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ನಗರ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ

BENGALURU
CITY UNIVERSITY

Office of the Registrar, Central College Campus, Dr. B.R. Ambedkar Veedhi, Bengaluru – 560 001.
PhNo.080-22131385, E-mail: registrarbcu@gmail.com

No.BCU/BoS/Syllabus-PG/Science/ 332 /2025-26 Date: 23.09.2025

NOTIFICATION

Sub: Syllabus for the Post Graduate Courses in the Faculty of Science– reg

Ref: 1. Recommendations of the Boards of Studies in the Faculty of Science
2. Academic Council resolution No.04 dated.22.09.2025
3. Orders of Vice-Chancellor dated. 23.09.2025

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The Academic Council in its meeting held on 22.09.2025 has approved the syllabus prepared by different Board of Studies for the Post Graduate Courses in the Faculty of Science. Accordingly, the following CBCS Syllabus for the Semester PG Courses of Science Faculty are hereby notified for implementation effective from the academic year 2025-26.

Sl. No.	Programmes
1.	M.Sc. Chemistry – I & II Semester
2.	M.Sc. Biochemistry – I to IV Semester
3.	M.Sc. Physics – I & II Semester
4.	M.Sc. Mathematics – I to IV Semester
5.	M.Sc. Psychology– I to IV Semester
6.	M.Sc. Counselling Psychology – I to IV Semester
7.	M.Sc. Fashion & Apparel Design – I to IV Semester
8.	M.Sc. Zoology – I & II Semester
9.	M.Sc. Botany – I to IV Semester
10.	M.Sc. Computer Science – I & II Semester
11.	M.Sc. Speech Language Pathology – I to IV Semester
12.	Master of Computer Applications – I & II Semester

The detailed Syllabi for above subjects are notified in the University Website: www.bcu.ac.in for information of the concerned.

REGISTRAR

Copy to;

1. The Registrar(Evaluation), Bengaluru City University
2. The Dean, Faculty of Science, BCU.
3. The Principals of the concerned affiliated Colleges of BCU- through email.
4. The P.S. to Vice-Chancellor/Registrar/Registrar (Evaluation), BCU.
5. Office copy / Guard file / University Website: www.bcu.ac.in

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BENGALURU CITY UNIVERSITY

BE BOUNDLESS

Syllabus

for

M. Sc. Biochemistry
Choice based credit system (CBCS)

With effect from 2025 – 2026

Department of Biochemistry
Central College Campus
Bengaluru-560001

Preamble

Curriculum updating and adoption of innovative pedagogy are major components of academic excellence aimed at providing exposure tocutting edge technological advancements. The Board of Studies in Biochemistry (PG) is pleased to submit the revised syllabusfor M.Sc. Biochemistry course of the Bengaluru City University with effect from the academic year, 2025-2026.

Keeping in mind, the advancements in the subject over the past decade,the board has gone through the existing syllabus and has incorporated few recent developments to provide a broader perspective of the subject to the students.

Introduction

Seeds of the current fruits of modern biology, such as genomics, metabolomics, proteomics so on, were sown during previous century in the form of interdisciplinary collaborations among basic science disciplines contributing to landmark technological innovations. One of the basic science disciplines which lead to biotechnological advancement is Biochemistry, a hybrid of biology and chemistry. Considering its pivotal role in biological sciences, it is imperative to strengthen the fundamental concepts of biochemistry at Postgraduate level with clear and tangible pedagogical approaches.

The present curriculum for M.Sc. Biochemistry has been prepared with the objective of providing comprehensive knowledge of biochemistry including biochemical mechanistic basis of genetic and physiological processes, metabolism under normal and pathological conditions, drug discovery and drug design, and clinical research. Apart from its traditional approach of providing more weightage to metabolism and molecular physiological aspects, the curriculum has greater emphasis on recent advancement in techniques of biochemistry and molecular biology which enable the students to better understand the core biochemistry and the offshoots such as bioinformatics,genomics, metabolomics, and proteomics.

