIRONMENTAL BIOTECHNOLOGY

Paper Code (BBT 5004)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- Recall knowledge on different environmental factors.

- To study concept of environmental pollution, bioremediation and its applications in environmental clean up.
- To develops an attitude of concern for the environment and acquiring skills to help the concerned individuals in identifying and solving environmental problems.

Course Outcome(s):

- They would understand and analyze environmental relationships with a better assessment of the mechanisms of environmental components like atmosphere, hydrosphere and lithosphere.
- Students will become skilled at basic theoretical concepts highlighting in the field of ecology, and how these are applied to different ecological approaches.
- The studies of ecology, biogeography and ecosystem structure will provide the awareness on ecological and historical foundations for understanding the distribution and abundance of species and the changes in their distribution and abundance over time and climatic impact.
- Student understood the concept of environmental pollution, types of pollutants and related hazards. Acquire knowledge of bioremediation and its applications in environmental clean up and various waste and disaster management methods and policies.
- Build awareness about environment conservation, environment protection acts. Studies on current global environmental issues will make aware to students about their causes and effect measure should be consider.

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)
Bioleaching, Enrichment of ores by microorganisms (Gold, Copper and Uranium). Environmental significance of genetically modified microbes, plants and animals.

PRACTICALS

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

SUGGESTED READING

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

DSE3 MICROBIAL BIOTECHNOLOGY

Paper Code (BBT 5005)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- Recall knowledge on medium formulation and strain improvement for enhanced production of bioproducts.
- Develop fundamental knowledge to explore microbes for the production of industrially relevant primary and secondary metabolites.
- Extend knowledge on the industrial method of fermentation processes for the production of bioproducts.

Course Outcome(s):

- Understands importance of microorganisms in various milk and food processing.

- Understand the significance and activities of microorganisms in various food and factors affecting on microbial growth in food leading to spoilage and understand the principles underlying the preservation methods.
- Recognize and describe the characteristics of important food borne pathogens, pathogenesis and prevention.
- Know the conceptual basis for understanding pathogenic microorganisms and mechanism of their pathogenesis, treatment and prevention.
- Explains various aspects of wastewater treatment, also know various test to determine potability of water.
- Acquire knowledge about application of microorganisms in bioleaching of metals, agriculture, biosynthetic and biosynthetic material production.
- Understands norms and regulations of GMO and its responsible use.

THEORY

Unit 1: Microbial Biotechnology and its Applications (Lectures: 10)
Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology Use of prokaryotic and eukaryotic microorganisms in biotechnological applications Genetically engineered microbes for industrial application: Bacteria and yeast

Unit 2: Therapeutic and Industrial Biotechnology (Lectures: 10)
Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine) Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics Microbial biosensors

Unit 3: Applications of Microbes in Biotransformations (Lectures: 8)
Microbial based transformation of steroids and sterols Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute Unit 4 Microbial Products and their Recovery No. of Hours: 10 Microbial product purification: filtration, ion exchange & affinity chromatography techniques Immobilization methods and their application: Whole cell immobilization

Unit 5: Microbes for Bio-energy and Environment (Lectures: 08)
Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents

Unit 6: RNAi (Lectures: 4)

RNAi and its applications in silencing genes, drug resistance, therapeutics and host pathogen interactions

PRACTICALS

1. Study yeast cell immobilization in calcium alginate gels
2. Study enzyme immobilization by sodium alginate method
3. Pigment production from fungi (Trichoderma / Aspergillus / Penicillium)
4. Isolation of xylanase or lipase producing bacteria
5. Study of algal Single Cell Proteins

SUGGESTED READING

1. Ratledge, C and Kristiansen, B. (2001). Basic Biotechnology, 2nd Edition, Cambridge University Press.
2. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
3. Swartz, J. R. (2001). Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.
4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ (2014), 9th edition, Mc Graw Hill Publishers.
5. Gupta PK (2009) Elements of Biotechnology 2nd edition, Rastogi Publications, 6. Glazer AN and Nikaido H (2007) Microbial Biotechnology, 2nd edition, Cambridge University Press
7. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
8. Stanbury PF, Whitaker A, Hall SJ (1995) Principles of Fermentation Technology 2nd edition., Elsevier Science
9. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.

