SEMESTER III

CORE COURSES: Metabolism of Biomolecules

ELECTIVE COURSES: Tools and Techniques in Biochemistry, Enzymology, Fundamentals of Microbiology, Plant Biochemistry

BCH-III.C-5: METABOLISM OF BIOMOLECULES (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Concepts of Metabolism; Carbohydrate metabolism	**1.1: Basic Concepts and Design of Metabolism** Metabolism: Catabolism and Anabolism, ATP as energy source, ATP cycle, ATP as energy currency, energy relationship between catabolic and anabolic pathways, other energy rich molecules **1.2:Carbohydrate Metabolism** Glycolysis, Fate of pyruvate, Fermentation, Tri-Carboxylic Acid cycle, Pentose-Phosphate pathway, Gluconeogenesis, Glycogen synthesis and breakdown, Glyoxylate pathway, Lactose intolerance, Wernicke-Korsakoff Syndrome	**04** **11**	**15**
MODULE 2: Oxidative Phosphorylation and Fatty acid metabolism	**2.1: Oxidative Phosphorylation** The respiratory chain in mitochondria, proton gradient powering ATP synthesis, inhibitors of oxidative phosphorylation: Cyanide, Carbon monoxide, Oligomycin. Transfer of cytosolic reducing equivalents to mitochondria: glycerol-3- phosphate and malate-aspartate shuttle **2.2: Fatty Acid Synthesis and Degradation** Digestion, mobilisation and transport of cholesterol and triacyl glycerols, β-oxidation of fatty acids, ketone bodies, ketoacidosis Biosynthesis of saturated and unsaturated fatty acids, and elongation of fatty acids	**05** **10**	**15**
MODULE 3: Amino acid and Nucleotide metabolism	**3.1: Amino acid Metabolism** Overview of biosynthesis and catabolism of amino acids, Phenylketonuria; regulation of amino acid biosynthesis, Urea cycle, urea cycle disorders	**07**	**15**

	3.2: Nucleotide Metabolism Biosynthesis - de novo and salvage pathways, degradation, ADA deficiency, Lesch-Nyhan syndrome, Gout	**08**	

BCH-III.C-5: METABOLISM OF BIOMOLECULES (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Lactic Acid fermentation	01
2.	Alcohol Fermentation by Yeast	02
3.	Estimation of blood glucose	01
4.	Separation of lipids by TLC	02
5.	Isolation of lecithin from egg yolk	03
6.	Isolation of cholesterol from egg yolk	03
7.	Estimation of protein and nucleic acid by direct spectroscopy	01
8.	Urea estimation	01
9.	Uric acid estimation	01
	Total	**15**

REFERENCES for BCH-III.C-5 (Latest Editions)

Mandatory Reading

- Nelson, D. L. and Cox, M.M. Lehninger's Principles of Biochemistry. Worth Publishers, New York, USA

Supplementary Reading

- Stryer, L., Berg, J., Tymoczko, J. and Gatto, G. Biochemistry. W. H. Freeman and Co., New York, USA.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.
- Jain, J. L., Jain, S. and Jain, N. Fundamentals of Biochemistry. S. Chand and Company, Ltd., New Delhi.
- Plummer, D. T. An Introduction to Practical Biochemistry. Tata McGraw-Hill Publishing Company Limited, New Delhi.
- Harvey, R.A. and Ferrier, D.R. Lippincott's Illustrated Reviews, Biochemistry. Lippincott Williams and Wilkins.

- Voet, D. and Voet, J. G. Biochemistry John Wiley and Sons, Inc, USA.

Web References

- https://www.coursera.org/learn/energy-metabolism
- https://online-learning.harvard.edu/course/principles-biochemistry-1
- https://nptel.ac.in/courses/102/105/102105034/
- https://openstax.org/details/books/biology-2e

BCH-III.E-1: TOOLS AND TECHNIQUES IN BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Chromatography and Centrifugation Techniques	**1.1: Chromatographic techniques** Basic principles of chromatography: Partition coefficient, concept of theoretical plates. Various modes of chromatography, Instrumentation and Applications – Plane chromatography (paper, TLC, 2D), Column chromatography - HPLC, Molecular Sieve Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Gas Chromatography. **1.2: Centrifugation** Basic principle of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, Preparative centrifuge - differential centrifugation, density gradient centrifugation (Rate zonal and Isopycnic), Analytical centrifuge.	**09** **06**	**15**
MODULE 2: Electrophoretic and Spectroscopic Techniques	**2.1: Electrophoretic and Blotting techniques** Basic Principle of electrophoresis, Electrophoresis of protein and nucleic acids - Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native gels, denaturing gels, agarose gel electrophoresis, Northern Blotting, Southern Blotting and Western blotting techniques – principle and applications **2.2: Spectroscopic techniques** Basic principle and working of – UV/VIS light spectroscopy, Fluorescence	**08** **07**	**15**

	spectroscopy, NMR, IR spectroscopy, X-ray diffraction.		
MODULE 3: Microscopy and Radioisotopes	**3.1: Microscopic techniques** Basic components of the microscope. Working and representation and application of – compound microscope, electron microscope, Scanning electron microscope and confocal microscope, Specimen preparation for electron microscope, scanning electron microscope and confocal microscope. **3.2: Radioisotopes** Concept of half-life, decay constant, detection methods - GM counter, solid and liquid scintillation counter, autoradiography; handling and safety of radioisotope, Applications of radioisotopes in biology.	**08** **07**	**15**

BCH-III.E-1: TOOLS AND TECHNIQUES IN BIOCHEMISTRY (PRACTICAL)

SR.NO.	PRACTICAL	NO. OF PRACTICAL
1.	Estimation of proteins by Bradford's method	02
2.	Estimation of carbohydrate by DNSA method	02
3.	Separation and identification of amino acids by paper chromatography	02
4.	Isolation of cell organelle using density gradient centrifugation	02
5.	Demonstration of gel filtration chromatography	02
6.	SDS-PAGE analysis of proteins	03
7.	Lipid isolation by reverse phase chromatography	02
	Total	**15**

REFERENCES:

Mandatory Reading:

- Wilson K and Walker J. 2005. Principles and Techniques of Practical Biochemistry, 6th Edition, Cambridge University Press.

Additional Reading:

- Upadhyay A, Upadhyay K and Nath N. 2009. Biophysical Chemistry: Principles and Techniques, 3rd Edition, Himalaya Publishing, New Delhi.
- Plummer D. 1988. An introduction to Practical Biochemistry, Tata McGraw Hill Publishing Company, New Delhi.
- Jayraman J. 2011. Laboratory Manual in Biochemistry. New Age International Pvt Ltd Publishers, New Delhi.
- Sadasivam S. and Manickam A. 2007. Biochemical Methods, 3rd edition, New Age International Publishers, New Delhi.

Web-links:

- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-reproductive-system/a/hs-the-reproductive-system-review
- https://www.khanacademy.org/science/high-school-biology/hs-cells/hs-introduction-to-cells/a/microscopy
- https://www.khanacademy.org/test-prep/mcat/physical-processes/atomic-nucleus/a/decay-graphs-and-half-lives-article
- https://www.khanacademy.org/science/organic-chemistry/spectroscopy-jay/uv-vis-spectroscopy/v/uv-vis-spectroscopy

BCH-III.E-2: ENZYMOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to enzymes and Features of enzyme catalysis	**1.1: Introduction to enzymes (8 L)** Nature of enzymes - protein and non-protein (ribozyme); co-enzymes, cofactor & prosthetic group; apoenzyme; holoenzyme; ribozymes & isoenzymes; multienzyme complex, specificity of enzymes; classification of enzymes. **1.2: Features of enzyme catalysis** Fischer's lock and key hypothesis; Koshland's induced fit hypothesis; factors affecting the rate of reactions (time, enzyme concentration, substrate concentration, pH and temperature)	**08** **07**	**15**
MODULE 2: Enzyme Kinetics and Inhibition	**2.1: Enzyme kinetics** Principles of reaction rates; order of reactions and equilibrium constants; derivation of Michaelis-Menten equation and Lineweaver- Burk plot; significance of K_m and V_{max}, K_{cat} and turnover number **2.2: Enzyme inhibition**	**08**	**15**

	Reversible inhibition (competitive, uncompetitive, non-competitive, mixed and suicide, end product); mechanism-based inhibitors - antibiotics as inhibitors; types of irreversible inhibition; allosteric inhibition	**07**	
MODULE 3: Mechanism of enzymes, Purification & applications of enzymes	**3.1: Mechanisms of enzyme action and regulation** Mechanism of action of chymotrypsin; regulation of enzyme activity and its importance - aspartate transcarbamoylase **3.2: Enzyme purification** Purification of enzymes: salt precipitation; dialysis; molecular exclusion chromatography; PAGE; Molecular weight determination by SDS-PAGE **3.3: Applications of enzymes** Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases); enzyme immunoassay (HRPO); applications of enzymes in industry – detergents, leather, food	**04** **06** **05**	**15**

BCH-III.E-2: ENZYMOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Preparation of buffers and solutions for the study of enzyme activity	01
2.	Effect of pH on enzyme activity	02
3.	Effect of temperature on enzyme activity	02
4.	Effect of substrate concentration and determination of K_m and V_{max}	02
5.	Partial purification of an enzyme from a suitable source, ammonium sulphate precipitation, dialysis	03
6.	Assay of enzyme activity and specific activity	01
7.	Native-PAGE	03
8.	Zymogram	01
	Total	**15**

REFERENCES for BCH-III.E-2 (Latest Editions)

Mandatory Reading

- Malcolm, D. and Edwin C. Webb. Enzymes. Academic Press Inc., Publishers, New York

Supplementary Reading

- Nelson, D. L. and Cox, M. M. Lehninger's Principles of Biochemistry. Worth Publishers, New York, USA.
- Stryer, L., Berg, J., Tymoczko, J. and Gatto, G. Biochemistry. W. H. Freeman and Co., New York, USA.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.
- Jain, J. L., Jain, S. and Jain, N. Fundamentals of Biochemistry. S. Chand and Company, Ltd., New Delhi.
- Harvey, R.A. and Ferrier, D.R. Lippincott's Illustrated Reviews, Biochemistry. Lippincott Williams and Wilkins.
- Voet, D. and Voet, J. G. Biochemistry. John Wiley & Sons, Inc, USA.

