B.Sc. (H) Microbiology

THREE-YEAR FULL-TIME PROGRAMME
(Six-Semester Course)

COURSE CONTENTS

(Effective from the Academic Year 2010-2011)

UNIVERSITY OF DELHI

DELHI – 110 007

Course Structure

YEAR-1

PART I: Semester – 1

Paper 1	MIHT 101	Introduction to Microbial World
Paper 2	MIHT 102	Bacteriology
Paper 3	CHCT 301	Chemistry I
Paper 4	ENAT 101*/ CSAT 101*	Technical Writing and Communication in English/ Computational Skills

PART I: Semester – 2

Paper 5	ENAT 201*/ CSAT 201*	Technical Writing and Communication in English/ Computational Skills
Paper 6	MIHT 203	Phycology and Mycology
Paper 7	CHCT 402	Chemistry II
Paper 8	MACT 303	Mathematics and Statistics

***The college will have an option to take either of the two papers in a particular semester for a particular course, while students have to appear in both the papers**

In addition, there shall be one qualifying paper in self-learning mode called Environmental Studies offered in Semester-2

YEAR-2

PART II: Semester – 3

Paper 9	MIHT 304	Virology
Paper 10	MIHT 305	Microbial Physiology and Metabolism I
Paper 11	CBHT 301	Cell Biology I
Paper 12	MBHT 301	Molecular Biology I

PART II: Semester – 4

Paper 13	MIHT 406	Microbial Physiology and Metabolism II
Paper 14	MIHT 407	Microbial Ecology
Paper 15	CBHT 402	Cell Biology II
Paper 16	MBHT 402	Molecular Biology II

YEAR-3

PART III: Semester – 5

Paper 17	MIHT 508	Plant Pathology
Paper 18	MIHT 509	Immunology
Paper 19	MIHT 510	Industrial Microbiology
Paper 20	GGHT 501	Genetics & Genomics I

PART III: Semester – 6

Paper 21	MIHT 611	Medical Microbiology
Paper 22	MIHT 612	Food and Dairy Microbiology
Paper 23	MIHT 613	Recombinant DNA Technology and Biotechnology
Paper 24	GGHT 602	Genetics & Genomics II

Preamble

The B.Sc. (Hons.) Microbiology course has been running in different colleges of University of Delhi as annual system since 1987. From 2010 onwards, it will follow semester system. This course would be of three years duration, divided into three parts- Part I, Part II and Part III. Each part would consist of two semesters. Each semester would comprise of four theory papers including practicals. There would be 13 cores, 6 common and 5 interdisciplinary papers, making a total of 24 papers. This new course will commence from the academic session 2010-11. The new syllabus has been prepared keeping in view the unique requirements of B.Sc. (Hons.) microbiology students. The contents have been drawn to accommodate the widening horizons of the Microbiology discipline. It reflects the changing needs of the students, pertaining to the fields of Chemistry, Mathematics, Statistics and Computational skills. The detailed syllabus for each paper is appended with a list of suggested readings.

Teaching time allotted for each paper shall be 4 periods for each theory paper and 4 periods for each practical class per week and 1 tutorial period for each paper per week. Each practical batch should not have more than 15 students. Any number exceeding 15 will be divided into two equal batches. This is because microbiology practicals require individual attention for imparting correct and adequate hands - on training to the students. The six common papers (Cell Biology - I and II, Genetics and Genomics – I and II and Molecular Biology I and II) will be taught by teachers of the department of microbiology of respective colleges. The interdisciplinary courses (Mathematics and Statistics, Computational Skills, Chemistry and Technical Writing and Communication in English) will be taught by teachers of the respective departments. One short educational trip will be conducted to industry/national/research institutes in the 5^{th} semester to keep the students abreast with latest developments in the field of microbiology.

Paper 1-MIHT 101
INTRODUCTION TO MICROBIAL WORLD

THEORY **Marks: 100**

Unit 1 History of development of Microbiology (Ch 2 Pelczar *et al*., Ch 1 Stanier) (10 periods)

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis, development of various microbiological techniques, concept of fermentation, establishment of fields of medical microbiology, immunology and environmental microbiology with special reference to the work of following scientists : Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Elie Metchnikoff, Norman Pace, Carl Woese and Ananda M. Chakraborty

Unit 2 Diversity of Microbial world

A. Systems of classification (Ch 1 Pelczar *et al*., Ch 1 Willey *et al*.) (2 periods)

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility.
Difference between prokaryotic and eukaryotic microorganisms

B. **General characteristics** of different groups: **Acellular** microorganisms (Viruses, Viroids, Prions) and **Cellular** microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

- **Viruses, viroids and prions**

(Ch 20 Pelczar *et al*., Ch 13 Tortora *et al*.) (7 periods)

A general introduction with special reference to the structure of the following: TMV, poliovirus, T4 and λ phage, lytic and lysogenic cycles, one step multiplication curve

- **Bacteria** **(Ch 2 Madigan *et al*.) (1 period)**

A very precise account of typical eubacteria, chlamydiae & rickettsiae (obligate intracellular parasites), mycoplasma, and archaebacteria (extremophiles).

- **Algae** **(Ch 1, 2 &12 Kumar) (10 periods)**

History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Detailed life cycle of *Chlamydomonas* and *Spirogyra*.

- **Fungi** **(Ch 2, 5, 11 Alexopoulus *et al*.) (10 periods)**

Historical developments in the field of Mycology including significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus

organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Detailed life cycle of *Aspergillus* and *Rhizopus*.

- **Protozoa** **(Ch 19 Pelczar *et al*., Ch 12 Tortora *et al*.) (5 periods)**

General characteristics with special reference to *Amoeba, Paramecium and Giardia*

Unit 3 An overview of Scope of Microbiology (Ch 1 Willey *et al*.) (1 period)

Paper 1-MIHP 101
INTRODUCTION TO MICROBIAL WORLD

PRACTICALS Marks: 50

1. Study of the life history of the following scientists and their contributions with the help of their photographs: Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei N. Winogradsky, Alexander Fleming, Selman A. Waksman, Elie Metchnikoff and Ananda M. Chakraborty.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven) used in the microbiology laboratory.
3. Study of the following algae by preparing temporary mounts: *Chlamydomonas* and *Spirogyra*.
4. Study of the following fungi by preparing temporary mounts: *Rhizopus* and *Aspergillus.*
5. Study of the following protozoans using permanent mounts/photographs: *Amoeba, Paramecium and Giardia*.
6. Study of the following viruses using electron micrographs : TMV, Polio virus, T4 and λ phage.

SUGGESTED READINGS

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John and Sons, Inc.
2. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM.T.Brown Publishers.
3. Cappucino J and Sherman N. (2010). *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education limited.
4. Kumar HD. (1990). *Introductory Phycology*. 2nd edition. Affiliated East Western Press.

5. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/Benjamin Cummings.
6. Pelczar MJ, Chan ECS and Krieg NR. (1993). *Microbiology*. 5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). *General Microbiology*. 5th edition. McMillan.
8. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition. Pearson Education.
9. Vashishta BR and Sinha AK. (2008). *Fungi*. S. Chand and Company Ltd.
10. Vashishta BR. (2005). *Algae*. 3rd edition. S. Chand and Company Limited, New Delhi.
11. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

Paper 2-MIHT 102
BACTERIOLOGY

THEORY **Marks: 100**

Unit 1 Cell organization (Ch 6 Stanier *et al*., Ch 3 Willey *et al*.) (15 periods)

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili.

Cell-wall: Composition and detailed structure of gram positive and gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall.

Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids

Endospore: Structure, formation, stages of sporulation.

Unit 2 Bacteriological techniques (Ch 8 Pelczar *et al*.) (4 periods)

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria

Unit 3 Growth and nutrition (Ch 7 Tortora *et al*., Ch 5 Willey *et al*.) (5 periods)

Nutritional requirements in bacteria and nutritional categories;

Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media

Sterilization and Disinfection

Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation

Chemical methods of microbial control: disinfectants, types and mode of action

Unit 4 Reproduction in Bacteria

(Ch 7 Pelczar *et al*., Ch 6 Tortora *et al*.) (3 periods)

Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate

Unit 5 Bacterial Systematics (Ch 19 Willey *et al*.) (8 periods)

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria

Unit 6 Important archaeal and eubacterial groups

(Ch 11 -13 Madigan *et al*., Ch 20–24 Willey *et al*.) (12 periods)

According to Bergey's Manual of Systematic Bacteriology (Second Edition)

Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*), and Halophiles (*Halobacterium, Halococcus*)]

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative:

- **Non proteobacteria**
  Aquifex, Thermotoga, Deinococcus, Thermus, Chlorobium, Chloroflexus, Chlamydiae, Spirochaetes.
- **Alpha proteobacteria**
  Rickettsia, Coxiella, Caulobacter, Rhizobium, Hyphomicrobium, Agrobacterium.
- **Beta proteobacteria**
  Neisseria, Burkholderia, Thiobacillus
- **Gamma proteobacteria**
  Enterobacteriaceae family, Purple sulphur bacteria, *Pseudomonas, Vibrio, Beggiatoa, Methylococcus, Haemophilus.*
- **Delta proteobacteria**
  Bdellovibrio, Myxococcus
- **Epsilon proteobacteria**
  Helicobacter, Campylobacter

Gram Positive:

- **Low G+ C (Firmicutes)**
  Mycoplasmas, *Clostridium, Heliobacterium, Lactobacillus, Lactococcus, Staphylococcus, Streptococcus, Leuconostoc, Bacillus.*

- **High G+C (Actinobacteria)**
  Arthrobacter, Bifidobacterium, Corynebacterium, Frankia, Mycobacterium, Nocardia, Streptomyces, Thermomonospora, Propionibacterium

Cyanobacteria : *An Introduction*

Paper 2-MIHP 102
BACTERIOLOGY

PRACTICALS Marks: 50

1. Introduction to light microscope
2. Preparation of different media: synthetic media BG-11, Complex media-nutrient agar, McConkey agar, EMB agar.
3. Simple staining
4. Negative staining
5. Gram's staining
6. Acid fast staining-permanent slide only.
7. Capsule staining
8. Spore staining.
9. Isolation of pure cultures of bacteria by streaking method.
10. Estimation of CFU count by spread plate method.
11. Motility by hanging drop method.