It is hoped, that during the two year program, typical attributes of a competent science postgraduate such as; spirit of inquiry, critical thinking, problem solving, analytical and scientific reasoning, research/industry related skills are discovered and nurtured.

The revised M.Sc. Biochemistry syllabus was approved by the Board of Studies in Biochemistry (PG)by circulation.

The Following members of the Board have provided their valuable input in framing the final syllabus. The BCU is happy to place on record their valuable contributions.

1. Prof. C. S. Karigar
   Dept. of Biochemistry,
   Bangalore University, Jnanabharathi Campus
   Bengaluru-560056

2. Prof. H. Manjunatha,
   Dept. of Biochemistry,
   Bangalore University, Jnanabharathi Campus
   Bengaluru-560056.

3. Prof. G. J. Satisha
   Dept. of Biochemistry,
   Kuvempu University, Shankaraghatta
   Shimoga-577451

4. Prof. Vadlapudi Kumar
   Dept. of Biochemistry,
   Davanagere University,
   Tholahunase
   Davanagere-577002

5. Prof. K. Kemparaju
   Dept. of Biochemistry,
   University of Mysore
   Mysore-570006

6. Dr.VishwanathChachadi
   Dept. of Biochemistry,
   Karnataka University
   Dharawad-570008

7. Dr. R. NageshBabu
   Dept. of Biochemistry
   Maharani Cluster University
   Bengaluru-560009.

8. Prof. V.R. Devaraj
   Dept. of Biochemistry
   Bengaluru City University
   Central College Campus
   Bengaluru-560001

Name of the Course:	**M. Sc. Biochemistry**
Duration of the course:	The course for the degree of M.Sc. shall consist of two academic years divided into four semesters.
Objective:	To Provide an in depth understanding of modern biology in terms of biochemistry, and the state of the art technological developments and their applications in metabolomics, genomics, proteomics, bioinformatics, clinical research, developmental biology and allied research and development domains.To hone practical skills,encourage intuitive and analytical skills, and research aptitude in order to prepare students for careers in research and development, academia and Pharma- biotech-based industries.
Eligibility for Entrance/Admission:	Candidate must have secured **40%** in aggregate and studied ***Chemistry OR Biochemistry*** as one of the cognate subjects securing 50% marks at B.Sc. level, and studied Biology at PUC OR10+2 level.
Intake:	As per the Regulations of the University
Admission:	Based on the performance in the Entrance test/ Guidelines prescribed by the University

SCHEME OF STUDY AND EXAMINATION								
Semester	Subject code	Title of the paper	Instruction hr/week	Exam marks			Duration of exam (hrs)	Credits
				Exam	CIA	Total		
I	BCHT- 01	Cell Biology	4	70	30	100	3	4
	BCHT- 02	Intermediary Metabolism	4	70	30	100	3	4
	BCHT-03	Analytical Biochemistry – I	4	70	30	100	3	4
	BCHT-04	Protein structure and Enzymology	4	70	30	100	3	4
	BCHSCT-05	Plant Biochemistry	3	70	30	100	3	2
	BCHP – 06	Metabolism and Cell Biology	8	70	30	100	4	4
	BCHP – 07	Bioanalytical techniques	8	70	30	100	4	4
Total credits for the semester								**26**
II	BCHT- 08	Molecular Biology	4	70	30	100	3	4
	BCHT- 09	Molecular Genetics	4	70	30	100	3	4
	BCHT-10	Analytical Biochemistry – II	4	70	30	100	3	4
	BCHT-11	Immunology and Microbiology	4	70	30	100	3	4
	BCHSCT-12	Biostatistics and Research Methodology	3	70	30	100	3	2
	BCHP – 13	Immunology and Microbiology	8	70	30	100	4	4
	BCHP – 14	Enzymology	8	70	30	100	4	4
Total credits for the semester								**26**
III	BCHT-15	Gene Regulation	4	70	30	100	3	4
	BCHT-16	Biochemistry of Cell Signalling	4	70	30	100	3	4
	BCHT-17	Bioinformatics	4	70	30	100	3	4
	BCHT-18	Open elective	4	70	30	100	3	4
	BCHP -19	Molecular Biology	8	70	30	100	4	4
	BCHP -20	Bioinformatics and Gene regulation	8	70	30	100	4	4
Total credits for the semester								**24**
IV	BCHT-21	Developmental Biology & Aging	4	70	30	100	3	4
	BCHT-22	Omic Technologies	4	70	30	100	3	4
	BCHT-23	Genetic Engineering	4	70	30	100	3	4
	BCHT-24	Biochemical Pharmacology	4	70	30	100	3	4
	BCHP-25	Genetic Engineering and Protein chemistry	8	70	30	100	4	4
	BCHPR- 26	Project (Report and Viva-Voce; 45+25)	8	70	30	100	-	4
Total credits for the semester-IV								**24**
Total credits for the course								**100**