Web References

- https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-structure-and-function/a/enzyme-structure-and-function
- https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-kinetics/v/an-introduction-to-enzyme-kinetics
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5956270/
- http://web.sungshin.ac.kr/~spark/class/enzchem/EnzChem_ch02.pdf
- https://www.chem.wisc.edu/deptfiles/genchem/netorial/modules/biomolecules/modules/enzymes/enzyme3.htm
- https://www.creative-enzymes.com/resource/enzyme-definition-and-classification_18.html
- https://www.youtube.com/watch?v=OY1WsqlcUdo
- https://www.youtube.com/watch?v=Z2ZN_9nFl1E

BCH-III.E-3: FUNDAMENTALS OF MICROBIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: History & Development of Microbiology; Ultrastructure of a bacterial cell, growth curve – types, characteristics	**1.1 : History and Scope of Microbiology** Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Paul Ehrlich, Elie Metchnikoff, Edward Jenner in the fields of microbiology and immunology. Basics of Binomial Nomenclature; Classification systems of Whittaker (five Kingdom) and Carl Woese (three Domain).	**05**	**15**

	Tree of Life. **1.2: Basics of Microscopy** Principle, design and working of light microscope (Bright-field, Dark-field, Phase-contrast, Fluorescence). Preparation of samples. **1.3: Bacterial cell organization, reproduction and growth curve** Bacterial cell: Organization and ultrastructure; Gram characteristics. Reproduction in bacteria - Binary fission Bacterial growth curve- characteristics of growth phases; diauxic growth curve	**03** **07**	
MODULE 2: Methods of cultivating and preserving bacteria	**2.1: Cultivation of microorganisms** Sterilization: Principle and methods. Types of culture media: Synthetic/defined, complex, solid, liquid, enrichment, selective, differential. Cultivation of microorganisms: Aerobic and anaerobic, Broth cultures, agar plate, pour plate. Determination of viable count: MPN, Serial dilution, spread plating, pour plating, determination of colony forming units (cfu) and calculation of viable count. Isolation of pure cultures: Streak plate; colony characteristics **2.2: Maintenance and preservation of microbial cultures** Slant and stab cultures, periodic transfer, storage in sterile soil, overlaying with mineral oil, glycerol stocks, preservation in liquid nitrogen, lyophilisation	**10** **05**	**15**

MODULE 3: **Fungi and Viruses**	**3.1: Fungi** General characteristics of fungi: habitat, nutritional requirements, cell ultra-structure, thallus organization, cell wall structure. Reproduction: sexual and asexual reproduction. Mycotoxins. **3.2: Viruses** Structure and classification: Bacterial, plant and animal viruses. Bacteriophage multiplication (lytic and lysogenic)	**08** **07**	**15**

BCH-III.E-3: FUNDAMENTALS OF MICROBIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Introduction to microbiology laboratory equipments: Autoclave, millipore filters and assembly, incubators, hot air oven, Laminar air flow, Biosafety cabinet, microscope, pH meter.	01
2.	Preparation and sterilization of glasswares	01
3.	Preparation and sterilization of liquid and solid culture media.	01
4.	Preparation of media agar plates, butts and slants.	01
5.	Determination of viable count (soil and water sample): Serial dilution, spread plating, quantification of colony forming units (cfu) and calculation of viable count.	03
6.	Isolation of pure cultures: Streak plate (T-streak, quadrant, radiant); colony characteristics	01
7.	Gram staining and cell morphology.	01
8.	Demonstration of coliphage in water sample.	02
9.	Isolation and staining of Fungi (Rhizopus, Mucor, Aspergillus, Penicillium) by lactophenol cotton blue.	02
10.	Decontamination and disposal of cultures	01
	Total	**15**

REFERENCES for BCH-III.E-3 (Latest Editions)

Mandatory Reading

- Pelczar, M. J., Chan E, C.S., and Krieg, N.R. Microbiology. McGraw Hill Education.
- Willey, J. M., Sherwood, L., Woolverton, C. J. and Prescott, L. M. Prescott, Harley, and Klein's microbiology. New York, McGraw-Hill Higher Education.

Supplementary Reading

- Atlas, R.M., Anantnaryan, R. and Paniker, C.K.J. Textbook of Microbiology, The Orient Blackswan.
- Madigan, M. T., Martinko. J. M. and Parker J. Brock's Biology of Microorganisms, Prentice Hall College Div.
- Stanier, R.Y. General Microbiology, Cambridge University.

Web References

- https://openstax.org/details/books/microbiology
- https://vlab.amrita.edu/?sub=3&brch=73&sim=1105&cnt=1
- http://textbookofbacteriology.net/growth_3.html
- https://www.khanacademy.org/science/biology/bacteria-archaea/prokaryote-structure/v/bacteria

BCH-III.E-4: PLANT BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Plant Structure and Photosynthesis	**1.1: Introduction to Plant cell structure** Structural and functional organization of a plant cell **1.2: Photosynthesis** Structure of organelle involved in photosynthesis; Structure of PSI and PSII complexes – Oxygenic and non-oxygenic photosynthesis; Photosynthetic pigments: Chlorophylls, Beta carotene, bacteriochlorophyll and phycoerythrobilin, Proton gradient and electron transfer in plants, purple bacteria and green-sulphur bacteria. Light reactions (Cyclic and noncyclic photophosphorylation). Calvin cycle and its regulation; Photorespiration; C4 cycle and Crassulacean acid metabolism (CAM)	**05** **10**	**15**

MODULE 2: Nitrogen Metabolism and Secondary Metabolites	**2.1: Nitrogen Metabolism** Nitrogen Cycle, Biological Nitrogen fixation by free living and in symbiotic association, formation of nodules, nitrogenase enzyme. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants. Urea metabolism. **2.2: Secondary Metabolites** Introduction to secondary metabolites and their biological roles and economic importance. Representatives alkaloid group and their amino acid precursors, function of alkaloids. Examples of major phenolic groups; simple phenylpropanoids,coumarins, benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics Classification of terpenoids and representative examples from each class, biological functions of terpenoids. Saponins	**06** **09**	**15**
MODULE 3: Plant Growth and Regulation	**3.1 Regulation of plant growth** Overview of Phytohormones. Auxins, Cytokinins, Gibberellins, Ethylene and Abscisic acid: physiological and developmental effects Commercial applications of plant growth hormones. **3.2 Plant tissue culture** General technique of plant tissue culture. Nutrient media and growth hormones. Types of Cultures: Callus culture, Suspension culture and Protoplast culture. Organogenesis and somatic embryogenesis Somaclonal variations and its advantages. Commercial applications of plant tissue culture.	**07** **08**	**15**

BCH-III.E-4: PLANT BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS

1.	Extraction and separation of photosynthetic pigments by TLC	02
2.	Preparation and observation of leaf cross-section of C3 and C4 plants	01
3.	Extraction and Assay of urease	02
4.	Isolation of nodule forming bacteria from root nodules	02
5.	Extraction and estimation of β-carotene from carrot	02
6.	Estimation of phenolic compounds from mint and tulsi leaves	02
7.	Demonstration of Callus culture	02
8.	Effect of growth hormones on germination of seeds	02
	Total	**15**

REFERENCES for BCH-III.E-4 (Latest Editions)

Mandatory Reading

- Taiz, L. and Zeiger, E. Plant Physiology. Sunderland Sinauer Associates Inc.

Supplementary Reading

- Nelson, D. L. and Cox, M.M. Lehninger's Principles of Biochemistry. Worth Publishers, New York, USA.
- Chawla, H.S. Introduction to Plant Biotechnology, USA, Science Publishers Inc.
- Singh, B. D. Plant Biotechnology, Kalyani Publishers.
- Stumpf, G., Bruening and Doi, R.Y. Outlines of Biochemistry. E E Conn, P K. John Wiley and Sons, New York.