SEMESTER 6
C13 RECOMBINANT DNA TECHNOLOGY
Paper Code (BBT 6001)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- Recall different DNA modifying enzymes used in recombinant DNA technology

- Compare different vectors and their applications in recombinant DNA technology
- Illustrate different techniques used in genetic engineering

Course Outcome(s):

- Students will take practical training in the recent techniques of recombinant DNA technology such as quantification of DNA, isolation of chromosomal DNA, isolation of plasmid DNA from bacterial cells, restriction digestion of DNA and their separation using Agarose gel electrophoresis, amplification of DNA fragment by PCR. With learning these techniques students will gain expertise to work further in the area of recombinant DNA technology.

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

Restriction and modification system, restriction mapping. Southern and Northern hybridization. Preparation and comparison of Genomic and cDNA library, screening of recombinants, reverse transcription, Genome mapping, DNA fingerprinting, Applications of Genetic Engineering Genetic engineering in animals: Production and applications of transgenic mice, role of ES cells in gene targeting in mice, Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

1. Isolation of chromosomal DNA from plant cells
2. Isolation of chromosomal DNA from E.coli

3. Qualitative and quantitative analysis of DNA using spectrophotometer
4. Plasmid DNA isolation
5. Restriction digestion of DNA
6. Making competent cells
7. Transformation of competent cells.
8. Demonstration of PCR

SUGGESTED READING

1. Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik NJ. (2009). Biotechnology-Applying the Genetic Revolution. Elsevier Academic Press, USA.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington
4. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
5. Sambrook J, Fritsch EF and Maniatis T. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press.

C14 GENOMICS AND PROTEOMICS

Paper Code (BBT 6002)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- Gaining a better understanding of the interactions between genes and the environment by means of genomics is helping researchers find better ways to improve health and prevent disease, Proteomics research permits the discovery of new protein markers for diagnostic purposes and the study of novel molecular targets for drug discovery. The protein markers identified have a broad range of potential applications. They may be used for clinical diagnostic or prognostic purposes.

Course Outcome(s):

- Be able to describe the development of Omics technologies, with emphasis on genomics and proteomics;
- Be able to synthesise information to discuss the key technological developments that enabled modern genomic and proteomic studies;

- be able to describe advanced genomics and proteomics technologies and the ways in which their data are stored;
- be able to use bioinformatics techniques to query examples of genomic and proteomic databases to analyse cell biology;
- be able to describe the different types of genome variation and their relationship to human diseases;
- be able to discuss how biological systems information relating to genes, proteins and cellular structures can be used to model living cells, and even to create new synthetic cells.
- Genomics: an introduction to genomics, databases and sequence comparison techniques, genes and the genome, principles and applications of DNA microarray technology, transcriptional profiling, micro-array applications, SNP, QTL and genotyping, modern genome sequencing, genome variation and phylogeny, biomes, and transcriptomics.
- Proteomics: early origins of proteomics, gel-based proteome profiling, the rise of different mass spectrometry methods, modern high throughput mass spectrometry, protein data bases

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
6. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
7. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
8. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
9. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington. 6. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition. John Wiley & Son

DSE4 PLANT BIOTECHNOLOGY

Paper Code (BBT 6003)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- Explain the developmental processes operating in plants
- Demonstrate plant tissue culture methods
- Analyze biotechnological tools for engineering plants in agriculture and industry

Course Outcome(s):

- Learning outcomes for this course include detailed understanding of metabolic processes specific for plants such as nitrate assimilation, photosynthesis, respiration, nitrogen fixation and the role of different metabolic pathways in plant growth and development.
- Students will also gain insight to various stressful conditions of the environment that affect plant growth and productivity as well as the defense mechanisms in plants due to which plants survive under stresses.