SUGGESTED READINGS

1. Atlas RM. (1997). *Principles of Microbiology*. 2nd edition. WM.T.Brown Publishers.
2. Black JG. (2008). *Microbiology: Principles and Explorations*. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2006). *Brock Biology of Micro-organisms*. 8th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). *Microbiology*. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). *Understanding Bacteria*. Kluwer Academic Publishers, Dordrecht
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*. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

Paper 3-CHCT 301
CHEMISTRY-I

THEORY **Marks: 100**

Section A: Inorganic Chemistry **(30 Periods)**

Unit 1 **Atomic Structure:** *Recapitulation of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Need of a new approach to Atomic structure.*

What is Quantum mechanics? Time independent Schrodinger equation ($H \psi = E\psi$) and meaning of various terms in it. Significance of ψ and ψ^2, Schrodinger equation for hydrogen atom in Cartesian coordinates (x,y,z). Need of polar coordinates, transformation of Cartesian coordinates (x,y,z) into polar coordinates (r,θ,ϕ). Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals. (Only graphical representation), Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distances with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_r and m_s. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit 2 **Chemical Bonding and Molecular Structure**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and salvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Lande equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: *VB Approach* Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of, linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures.

(30 Periods)

Section B: Physical Chemistry

Unit 3 Chemical Thermodynamics

What is thermodynamics? State of a system, state variables, intensive and extensive variables, concept of heat and work, thermodynamic equilibrium, thermodynamic properties, various types of systems and processes. First Law of thermodynamics. Calculation of work (w), heat (q), changes in internal energy (ΔU) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, ΔU and ΔH for processes involving changes in physical states. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution

Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.

Various statements of Second Law of thermodynamics, Carnot cycle, concept of entropy, Gibbs free energy and Helmholtz energy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity. Gibbs - Helmholtz equation. Maxwell's relations.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit 4 Ionic Equilibria

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect,

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts -applications of solubility product principle.

Qualitative treatment of acid base titration curves (calculation of pH at various stages of HCl –NaOH titration only). Theory of acid – base indicators.

Paper 3-CHCP 301
CHEMISTRY-I

PRACTICALS Marks: 50

Section A: Inorganic Chemistry

Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.
6. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

Section B: Physical Chemistry

I. **Surface tension measurement (**use of organic solvents excluded)

Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

II. **Viscosity measurement (**use of organic solvents excluded)

Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

III. **Kinetic studies**

Study of the kinetics of the following reaction by integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid volumetrically

SUGGESTED READINGS

1. Barrow GM. (2007). *Physical Chemistry*. Tata McGraw-Hill.
2. Castellan GW. (2004). *Physical Chemistry*. 4th edition. Narosa.
3. Cotton FA and Wilkinson G. (Year). *Basic Inorganic Chemistry*. John Wiley.
4. Douglas, McDaniel and Alexader. (Year). *Concepts and Models in Inorganic Chemistry*. John Wiley.
5. Huheey JE, Keiter E and Keiter R. (Year). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Publication.
6. Khosla B.D. *Senior Practical Physical Chemistry.* R. Chand & Co.
7. Kotz JC, Treichel PM and Townsend JR. (2009). *General Chemistry*. Cengage Learning India Pvt. Ltd., New Delhi.
8. Lee JD. (Year). *A New Concise Inorganic Chemistry*, E L. B. S.
9. Mahan BH. (1998). *University Chemistry*. 3rd edition. Narosa
10. Vogel A.I. *Vogel's Qualitative Inorganic Analysis*. 7th edition. Prentice Hall
11. Vogel A.I. *Vogel's Quantitative Chemical Analysis*. 6th edition. Prentice Hall.

Paper 4/5-ENAT 101/201

Technical Writing and Communication in English

Marks: 100

Unit 1

Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Unit 2

Writing Skills; Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit 3

Technical Writing: Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

SUGGESTED READINGS

1. M. Frank. Writing as thinking: *A guided process approach, Englewood Cliffs,* Prentice Hall Reagents.
2. L. Hamp-Lyons and B. Heasely: Study Writing; *A course in written English.* For academic and professional purposes, Cambridge Univ. Press.
3. R. Quirk, S. Greenbaum, G. Leech and J. Svartik: *A comprehensive grammar of the English language*, Longman, London.
4. Daniel G. Riordan & Steven A. Panley: *"Technical Report Writing Today"* - Biztaantra.

Additional Reference Books

5. Daniel G. Riordan, Steven E. Pauley, Biztantra (2004).: *Technical Report Writing Today*, 8th edition
6. *Contemporary Business Communication*, Scot Ober, Biztantra, 5th Edition (2004).

Paper 4/5-CSAT 101/201

COMPUTATIONAL SKILLS

THEORY Marks: 100

Computer Fundamentals (12 Periods)

Introduction to Computers: Characteristics of Computers, Uses of computers, Types and generations of Computers

Basic Computer Organization - Units of a computer, CPU, ALU, memory hierarchy, registers, I/O devices

User Interface with the Operating System, System Tools

Data Representation (8 Periods)

Binary representation of integers and real numbers, 1's Complement, 2's Complement, Addition and subtraction of binary numbers, BCD, ASCII, Unicode;

Networks terminology (4 Periods)

Types of networks, router, switch, server-client architecture

Multimedia (4 Periods)

Introduction, Characteristics, Elements, Applications

Problem Solving (10 Periods)

Notion of algorithms, stepwise methodology of developing an algorithm, developing macros in spreadsheet

General Awareness (4 Periods)

IT Act, System Security (virus/firewall etc.) ***I-Tax, Reservations,Banking***

Paper 4/5-CSAP 101/201
COMPUTATIONAL SKILLS

PRACTICALS Marks: 50

1. Defined projects will be done by the students and evaluated by the instructor.
2. Document Preparation
3. Presentation Software
4. Familiarizing with the Operating System, Control Panel, Networking Configuration, Firewall setting
5. Spreadsheet Handing, Working with worksheets, Creating a spreadsheet, entering and formatting information, basic functions and formulas, creating charts, tables and graphs.

SUGGESTED READING

[1] V Rajaraman, **Fundamentals of Computers,** Fourth Edition, PHI.

[2] Anita Goel, **Fundamentals of Computers;** Forthcoming title in Pearson-Education

Note: Use of Open Office/Star Office is recommended, as they are freely downloadable.

Reference manual for Open Office available at: http://www.openffice.org

Reference manual for Star Office available at: http://www.sun.com/software/staroffice/

Paper 6-MIHT 203

PHYCOLOGY & MYCOLOGY

THEORY **Marks: 100**

Section A: Phycology

Unit 1 **Classification of Algae** **(Ch 1 Kumar, Ch 2 Sharma) (2 periods)**

Unit 2 **Study of the following classes with reference to genera listed below (occurrence, thallus organization and life cycles):**

a) Chlorophyceae*: Volvox, Coleochaete*
(Ch 12 Kumar, Ch 9 Sharma) (3 periods)
b) Charophyceae: *Chara* **(Ch 12 Kumar, Ch 9 Sharma) (3 periods)**
c) Diatoms: General features with reference to pinnate and centric diatoms
(Ch 7 Kumar, Ch 11 Sharma) (3 periods)
d) Xanthophyceae: *Vaucheria* **(Ch 10 Kumar, Ch 10 Sharma) (2 periods)**
e) Phaeophyceae: *Ectocarpus* **(Ch 11 Kumar, Ch 12 Sharma) (3 periods)**
f) Rhodophyceae: *Polysiphonia* **(Ch 4 Kumar, Ch 13 Sharma) (3 periods)**
g) Cyanobacteria: *Nostoc* **(Ch 3 Kumar, Ch 8 Sharma) (2 periods)**

Unit 3 **Applications of algae** in Agriculture, Industry, Environment and Food
(Ch 14 Kumar) (3 periods)

Section B: Mycology

Unit 4 **Classification of fungi** **(Ch 3 Alexopoulos *et al.*, Ch 1 Sumbali) (2 periods)**

Unit 5 **Study of the following classes with reference to the genera listed below (occurrence, somatic structure and life cycles):**

a) Cellular slime molds - *Dictyostelium* **(Ch 27 Alexopoulos *et al.*) (1 period)**
b) True slime molds (Myxomycetes) - *Physarum*
(Ch 29 Alexopoulos *et al.*) (1 period)
c) Oomycetes - *Saprolegnia, Phytophthora* **(Ch 23 Alexopoulos *et al*) (3 periods)**
d) Chytridiomycetes - *Neocallimastix* **(Ch 4 Alexopoulos *et al.*) (1 period)**
e) Zygomycetes – *Mucor* **(Ch 5 Alexopoulos *et al.*) (1 period)**
f) Ascomycetes - *Saccharomyces, Penicillium, Neurospora*
(Ch 10 -12 Alexopoulos *et al.*) (3 periods)
g) Basidiomycetes - *Agaricus*
(Ch 17 Alexopoulos *et al.*) (2 periods)
h) Deuteromycetes - *Candida, Alternaria*
(Ch 8 Alexopoulos *et al.*) (2 periods)

Unit 6 **Lichens** **(Ch 13 Alexopoulos *et al.*, Ch 5 Sumbali) (2 periods)**

Unit 7 **Economic importance of fungi with examples** in Agriculture, Environment, Industry, Medicine, Food, Biodeterioration (of wood, paper, textile, leather), Mycotoxins **(Ch 1 Alexopoulos *et al.*, Ch 5 Sumbali) (6 periods)**