Web References

- http://ecoursesonline.iasri.res.in/course/view.php?id=140
- https://openstax.org/subjects/science
- https://nptel.ac.in/courses/102103016/

SEMESTER IV

CORE COURSES: Immunology

ELECTIVE COURSES: Human Physiology, Nutritional Biochemistry, Endocrinology, Advanced Cell Biology

BCH-IV.C-6: IMMUNOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to the immune system and the cells and organs involved	**1.1: The immune system** Introduction to the immune system - historical perspective; types of immunity (innate and acquired); barriers of innate immunity – anatomic, physiologic, phagocytic, inflammatory; collaboration between innate and adaptive immunity; introduction to humoral and cell mediated immunity **1.2: Cells and Organs of the Immune system** Cells (myeloid and lymphoid lineage); immune-reactive cells (macrophages, granulocytes, NK Cells); primary lymphoid organs (bone marrow and thymus); secondary lymphoid organs; (spleen, lymph nodes, GALT and MALT).	**08** **07**	**15**
MODULE 2: B & T cells, Antigen-antibody interactions and the Complement system	**2.1: B and T cells** B-cells & T-cells – structure; function and significance; maturation, activation of B-cells and T-cells **2.2: Antigen-Antibody Interactions** Introduction to antigens and antibodies; structure, types, classes, properties and variants (e.g. immunogens, antigens, haptens, adjuvants); paratope and epitope; antigen – antibody interaction; forces involved in antigen-antibody reaction; concept of affinity, avidity, precipitation, agglutination reactions; immunoelectrophoresis, applications in diagnostics. RIA, ELISA. **2.3: The complement system** The complement system; functions, components and activation pathways (classical, alternate & lectin)	**04** **08** **03**	**15**

MODULE 3: MHC & Hypersensitivity, Vaccines & Monoclonal antibodies and Autoimmunity	**3.1: MHC and Autoimmunity** Major histocompatibility complex (MHC); introduction and discovery of human histocompatibility complex; structure of MHC I and II; presence of MHC I and II on different cells and their significance; Introduction to autoimmunity with examples; introduction to immunodeficiency types with examples **3.2: Hypersensitivity** Introduction and types of hypersensitivity **3.3: Vaccine and Monoclonal Antibodies** Introduction to vaccines and types of vaccines; Polyclonal & Monoclonal antibodies (hybridoma technology)	**05** **05** **05**	**15**

BCH-IV.C-6: IMMUNOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of lymphoid organs and cells of the Immune System	01
2.	Total count of WBC & RBCs using haemocytometer	02
3.	Differential count of WBC	01
4.	Blood grouping & Rh factor	01
5.	Preparation of serum	01
6.	Single Radial Immuno-diffusion	02
7.	Ouchterolony's double diffusion method and antibody titre calculation	02
8.	Immuno-electrophoresis	01
9.	ELISA (Demonstration)	02
10	Serological tests involving precipitations (Pregnancy &Widal)	02
	Total	**15**

REFERENCES for BCH-IV.C-6

Mandatory Reading

- Richard, A. G., Thomas, J. K. & Barbara A. O., (2018). Kuby Immunology, (7th Edition). W. H. Freeman & Company, New York.

Supplementary Reading

- Punt J., Stranford S., Jones P, Owen, J. A. (2018). Kuby Immunology, (8th Edition). W. H. Freeman & Company, New York.
- Arora, M.P. (2006). Cell Biology, Immunology and Environmental Biology, Himalaya Publishing House.
- Rao, C. V. (2011). Immunology (5th Edition), Narosa Publishing House Pvt. Ltd.
- Roitt, I., Brostoff, J. & Male, D.K. (2012). Immunology, (8th Edition). Elsevier Health, UK

Web References

- https://www.khanacademy.org/test-prep/nclex-rn/rn-immune-system
- https://www.youtube.com/watch?v=yDAGxVxY-L8
- https://www.frontiersin.org/articles/10.3389/fimmu.2017.00292/full
- https://www.ncbi.nlm.nih.gov/books/NBK459471/
- https://www.immunology.org/public-information/bitesized-immunology/immune-dysfunction/autoimmunity-introduction
- https://www.youtube.com/watch?v=2-57bqFSJ1E

BCH-IV.E-5: HUMAN PHYSIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: General Physiology and Body Fluids	**1.1: Introduction to General physiology** Overview of cell structure, composition, tissues, organs and systems, Transport through cell membrane – Passive and Active transport, Homeostasis	**06**	**15**
	1.2: Body Fluids Body fluids: intracellular, extracellular and interstitial fluid, Plasma, Blood, Lymph: RBCs, WBCs, clotting cascade mechanism, Blood related disorders: anemia, hemophilia, polycythemia, thalassemia, acidosis	**09**	
MODULE 2: Organ Systems I	**2.1: Skeletal and Muscular System (5 L)** Introduction to skeletal system, types of bones, composition, functions of bones. Introduction to muscular system, types of muscles, structure of muscle, Physiology of	**05**	**15**

	muscle contraction: proteins involved, neuromuscular junction, role of acetylcholine. Disorders of skeletal muscle: Duchenne muscular dystrophy, Myasthenia gravis, Osteoporosis, arthritis – physiological and immunological. **22.2: Digestive System** Introduction, parts of digestive system, gastrointestinal hormones, digestion and absorption, peristaltic system. Accessory organs of digestive system, Disorders of GI tract: GERD, Gastritis, Celiac disease and Liver cirrhosis. **2.3: Respiratory and Cardiovascular system** Introduction to respiratory system, functional anatomy of respiratory tract, lung volumes, Cardiovascular system: heart, blood vessels, divisions of circulation, Pacemaker, Cardiac cycle, ECG, Heart sounds, cardiovascular diseases: MI and Arrhythmia.	**04** **06**	
MODULE 3: Organ Systems II	**3.1: Excretory System** Introduction, anatomy and functions of excretory system, Nephron, Renal circulation, Urine formation, Renal function tests, Renal disorders: Nephrosis, kidney stones. **3.2: Nervous system** Introduction, parts of brain, spinal cord, neuron and its associated functions, membrane potential, synapse, neurotransmitters, EEG, Disorders: Alzheimer's. Epilepsy and Meningitis. **3.3: Reproductive system** Functional anatomy of male and female reproductive system, menstrual cycle, spermatogenesis and oogenesis, PCOS, uterine fibroids, prostatitis and erectile dysfunction.	**05** **05** **05**	**15**

BCH-IV.E-5: HUMAN PHYSIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Determination of clotting time	01
2.	Estimation of hemoglobin	01
3.	Observation of permanent slides – Transverse section of mammalian gonads, muscles, nerve cells	01
4.	Analysis of human blood pressure and pulse rate in man	01
5.	Determination of glucose and albumin in urine	02
6.	Determination of sugar in blood	01
7.	Determination of ESR and PCV	02
8.	Effect of different salt solutions on RBC's	01
9.	Liver function test	01
10.	Kidney function tests	01
11.	Progesterone estimation (kit based)	01
12.	Analysis of ECG	01
13.	Case Study	01
	Total	**15**

REFERENCES for BCH-IV.E-5

Mandatory Reading

- Sembulingam K. and Sembulingam P. Essentials of Medical Physiology, Jaypee brothers medical publishers (P) Ltd, New Delhi**.**

Supplementary Reading

- Arora, M.P. Animal physiology, Himalaya publishing house, New Delhi.
- Verma, S.K., Tyagi, A.K. and Agarwal, B.B.L. Animal Physiology, S. Chand and Company.
- Guyton, A.C and Hall, J.E. Textbook of Medical Physiology, Reed Elseviers India Pvt. Ltd. New Delhi.
- Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. Harper's Illustrated Biochemistry. McGraw-Hill Companies.

- Buja L. M. and Krueger G. R. F. Netter's Illustrated Human Pathology. Elsevier Inc., Philadelphia.
- Sadasivam, S. and Manickam A. Biochemical Methods, New Age International Publishers, New Delhi.

Web References

- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-body-structure-and-homeostasis/a/tissues-organs-organ-systems
- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-body-structure-and-homeostasis/a/homeostasis
- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-digestive-and-excretory-systems/a/hs-the-digestive-and-excretory-systems-review
- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-circulatory-and-respiratory-systems/a/hs-the-respiratory-system-review
- https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-circulatory-and-respiratory-systems/a/hs-the-circulatory-system-review
- https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-membrane-potential
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- https://openstax.org/details/books/biology-2e

BCH-IV.E-6: NUTRITIONAL BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Nutrition & Energy Metabolism, Dietary Carbohydrates and Dietary Lipids	**1.1: Nutrition and Energy Metabolism** Introduction, role of nutrients, unit of energy; Biological oxidation of foodstuff, calorific value of food, Physiological energy value of foods, antioxidants and their role, Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances (RDA) for different age groups, Basal Metabolic Index (BMI), Water metabolism, electrolyte imbalance; dehydration, Probiotics and prebiotics: sources and significance in the diet **1.2: Dietary Carbohydrates** Food sources, RDA, hormonal regulation of blood glucose, Diabetes: types and nutrition intake, Glycemic Index, Fiber; food sources, significance, Problems associated with carbohydrate intake. **1.3: Dietary Lipids**	**07** **03** **05**	**15**

	Food sources, RDA, significance of: MUFA, PUFA, Saturated fatty acids, Omega fatty acids, TGs, Cholesterol, Lipoproteins, Phospholipids, deficiency and disorders related to dietary lipids.		
MODULE 2: Dietary Proteins, Vitamins and Mineral metabolism	**2.1: Dietary proteins** Essential and non-essential amino acids, Food source, Protein malnutrition, Nitrogen balance Supplements – risk of imbalance and toxicity of amino acids. **2.2: Vitamins** Fat soluble vitamins: Types and sources, physiological role, deficiency disorders, toxicity. Water soluble vitamins: Types and sources, physiological role, deficiency disorders, toxicity. **2.3: Mineral Metabolism** Macronutrients – calcium, magnesium, sodium, potassium, phosphorus, sulphur and chlorine; physiological role, deficiency disorders and toxicity. Trace elements – essential and non-essential - physiological role, deficiency disorders and toxicity.	**04** **06** **05**	**15**
MODULE 3: Food Allergens and Diet Plans	**3.1: Food allergens** Food allergens: gluten, milk and milk products, nuts, soy products, fish and shellfish. PEM – Marasmus and Kwashiorkar and Bulimia. **3.2: Diet Plans** Atkin's Diet, Keto Diet, Paleo Diet, Vegetarian and Veganism, Intermittent fasting and its effects on health. Diet plans for different age groups.	**05** **10**	**15**