THEORY

UNIT I (10 Periods)

Introduction, Cryo and organogenic differentiation, Types of culture: Seed, Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation.

UNIT- II (10 Periods)

In vitro haploid production Androgenic methods: Anther culture, Microspore culture andogenesisSgnificance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

UNIT - III (10 Periods)

Protoplast Isolation and fusion Methods of protoplast isolation, Protoplast development, Somatic hybridization, identifiation and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations. Somaclonal variation Nomenclautre, methods, applications basis and disadvantages.

UNIT – IV (10 Periods)

Plant Growth Promoting bacteria. Nitrogen fixation, Nitrogenase, Hydrogenase, Nodulation, Biocontrol of pathogens, Growth promotion by free-living bacteria.

PRACTICALS

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 selection, Prune, sterilize and prepare an explant for culture.
4. Significance of growth hormones in culture medium.
5. To demonstrate various steps of Micropropagation.

SUGGESTED READING

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
4. Raven, P.H., Johnson, GB.,Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture. Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
7. Sambrook& Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

DSE5 BIOINFORMATICS
Paper Code (BBT 6004)

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- Recall the basic practical techniques of bioinformatics.
- Extend the knowledge of bioinformatics and biological databases to solving real research problems.
- Formulate the use of a wide variety of tools, servers, biological databases and apply them in appropriate fields.

Course Outcome(s):

- By studying this course, the students completing B.Sc. Biotechnology will have an understanding of the tools of bioinformatics and computational biology and will be in a position to access biological data bases and softwares which will be helpful in understanding sequence alignments and predicting the structures of biomolecules such as proteins. Students will be exposed to available bioinformatics tools and databases.
- They will be in a position to comprehend the fundamental aspects of in-silico protein structure prediction.

- They will understand application of theoretical approaches to biological systems. Students will get trained in the application of programs used for database searching, protein and DNA sequence analysis, and prediction of protein structures.

THEORY

UNIT I (10 Periods)

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

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

DSE6 BIOPROCESS TECHNOLOGY

Paper Code (BBT 6005)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 40

Course Objective(s)

- To teach the concept and application bioprocess technology
- To develop understanding bioformulation and fermentation techniques.
- To provide knowledge recycling and quality control.

Course Outcome(s):

- This paper presents the basics of fermentation technology, media components as applied to lab scale, pilot scale and industrial scale upstream and downstream processing.
- This paper is introduced to acquire requisite skills for the design and development of bioreactors, production optimization, and preparation of sterile base materials for downstream processing.
- On successful completion of the course the students should have understood the basics of fermentation technology and learnt the concept of screening, optimization and maintenance of cultures.

THEORY

UNIT I (10 Periods)

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Basic principle components of fermentation technology. Types of microbial culture and its growth kinetics– Batch, Fed batch and Continuous culture.

UNIT II (10 Periods)

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

UNIT III (10 Periods)

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

UNIT IV (10 Periods)

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

PRACTICALS

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

SUGGESTED READING

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

SEMESTER 7
C15 APPLIED BIOTECHNOLOGY
Paper Code (BBT 7001 [A])

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 20

Course Objective(s)

- **To study microbial growth and its maintenance.**
- To develop understanding different bioreactors.
- To provide knowledge biochemistry of different industrial chemicals

Course Outcome(s):

- Learn basics of fermentation technology, bioreactors, production optimization, and downstream processing.

- On successful completion of the course the students should have understood the basics of fermentation technology and learnt the concept of different metabolite production by microbes in industrial setup.

THEORY

Unit-I Microbial Cell Growth and Death Kinetics: (10 Lectures)
Screening and Improvement of industrially important microorganisms, Microbial Growth and Death Kinetics, Media for Industrial Fermentation, Air and Media Sterilization.