Paper 6-MIHP 203
PHYCOLOGY & MYCOLOGY

PRACTICALS Marks: 50

Section A - Phycology

1. Study of the following genera through temporary and permanent slides: *Volvox, Coleochaete, Vaucheria, Ectocarpus, Polysiphonia and Nostoc*

Section B - Mycology

2. Preparation of Potato Dextrose Medium

3. Study of the vegetative and reproductive structures of following genera through temporary and permanent slides: *Mucor, Saccharomyces, Penicillium, Agaricus* and *Alternaria*

SUGGESTED READINGS

Section A - Phycology

1. Barasanti L and Guaaltieri P. (2006). *Algae: Anatomy Biochemistry and Biotechnology*. Taylor and Francis Group, New York.
2. Graham LE, Graham JM and Wilcox LW. (2009). *Algae*. 2nd edition. Benjamin Cumming, New York.
3. Kumar HD. (1990). *Introductory Phycology*. 2nd edition. Affiliated East Western Press.
4. Kumar HD. (1995). *The Text Book on Algae*. 4th edition. Affiliated East Western Press.
5. Lee RE. (1999). *Phycology*. 4th edition. Cambridge Press.
6. Sharma OP. (2005). *Textbook of Algae*. Tata McGraw Hill Publishing Co. Ltd.
7. Vashishta BR. (2005). *Algae*. 3rd edition. S. Chand and Company Ltd., New Delhi.

Section B - Mycology

1. Alexopoulos CJ, Mims CW and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John Wiley and Sons, Inc.
2. Dube HC. (1981). *An Introduction to Fungi*. Vikas Publishing House Pvt. Ltd.
3. Sumbali G. (2005). *The Fungi*. 1st edition. Narosa Publishing India House.
4. Vashishta BR and Sinha AK. (2008). *Fungi*. S. Chand and Company Ltd.
5. Webster J. (1980). *Introduction to Fungi*. 2nd edition. Cambridge University Press.

Paper 7-CHCT 402

CHEMISTRY-II

THEORY **Marks: 100**

Section A: Basic Organic Chemistry **(30 Periods)**

Unit 1 Fundamentals of Organic Chemistry

Concept of hybridization of carbon. Cleavage of a covalent bond: homolysis and heterolysis.

Electronic effects and their applications (inductive, electromeric, hyperconjugation and resonance). Structure and stability of reactive intermediates (carbocations, carbanions and free radicals). Relative strength of carboxylic acids (aliphatic, aromatic and halo-substituted aliphatic), alcohols, phenols and nitro-phenols. Relative basic strength of amines (aliphatic and aromatic) Intermolecular and intramolecular forces: types of intermolecular forces and their characteristics (ion-dipole, dipole-dipole, dipole-induced dipole and dispersion forces). Intermolecular and intramolecular hydrogen bonding. Effect of intermolecular and intramolecular forces on properties such as solubility, vapour pressure, melting and boiling points of organic compounds.

Unit 2 Stereochemistry

Conformations w.r.t. ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newman, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Section B: Chemistry of Biomolecules **(30 Periods)**

Unit 3 Carbohydrates

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellobiose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Unit 4 Amino Acids, Peptides and Proteins

Preparation of Amino Acids: Strecker synthesis, using Gabriel's phthalimide

synthesis. Zwitter ion, Isoelectric point and Electrophoresis. *Reactions of Amino acids*: ester of –COOH group, acetylation of $–NH_2$ group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Paper 7-CHCP 402
CHEMISTRY-II

PRACTICALS Marks: 50

Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing up to two extra elements).
2. Systematic **Qualitative Organic Analysis** of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, 1^o amines) and preparation of one derivative.

SUGGESTED READINGS

1. T. W. Graham Solomons. *Organic Chemistry,* John Wiley and Sons.
2. Bahl A and Bahl BS. *Advanced Organic* Chemistry. S. Chand.
3. Eliel EL. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill.
4. Finar L. *Organic Chemistry* (Vol. I & II), E. L. B. S.
5. Morrison RT and Boyd RN. *Organic Chemistry*, Prentice Hall.
6. Vogel A.I. *Textbook of Practical Organic Chemistry*. 5^{th} edition. Prentice Hall.
7. Mann FG and Saunders BC. (1960). *Practical Organic Chemistry*. Orient Longman.

Paper 8-MACT 303

MATHEMATICS AND STATISTICS

THEORY Marks: 100

Unit 1 **(24 Periods)**

Sets. Functions and their graphs : polynomial, sine, cosine, exponential and logarithmic functions. Motivation and illustration for these functions through projectile motion, simple pendulum, biological rhythms, cell division, muscular fibres etc. Simple observations about these functions like increasing, decreasing and, periodicity. Sequences to be introduced through the examples arising in Science beginning with finite sequences, followed by concepts of recursion and difference equations. For instance, the Fibonacci sequence arising from branching habit of trees and breeding habit of rabbits. Intuitive idea of algebraic relationships and convergence. Infinite Geometric Series. Series formulas for e^x, log (1+x), sin x, cos x. Step function. Intuitive idea of discontinuity, continuity and limits. Differentiation. Conception to be motivated through simple concrete examples as given above from Biological and Physical Sciences. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions. Integration as reverse process of differentiation. Integrals of the functions introduced above.

Unit 2 **(14 Periods)**

Points in plane and space and coordinate form. Examples of matrices inducing Dilation, Rotation, Reflection and System of linear equations. Examples of matrices arising in Physical, Biological Sciences and Biological networks. Sum and Produce of matrices upto order 3.

Unit 3 **(20 Periods)**

Measures of central tendency. Measures of dispersion; skewness, kurtosis. Elementary Probability and basic laws. Discrete and Continuous Random variable, Mathematical Expectation, Mean and Variance of Binomial, Poisson and Normal distribution. Sample mean and Sampling variance. Hypothesis testing using standard normal variate. Curve Fitting. Correlation and Regression. Emphasis on examples from Biological Sciences.

SUGGESTED READINGS

1. H. S. Bear: *Understanding Calculus*, John Wiley and Sons (Second Edition); 2003.
2. E. Batschelet : *Introduction to Mathematics for Life Scientists,*Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)
3. A. Edmondson and D. Druce : *Advanced Biology Statistics*, Oxford University Press; 1996.
4. W. Danial : Biostatistics : *A foundation for Analysis in Health Sciences*, John Wiley and Sons Inc; 2004.
Note: It is desirable that softwares should be used for demonstrating visual, graphical and application oriented approaches.

Paper 9-MIHT 304

VIROLOGY

THEORY **Marks: 100**

Unit 1 **Introduction** **(Ch 1 Flint, Ch 1 Wagner and Hewlett) (6 periods)**
Discovery of viruses, nature and definition of viruses, general properties of viruses. Concept of viroids, virusoids, satellite viruses and prions. Theories of viral origin

Unit 2 **Structure of viruses**
(Ch 3 Carter and Saunders, Ch 3 Dimmock *et al*., Ch 4 Flint) (3 periods)
Capsid symmetry, enveloped and non-enveloped viruses

Unit 3 **Isolation, purification and cultivation of viruses (Ch 11 Wagner and Hewlett) (2 periods)**

Unit 4 **Viral Taxonomy**
(Ch 3, 10 Carter and Saunders, Appendices Dimmock *et al*.) (6 periods)
Classification and nomenclature of different groups of viruses infecting microbes, plants and animals

Unit 5 **Salient features of viral genomes** **(5 periods)**
(Ch 4, Dimmock and Primrose, Appendix Flint)
Unusual bases (TMV, T4 phage), overlapping genes (ΦX174, Hepatitis B virus), alternate splicing (Picornavirus), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), ambisense genomes (arenavirus), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (influenza virus) and non segmented genomes (picornavirus), capping and tailing (TMV).

Unit 6 **Bacteriophages** **(6 periods)**
(Ch 5, 9, 15 Dimmock *et al*, Ch 19 Carter and Saunders)
Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda and P1 phage), concept of early and late proteins, regulation of transcription in lambda phage and applications of bacteriophages.

Unit 7 **Viral multiplication and replication strategies** **(8 periods)**
(Ch 5,6, 7, 8, 9, 10 Dimmock *et al*)
Interaction of viruses with cellular receptors and entry of viruses.
Replication strategies of viruses as per Baltimore classification.
Assembly, maturation and release of virions.
Concept of defective particles

Unit 8 **Transmission of viruses** **(Ch 4 Carter and Saunders, Ch 11 Mathews) (2 periods)**
Persistent and non-persistent mode

Unit 9 **Oncogenic viruses** **(Ch 20 Dimmock *et al*., Ch 18 Flint) (3 periods)**
Types of oncogenic DNA and RNA viruses. Concepts of oncogenes, proto-

oncogenes and tumor suppressor genes

Unit 10 Prevention and control of viral diseases

(Ch 21 Dimmock *et al*, Ch 19 Flint) (5 periods)

Antiviral compounds, interferons and viral vaccines.