BCH-IV.E-6: NUTRITIONAL BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Preparation of Probiotics, microscopy and sensory evaluation	02
2.	Assessment of Vitamin constituents in various foods: Lycopene, -	06

	β carotene	
3.	Assessment of Nutritional Disorders: Anaemia, Hyperglycemia	02
4.	Formulating a Diet Plan: Diabetes, Sports Persons, Pregnancy	05
	Total	**15**

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Mandatory Reading

- Gibson, R. Principles of Nutritional Assessment. Oxford University Press**.**

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- Frazier, W.C and Westhoff, D.C. Food Microbiology. McGraw Hill Education (India) Private Limited: New Delhi
- Tiwari, R.P., Hoondal, G.S. and Tewari, R. Laboratory Techniques in Microbiology and Biotechnology, Abhishek Publications Chandigarh (India).
- Murray, R.K., Granner, D.K., Mayes, P.A. and Rodwell, V.W. Harper's Illustrated Biochemistry, Twenty-Sixth Edition Lange Medical Publications. New York
- Williams, M.H., Anderson, D.E. and Rawson, E.S. Nutrition for health, fitness and sport; McGraw Hill international edition.

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- https://www.khanacademy.org/science/high-school-biology/hs-biology-foundations/hs-biological-macromolecules/v/introduction-to-vitamins-and-minerals
- https://www.khanacademy.org/test-prep/mcat/biomolecules/enzyme-structure-and-function/v/cofactors-coenzymes-and-vitamins
- https://www.khanacademy.org/science/health-and-medicine/gastrointestinal-system-diseases/celiac-disease/v/what-is-gluten
- https://www.khanacademy.org/test-prep/mcat/biological-sciences-practice/biological-sciences-practice-tut/e/the-underlying-mechanism-of-milk-allergies-

BCH-IV.E-7: ENDOCRINOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to endocrinology	**1.1 Introduction to endocrine system** Overview of organ system and their role in hormone production. **1.2: Hormone, Receptor mechanism and Control system** Chemical classification of hormones,	**01** **04**	**15**

	Pathways of hormone action , Regulation of hormone secretion. **1.3: Hypothalamic and pituitary hormones** Classification of hypothalamic and pituitary hormones. Overview on ADH, GH, MSH, ACTH, Ghrelin, Oxytocin, Prolactin. Feedback regulation. Pathophysiology - gigantism, dwarfism and diabetes insipidus	**10**	
MODULE 2: Thyroid and Parathyroid Hormone	**2.1: Thyroid Hormone** Physiology and biosynthesis of thyroid hormone and its regulation; TSH - physiological and biochemical action. Pathophysiology - Goiter, Grave's disease, cretinism **2.2: Parathyroid Hormone** Bone physiology. Chemistry, physiology and mechanism of role of PTH, Vitamin D and calcitonin in regulation of Ca^{+} homeostatis. Pathophysiology - rickets, osteomalacia, osteoporosis	**07** **08**	**15**
MODULE 3: Pancreatic, Adrenal and Reproductive Hormone	**3.1: Pancreatic and GI Hormones** Synthesis and regulation of release of insulin and glucagon, gastrin, secretin, CCK Pathophysiology - diabetes type I and type II. **3.2: Adrenal Hormones** Synthesis and mechanism of action of Epinephrine and norepinephrine. Fight or flight response. Pathophysiology – Addison's disease, Cushing syndrome **3.3: Reproductive Hormones** Synthesis and regulation of male and female sex hormones, Hormones during menstrual cycle, pregnancy, parturition.	**05** **05** **05**	**15**

BCH-IV.E-7: ENDOCRINOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Histology of endocrine structures	03
2.	hCG based pregnancy test	01
3.	Ovulation test	01
4.	Case studies	10

REFERENCES for BCH-IV.E-7

Mandatory Reading

- Kovac's, W.J. and Ojeda, S.R. Textbook of Endocrine Physiology. Oxford University Press

Supplementary Reading

- Sembuligam K. and Sembulingam P. Essentials of Medical Physiology Jaypee Brothers Medical Publishers, New Delhi, India.
- Hadley, M.C. and Levine. Endocrinology J.E. Pearson Education, New Delhi.

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- https://opentextbc.ca/biology/chapter/24-4-hormonal-control-of-human-reproduction/
- https://www.youtube.com/watch?v=HZhz-7Grux0
- https://www.khanacademy.org/science/health-and-medicine/advanced-endocrine-system/endocrine-system-introduction/v/hypothalamus-and-pituitary-gland
- https://www.youtube.com/watch?v=dX1QsJ7e7LI
- https://openstax.org/details/books/biology-2e

BCH-IV.E-8: ADVANCED CELL BIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Membrane Transport	**1.1: Membrane Transport** Composition and properties of cell	**12**	**15**

and potentials; Nerve impulses	membrane; structure of nuclear envelope; nuclear pore complex Transport across nuclear envelope -Simple diffusion and facilitated diffusion -Passive transport - glucose transporter, anion transporter -Primary active transporters - P type ATPases, V type ATPases, F type ATPases -Secondary active transporters – Na + glucose symporter -Ion channels: voltage-gated ion channels (Na + /K + voltage-gated channel) **1.2: Membrane potentials and Nerve impulses** Resting potential , Action potential, Propagation of action potentials, Neurotransmission	**03**	
MODULE 2: Cell Cycle and Programmed Cell Death	**2.1: Cell Cycle and Programmed Cell Death** Cell cycle; events of mitosis; cytokinesis; Events of meiosis; regulation of cell division; Apoptosis (extrinsic and intrinsic pathway)	**15**	**15**
MODULE 3: Cancer Biology and Tools used in Cell Biology	**3.1: Cancer Biology** Development and causes of cancer; genetic basis; oncogenes, tumor viruses **3.2: Tools in Cell Biology** Microscopy: Light microscope, Phase contrast microscope, Inverted microscope, Fluorescence microscope, Confocal microscope, Electron microscope Centrifugation: Differential and gradient centrifugation for sub-cellular fractionation	**09** **06**	**15**

BCH-IV.E-8: ADVANCED CELL BIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Identification of different stages of mitosis (in onion root tip/WBC)	02
2.	Identification of different stages of meiosis (in flower buds)	01
3.	Study of cell viability by neutral red (viable cells) and trypan blue	01

	(non-viable cells)	
4.	Identification and study of cancerous cells using permanent slides/ photomicrographs	02
5.	Study of plant, animal and human tumour viruses using photomicrographs	01
6.	Differential centrifugation for separation of cellular components	01
7.	Preparation of sucrose density gradient and purification of sub cellular organelles: visualization of nuclear fraction by acetocarmine stain and mitochondria by Janus green stain	05
8.	Study of electron micrographs of sub-cellular organelles	01
	Total	**15**

REFERENCES for BCH-IV.E-8 (Latest editions)

Mandatory Reading

- Krebs, J.E., Goldstein, E.S. & Kilpatrick, S.T. (2014). Lewin's Genes XI, Jones and Bartlett India Pvt. Ltd.

Supplementary Reading

- Nelson, D. L. & Cox, M.M. (2017). Lehninger's Principles of Biochemistry (7th Edition). Worth Publishers, New York, USA.
- Karp, G. & Harris, D. (2013). Cell and Molecular Biology – Concepts and Experiments (7th Edition), John Wiley & Sons Inc, New York.
- Robertis, E. D. P. & Robertis, E. M. F. (2017). Cell Biology and Molecular Biology (8th Edition). Sauders College.
- Watson, J.D., Hopkins, N.H. et al. (2008). Molecular Biology of the Gene, Garland Publishing (Taylor & Francis Group), New York & London.
- Verma P. S. & Agarwal V. K. (2005). Cell Biology, Genetics, Molecular Biology, Evolution, and Ecology (14th edition). S. Chand & Company Ltd., New Delhi

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- https://bio.libretexts.org/Bookshelves/Genetics/Book %3A_Online_Open_Genetics_(Nickle_and_Barrette-Ng)/13%3A_Cancer_Genetics/ 13.2%3A_Cancer_Cell_Biology
- https://bio.libretexts.org/Bookshelves/Cell_and_Molecular_Biology/Book%3A_Cells_-_Molecules_and_Mechanisms_(Wong)/16%3A_Viruses%2C_Cancer %2C_and_the_Immune_System/16.3%3A_Cancer

SEMESTER V

CORE COURSES: Molecular Biology

ELECTIVE COURSES: Concept of Genetics, Regulation of Gene Expression, Industrial Microbiology, Bioinformatics