Scheme for Continuous Evaluation:

Theory Paper (each)	
Attendance:	5 Marks
Tests[#]:	20 Marks
Seminar/assignment	05 Marks
Total:	**30Marks**

[#]*Two tests will be conducted and average of marks from two tests shall be computed for continuous evaluation*

Practical (each Practical)	
Attendance:	5 Marks
Tests[#]:	20 Marks
Record	05 Marks
Total:	**30 Marks**

[#]*Two tests shall be conducted and average of marks from two testsshall be computed for continuous assessment.*

Question paper pattern for End semester theory Examination

Instruction to the students: *Answer Section-A,and* ***any four questionseach*** *from section-**B**and-**C.***

Section-B

Question No. 1 shall have **nine** sub questions ***a*to *i***oftwo marks each, and the student has to answer ***any seven*** of them. **(2X7=14)**

Section-B

Question No. 2 to 6 carry **four marks** each and the student has to answer ***any four*** of them.

(4X4=16)

Section-C

Question No.7 to 11 will have two sub questions of **5+5** or **6+4**marks; student has to answer ***anyfour*** main questions.

(10X4=40)

Question paper pattern for end semester Practical Examination

Time: 4h **Max. Marks: 70**

1. Give the principle and procedure for …. 10
2. Perform any one of the experiments listed in the syllabus for the semester. 35
3. Viva-Voce. 15
4. Practical record. 10

Project Evaluation: **Max. Marks: 100**

Internals Max.30	Report Max. 50	Viva-Voce (Max.20)
to be provided by the Supervisor through the Chairman/Principal	To be evaluated for overall objective and quality of work presented in the report.	performance of the candidate

FIRST SEMESTER

BCHT– 01:Cell Biology

4 units (52 hrs)

UNIT-I

Cell organization and movement:

Microfilaments, structure of actin, dynamics of actin filaments, mechanism of assembly of actin filaments- branched and un-branched filament assemblies. Capping proteins, Arp2/3, intracellular cellular movement and actin polymerization, Role of cross-linking and adaptor proteins in actin bundling and membrane association.

Myosin and other actin-based motor proteins in myosin-powered movement, cell migration, spindle formation during mitosis, and chemotaxis.

Microtubules and intermediate filaments; Structure and organization of microtubules, dynamics, regulation of microtubule structure and dynamics, kinesin and dynein, microtubule-based motor proteins.

Cilia and flagella, microtubule-based surface structures. Intermediate filaments, lamins, keratins, desmins, and vimentins, coordination and cooperation between cytoskeletal elements.

5 hrs

Cell-Cell and Cell- matrix adhesion

Major adhesive interactions that bind cells to each other and to the extracellular matrix (ECM).

Families of cell adhesion molecules (CAMs); cadherins, immunoglobulin (Ig) superfamily, integrins, and selectins. Domains of CAMs, and their receptors. Junctions defining epithelial tissues; Occurrence, molecular structure and functions of tight junctions and gap junctions. Role of adherens junctions, spot desmosomes, and hemidesmosomes—are critical to cell–cell and cell–matrix adhesion and signalling. Cell-Cell- adhesion- constituents and role of cadherins and desmocadherins. Basal lamina- composition, role of type-IV collagen and laminin.