Unit 11 Applications of Virology

(Ch 23 Dimmock *et al*, Ch 22 Wagner) (1 period)

Use of viral vectors in cloning and expression, Gene therapy and Phage display

Paper 9-MIHP 304
VIROLOGY

PRACTICALS Marks: 50

1. To study structure of important animal viruses (rhabdo, influenza, paramyxo, Hepatitis B & retroviruses) using electron micrographs
2. To study structure of important plant viruses (caulimo, gemini, tobacco ring spot, cucumber mosaic & alpha-alpha mosaic viruses) using electron micrographs
3. To study structure of important bacterial viruses (λ, T4 & ϕX174) using electron micrographs
4. Isolation and enumeration of bacteriophages from water/sewage sample using double agar layer technique
5. Isolation and propagation of animal viruses by cell culture and chick embryo techniques
6. Study of cytopathic effects using photographs
7. To perform local lesion technique for assaying plant viruses

SUGGESTED READINGS

1. Dimmock NJ, and Primrose SB. (1994). *Introduction to Modern Virology*. 4th edition. Blackwell Science Ltd.
2. Dimmock, NJ, Easton, AL, Leppard, KN (2007). *Introduction to Modern Virology*. 6th edition (First Indian reprint 2007), Blackwell Publishing Ltd.
3. Carter J and Saunders V (2007). *Virology: Principles and Applications*. John Wiley and Sons.
4. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). *Principles of Virology, Molecular biology, Pathogenesis and Control*. 2nd edition. ASM press Washington DC.
5. Levy JA, Conrat HF, Owens RA. (2000). *Virology*. 3rd edition. Prentice Hall publication, New Jersey.
6. Wagner EK, Hewlett MJ. (2004). *Basic Virology*. 2nd edition. Blackwell Publishing.
7. Mathews. (2004). *Plant Virology*. Hull R. Academic Press, New York.
8. Nayudu MV. (2008). *Plant Viruses*. Tata McGraw Hill, India.

9. Bos L. 1999 Plant viruses-A text book of plant virology by. Backhuys Publishers.
10. Versteeg J. (1985). *A Color Atlas of Virology*. Wolfe Medical Publication.

Paper 10-MIHT 305

MICROBIAL PHYSIOLOGY AND METABOLISM-I

THEORY **Marks: 100**

Unit 1 **Nutritional classification of microorganisms** based on carbon, energy and electron sources **(Ch 1 Gottschalk, Ch 5 Willey *et al.*) (1 Period)**

Unit 2 **Metabolite Transport** **(Ch 5 Gottschalk, Ch 9 Moat *et al.*) (6 Periods)**
Diffusion: Passive and facilitated, Primary active and secondary active transport, Group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electro neutral transport, transport of Iron.

Unit 3 **Microbial Growth**
(Ch 7 Stanier *et al.*, Ch 6 Willey *et al.*) (12 Periods)
Definition of growth, balanced and unbalanced growth, growth curve, the mathematics of growth-generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxie growth curve.

Unit 4 **Measurement of microbial growth** **(Ch 7 Willey *et al.*) (2 periods)**
Measurement of cell numbers, cell mass and metabolic activity

Unit 5 **Effect of the environment on microbial growth**
(Ch 18 Moat & Foster, Ch 8 Stanier *et al.*, Ch 6 Willey *et al.*) (8 Periods)
Temperature- temperature ranges for microbial growth, classification based on temperature ranges and adaptations, pH-classification based on pH ranges and adaptations, solutes and water activity, oxygen concentration, radiation and pressure.

Unit 6 **Chemolithotrophic metabolism** **(Ch 8 & 9 Gottschalk, Ch 12, 17 Madigan *et al.*) (5 Periods)**
Physiological groups of aerobic and anaerobic chemolithotrophs. Hydrogen-oxidizing bacteria and methanogens.

Unit 7 **Phototrophic metabolism** **(Ch 9 Gottschalk) (12 periods)**
Historical account of photosynthesis, diversity of phototrophic bacteria, anoxygenic and oxygenic photosynthesis, photosynthetic pigments: action and absorption spectrum, type, structure and location, physiology of bacterial photosynthesis: light reactions, cyclic and non-cyclic photophosphorylation.

Unit 8 **Carbon dioxide fixation** **(Ch 9 Gottschalk) (2 periods)**
Calvin cycle and reductive TCA cycle.

Paper 10-MIHP 305

MICROBIAL PHYSIOLOGY AND METABOLISM-I

PRACTICALS Marks: 50

1. To study and plot the growth curve of *E coli* using turbidometric method and to calculate specific growth rate and generation time.
2. To study and plot the growth curve of *Aspergillus niger* by radial growth measurements.
3. To study the effect of pH on the growth of *E. coli*
4. To study the effect of temperature of *Aspergillus niger* by dry weight method.
5. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

SUGGESTED READINGS

1. Devlin RM. (1975). *Plant Physiology*. 3rd edition, Willard Grant Press.
2. Gottschalk G. (1986). *Bacterial Metabolism*. 2nd edition. Springer Verlag
3. Madigan MT, Martinko JM and Parker J. (2003). *Brock Biology of Microorganisms*. 10th edition. Pearson/ Benjamin Cummings.
4. Moat AG and Foster JW. (2002). *Microbial Physiology*. 4th edition. John Wiley & Sons.
5. Reddy SR and Reddy SM. (2005). *Microbial Physiology*. Scientific Publishers India.
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). *General Microbiology*. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

Paper 11-CBHT 301

CELL BIOLOGY-I

THEORY **Marks: 100**

Unit 1. An Overview of Cells **(Ch 1 Cooper *et al.*/ Ch 1 Karp)**

Overview of prokaryotic and eukaryotic cells, cell size and shape, Phages, Viriods, Mycoplasma and *Escherichia coli*.

Unit 2. Tools and techniques of Cell Biology

(Ch 1 Cooper *et al.*/ Ch 18 Karp/ Ch 3 De Robertis

Microscopic-Principles of Light microscopy; Phase contrast microscopy; Confocal microscopy;Electron microscopy (EM)- scanning EM and scanning transmission EM (STEM); Fluorescence microscopy;

Analytical-Flow cytometry- flurochromes, fluorescent probe and working principle; Spectrophotometry; Mass spectrometry; X-ray diffraction analysis.

Separation-Sub-cellular fractionation- differential and density gradient centrifugation; Chromatography- paper, thin-layer, gel-filtration, ion-exchange, affinity and High-Performance Liquid Chromatography (HPLC).

Unit 3. Composition of Cells **(Ch 2 Cooper *et al.*)**

Molecules of cell, cell membranes and cell Proteins.

Unit 4. The Nucleus **(Ch 9 Cooper *et al.*)**

Nuclear Envelope- structure of nuclear pore complex, nuclear lamina, Transport across Nuclear Envelope, Chromatin: molecular organization, Nucleolus and rRNA Processing.

Unit 5. Protein Sorting and Transport **(Ch 10 Cooper *et al.*)**

The Endoplasmic reticulum, The Golgi Apparatus, Mechanism of Vesicular Transport, Lysosomes.

Unit 6. Mitochondria, Chloroplasts and Peroxisomes **(Ch 11 Cooper *et al.*)**

Structural organization, Function, Marker enzymes,Mitochondrial biogenesis, Protein import in mitochondria, Semiautonomous nature of mitochondria and chloroplast, chloroplast DNA, Peroxisomes'assembly

Unit 7. Cytoskeleton and Cell Movement **(Ch 12 Cooper *et al.*)**

Structure and organization of actin filaments; actin, myosin and cell movement; intermediate filaments; microtubules.

Paper 11-CBHP 301
CELL BIOLOGY-I

PRACTICALS Marks: 50

1. Separation of nucleic acid bases by paper chromatography.
2. Microscopy- Theoretical knowledge of Light and Electron microscope.
3. Study of the following techniques through electron / photo micrographs: Fluorescence microscopy, autoradiography, positive staining, negative staining, freeze fracture, freeze etching, shadow casting.
4. Study of structure of cell organelles through electron micrographs.

Permanent slide preparation:

5. Cytochemical staining of DNA-Feulgen.
6. Cytochemical staining of DNA and RNA- Methyl Green Pyronin (MGP).
7. Cytochemical staining of Polysaccharides-Periodic Acid Schiff's (PAS).
8. Cytochemical staining of Total proteins- Bromophenol blue.
9. Cytochemical staining of Histones -Fast Green.

SUGGESTED READINGS

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. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V 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. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Paper 12-MBHT 301
MOLECULAR BIOLOGY-I

THEORY **Marks: 100**

Unit 1. Nucleic Acids convey Genetic Information (Ch 2 Watson)

DNA as the carrier of genetic information, Key experiments establishing-The Central Dogma, DNA Double helix, Genetic code, Direction of Protein Synthesis, Genomics.

Unit 2. The Structures of DNA and RNA / Genetic Material
(Ch 6 Watson/ Ch 18 Becker)

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves.

DNA topology - linking number, topoisomerases; Organization of DNA- Prokaryotes, Viruses, Eukaryotes.

RNA Structure

Organelle DNA -- mitochondria and chloroplast DNA.

Unit 3. Genome Structure, Chromatin and the Nucleosome
(Ch 7 Watson/ Ch 18 Becker)

Genome Sequence and Chromosome Diversity, Chromosome Duplication and Segregation, The Nucleosome

Chromatin structure- Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin.

Regulation of Chromatin Structure and Nucleosome Assembly.

Organization of Chromosomes

Unit 4. The Replication of DNA (Prokaryotes and Eukaryotes)
(Ch 8 Watson/ Ch 19 Becker)

Chemistry of DNA synthesis, general principles - bidirectional replication, Semi-conservative, Semi discontinuous,RNA priming, Various models of DNA replication including rolling circle, D-loop (mitochondrial), Θ (theta) mode of replication, replication of linear ds-DNA, replicating the 5'end of linear chromosome. Enzyme involved in DNA replication – DNA polymerases, DNA ligase, Primase, Telomerase and other accessory proteins

Unit 5. The Mutability and Repair of DNA (Ch 9 Watson)

Replication Errors, DNA Damage and their repair.

Paper 12-MBHP 301
MOLECULAR BIOLOGY-I

PRACTICALS Marks: 50

1. Preparation of Polytene chromosome from *Chironomous* larva/*Drosophila* larva
2. Demonstration of mammalian sex chromatin.
3. Preparations of temporary mount and study the different stages of Mitosis (Onion root tip).
4. Perform Southern Blot Hybridization (Restrict DNA for Southern Blot electrophoresis, perform electrophoresis of restricted DNA, perform southern transfer, hybridization and detection of gene of interest)
5. Demonstration of Northern Blotting.
6. Demonstration of Western Blotting.
7. Perform DNA amplification by PCR.
8. Study of semiconservative replication of DNA through micrographs/schematic representations.