BCH-V.C-7: MOLECULAR BIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Chemical Nature of Genetic Materials	**1.1: Nucleic Acids, bonds, types of DNAs, DNA packaging and model organisms** Structural components of nucleic acid: Sugar, Phosphate, Nucleosides and Nucleotides; Structure of DNA: Watson – Crick Model, Different forms of DNA (B, Z), Forces stabilizing the structure of DNA, Unusual structures of DNA (palindromic, mirror repeat, hairpin bent, cruciform); Structure of RNA, Different forms of RNA (mRNA, rRNA, tRNA); Differences between DNA and RNA Chargaff's experiments and Law **1.2: Chromosome** Fundamental functions of DNA. Chromosomal DNA and its packaging in the chromatin fibre. Chromatin structure, structural features (Telomere, Centromere and Repetitive sequences) of chromosomes and their functions, prokaryotic chromosomes, plasmids.	**10** **05**	**15**
MODULE 2: DNA/RNA a genetic material and DNA Replication	**2.1: DNA/RNA as genetic material** DNA as genetic material: Griffith's transforming principle, and Avery, Hershey and Chase Experiment proving DNA as genetic material RNA as the genetic material of some viruses **2.2: DNA Replication** Experimental evidence for semi-conservative DNA replication in E.coli - Messelson and Stahl's experiment DNA template, Enzymes - DNA polymerases, ligase, DNA gyrase, Structure and function, Ancillary proteins	**08** **07**	**15**

	associated with replication Mechanism of replication: Initiation, Elongation and Termination; Introduction to theta and rolling circle models DNA Proof reading.		
MODULE 3: **DNA damage, repair and recombination**	**3.1: DNA Damage and its Repair** Types of DNA damage (spontaneous and induced). AMES Test Mechanisms/pathways to repair DNA: Excision repair, mismatch repair, recombination repair in *E. coli* and SOS Repair. Role of *RecA* in DNA damage repair, Photoreactivation repair in *E.coli* involving photolyase. **3.2: Mechanisms of Genetic Recombination** General and site specific recombination. Heteroduplex DNA formation (Homologous recombination). Synaptonemal Complex, Bacterial *RecBCD* system and its stimulation of chi sequences. Role of *RecA* protein, homologous recombination, Holliday junctions.	**08** **07**	**15**

BCH-V.C-7: MOLECULAR BIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Isolation of genomic DNA from prokaryotes and eukaryotes	05
2.	Isolation of RNA from prokaryotes	02
3.	Agarose gel electrophoresis of genomic DNA and its elution	05
4.	Mutagenesis in *E.coli* cells – UV	03
	Total	**15**

REFERENCES for BCH-V.C-7 (Latest Editions)

Mandatory Reading

- David, C., Nanette, P. and Michelle, M. Molecular Biology. Elsevier Academic Press.

Supplementary Reading

- Murray, R., Granner, D., Mayes, P. and Rodwell, V. Harper's Illustrated Biochemistry. Mc Graw Hill.
- Watson, J. D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R.M. Molecular biology of the gene. Menlo Park, CA: Benjamin-Cummings.
- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. New York: Garland Science.
- Gardner, M. J., Simmons D.P. Snustad. Principles of Genetics. John Wiley & Sons.
- Dubey, R.C. Advanced Biotechnology. S. Chand Publishing.

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BCH-V.E-9: CONCEPTS IN GENETICS (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Mendelian Genetics, Model Organisms and Gene transfer mechanisms	**1.1: Mendelian Genetics** History of Mendelian Genetics, First Law of Inheritance, Second Law of Inheritance, Monohybrid and Dihybrid cross, Test cross and Back cross and their significance. Deviations in Mendel's Laws: Dominance, Co- dominance, Incomplete dominance; Multiple alleles: ABO blood group, Rh incompatibility Gene interaction - Epistasis: Dominant and Recessive epistasis with example; Non-epistatic gene interactions **1.2: Model Organisms used in Genetics Study** Model organisms: Escherichia coli, *Saccharomyces cerevisiae, Neurospora crassa, Drosophila melanogaster, Caenorhabditis elegans, Arabidopsis thaliana* **1.3: Genetic exchange in bacteria**	**08** **03** **04**	**15**

	Mechanism of genetic exchange – Conjugation, Transformation and Transduction		
MODULE 2: Chromosomal Linkage and Crossing-over and Human Genetics	**2.1: Chromosomal Linkage and Crossing-over** Sutton-Boveri chromosome theory of heredity; Bateson and Punnet's coupling and repulsion hypothesis, Morgan's views on linkage, Theory of linkage; Kinds of linkage: Complete linkage, incomplete linkage; Significance of linkage Types of crossing over: Somatic or mitotic crossing over, Germinal or meiotic crossing over Mechanism of meiotic crossing over: Synapsis, Duplication of chromosomes, Crossing over by breakage and union, Terminalisation, Significance of crossing over; Transposable elements. **2.2: Human Genetics** Importance of human genetics study, techniques involved: Amniocentesis, CVS, Pedigree analysis; Human traits; Disorders due to mutant genes: PTC tasters, Huntington's chorea, Tongue rolling; Hemophilia	**09** **06**	**15**
MODULE 3: Chromosomal aberrations, Determination of Sex and Sex differentiation and Population Genetics	**3.1: Chromosomal Mutations** Concept of gene doses, Barr bodies, Types of structural changes (Deletion, Duplication, Inversion, Translocation, Variation in chromosome morphology) Disorders – Down's syndrome, Klinefelter's syndrome Types of numerical changes (Euploidy and Aneuploidy) - Monosomy and Trisomy of Sex and Autosomes Disorders – Turner's Syndrome, Cri-du-chat syndrome. Disorders due to inborn errors of metabolism — Phenylketonuria (PKU), Alkaptonuria, Sickle-cell anaemia **3.2: Genetically controlled sex determination and differentiation** Mechanisms: (Heterogamesis); Types: Heterogametic males, Heterogametic	**06** **06**	**15**

	females; Genic balance mechanism; Sex determination in *Drosophila melanogaster* and man; Male haploidy or haplodiploidy mechanism; Hormonally controlled sex determining mechanism eg. Sex in *Bonellia*; Environmentally controlled sex determining mechanism- eg. Marine annelid *Ophryotrocha* **3.2: Population Genetics** Hardy-Weinberg law, Factors affecting Hardy Weinberg theory, Predicting allele and Genotype frequencies and exceptions to Hardy-Weinberg principle, Speciation: types and examples.	**03**	

BCH-V.E-9: CONCEPTS IN GENETICS (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of a Dissection microscope	01
2.	Study of Mendelian traits in Human Population	03
3.	Pedigree analysis and problem solving	03
4.	Karyotype analysis of chromosomal abnormalities	03
5.	Smear technique to demonstrate sex chromatin in buccal epithelial cells	01
6.	Study of Barr bodies in sex determination	01
7.	Problem solving on Mendel's laws and Hardy-Weinberg's law	03
	Total	**15**

REFERENCES for BCH-V.E-9

Mandatory Reading

- Tamarin, R.H. (2017). Principles of Genetics (7th Edition). Tata McGraw-Hill Publishing Company Ltd.
- Verma, P. S. and Agarwal, V. K. (2013). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Pvt. Ltd.

Supplementary Reading

- Stryer, L; Berg, J; Tymoczko, J & Gatto, G. (2019). Biochemistry (9th Edition). W. H. Freeman and Co., New York, USA.
- Murray, R. K, Granner, D. K., Mayes, P. A. & Rodwell, V. W. (2018). Harper's Illustrated Biochemistry (31st Edition). McGraw-Hill Companies.
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- Verma, P. S. and Agarwal, V. K. (2013). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Pvt. Ltd.
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- https://study.com/academy/lesson/hardy-weinberg-equilibrium-i-overview.html
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- https://www.khanacademy.org/science/biology/classical-genetics/chromosomal-basis-of-genetics/a/discovery-of-the-chromosomal-basis-of-inheritance

BCH-V.E-10: REGULATION OF GENE EXPRESSION (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Tanscription in Prokaryotes and Eukaryotes	**1.1: Concept of Central Dogma** **1.1: Transcription in Prokaryotes** Introduction to genetic code: Features of genetic code, wobble hypothesis Prokaryotes: RNA polymerases, Sigma factor, Bacterial promoters; RNA synthesis, Rho-dependent and Rho-independent termination; Inhibitors of transcription and applications as anti-microbial drugs **1.2: Transcription in Eukaryotes** Transcription by RNA polymerase II, RNA polymerase II core promoters, General transcription factors, Various types of RNA	**01** **07**	**15**

	processing, Transcription by RNA polymerase I and III. Inhibitors of eukaryotic transcription and their Applications Comparison between Prokaryotic and Eukaryotic transcription	**07**	
MODULE 2: Splicing, Translation, Gene regulation	**2.1: RNA Splicing** The spliceosome machinery, Group I and group II introns, Alternative splicing, Exon shuffling **2.2: Translation in Prokaryotes and Eukaryotes** Ribosomes in Prokaryotes and Eukaryotes; Messenger RNA, Transfer RNA, Attachment of amino acids to tRNA, Ribosomal RNAs in Prokaryotes and Eukaryotes Comparison of Translation in Prokaryotes and Eukaryotes Inhibitors of Translation and Applications as anti-microbial drugs 2.3: Introduction to gene regulation	**03** **09** **03**	**15**
MODULE 3: Regulation of Gene Regulation in Prokaryotes and Eukaryotes	**3.1: In Prokaryotes** Concept of operon - structural and regulatory genes, Operator, promoter. Negative and positive regulation. Operon; Lactose operon, Tryptophan operon **3.2: Regulation of Gene Expression in Eukaryotes** Euchromatin and heterochromatin, Trans-acting molecules, Cis-acting regulatory elements. Regulation by co- and post transcriptional processing of mRNA- Splicing, mRNA editing, RNA interference (RNAi), Regulation of mRNA at translational level Regulation through modifications to DNA	**07** **08**	**15**

BCH-V.E-10: REGULATION OF GENE EXPRESSION (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS

1.	Isolation of RNA from prokaryotes and eukaryotes	04
2.	Northern Blotting and Western Blotting to study gene expression (virtual laboratory)	02
3.	UV absorption spectra and direct spectrophotometric estimation of DNA and RNA	01
4.	Determination of the Tm and GC content of DNA	02
5.	To study the viscosity of DNA solutions	01
6.	To study gene expression by induction of enzyme(s) from suitable sources and confirmation by qualitative/quantitative assay/electrophoresis	05
	Total	**15**

REFERENCES for BCH-V.E-10

Mandatory Reading

- Nelson, D. L. & Cox, M.M. (2017). Lehninger's Principles of Biochemistry (7th Edition). Worth Publishers, New York, USA.