Structure and functions of fibronectin- organization of chains, RGD sequences, role of integrins in linking ECM and cytoskeleton to fibronectin.

Adhesive interaction of nonepithelial cells; ligand integrin interactions, model for integrin activation, molecular connection between ECM and cytoskeleton- muscular dystrophies.

Duchenne muscular dystrophy (DMD),

8 hrs

UNIT-II

Cell membrane and dynamics

Membrane models, composition and architecture of membranes, lateral diffusion of lipids, lipid rafts, membrane curvature and fusion. Membrane proteins- association with membranes, hydrophobic interactions with the lipid bilayer, and the use of hydropathy plots to predict transmembrane domains; topology of integral membrane proteins. Solute transport across membrane, osmosis, diffusion, passive transport facilitated by membrane proteins, Membrane transporters and channels; glucose transporter, chloride bicarbonate exchanger. Active transport- P-type, V-type ATP driven pumps. ABC-transporters, secondary active transporters. Aquaporins, ion-selective channels, CFTR. Targeting vesicles to particular organelles, exocytosis, lysosomes, plant cell vacuoles. Endocytosis, phagocytosis, receptor mediated endocytosis- LDL receptor, protein trafficking in endocytosis, recycling of synaptic vesicles, Post translational uptake of proteins by mitochondria and chloroplasts through TOM/TIM and TOC/TIC complexes.

*Sub-cellular organelles:*Structure and functions of intracellular organelles; including the nucleus, mitochondria. Single membrane bounds organelles- endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, vacuoles. Non-membrane bounds organelles- Ribosomes, nucleoles and centrioles.

13 hrs

UNIT-III

Cell Division

Phases and regulation of the cell cycle Cell Cycle, control by cyclin-dependent kinases through phosphorylation and dephosphorylation, and controlled proteolysis. Cell cycle check points and their control, Cdk inhibitors. Role of various cycle-CD, ubiquitin protein ligase –SCF and APC/C complexes in the control of cell cycle. M-phase and cytokinesis, overview of molecular events at prometaphase, metaphase, anaphase and telophase and cytokinesis, motor proteins for mitotic movement and cytokinesis. Overview and stages of meiosis.

6 hrs

Cell death and Cell renewal

Apoptosis and the genes required for it, initiator and effector caspases and their targets. Extrinsic and intrinsic pathways of apoptosis and regulation by the Bcl-2 family. Signalling pathway regulating apoptosis, PI 3-kinase pathway and cell survival. Cell death receptors., alternate pathways of programmed cell death, autophagy. Necroptosis, and ferroptosis.

Stem Cells and maintenance of adult tissues, proliferation of differentiated cells. Properties of stem cells, proliferation, formation of blood cells, renewal of intestinal epithelium. Embryonic stem cells, Culturing embryonic stem cells, Applications of stem cells in medicine, embryonic stem cells and therapeutic cloning. Induced pluripotent stem cells applications.

7 hrs

UNIT-IV

Cancer

Basic Properties of a Cancer Cell, development- tumorclonality stages of tumor development, causes of Cancer. Properties of cancer cells, density dependent inhibition, contact inhibition, Transformation of cells in culture.Tumor viruses and their roles: Hepatitis B and C in hepatocellular carcinoma, human, SV40, Adenovirus, and papillomavirus (HPV) in cervical cancer. Oncogenes, *raf,* and *rab* oncogenes, protooncogenes, retroviral oncogenes. Functions of oncogene products, oncogenes and ERK signalling pathway. Oncogenic activity of Wnt pathway, , activity of PML/RAR α oncogene protein. Tumor suppressor genes, identification, mutation in Rb during retinoblastoma development, functions of tumor suppressor gene products. Role of oncogenes and tumor suppressor genes in tumor development. Molecular approach to cancer treatment, molecular diagnosis, oncogene targeted therapies.