SUGGESTED BOOKS

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.

Paper 13-MIHT 406
MICROBIAL PHYSIOLOGY AND METABOLISM-II

THEORY **Marks: 100**

Unit 1 Enzymes and their regulation
(Ch 7 Conn & Stumpf, Ch 7 Gottschalk, Ch 8-9 Lehninger, Ch 8-9, 16 Stryer) (9 periods)

Importance, structure and classification of enzymes. Apoenzyme and cofactors. Prosthetic group, coenzyme and metal cofactors. Active site and its salient features.

Mechanism of enzyme action. Activation energy, Lock and key hypothesis, induced fit.

Enzyme kinetics and inhibition. Substrate saturation curve, Michaelis-Menten kinetics, Lineweaver-Burke plot. Effect of pH and temperature on enzyme activity. Enzyme unit, specific activity, turnover number. Irreversible and reversible inhibition: competitive and non-competitive inhibition.

Enzyme regulation. Synthesis: introduction of enzyme induction and repression.

Activity: allostery, covalent modification and feedback inhibition.

Multienzyme: pyruvate. dehydrogenase complex, isozymes: lactate dehydrogenase.

Unit 2 Microbial Energetics
(Ch 5 Atlas, Ch 2, 4, 5, 8 Gottschalk, Ch 16, 17, 19 Lehninger) (26 periods)

Concept of aerobic respiration, anaerobic respiration and fermentation.

Central metabolic pathways: EMP pathway, ED pathway, PP pathway, and TCA cycle. Anaplerotic reactions, gluconeogenesis, glyoxylate cycle.

Mitochondrial and bacterial electron transport. Oxidation-reduction potential and energetic of electron transport. Components of respiratory chain, and their inhibitors. Anaerobic respiration, denitrification, nitrate/nitrite respiration. Oxidative phosphorylation: ATP synthesis and ATP synthase. Uncouplers, inhibitors and ionophores. Chemical coupling, conformational coupling and chemiosmotic hypotheses.

Fermentations: alcohol fermentation, Pasteur effect, lactate and butyrate fermentation, Fermentation balances, branched *versus* linear fermentation pathways.

Unit 3 Nitrogen Fixation **(Ch 10 Gottschalk) (10 periods)**

Physiology of nitrogen cycle. Assimilatory and dissimilatory nitrate reduction, biological nitrogen fixation. Nitrogen fixers and mechanism of nitrogen fixation, properties of nitrogenase, and ammonia assimilation. Genetics of nitrogen fixation and regulation of nitrogenase activity and synthesis. Alternate nitrogenase

Paper 13-MIHP 406
MICROBIAL PHYSIOLOGY AND METABOLISM-II

PRACTICALS Marks: 50

1. Demonstration of activity of enzyme catalase and study of effect of temperature, pH and heavy metals on enzyme activity.
2. Demonstration of activity of enzyme urease and study of effect of temperature, pH and heavy metals on enzyme activity.
3. Demonstration of alcoholic fermentation.
4. Effect of different nitrogen sources on growth of *E. coli*.
5. Effect of different carbon sources on growth of *E. coli*.

SUGGESTED READINGS

1. Atlas RM. (1989). *Microbiology: Fundamentals and Applications*. 2nd Edition, MacMillan Publishing Company, New York.
2. Conn EE and Stumpf PK. (1976). *Outlines of Biochemistry*. John Wiley & Sons.
3. Gallon JR and Chaplin AE. (1987). *An Introduction to Nitrogen Fixation*. Cassell Education Ltd.
4. Gottschalk G. (1986). *Bacterial Metabolism*. 2nd edition. Springer Verlag.
5. Lehninger A. (1982). *Biochemistry*. Worth Publ.
6. Moat AG and Foster JW. (2002). *Microbial Physiology*. John Wiley and Sons.
7. Stanier RY, Ingrahm, JI, Wheelis, M L and Painter PR. (1987). *General Microbiology*. 5th edition. McMillan Press.
8. Stryer L. (1988). *Biochemistry*. Freeman & Co. NewYork

Paper 14-MIHT 407
MICROBIAL ECOLOGY

THEORY **Marks: 100**

Unit 1 History, significance and developments in the field of microbial ecology (Ch 1 Atlas and Bartha) (2 periods)

Contributions of Beijerinck, Winogradsky, Kluyver, Van Niel, Martin Alexander, Selman A. Waksman

Unit 2 Microorganisms & their natural habitats (Ch 9 Atlas and Bartha)

A. *Terrestrial Environment*: Soil characteristics, Soil profile, Soil formation, Soil as a natural habitat of microbes, Soil microflora **(3 periods)**

B. *Aquatic Environment*: Stratification & Microflora of Freshwater & Marine habitats **(3 periods)**

C. *Atmosphere*: Stratification of the Atmosphere, Aeromicroflora, Dispersal of Microbes **(2 periods)**

D. *Animal Environment*: Microbes in/on human body (Microbiomics) & animal (ruminants) body. **(3 periods)**

E. *Extreme Habitats*: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels. **(4 periods)**

Unit 3 Succession of microbial communities in the decomposition of plant organic matter (Ch 6 Atlas and Bartha) (2 periods)

Unit 4 Biological Interactions (Ch 3-5 Atlas and Bartha)

A. *Microbe–Microbe Interactions* **(3 periods)**
Mutualism, Synergism, Commensalism, Competition, Amensalism, Parasitism, Predation, Biocontrol agents

B. *Microbe–Plant Interactions* **(3 periods)**
Roots, Aerial Plant surfaces, Biological Nitrogen fixation (symbiotic/non-symbiotic - biofertilizers)

C. *Microbe–Animal Interactions* **(2 periods)**
Role of Microbes in Ruminants, Nematophagus fungi, Luminescent bacteria as symbiont

Unit 5 Biogeochemical cycles an introduction (Ch 10, 11 Atlas and Bartha)

Carbon cycle: **(3 periods)**
Microbial degradation of polysaccharide (cellulose, hemicellulose, lignin, chitin)

Nitrogen cycle: **(3 periods)**
Ammonification, nitrification, denitrification & nitrate reduction. Nitrate pollution.

Phosphorous cycle: **(1 period)**

Phosphate immobilization and phosphate solubilization

Sulphur Cycle: **(1 period)**

Microbes involved in sulphur cycle

Unit 6 Solid Waste Management (Ch 12 Atlas and Bartha) (3 periods)

Sources and types of solid waste, methods of disposal of solid waste (incineration, composting, sanitary landfill)

Unit 7 Liquid Waste Management (Ch 12 Atlas and Bartha) (7 periods)

Composition of sewage; strength of sewage (BOD and COD); Primary, secondary (aerobic – oxidation pond, trickling filter, rotating biological contractor/biodisc system, activated sludge process and anaerobic – septic tank, imhoff tank, anaerobic digestor) and tertiary sewage treatment

Unit 8 Bioleaching (Ch 17 Atlas) (1 period)

Unit 9 Biodeterioration (Ch 17 Atlas) (2 periods)

Microbial deterioration of metals (corrosion), textile and paper

Paper 14-MIHP 407
MICROBIAL ECOLOGY

PRACTICALS Marks: 50

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC)
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Detection (qualitative) of the presence of enzymes (dehydrogenase, amylase, urease) in soil.
5. Isolation of *Rhizobium* from root nodules of legumes
6. Isolation of *Azotobacter/Azospirillum* from soil
7. Isolation of phosphate solubilizers from soil

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). *Microbial Ecology: Fundamentals & Applications*. 4th edition. Benjamin/Cummings Science Publishing, USA.
2. Atlas RM. (1989). *Microbiology: Fundamentals and Applications*. 2nd Edition, MacMillan Publishing Company, New York.
3. Madigan MT, Martinko JM and Parker J. (2009). *Brock Biology of Microorganisms*. 12th edition. Pearson/ Benjamin Cummings.
4. Campbell RE. (1983). *Microbial Ecology*. Blackwell Scientific Publication, Oxford, England.
5. Coyne MS. (2001). *Soil Microbiology: An Exploratory Approach*. Delmar Thomson Learning.
6. Lynch JM & Hobbie JE. (1988). *Microorganisms in Action: Concepts & Application in Microbial Ecology*. Blackwell Scientific Publication, U.K.
7. Maier RM, Pepper IL and Gerba CP. (2009). *Environmental Microbiology*. 2nd edition, Academic Press.
8. Martin A. (1977). *An Introduction to Soil Microbiology*. 2nd edition. John Wiley & Sons Inc. New York & London.
9. Stolp H. (1988). *Microbial Ecology: Organisms Habitats Activities*. Cambridge University Press, Cambridge, England.
10. Subba Rao NS. (1999). *Soil Microbiology*. 4th edition. Oxford & IBH Publishing Co. New Delhi.

Paper 15-CBHT 402
CELL BIOLOGY-II

THEORY **Marks: 100**

Unit 1. The Plasma Membrane **(Ch 13 Cooper *et al.*)**

Structure; Transport of small molecules, Endocytosis

Unit 2. Cell Wall, the Extracellular Matrix and Cell Interactions

(Ch 14 Cooper *et al.*)

Bacterial and Eukaryotic Cell Wall; the extracellular matrix and cell matrix interactions; cell-cell interactions.

Unit 3. Cell Signaling **(Ch 15 Cooper *et al.*)**

Signaling molecules and their receptor; functions of cell surface receptors; Intracellular signal transduction pathway; signaling networks.