Supplementary Reading

- Stryer, L; Berg, J; Tymoczko, J & Gatto, G. (2019). Biochemistry (9th Edition). W. H. Freeman and Co., New York, USA.
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- https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/06%3A_DNA_and_Protein_Synthesis/6.07%3A_Regulation_of_Gene_Expression

BCH-V.E-11: INDUSTRIAL MICROBIOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Industrial Microbiology	**1.1: Introduction** Overview of industrial fermentation technology, scope and applications. **1.2: Industrial bioreactor** Fermenters: Structure of an Ideal fermentor Parts of the fermentor and their uses – Impellers, Spargers, Baffles, Headspace, Controls and Sensors (temperature, pH, antifoam) Types of reactors (definition, description, diagram and uses) - Bubble columns, Airlift, Fluidized bed, Packed bed, Tray bioreactors, Photo-bioreactors Sterilization of bioreactors **1.3: Fermentation Media** Characteristics of an ideal fermentation medium, types of media – crude and synthetic, composition of fermentation media. Sterilization of media	**01** **08** **06**	**15**
MODULE 2: Fermentation, fermentors and Screening of microorganisms	**2.1: Types of fermentation** Submerged, Surface/Solid state, Batch, Fed-batch, Continuous. Lab scale, Pilot Scale and Industrial scale fermentors **2.2: Screening of microorganisms** Characteristics of microorganisms, strain improvement, Screening procedures: Primary screening: Definition, Methods of primary screening – Crowded plate, Auxanography, Enrichment, Indicator dye Secondary screening: Definition and features, Example of secondary screening (giant colony method)	**07** **08**	**15**
	3.1: Detection and Assays of Fermentation products Physical and Chemical assays - Titration	**05**	

MODULE 3: Fermentation products	and gravimetric assay, Turbidity analysis and Cell determination, Spectrophotometric assay, Chromatographic method Biological assays - Diffusion assays, Turbidometric and Growth assay **3.2: Industrial production of economically important products** Citric acid, Vinegar, Ethanol, SCP, Beer, Wine, Yogurt, Penicillin, Amylase, Steroids	**10**	**15**

BCH-V.E-11: INDUSTRIAL MICROBIOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study and handling of a fermentor	02
2.	Media preparation for batch fermentation process	01
3.	A study on the phases of growth of microorganisms during fermentation	02
4.	Isolation of antibiotic producing bacteria – crowded plate technique and secondary screening using giant colony technique	03
5.	Production of wine (from fruit) using yeast	02
6.	Production of vinegar	02
7.	MIC of Penicillin for Gram positive bacteria (S. aureus or Bacillus)	01
8.	Production of amylase in solid state fermentation	02
	Total	**15**

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Mandatory Reading

- Stanbury P. F, Whitaker A. and Hall. (1997). Principles of fermentation technology, 2nd Edition, Aditya Books Pvt. Ltd, New Delhi.
- Casida L. E. (2009). Industrial Microbiology, New Age International (P) Ltd. New Delhi.

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- Okafor N. (2007). Modern Industrial Microbiology and Biotechnology, Science Publishers Enfield, NH, USA.
- Patel A. H. (2012). Industrial Microbiology, MacMillan Publishers India Ltd.

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BCH-V.E-11: BIOINFORMATICS (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Bioinformatics; Information resources	**1.1: Introduction to Bioinformatics** Definition, Scope of bioinformatics Introduction to use of computers in biology, Internet and software in biology, Medicine and research, Historical developments in biology Bioinformatics: Components and applications **1.2: Information resources** Introduction, Aim and objectives (NCBI, NLM, NIH, EBI and SRS)	**10** **05**	**15**
MODULE 2: Types of Databases	**2.1: Types of Databases** Biological databases: Primary databases – Gen Bank and EMBL, DDBJ; Secondary databases - Swiss-PROT, PDB and PIR; Composite databases – OWL and PROSITE Structural databases: PDB, MMDB, CATH and SCOP; Visualization of proteins – Cn3D and Rasmol Literature databases: Pubmed, MedLINE and OMIM		**15**
MODULE 3: Sequence Alignment tools & phylogeny;	**3.1: Sequence Alignment Tools and Phylogeny** Introduction to sequence alignment and	**10**	**15**

HGP	phylogeny; BLAST and FASTA, and their types; ORF Pairwise sequences alignment, Multiple sequence alignment using Clustal-W Omega Phylogenetic tree: Introduction, Definition, Structure, Types and Construction Cladogram and differences with phylogenetic tree **3.2: Human Genome Project** Introduction to Human Genome Project (HGP), Objectives, Ethical and social issues	**05**	

BCH-V.E-12: BIOINFORMATICS (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Usage of NCBI resources for biological databases – Protein or amino acid sequences – DNA or gene sequences	05
2.	Usage of NCBI resources for – Structure databases – Literature databases	03
3.	Database search and Pairwise sequence alignment using NCBI BLAST: BLASTp, BLASTn	02
4.	Multiple sequence alignment using Clustal-W	01
5.	Construction of phylogenetic tree using Clustal-W	01
6.	DNA sequence analysis to find restriction enzymes sites using NEB cutter	01
7.	Visualization of protein structures using Cn3D/ Rasmol	02
	Total	**15**

REFERENCES for BCH-V.E-12

Mandatory Reading

- Harisha, S. (2007). Fundamentals of Bioinformatics, I. K. International Publishing House, Mumbai.

Supplementary Reading

- Ignacimuthu, S. (2005). Basic Bioinformatics, Narosa Publishing House, New Delhi.
- Mount, D. W. (2004). Bioinformatics – sequence and Genome analysis, CBS Publishers.
- Murthy, C. S. V. (2003). Bioinformatics, Himalaya Publishing House, Mumbai.
- Rastogi, S. C., Mendiratta, N. and Rastogi, P. (2004). Bioinformatics: Concepts, Skills and Applications, CBS Publishers.
- Xiong, J. (2006). Essential Bioinformatics, Cambridge University Press.

SEMESTER VI

CORE COURSES: Clinical Biochemistry

ELECTIVE COURSES: Introduction to Pharmacology, Food Biochemistry, Genetic Engineering and Biotechnology, Environmental Chemistry

BCH-VI.C-8: CLINICAL BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Laboratory Analysis of clinical samples	**1.1: Blood, Serum and Urine** Composition of Blood, Serum, Cerebrospinal Fluid and Urine. Collection, Preservation, Handling and Processing of clinical samples. Blood Bank **1.2: Analysis of Blood, Serum, Urine and CSF** **Blood**: Haemoglobin, Total cell and Differential cell (TC/DC) counts, Erythrocyte sedimentation Rate (ESR); Clotting time, Glucose tolerance test, Urea; Gases: Oxygen and Carbon dioxide levels; pH. **Serum**: Proteins, Albumin/Globulin Ratio; Bilirubin; Creatinine; Uric acid; Electrolytes. **Urine**: Colour, Odour, Sediment, Crystals, Glucose; Protein/Albumin **CSF:** Colour, Ph, microscopic examination (lymphocytes), chemical examination (protein, glucose, calcium), microbiological examination.	**02** **13**	**15**
MODULE 2: Congenital and Metabolic disorders	**2.1: Congenital disorders** Disorders associated with: a) Carbohydrate metabolism- Glycogen storage diseases, Galactosemia. b) Protein metabolism – Phenylketonuria, Alkaptonuria. c) Lipid metabolism – Niemann – Pick disease, Tay- Sach's disease. Disorders due to chromosomal aberrations: Down syndrome, Turner syndrome, Klinefelter syndrome **2.2 : Metabolic disorders** Carbohydrate – Diabetes mellitus Type I and Type II; Ketosis. Lipids – Dyslipidemia.	**09** **06**	**15**

	Proteins – Albuminuria Blood – Anaemia: Haemolytic, Pernicious, Sickle Cell Anaemia, Iron deficiency. Heart – Hypertension, Atherosclerosis Liver – Wilson's disease, Gaucher disease Kidney –Diabetes insipidus		
MODULE 3: Infectious diseases and Diagnostic Tests	**3.1: Infectious diseases:** **Viral infection:** Polio, Measles, Mumps, HIV, Influenza Bacterial infection: Diphtheria, Tuberculosis, Typhoid, Cholera. **3.2: General Diagnostic tests** **Blood:** Total and differential blood count, Blood groups and Rh factor incompatibility. **Liver disorders and Liver function tests:** Bilirubin metabolism. **Renal function tests:** Glomerular filtration rate, Renal threshold and clearance values. **Heart:** Role of enzymes and other proteins in assessment of myocardial infarction.	**15**	**15**

BCH-VI.C-8: CLINICAL BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Identification of blood collection tubes and preparation of blood, plasma and serum	01
2.	Sample collection and processing – blood and urine	01
3.	Blood staining	01
3.	Bleeding and Clotting time	01
4..	Erythrocyte Sedimentation Rate	01
5.	Glucose Tolerance Test	01
6.	PCV Test	01
7.	Physical & Chemical Examination of Urine	02
8.	Liver function test	03

9.	Renal function test	02
10.	Cholesterol test	01
	Total	**15**

REFERENCES for BCH-V.C-8

Mandatory Reading

- Pattabiraman R. N. Text book of Biochemistry, All India Publisher distribution.