Unit-II Operation and Control of Bioreactors: (10 Lectures)
Types of Fermentation Processes: Analysis of batch, fed-batch and continuous bioreactors, stability of microbial bioreactors, analysis of mixed populations, specialized bioreactors-pulsed, fluidized, photo bioreactors, etc. Measurement and Control of bioprocess parameters. Downstream processing, Whole cell immobilization and their industrial applications.

Unit-III Fermentation Technology: (10 Lectures)
Industrial production of chemicals: Ethanol, Acids (citric, acetic and gluconic acid), Solvents (glycerol, acetone, butanol), Antibiotics (penicillin, streptomycin, tetracyclin), Semi-synthetic antibiotics, Amino acids (lysine, glutamic acid), Single cell protein.

Unit-IV Applications of Bioprocess Engineering: (10 Lectures)
Agitation and aeration: requirement in industrial processes, concept of volumetric oxygen transfer coefficient and its determination (Kla), Factors affecting Kla values; Uses of microbes in mineral beneficiation and oil recovery. Introduction to food technology; Elementary idea of canning and packaging, Sterilization and pasteurization of food products.

PRACTICALS

1. To plot Microbial growth curve for shake flask culturing using turbidity method.
2. Prepare a standard curve of reducing sugar by 3,5-Dinitrosalicylic acid method
3. To produce invertase enzyme and find its activity from Baker's Yeast
4. Preparation of standard curve of Ethanol.
5. Quantitative estimation of ethanol produced during Yeast fermentation
6. Production of Penicillin and assaying its activity.
7. To get familiarized with the lab scale fermenter (bench top fermenter)
8. To determine dissolved oxygen concentration in tap and aerated water.
9. To determine the volumetric transfer coefficient (K la)
10. Estimation of BOD in a given waste water sample.
11. Centrifugation studies during settling of yeast cells.

12. Yeast cell disruption by mechanical methods.

SUGGESTED BOOKS

1. Bioprocess Engineering, Shular M &Kargi F, Prentice Hall
2. Biochemical Engineering Fundamentals, Bailey JE &Ollis DF
3. Bioprocess Engineering Principles, Doran, PM, Academic Press, California

CC 15 APPLIED BIOCHEMISTRY
Paper Code (BBT 7001 [B])

(Credits: Theory-4, Practicals-2)
THEORY Lectures: 40

Course Objective(s)

- To develop understading for the application of applied biochemistry.
- To train students in emerging field of applied biochemistry.

Course Outcome(s):

- Students will learn basics and application of radiochemistry, immunochemistry, and immunoassay.

THEORY

Unit I- (10 Lectures)

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

Unit II- (10 Lectures)

Aminoacid composition and primary structure of proteins: analysis methods. Protein fragmentation and peptide production: first elements of mass spectrometry in the proteome analysis. Electrophoresis: first elements and physical laws. Electrophoresis in liquid and semisolid media: agarose gels and polyacrilamide gels. SDS-PAGE and molecular mass determination of proteins. Native PAGE. Gradiente gels. Isoelectrofocusing and protein pI. Detection, evaluation

and recovery of protein from gel. Western and South-Western blotting. Agarose and polyacrilamide gel electrophoresis of nucleic acids. Pulsed field gel electrophoresis (PFGE) DNA sequencing: Sanger and Maxam-Gilbert methods. Chromatography: first elements and theoretical principles. TLC chromatography. Column low pressure chromatography. High performance liquid chromatography (HPLC, FPLC). Adsorption chromatography. Partition chromatography. Normal phase and reversed phase (RPC) chromatography. Ion pair RPC. Hydrophobic interaction chromatography (HIC). Ion exchange chromatography (IEX). Gel filtration chromatography. Affinity chromatography. Working out of protein purification protocols.

Unit III- (10 Lectures)

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

Unit IV- (05 Lectures)

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

Unit V- (05 Lectures)

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

PRACTICALS

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

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

SUGGESTED READING

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

C 15 APPLIED MIICROBIOLOGY

Paper Code (BBT 7001 [C])

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 50

Course Objective(s)

- Recall necessary information related to all microorganisms and their application in various sectors Elaborate on laboratory safety and specialized microbiological laboratory skills

Course Outcome(s):

- Learn the structure, diversity, classification, and application of microorganisms.
- Relate the role of microbes in the fields of food, agriculture, medicine and biotechnology.