Unit 4. The Cell Cycle **(Ch 16 Cooper *et al.*)**

Eukaryotic Cell Cycle, Regulation of Cell cycle progression, Events of Mitotic Phase, Meiosis and Fertilization.

Unit 5. Cell Death and Cell Renewal **(Ch 17 Cooper *et al.*)**

Programmed Cell Death, Stem Cells and Maintenance of adult tissues, Embryonic Stem Cells and Therapeutic cloning.

Unit 6. Cancer **(Ch 18 Cooper *et al.*)**

Development and Causes of Cancer, Tumor Viruses, Oncogenes, Tumor Suppressor genes, Cancer Treatment- molecular approach.

Paper 15-CBHP 402
CELL BIOLOGY-II

PRACTICALS Marks: 50

1. To demonstrate the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
2. Study of polyploidy in Onion root tip by colchicine treatment.
3. Preparations of temporary mount of Grasshopper testis / onion flower bud anthers and study the different stages of Meiosis.
4. Study of mitosis and meiosis from permanent slides.
5. Identification and study of cancer cells- Slides/Photomicrographs.

SUGGESTED READINGS

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. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. V 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. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Paper 16-MBHT 402
MOLECULAR BIOLOGY-II

THEORY **Marks: 100**

Unit 1. Mechanism of Transcription **(Ch 12 Watson/ Ch 21 Becker)**

RNA Polymerase and the transcription unit
Transcription in Prokaryotes
Transcription in Eukaryotes

Unit 2. RNA Modifications **(Ch 13 Watson)**

Split genes, concept of introns and exons, removal of Introns, spliceosome machinery, splicing pathways, alternative splicing, exon shuffling, RNA editing, and mRNA transport.

Unit 3. Translation (Prokaryotes and Eukaryotes)
(Ch 14 Watson/ Ch 22 Becker/ Ch 21 DeRobertis)

Assembly line of polypeptide synthesis - ribosome structure and assembly, various steps in protein synthesis. Charging of tRNA, aminoacyl tRNA synthetases. Proteins involved in initiation, elongation and termination of polypeptides. Fidelity of translation. Inhibitors of protein synthesis.
Regulation of translation
Translation-dependent regulation of mRNA and Protein Stability.

Unit 4. Transcription Regulation in Prokaryotes **(Ch 16 Watson)**

Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons

Unit 5. Transcription Regulation in Eukaryotes **(Ch 17 Watson)**

Conserved mechanism of regulation, Eukaryotic activators, Signal integration, combinatorial control, transcriptional repressors, signal transduction and control of transcriptional regulator, Gene Silencing

Unit 6. Regulatory RNAs **(Ch 18 Watson)**

Riboswitches, RNA interference, miRNA, siRNA, Regulatory RNA and X-inactivation

Paper 16-MBHP 402
MOLECULAR BIOLOGY-II

PRACTICALS **Marks: 50**

1. Preparation of culture medium (LB) for *E.coli (both solid and liquid)* and raise culture of *E.coli*.
2. Demonstration of antibiotic resistance. (Culture of *E.coli* containing plasmid (pUC 18/19) in LB medium with/without antibiotic pressure and interpretation of results).
3. Isolation and quantitative estimation of salmon sperm / calf thymus DNA using colorimeter (Diphenylamine reagent) or spectrophotometer (A260 measurement).
4. To perform Ames test in *Salmonella / E.coli* to study mutagenicity.

SUGGESTED READINGS

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.

Paper 17-MIHT 508

PLANT PATHOLOGY

THEORY **Marks: 100**

Unit 1 Introduction and History of plant pathology (Ch 1 Agrios) (4 periods)

Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases.

Significant landmarks in the field of plant pathology- Contributions of Anton De Bary, Millardet, Burrill, E. Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists.

Unit 2 Stages in development of a disease (Ch 2 Agrios) (1 period)

Infection, invasion, colonization, dissemination of pathogens and perennation.

Unit 3 Plant disease epidemiology (Ch 8 Agrios) (3 periods)

Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context.

Unit 4 Host Pathogen Interaction

A. ***Microbial Pathogenicity*** **(Ch 3, 5 Agrios)**

Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development. **(4 periods)**

Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction). **(3 periods)**

B. ***Genetics of Plant Diseases*** **(Ch 4 Agrios) (3 periods)**

Concept of resistance (R) gene and avirulence (avr) gene; gene for gene hypothesis, types of plant resistance: true resistance– horizontal & vertical, apparent resistance.

C. ***Defense Mechanisms in Plants*** **(Ch 6 Agrios) (4 periods)**

Concepts of constitutive defense mechanisms in plants**,** inducible structural defenses (histological-cork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts].

Unit 5 Control of Plant Diseases (Ch 9 Agrios) (7 periods)

Principles & practices involved in the management of plant diseases by different methods, *viz.*

regulatory - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material
cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches

chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals.
biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants
genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes

Unit 6 Specific Plant diseases (Agrios, Singh)

Study of some important plant diseases giving emphasis on its etiological agent, symptoms, epidemiology and control

A. Important diseases caused by fungi **(9 periods)**

- White rust of crucifers - *Albugo candida*
- Downy mildew of onion - *Peronospora destructor*
- Late blight of potato - *Phytophthora infestans*
- Powdery mildew of wheat - *Erysiphe graminis*
- Ergot of rye - *Claviceps purpurea*
- Black stem rust of wheat - *Puccinia graminis tritici*
- Loose smut of wheat - *Ustilago nuda*
- Wilt of tomato - *Fusarium oxysporum* f.sp. *lycopersici*
- Red rot of sugarcane - *Colletotrichum falcatum*
- Early blight of potato - *Alternaria solani*

B. ***Important diseases caused by phytopathogenic bacteria*** **(3 periods)**
Angular leaf spot of cotton, bacterial leaf blight of rice, crown galls, bacterial cankers of citrus

C. ***Important diseases caused by phytoplasmas*** **(1 period)**
Aster yellow, citrus stubborn

D. ***Important diseases caused by viruses*** **(2 periods)**
Papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro

E. ***Important diseases caused by viroids*** **(1 period)**
Potato spindle tuber, coconut cadang cadang

Paper 17-MIHP 508

PLANT PATHOLOGY

PRACTICALS Marks: 50

1. Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens.
2. Study of important diseases of crop plants by cutting sections of infected plant material - *Albugo, Puccinia*, *Ustilago, Fusarium, Colletotrichum.*

SUGGESTED READINGS

1. Agrios GN. (2006). *Plant Pathology*. 5th edition. Academic press, San Diego,
2. Lucas JA. (1998). *Plant Pathology and Plant Pathogens*. 3rd edition. Blackwell Science, Oxford.
3. Mehrotra RS. (1994). *Plant Pathology*. Tata McGraw-Hill Limited.
4. Rangaswami G. (2005). *Diseases of Crop Plants in India*. 4th edition. Prentice Hall of India Pvt. Ltd., New Delhi.
5. Singh RS. (1998). *Plant Diseases Management*. 7th edition. Oxford & IBH, New Delhi.

Paper 18-MIHT 509
IMMUNOLOGY

THEORY **Marks: 100**

Unit 1 Introduction (Ch 1 Goldsby *et al.*) (3 periods)
Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa

Unit 2 Immune Cells and Organs (Ch 2 Goldsby *et al.*) (6 periods)
Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT

Unit 3 Antigens (Ch 4 Goldsby *et al.*) (3 periods)
Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants

Unit 4 Antibodies (Ch 4, 5 Goldsby *et al.*) (6 periods)
Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies

Unit 5 Major Histocompatibility Complex (Ch 8 Goldsby *et al.*) (5 periods)
Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways)

Unit 6 Complement System (Ch 7 Goldsby *et al.*) (3 periods)
Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement activation

Unit 7 Generation of Immune Response (Ch 10-11, 14 Goldsby *et al.*) (7 periods)
Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance

Unit 8 Immunological Disorders and Tumor Immunity

(Ch 15-16, 20, 21 Goldsby *et al.*) (6 periods)

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak-Higashi syndrome, Leukocyte adhesion deficiency, CGD; Characteristics of tumor antigens

Unit 9 Immunological Techniques (Ch 6 Goldsby *et al.*) (6 periods)

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluoresence, Flow cytometry, Immunoelectron microscopy, RIST, RAST, MLR

Paper 18-MIHP 509
IMMUNOLOGY

PRACTICALS Marks: 50

1. Identification of human blood groups.
2. To perform Total Leukocyte Count of the given blood sample.
3. To perform Differential Leukocyte Count of the given blood sample.
4. To separate serum from the blood sample (demonstration).
5. To perform immunodiffusion by Ouchterlony method.
6. To perform DOT ELISA.
7. To perform immunoelectrophoresis.

SUGGESTED READINGS

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

Paper 19-MIHT 510
INDUSTRIAL MICROBIOLOGY

THEORY **Marks: 100**

Unit 1 Introduction to industrial microbiology
(Ch 1 Casida, Ch 1 Stanbury *et al.*) (2 periods)
Brief history and developments in industrial microbiology

Unit 2 Fermentation processes (**Ch 2 Stanbury *et al.*) (4 periods)**
Solid-state and liquid-state (stationary and submerged) fermentations; Batch, fed-batch and continuous fermentations

Unit 3 Bioreactors/fermenters (Ch 3 Casida, Ch 7 Stanbury *et al.*) (7 periods)
Components of a typical bioreactor, types of bioreactors-Laboratory, pilot- scale and production fermenters; constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 4 Measurement and control of fermentation parameters
(Ch 8-9 Stanbury *et al.)* (4 periods)
pH, temperature, dissolved oxygen, foaming and aeration

Unit 5 Isolation of industrially important microbial strains
(Ch 4 Casida, Ch 3 Patel) (4 periods)
Primary and secondary screening, strain development, preservation and maintenance of industrial strains

Unit 6 Media and ingredients for industrial fermentations
(Ch 7 Casida, Ch 4 Stanbury *et al.*) (3 periods)
Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey and yeast extract.