Supplementary Reading

- Chatterjee M. N., Shinde, R. Text book of Medical Biochemistry, Jaypee Publishers.
- Vasudevan, D. M., Sreekumari S., Text book of Biochemistry for Medical Students, Jaypee Publishers.
- Berg, Jeremy M., Tymoczko, John L., Stryer Lubert. Biochemistry, W.H. Freemann, N. York.
- David, L. N., Michael, M. C., Lehninger, Albert, Biochemistry, Kalyani Publications, N.

Web References:

- George, F. Hoffmann., Johannes, Z., William, L. Nyhan. Inherited Metabolic Disorders: A clinical approach, Springer.
- Fernandes, J., Saudubray, J.M., van Den Berghe, G. Inborn Metabolic Diseases. Springer.

BCH-VI.E-13: INTRODUCTION TO PHARMACOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Principles of pharmacology, Pharmacodynamics and Pharmacokinetics	**1.1: General Principles Of Pharmacology** Introduction to Pharmacology, Therapeutics; History – Traditional & Modern Medicine; Concepts of Pharmacology; Common terminologies used in pharmacology Nature of drugs; Sources of drugs, Scientific basis of use of drugs in humans Introduction to Pharmacopeia **1.2: Pharmacodynamics & Pharmacokinetics** Introduction; Pharmacodynamics: -	**05** **10**	**15**

	Transport across biological membranes; Absorption of drugs, Bioavailability Pharmacokinetics: - Biotransformation, Excretion, Prolongation of drug action Mehcanism of drug action, Placebo effect Receptors & Signal Transduction; Agonists, Antagonism; Slow processes, Non-receptor mechanism Constant Rate infusion; Single bolus dose, Repeated (multiple) dosing		
MODULE 2: Drug Absorption & Routes of Administration; Drug Development	**2.1: Drug Formulation and its administration** Bioavailability, Bioequivalence and generic vs. Proprietary prescribing; Prodrugs; routes of administration – Oral, Buccal & Sublingual, Rectal route, Skin, Lungs, Nose, Eye, Ear & Vagina, Intramuscular Injection, Subcutaneous injection, Intravenous injection, Intrathecal injection **2.2: Drug Development** Introduction to drug development, processes involved in drug development, Toxicity, Clinical trials	**10** **05**	**15**
MODULE 3: Types of drugs for different applications	**2.2: Drugs for the Nervous and Musculoskeletal Systems** (Include brief pathophysiology of diseases wherever necessary) Mechanism of drugs against Insomnia, Anxiety, Schizophrenia, Depressive illnesses, Parkinson's, Myasthenia gravis, Alzheimer's, Migranes. Anasthetics & Muscle relaxants, Analgesics Anti Inflammatory drugs **3.1: Drugs for the Circulatory & Respiratory system** (Include brief pathophysiology of diseases wherever necessary) Antihypertensive drugs, drugs used in ischaemic heart disease, Anticoagulants & antiplatelet drugs, drugs for heart failure Drugs used to treat asthma, bronchitis, cough **3.2: Drugs for the Gastrointestine** (Include brief pathophysiology of diseases wherever necessary) Drugs for peptic ulceration & Oesophagal disorders Diarrhoea, Irritable bowel	**05** **05** **03**	**15**

	syndrome, Liver diseases, Drugs that modify appetite **3.3: Antimicrobial drugs** Antibacterial, Antiviral, Antifungal drugs	**02**	

BCH-VI.E-13: INTRODUCTION TO PHARMACOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Study of efficiency of any antibacterial and antifungal against standard organisms	04
2.	MIC of store purchased antibiotic	02
3.	Determining shelf life of a drug	02
4.	Estimating the quantity of active ingredient in a store brought drug (Vitamins, etc.)	02
5.	Study of mode of action of any commonly used drug and route of administration	04
6.	Study of dosage forms of drugs	01
	Comprehensive study of the Indian Pharmacopeia	
	Study on Clinical trials	
	Total	**15**

REFERENCES for BCH-VI.E-13

Mandatory Reading

- Tripathi K. D. (2019). Essentials of Medical Pharmacology (8th Edition). Jaypee Brothers Medical Publishers (P) Ltd., London.

Supplementary Reading

- Ritter J. M., Lewis L. D., Mant T. GK., and Ferro A., (2008). A Textbook of Clinical Pharmacology and Therapeutics (5th Edition). Hachette Livre, U.K.
- Katzung B., (2017). Basic and Clinical Pharmacology (14th Edition). McGraw-Hill Education/Medical.
- Whalen K., (2018). Lippincott Illustrated Reviews: Pharmacology (Sangeeta Sharma & Thirumurthy Velpandian edition). Wolters Kluwer India Pvt. Ltd.

Web References:

- https://www.ncbi.nlm.nih.gov/books/NBK12815/
- https://www.youtube.com/watch?v=tobx537kFaI
- https://www.ncbi.nlm.nih.gov/books/NBK507791/
- https://www.youtube.com/watch?v=NKV5iaUVBUI

BCH-VI.E-14: FOOD BIOCHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction to Food Biochemistry and spoilage	**1.1: Introduction to Food biochemistry** Definition and composition of food. Food as a substrate for microorganisms **1.2: Spoilage of food** Intrinsic and Extrinsic factors - Hydrogen-ion concentration, moisture requirement, oxidation-reduction potential, nutrient content, inhibitory substances and biological structure. Enzymatic browning, Non – Enzymatic browning, Maillard reaction, Caramelization reaction, Ascorbic acid oxidation Classification of foods by ease of spoilage, Factors affecting kinds, numbers and growth of microorganisms in food, temperature, pressure Chemical changes caused by microorganisms	**02** **13**	**15**
MODULE 2: Principles of Food Preservation	**2.1: Principles of Food preservation** Preservation by high temperature – Factors affecting heat resistance (Thermal Death Time), Determination of heat resistance (Thermal Death Time), Heat treatments employed in food processing, Chemistry of canning Preservation by low temperature – Temperature employed in low-temperature storage. Principle of freezing, freezing curve, changes occurring during freezing, types of freezing i.e. slow freezing, quick freezing, Introduction to thawing, Mechanism of changes during thawing and its effect on food.	**15**	**15**

	Preservation by drying – Methods of drying, Factors in the control of drying Preservation by radiation – kinds of ionizing radiations used in food irradiation, mechanism of action, uses of radiation processing in food industry, concept of cold sterilization.		
MODULE 3: **Food Quality, New Product Development**	**3.1 : Food Quality** Objectives, type of food panels, characteristics of panel members, layout of sensory evaluation laboratory, sensitivity tests, threshold value, paired comparison test, duotrio test, triangle test, hedonic scale, chemical dimension of basic tastes, Amoore's classification of odorous compounds. Sherman and Sczezniak classification of food texture. Sensory attributes of cheese, cream, butter, ghee, juices. Application of texture measurement in cereals, fruits and vegetables, dairy, meat and meat products. Dimensions of colour and attributes of colour; gloss etc. Perception of colour, Colour Measurement: Munsell colour system, CIE colour system, Hunter colour system, etc. Grading of Milk, MBRT, Resazurin (include more tests for other foods) FSSAI and other Regulatory Bodies **3.2: Product Development** Importance, Need of product development, Steps of product development, Product development tools, Reasons for failure	**11** **04**	**15**

BCH-VI.E-14: FOOD BIOCHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Screening and evaluation of fresh and spoiled fruits and vegetables	02
2.	Texture evaluation of various processed food sample	01
3.	Processing and sensory evaluation of milk and milk products (milk, flavoured milk, curd, cheese, condensed milk, khoya)	05
4.	TDT of an organism isolated from spoilt fruit	01

5.	Spoilage of bakery product (bread, biscuits)	01
6.	Estimation of salt content in butter	01
7.	Study quality characteristics of foods preserved by drying/ dehydration/ freezing.	02
8.	Visit to a food industry or food research institute and preparation of report	02
	Total	**15**

REFERENCES for BCH-VI.E-14

Mandatory Reading

- Frazier, W. C. and Westhoff, D. C., Food Microbiology. TMH Publication, New Delhi.

Supplementary Reading

- Ramaswamy, H. and Marcott, M. Food Processing Principles and Applications. CRC Press.
- Ranganna, S. Handbook of Analysis and Quality Control for Fruits and Vegetable Products, TMH Education Pvt. Ltd.
- Potter, N.H. Food Science, CBS Publication, New Delhi.
- Owen, F. R. Food Chemistry, Marcell Dekker, New York.
- Gordon, F. W. New Product Development From Concept to Marketplace, CRC Press.
- Norman, D.W. and James, D. N. The technology of food preservation,Westport.
- Pomeranz, Y. and Meloan, C.E. Food Analysis – Theory and Practice, CBS Publishers and Distributors, New Delhi.