13 hrs

References

1. The Cell; A molecular Approach, 9thEdn., G. M.Copper, and Kennath Adams, Oxford University Press, (2022)
2. Becker's World of the Cell 10thEdn., J. Hardin, and J.P. Lodolce, Pearson Education Ltd, (2022).
3. Karp's Cell and Molecular Biology, 9thEdn., J. Ewasa and W. Marshall, Wiley, (2019).
4. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds], 6thEdn. Macmillan Publications (2012).
5. Molecular Cell Biology, 8thedn., H.Lodish, A. Berk, C. A. Kaiser, M. Krieger, A.Bretscher, H.Ploegh, A. Amon, K. C. Martin, (2016)
6. Molecular Biology of the Cell, Bruce Alberts, Alexander D Johnson, Julian Levis, David Morgan, Martin Raff, Garland Science (2014).
7. Essential Cell Biology,Alberts, B., Bray, D., Hopkin, K., Johnson, A.D., Morgan, D. Raff, M., Roberts, K., Walter, P.W. W. Norton and Company, (2018).
8. Autophagy: Cancer, Other Pathologies, Inflammation, Immunity, Infection, and Aging; M. Hayat (Ed.) Elsevier (2014).

BCHT-02: Intermediary Metabolism

4units (52 hrs)

UNIT-I

Bioenergetics and Biological Oxidation

Free energy and entropy. Phosphoryl group transfers and ATP. The electron transport chain - organization and role in electron capture. Importance of Coupled reactions, High energy compounds, simple problems. Oxidative phosphorylation - Electron transfer reactions in mitochondria. F1F0 ATPase; Structure and mechanism of action, ^{18}O exchange. Proton motive force and theMitchell hypothesis. The chemiosmotic theory. Inhibitors of respiratory chain and oxidative phosphorylation- uncouplers and ionophores. Partial reactions of oxidative phosphorylation, P/O ratios, sites of ATP production in electron transport chain. Regulationof oxidativephosphorylation. Mitochondrial transport systems- ATP/ADP exchange, malate/glycerophosphate shuttle, creatine-phosphate shuttle.

7hrs

Carbohydrate metabolism

Introduction, glycolytic pathway and regulation. Gluconeogenesis and regulation. Role of LDH. The TCA cycle and its regulation. Alternate pathways: HMP pathway, Enter – Doudoroff, Glucuronate and Glyoxylate pathway, Cori's cycle, futile cycles and anaplerotic reactions. Shuttle systems; glycerol-3-phosphate and malate-aspartate shuttle, Pasteur Effect, fermentative pathways in microorganisms. *Glycogen*-degradation, synthesis and regulation. Regulation of blood glucose level, hypo- and hyperglycaemia.

6hrs

UNIT-II

Lipid Metabolism

Oxidation of fatty acids - α, β and ω. Metabolism ofketone bodies - Formation, utilization, excretion and clinical significance. Fatty acid biosynthesis, Acetyl CoA carboxylase, fatty acid synthase, ACP structure and function. Energetics of fatty acid cycle, Metabolism of triglycerides, phospholipids and sphingolipids. Cholesterol - Biosynthesis, regulation, transport and excretion. Metabolism of lipoproteins. Eicosanoid metabolism.

6 hrs

General metabolic reaction of amino acids

Transamination, pseudo-transamination, glucose–alanine cycle, oxidative deamination (glutamate dehydrogenase), transdeamination, amino acid oxidase, and non–oxidative deamination (α–deaminase, dehydrase, asparaginase and glutaminase). Urea cycle- reactions and regulationand metabolic disorders.Biosynthesisof creatine and creatine phosphate, polyamines– putrescine, spermidine and spermine, glutathione (γ-glutamylcycle), physiologically active amines (γ–amino butyric acid, serotonin, α–histamine and catecholamines– dopamine, norepinephrine and epinephrine).