Unit 7 Down-stream Processing (Ch 10 Stanbury *et al.*) (5 periods)
Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying

Unit 8 Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses)
(Ch 8-9, 11-13, 15 Crueger and Crueger; Ch 17-18, 23-25 Casida) (13 periods)
Citric acid, ethanol, penicillin, glutamic acid, riboflavin, enzymes (amylase, cellulase, protease, lipase, glucose isomerase, glucose oxidase), wine, beer, bioinsecticides (Bt) and Steroid transformations

(Ch 11 Crueger and Crueger) (5 periods)

Unit 9 Enzyme immobilization

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**)**

Paper 19-MIHP 510
INDUSTRIAL MICROBIOLOGY

PRACTICALS Marks: 50

1. Microbial fermentations for the production and estimation (qualitative and quantitative) of:

   (a) Enzyme: Amylase
   (b) Amino acid: Glutamic acid
   (c) Organic acid: Citric acid
   (d) Alcohol: Ethanol
   (e) Antibiotic: Penicillin

2. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

SUGGESTED READINGS

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.

Paper 20-GGHT 501
GENETICS AND GENOMICS-I

THEORY **Marks: 100**

Unit 1. Introduction to Genetics **(Ch 1 Klug and Cummings)**

Mendel's work on transmission of traits, Genetic Variation, Molecular basis of Genetic Information.

Unit 2. Mitosis and Meiosis **(Ch 2 Klug and Cummings)**

Interrelation between the cell structure and the genetics function, Mitosis, Meiosis (explaining Mendel's ratios).

Unit 3. Mendelian Genetics and its Extension **(Ch 3-4 Klug and Cummings)**

Principles of Inheritance, Chromosome theory of inheritance, Laws of Probability, Pedigree analysis, Incomplete dominance and codominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Environmental effects on phenotypic expression, sex linked inheritance.

Unit 4. Linkage, Crossing Over and Chromosomal Mapping
(Ch 5 Klug and Cummings, Ch 7, Gardner)

Linkage and crossing over, Cytological basis of crossing over, Molecular mechanism of crossing over, Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and coincidence, Somatic cell genetics – an alternative approach to gene mapping.

Unit 5. Mutations **(Ch 8 Klug and Cummings/ Ch 11 Gardner)**

Chromosomal Mutations: Deletion, Duplication, Inversion, Translocation, Aneuploidy and Polyploidy. Gene mutations: Induced versus Spontaneous mutations, Back versus Suppressor mutations, Molecular basis of Mutations in relation to UV light and chemical mutagens, Detection of mutations: CLB method, Attached X method, DNA repair mechanisms.

Unit 6. Sex Determination **(Ch 7 Klug and Cummings)**

Chromosomal mechanisms, Environmental factors effecting sex determination, Barr bodies, Dosage compensation.

Unit 7. Extrachromosomal Inheritance
(Ch 9 Klug and Cummings/ Ch 20 Gardner)

Chloroplast mutation/Variegation in Four o' clock plant and *Chlymodomonas,* Mitochondrial mutations in *Neurospora* and yeast, Maternal effects, Infective heredity- Kappa particles in *Paramecium.*

Unit 8. Quantitative Genetics (Ch 25 Klug and Cummings/ Ch 21, Gardner)

Quantitative and multifactor inheritance, Transgressive variations, Heterosis.

Paper 20-GGHP 501
GENETICS AND GENOMICS-I

PRACTICALS Marks: 50

1. Mendelian laws and gene interaction using *Drosophila* crosses.
2. Chi-square and probability.
3. Study of Linkage, recombination, gene mapping using marker based data from *Drosophila*.
4. Study of Human and *Phlox/ Allium* Karyotype (normal and abnormal).
5. Pedigree analysis of some human inherited traits.
6. Study of Hardy-Weinberg Law using simulations (seeds).

SUGGESTED READINGS

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2008). VIII ed. Principles of Genetics. Wiley India.
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. XI Edition. Benjamin Cummings.
4. Russell, P. J. (2009). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. 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 & Sons.
7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

ADDITIONAL READINGS

Both students as well as teachers of genetics can further benefit from knowledge of following topics as given below-

- **Epigenetics-** http://www.nature.com/nrg/focus/epigenetics/index.html
- **Tetrad Analysis in fungi**
- **Centromere Mapping**
- **Cytogenetic Mapping**

Paper 21-MIHT 611
MEDICAL MICROBIOLOGY

THEORY **Marks: 100**

Unit 1 **Normal microflora of the human body (Ch 11 Brooks *et al.*) (2 periods)**
Skin, throat, gastrointestinal tract, urogenital tract

Unit 2 **Host-pathogen interaction (Ch 9 Brooks *et al.*) (3 periods)**
Definitions of invasion, pathogen, parasite, pathogenicity, toxigenicity, virulence, carriers and their types, nosocomial infections, opportunistic infections, septicemia, septic shock, transmission and spread of infection

Unit 3 **Sample collection, transport and diagnosis (Ch 47 Brooks *et al.*) (4 periods)**
Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, Complement fixation, PCR, DNA probes).

Unit 4 **Bacterial diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control)**
(Ch 12, 13, 15, 16, 18, 19, 21, 24, 25 Brooks *et al.*) (12 periods)
Bacillus anthracis, Corynebacterium diphtheriae, Streptococcus pyogenes, Escherichia coli, Salmonella typhi and paratyphi, Shigella dysenteriae, Helicobacter pylori, Vibrio cholerae, Haemophilus influenza, Neisseria gonorrhoeae, Mycobacterium tuberculosis, Treponema pallidum

Unit 5 **Viral diseases (with reference to symptoms, pathogenesis, transmission, prophylaxis and control)**
(Ch 33, 35-36, 38-39, 42-44 Brooks *et al.*) (15 periods)
Polio, Chicken pox, Herpes, Hepatitis, Rabies, Influenza with brief description of bird and swine flu, Dengue, AIDS, Viral cancers. An overview of emerging viral diseases: Japanese Encephalitis, Ebola, Marburg, SARS, Hanta, Nipah, Chandipura, Chikungunya.

Unit 6 **Introduction to protozoan diseases (Ch 46 Brooks *et al.*) (3 periods)**
Malaria, Kala-azar, and Toxoplasmosis

Unit 7 **Introduction to fungal diseases (Ch 46 Brooks *et al.*) (3 periods)**
Different types of mycoses with particular reference to Dermatomycoses and Opportunistic mycoses

Unit 8 **Antimicrobial agents and drug resistance (Ch 10 Brooks *et al.*) (4 periods)**
Mechanism of action of important chemotherapeutic agents. Principles of drug resistance in bacteria

Paper 21-MIHP 611
MEDICAL MICROBIOLOGY

PRACTICALS Marks: 50

1. To identify pathogenic bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) based on cultural, morphological and biochemical characteristics
   Cultural characteristics on nutrient agar and in nutrient broth, Gram characteristic, motility, presence of endospore and capsule, IMViC, TSI, sugar fermentation, nitrate reduction, urease production, oxidase and catalase tests.

2. To study composition and use of important differential media for identification of pathogenic bacteria
   EMB agar, McConkey agar, TCBS agar and Salmonella-Shigella agar (any two)

3. To perform antibacterial testing by Kirby-Bauer method

4. To study symptoms of the diseases with the help of photographs
   Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis, kaposi's sarcoma), dermatomycoses (ring worms), kala-azar

SUGGESTED READINGS

1. Ananthanarayan R and Paniker CKJ. (2005). *Textbook of Microbiology*. 7th edition (edited by Paniker CKJ). University Press Publication.
2. Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). *Jawetz, Melnick and Adelberg's Medical Microbiology*. 24th edition. McGraw Hill Publication.
3. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). *Mims' Medical Microbiology*. 4th edition. Elsevier.
4. Joklik WK, Willett HP and Amos DB (1995). *Zinsser Microbiology*. 19th edition. Appleton-Centuary-Crofts publication.
5. Willey JM, Sherwood LM, and Woolverton CJ. (2008). *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

Paper 22-MIHT 612
FOOD AND DAIRY MICROBIOLOGY

THEORY **Marks: 100**

Unit 1 **Foods as a substrate for microorganisms (Ch 3 Jay *et al.*) (6 periods)**
Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general

Unit 2 **Microbial spoilage of various foods**
(Ch 11, 13-14, 16, 18-19 Frazier and Westhoff) (8 periods)
Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned foods

Unit 3 **Principles and methods of food preservation (Ch 13-19 Jay *et al.*) (10 periods)**
Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit 4 **Fermented foods (Ch 7-8 Jay *et al.*) (10 periods)**
Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce and tampeh and probiotics.

Unit 5 **Food borne diseases (causative agents, foods involved, symptoms and preventive measures) (Ch 23–28, 30 Jay *et al.*) (8 periods)**
Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins; Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*, Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and *Campylobacter jejuni*

Unit 6 **Food sanitation and control (Ch 20-21 Jay *et al.*) (3 periods)**
HACCP, Indices of food sanitary quality and sanitizers

Unit 7 **Water Potability (Ch 27 Tortora *et al.*) (5 periods)**
Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

Paper 22-MIHP 612
FOOD AND DAIRY MICROBIOLOGY

PRACTICALS Marks: 50

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any pathogenic bacteria (*Staphylococcus* or *Salmonella*) from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt/Dahi.
7. Determination of potability and faecal contamination of water samples by presumptive test/MPN test, confirmed and completed tests.

SUGGESTED READINGS

1. Adams MR and Moss MO. (1995). *Food Microbiology*. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). *Basic Food Microbiology*. 1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). *Antimicrobials in Foods*. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). *Natural Antimicrobial Systems and Food Preservation*. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). *Food Microbiology*. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). *New Methods of Food Preservation*. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA. (2005). *Modern Food Microbiology*. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). *The Microbiological Safety and Quality of Foods*. Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). *Microbiology: An Introduction*. 9th edition. Pearson Education.