Web References:

- https://www.youtube.com/watch?v=LUQxrnEFzB0
- https://www.slideshare.net/natrajdurgannavar/sensory-evaluation-of-food
- http://ecoursesonline.iasri.res.in/mod/page/view.php?id=6091

BCH-VI.E-15: GENETIC ENGINEERING AND BIOTECHNOLOGY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Introduction of	**1.1: Introduction to Genetic Engineering and Biotechnology**	**03**	**15**

Genetic Engineering & the basic Tools required for it	General features and mechanisms of genetic engineering, Concept of biotechnology, Applications and ethical issues of recombinant DNA technology, Gene cloning **1.2: DNA Modifying enzymes and Vectors for Gene Cloning** Nucleases- Endonucleases (Restriction enzymes recognition sequences, Cleavage pattern), Exonucleases, Host control restriction and modification, DNA ligases, Reverse Transcriptases, Polynucleotide kinases, Alkaline phosphatases, Nucleotidyl transferases Vectors, Properties of ideal cloning vectors, Types of cloning vectors; Plasmid vectors: Properties, Classification, pBR322, pUC 18 Bacteriophage vectors, Lambda phage: Features, Insertional vectors and Replacement vectors, M13 Bacteriophage Hybrid vectors: Cosmids, Phagemids and Phasmids; Shuttle vectors; Plant vectors	**12**	
MODULE 2: Transformation methods and Blotting techniques for DNA & RNA	**2.1: Transformation methods and identification of recombinants** DNA insertion into vectors: Ligation, Use of linkers and Adaptors, Homopolymer tailing Competence (transformation in bacteria): Microinjection, Lipofection, Electroporation, Macroinjection, Sonication, DNA co-precipitation, Ultrasonication, Laser induced Identification of Recombinants: Principle and importance of identification of recombinants: Antibiotic resistance (amp, tet resistance), lac Z selection, Colony hybridization **2.2: Blotting Techniques for DNA and RNA** Isolation of Genomic DNA and RNA, Agarose gel electrophoresis, Southern blotting: Blotting of DNA from agarose gel by capillary action onto nitrocellulose membrane, Denaturing of DNA, Hybridisation with radiolabelled P 32 , Autoradiography Northern blotting: Blotting of RNA from agarose gel onto nitrocellulose membrane,	**10** **05**	**15**

	Hybridisation with radiolabelled probe, Autoradiography		
MODULE 3:	**3.1: DNA Amplification and Sequencing** DNA amplification: Polymerase chain reaction (PCR) – Principle, Components, Method and Applications DNA sequencing: Significance and importance, Basic methods: Maxam Gilbert's method, Sanger's method. Advanced method: Shotgun method, Automatic DNA sequencer **3.2: Genomic and cDNA libraries** Preparation of genomic library, cDNA library, Screening of Libraries **3.3: Applications in agriculture** Flavr Savr tomato, Golden rice, Plant resistance to desiccation, cold, heat, pests, herbicides **3.4: Applications in pharmaceuticals** Recombinant insulin, Blood clotting factor VIII, Edible vaccines **3.5: Applications in environment** Bioremediation and Superbug	**08** **02** **02** **02** **01**	**15**

BCH-VI.E-15: GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Isolation of plasmid DNA by alkaline lysis and boiling prep method, and molecular weight determination by gel electrophoresis	04
2.	Restriction digestion of plasmid DNA and analysis by gel electrophoresis	02
3.	Preparation of competent cells in bacteria	02
4.	Transformation in bacteria using plasmid vector (pUC 18)	04
5.	Deciphering the DNA sequence from a sequencing gel photograph by Maxam and Gilbert's method and Sanger's method	02
6.	Blotting techniques (virtual laboratory)	01

	Total	**15**

REFERENCES for BCH-VI.E-15

Mandatory Reading

- Singh, B. D. (2008). Biotechnology: Expanding Horizons, Kalyani Publishers.

Supplementary Reading

- Primrose, S. B. and Twyman, R. M. (2009). Principles of Gene Manipulation and Genomics, Blackwell Publishing.
- Jogdand, S. N. (2008). Gene Biotechnology, 2nd edition, Himalaya Publishing House, Mumbai.
- Purohit, S. S. (2009). Biotechnology: Fundamentals and Applications, Student Edition.
- Watson, J. D., Tooze, J. and Kurtz, D. T. (1983). Recombinant DNA: A short Course, Scientific American Books (WH Freeman), New York.

Web References:

- https://www.khanacademy.org/science/high-school-biology/hs-molecular-genetics/hs-biotechnology/v/introduction-to-genetic-engineering
- https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Bruslind)/18%3A_Genetic_Engineering
- https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/7%3A_Microbial_Genetics/7.23%3A_Genetic_Engineering_Products/7.23B%3A__Applications_of_Genetic_Engineering
- https://www.slideshare.net/gnsk143/gene-transformation-methods
- https://www.brainkart.com/article/Identification-of-Recombinants---Recombinant-DNA-Technology_21278/

BCH-VI.E-16: ENVIRONMENTAL CHEMISTRY (THEORY)

MODULE	TOPICS	CONTACT HOURS	TOTAL HOURS
MODULE 1: Ecological Concepts and Pollutants	**1.1: Basic ecological concept** Biogeochemical cycles (C, N, O, P, S, Water), Food chain and food webs, Ecological pyramids; Productivity and eco-energetic (10% law) **1.2: Pollutants** Pollutants of water, air and soil and their sources Eco-toxicology: concept of permissible limits, ED50 & LD50; acute and chronic exposures.	**09** **06**	**15**

	Significance of dissolved oxygen, BOD, COD.		
MODULE 2: Impact of environmental pollution and its control I	**2.1: Pollution monitoring** Bioindicators: Concept and examples (indicators of water quality; air pollution indicators) Tests for assessing Genetic damage: AMES Test Concept and applications of biosensors in pollution detection **2.2: Air Pollution** Impacts of air pollution on human health, animals, plants and climate, Removal of gaseous contaminants: Bioscrubbers, Biotrickling filters and Biofilters/Biobeds **2.3: Water Pollution** Impacts of water pollution on human health, animals Wastewater treatment: Activated sludge process, Rotating biological discs, Oxidation ponds, Trickling filters	**05** **05** **05**	**15**
MODULE 3: Impact of environmental pollution and its control II	**3.1: Soil Pollution** Hazardous and non-hazardous solid wastes **3.2: Bioremediation** Bioremediation: Definition, Mechanism of microbial bioremediation, Microbial desulphurization of coal (indirect mechanisms). Microbial processes – enzymatic transformations, co-metabolism, microbial adhesion, biofilms, production of extracellular polymers and emulsifiers. Phytoremediation Removal of metal pollutants through sedimentation, sorption, precipitation, speciation conversion Biodegradation of xenobiotics: Aromatic hydrocarbons (benzene) and alkanes Biosorption: Principle, Use of Fungi and Algae Genetically engineered microorganisms: Super Bug (Pseudomonas species) Concepts of Reuse, Recycle and Recovery. **3.3: Composting and Vermitechnology** Principle concept and method	**01** **10** **03**	**15**

	3.4: Hospital waste management	**01**	

BCH-VI.E-16: ENVIRONMENTAL CHEMISTRY (PRACTICAL)

SR. NO.	PRACTICAL	NO. OF PRACTICALS
1.	Water quality by MPN method for sewage water	02
2.	Routine analysis of potable water sample using Presumptive, Confirmatory and Confirmed tests for coliform	04
3.	Determination of Dissolved Oxygen concentration of water sample by Winkler's method	01
4.	Determination of Biological Oxygen Demand (BOD) of the water sample	01
5.	Determination of Chemical Oxygen Demand (COD) of the water sample	01
6.	Determination of Total Solids (TS) of the given water sample	01
7.	Isolation of xenobiotic degrading bacteria by selective enrichment	03
8.	Visit to an effluent treatment plant (report)	02
	Total	**15**

REFERENCES for BCH-VI.E-16

Mandatory Reading

- Dara, S.S. A text book of Environmental Chemistry and Pollution Control. S. Chand Publishers

Supplementary Reading

- Khopkar, S. M. Environmental Pollution Analysis. John Wiley and Sons.
- Mitchell, R. and Cu, J. D. Environmental Microbiology. Wiley- Blackwell Publication
- Ramesh, K. V. Environmental Microbiology. MJP Publishers, India.
- Maier, R., Pepper, I. and Gerba, C. Environmental Microbiology. Academic Press.
- Moore J. W. and Moore, E. A., Environmental Chemistry. Elsevier.
- Jadhav, H.V. Elements of Environmental Chemistry: For Undergraduate Science Students of Indian University. Himalaya Publishing House.

- Satake, M., Sethi, S. and Eqbal, S.A. Environmental Chemistry. Discovery Publishing Pvt.Ltd,
- Salle, A.J. Fundamental Principles of Bacteriology. McGraw Hill.
- Frobisher, M. and Hinsdale, R.D. Fundamentals of Microbiology. Saunders.

Web References:

- https://openoregon.pressbooks.pub/envirobiology/