THEORY

Unit 1- (10Lectures)

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

Unit 2- (10Lectures)

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

Unit 3- (10 Lectures)

Industrial Microbiology: Introduction to fermentation. Industrially important organisms – Isolation, preservation and strain improvement. Types of fermentation processes - Solid-state and

liquid-state (stationary and submerged) fermentations; batch, fed-batch and continuous fermentations. Components of a typical bio-reactor, types of bioreactors, downstream processing. Microbial productions: Wine and ethyl alcohol, citric acid, glutamic acid, penicillin Recombinant products: vaccine.

Unit 4- (10 Lectures)

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

Unit 5- (05 Lectures)

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

Unit 6- (05 Lectures)

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

PRACTICALS

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

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

SUGGESTED READINGS

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication.
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Bare Act, 2007.Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
4. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
5. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.
6. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
7. Goel D &Prashar S (2013).IPR, Biosafety and Bioethics. Pearson.
8. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier.

C15 APPLIED FOOD TECHNOLOGY

Paper Code (BBT 7001 [D])

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 20

Course Objective(s)

- To impart knowledge in areas of food science and technology.
- To understand the food composition along with physicochemical properties.
- To learn the basis of food processing and packaging

Course Outcome(s):

- Understand the process of food preservation and packaging requirements of food categories.
- Understand the material handling in food industry, thermal processing.

THEORY

Unit I- (10 Lectures)

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

Unit II- (10 Lectures)

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

Unit III- (10 Lectures)

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

Unit IV-(05 Lectures)

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

Unit V- (06 Lectures)

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

PRACTICALS

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

SUGGESTED READINGS

1. WimJongen- Fruit and vegetable processing improving quality, WoodheadPublishing Limited.

2. A. Chakraverty- Post harvest Technology of cereals, pulses and oilseeds, Oxford & IBH Publishers
3. SukumarDey- Outlines of Dairy Technology, Oxford Publishers.
4. William J. Stadelman, V. M. Olson, G. A. Shemwell, S. Pasch- Egg and Poultry-Meat Processing, VCH Publishers.

C16 RESEARCH METHODOLOGY

Paper Code (BBT 7002)

(Credits: Theory-4, Practicals-2)

THEORY Lectures: 20

Course Objective(s)

- Understand some basic concepts of research and its methodologies.
- To identify appropriate research topics and select and define appropriate research problem and parameters.

Course Outcome(s):

- Students will learn how to prepare a project proposal (to undertake a project).
- Organize and conduct research (advanced project) in a more appropriate manner
- Will write a research report and thesis • write a research proposal (grants)

THEORY

Unit 1 Introduction to Research Methodology (Lectures: 4)
Objectives and motivation in research.

Unit 2 Defining the Research Problem (Lectures: 4)
Selecting and defining a research problem, Reviewing and conducting literature search, Developing a research plan.

Unit 3 Designing of Experiment (Lectures: 4)
Different experimental designs – single and multifactorial design, Making measurements and sources of error in measurements, Methods of data collection and record keeping.

Unit 4 Data Processing and Statistical Analysis (Lectures: 8)
Processing operations, tabulation, and graphical representation, Statistics in research: Concepts of sample and population, Measure of central tendency, dispersion, asymmetry (skewness, kurtosis), Normal distribution (p-value), Statistical tests and hypothesis (Standard error, t-test, chi-square test), and regression analysis, Report writing, Writing a research paper - abstract, introduction, methodology, results and discussion.

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

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

SUGGESTED READINGS

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

C17 PROJECTS
Paper Code (BBT 8001)

(Credits: Practicals-4)

Course Objective(s)

Course Outcome(s):