Paper 23-MIHT 613

RECOMBINANT DNA TECHNOLOGY AND BIOTECHNOLOGY

THEORY Marks: 100

Unit 1 Introduction to basic biotechnology (Ch 14 Willey) (2 periods)

Milestones in genetic engineering and biotechnology

Unit 2 Tools of recombinant DNA technology

A. ***Hosts*** **(Ch 1 Clark, Ch 11 Primrose and Twyman) (2 periods)**

E. coli strains; Yeast (*Saccharomyces cerevisiae, Pichia pastoris*); Fungi (*Penicillium*, *Aspergillus*); Mammalian cell lines - names and genotypes

B. ***Enzymes*** **(Ch 4 Brown, Ch 3 Primrose and Twyman) (6 periods)**

Restriction modification systems: Types I, II and III. Mode of action, nomenclature. Application of Type II restriction enzymes in genetic engineering.

DNA modifying enzymes and their applications: Terminal deoxynucleotidyl transferase, kinases and phosphatases, DNA ligases and DNA polymerases, reverse transcriptases, bacteriophage RNA polymerases, exonuclease III, BAL31, mung bean nuclease, S1 nuclease

C. ***Vectors*** **(Ch 2, 7 Brown, Ch 4, 5 Primrose and Twyman) (4 periods)**

Cloning Vectors- Definition and Properties. Plasmid vectors-pBR and pUC series, Bacteriophage lambda and M13 based vectors. Cosmids. Shuttle vectors. BACs, YACs, MACs.

D. ***Mammalian Expression Vectors*** **(Ch 5 Primrose and Twyman) (3 periods)**

SV40, Vaccinia, Retroviral promoter based vectors

Unit 3 Basic DNA Cloning (Ch-5 Brown) (7 periods)

Simple cloning of DNA fragments, Vectors: Definition and properties. *E. coli* expression vectors-lac, tac and T7 promoter based vectors. Yeast expression vectors - pET yeast vectors, YIp, YEp and YCp vectors. Baculovirus based vectors. Ti based vectors (Binary and Cointegrated vectors) and cloning using linkers and adaptors. Transformation of DNA by chemical method and electroporation

Unit 4 Methods of gene delivery in plants and animals

(Ch 14 Primrose and Twyman) (1 period)

Microinjection, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium*-mediated delivery

Unit 5 Methods of DNA, RNA and Protein analysis and DNA typing
(Ch 3, 8 Clark, Ch 2 Primrose and Twyman) (9 periods)

Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot and colony hybridizations. Chromosome walking and jumping. DNA fingerprinting by RFLP and RAPD. Gel retardation assays. DNA footprinting by DNase I, DNA microarray analysis. SDS-PAGE and Western blotting. Phage display

Unit 6 Amplification of nucleic acids
(Ch 9 Brown, Ch 2 Primrose and Twyman) (4 periods)

Polymerase chain reaction - enzymes used, primer design. Cloning PCR products. RT-PCR and principles of real time PCR. Ligation chain reaction

Unit 7 Construction of Genomic and cDNA libraries
(Ch 8 Brown, Ch 6 Primrose and Twyman) (3 periods)

Genomic and cDNA libraries: Preparation and uses. Screening of libraries by colony hybridization and colony PCR

Unit 8 DNA sequencing and synthesis (Ch 10 Brown, Ch 4,8 Clark) (3 periods)

Maxam-Gilbert's and Sanger's method. Automated sequencing. Human genome sequencing project

Unit 9 Product of DNA technology
(Ch 14-15 Brown, Ch 26 Primrose and Twyman) (4 periods)

Human protein replacements-insulin, hGH and Factor VIII. Human therapies - tPA, interferon, antisense molecules. Bt transgenics-rice, cotton, brinjal

Paper 23-MIHP 613

RECOMBINANT DNA TECHNOLOGY AND BIOTECHNOLOGY

PRACTICALS Marks: 50

1. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
2. Ligation of DNA fragments.
3. Demonstration of PCR.
4. Interpretation of sequencing gel electropherograms.

SUGGESTED READINGS

1. Alcamo IE. (2001). *DNA Technology: The Awesome Skill*. 2nd edition. Elsevier Academic Press, USA.
2. Brown TA. (2006). *Gene Cloning and DNA Analysis*. 5th edition. Blackwell Publishing, Oxford, U.K.
3. Clark DP and Pazdernik NJ. (2009). *Biotechnology-Applying the Genetic Revolution*. Elsevier Academic Press, USA.
4. Glick BR and Pasternak JJ. (2003). *Molecular Biotechnology*. 3rd edition. ASM Press Washington D.C.
5. Nigam A and Ayyagari A. (2007). *Lab Manual in Biochemistry, Immunology and Biotechnology*. Tata McGraw Hill, India.
6. Primrose SB and Twyman RM. (2006). *Principles of Gene Manipulation and Genomics*, 7th edition. Blackwell Publishing, Oxford, U.K.
7. Sambrook J, Fritsch EF and Maniatis T. (2001). *Molecular Cloning-A Laboratory Manual*. 3rd edition. Cold Spring Harbor Laboratory Press.
8. Willey JM, Sherwood LM, and Woolverton CJ. (2008) *Prescott, Harley and Klein's Microbiology*. 7th edition. McGraw Hill Higher Education.

Paper 24-GGHT 602
GENETICS AND GENOMICS-II

THEORY **Marks: 100**

Unit 1. Genetic Analysis and Mapping in Bacteria and Bacteriophages
(Ch 6, Klug and Cummings/ Ch 5, Griffith *et al.*)

Conjugation; Transformation; Transduction, Recombination.

Unit 2. Genome Dynamics-Transposable genetic elements, Eukaryotic Viruses
(Ch 22, Klug and Cummings/ Ch 14, Griffith *et al.*)

Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P elements in *Drosophila*; Uses of transposons; Eukaryotic Viruses.

Unit 3. Developmental Genetics and Model System
(Ch 19, Klug and Cummings*)*

Study of model systems in developmental genetics- *Drosophila melanogaster Sachharomyces cerevisiae, Caenorhabditis elegans, Arabidopsis thaliana,* and *Xenopus laevis*.

Unit 4. Genomics, Bioinformatics and Proteomics
(Ch 21, Klug and Cummings/Ch 8-9, Russell/ Ch2, 3, 4 Ghosh, Z. and Mallick,V.)

Genomes of bacteria, *Drosophila* and Humans*;* Human genome project; Evolution and Comparative Genomics.

Introduction to Bioinformatics, Gene and protein databases; Sequence similarity and alignment; Gene feature identification.

Gene Annotation and analysis of transcription and translation; Post-translational analysis- Protein interaction.

Unit 5. Genomic Analysis- Dissection of Gene Function
(Ch 23, Klug and Cummings)

Genetic analysis using mutations, forward genetics, genomics, reverse genetics, RNAi, functional genomics and system biology.

Unit 6. Population Genetics **(Ch 27, Klug and Cummings)**

Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift.

Unit 7. Evolutionary Genetics **(Ch 28, Klug and Cummings)**

Genetic variation and Speciation.

Paper 24-GGHP 602
GENETICS AND GENOMICS-II

PRACTICALS Marks: 50

1. Genomic DNA isolation from *E.coli* (without plasmid*)*.
2. Restriction enzyme digestion of genomic DNA from *E.coli*.
3. Isolation of plasmid DNA and genomic DNA together from *E.coli*. and restriction enzyme digestion.
4. Restriction enzyme digestion (*EcoR*I) of genomic and plasmid DNA (obtained from Expt.3).
5. Estimation of size of a DNA fragment after electrophoresis using DNA markers.
6. Construction of Restriction digestion maps from data provided.
7. Demonstration of DNA fingerprinting.

SUGGESTED READINGS

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). *i*Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. 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 & Sons.
7. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.
8. Ghosh, Z. and Mallick,V. (2008). Bioinformatics-Principles and Applications. Oxford Univ. Press

SEMESTER SYSTEM AT THE UNDERGRADUATE LEVEL

Course of Study **B.Sc (Honours) Microbiology** **Total number of papers: 24**

Semester I

Paper 1
Introduction to Microbial World
MIHT 101

Paper 2
Bacteriology
MIHT 102

Paper 3
Chemistry-I
CHCT 301

Paper4
Technical Writing & Communication in English/Computational Skills
ENAT 101 / CSAT 101

Semester II

Paper 5
Technical writing & Communication in English/Computational Skills
ENAT 201 / CSAT 201

Paper 6
Phycology and Mycology
MIHT 203

Paper 7
Chemistry-II
CHCT 402

Paper 8
Mathematics & Statistics
MACT 303

Semester III

Paper 9
Virology
MIHT 304

Paper 10
Microbial Physiology and Metabolism I
MIHT 305

Paper 11
CELL BIOLOGY I
CBHT 301

Paper 12
MOLECULAR BIOLOGY I
MBHT 301

Semester IV

Paper 13
Microbial Physiology and Metabolism II
MIHT 406

Paper 14
Microbial Ecology
MIHT 407

Paper 15
CELL BIOLOGY II
CBHT 402

Paper 16
MOLECULAR BIOLOGY-II
MBHT 402

Semester V

Paper 17
Plant Pathology
MIHT 508

Paper 18
Immunology
MIHT 509

Paper 19
Industrial Microbiology
MIHT 510

Paper 20
GENETICS & GENOMICS-I
GGHT 501

Semester VI

Paper 21
Medical Microbiology
MIHT 611

Paper 22
Food and Dairy Microbiology
MIHT 612

Paper 23
Recombinant DNA Technology and Biotechnology
MIHT 613

Paper 24
GENETICS & GENOMICS-II
GGHT 602