7hrs

UNIT-III

Degradation of amino acids: Amino acids forming pyruvate (alanine, glycine, threonine, cysteine), oxaloacetate (aspartic acid), α- ketoglutarate (glutamic acid, arginine, histidine and proline), succinyl CoA (valine and isoleucine), acetoacetate and/or acetyl CoA (leucine and lysine), pyruvate, formaldehyde, acetoacetate and/or acetyl CoA (tryptophan), and fumarate, acetoacetate and/or acetyl CoA (phenylalanine and tyrosine). Inherited disorders associated with glycine, aromatic, branched chain, basic and sulphur containing amino acid metabolism.

6hrs

Biosynthesis of amino acids: Biosynthesis of non–essential amino acids from pyruvate (alanine), intermediates of glycolysis (serine) and TCA cycle (aspartic acid, glutamic

acid).essential amino acid (tyrosine), non – essential amino acid (glycine, proline and arginine), and essential & non – essential amino acid (cysteine). Biosynthesis of essential amino acids from aspartate family of amino acids (threonine, lysine and methionine), pyruvate family of amino acids (valine and leucine), pyruvate and α–ketobutyrate family of amino acid (isoleucine), aromatic family of amino acids (phenylalanine, tyrosine and tryptophan) and histidine. Regulation of amino acid biosynthesis by sequential & concerted feedback inhibition.

7hrs

UNIT-IV

Nucleotides:*de novo*synthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Biosynthesis of deoxyribonucleotides Role ofribonucleotide reductase (mechanism), and polynucleotides. Inhibitors of nucleic acid biosynthesis.

6 hrs

Porphyrins –Biosynthesis and degradation of porphyrins. Production of bile pigments, disorders of heme metabolism.

4 hrs

Polyamines- Biosynthesis, catabolism, diseases associated with polyamine metabolism, protective functions.

3 hrs

References

1. Lehninger- Principles of Biochemistry; DL Nelson and MM Cox [Eds), 6thEdn. Macmillan Publications (2017).
2. Biochemistry VII Edition; Jeremy M Berg, John L Toymoczko and LubertStryer, W H Freeman and Co. (2010).
3. Physical Biology of the Cell, 2ndEdn. Rob Phillips, Jane Kondev, Julie Theriot, Hernan Garcia, Garland Publishers (2012).
4. Biochemistry; David Rawn, J,Neil Patterson Publishers (1989).
5. Methods of Enzymatic Analysis; Berg Meyer Vol. 1-X, (1974).
6. Nucleic acid Biochemistry and Molecular Biology, Mainwaring et al., Blackwell Scientific (1982).
7. The polyamines: past, present and future. Wallace HM. Essays Biochem. 2009;46:1–9. https://doi.org/10.1042/bse0460001.
8. Proteins Structures and Molecular Properties 2ndEdn. Thomas E. Creighton,W H Freeman and Co. (1993).
9. Biochemistry Ed. Donald Voet& Judith G. Voet, John Wiley & Sons Inc.(2010).

BCHT-03:Analytical Biochemistry – I

4 Units (52 hrs)

UNIT-I

Overview of Biochemical Investigations: Outline of strategies in biochemical investigations employing whole animal studies, isolated organs, tissues, and cell cultures. Cell disruption methods, investigations with isolated organelles;mitochondria and ER. Model organisms; *E.coli* and its mutants,yeast, *Ceanorhabditiselegans, Arabidopsis thaliana* and *Drosophilamelanogaster*.

Extractions; Preparation of extracts for biochemicalinvestigations, physicochemical properties of metabolites and drugs extracts from biological materials. Physico-chemical properties of solvents, solubility and miscibility, ionic bonds, and salting out. Partition, ionization, buffering and their effects on extraction. Choice of solvent for solvent extraction, mixed solvents, solid phase extraction.

13 hrs

UNIT-II

Centrifugation: Principle of centrifugation, the Swedberg equation, types of centrifuges and rotors. Density gradient centrifugation- Caesium chloride and sucrose density gradients; examples of separations, Sub-cellular fractionation. Design and working of analytical ultracentrifuges, sedimentation velocity and sedimentation equilibrium analyses. basic calculations of centrifugation.

Ultra-filtration; Principle,instrumentation and application. Dialysis,principle and uses of equilibrium dialysis. Precipitation; methods and applications.

Flow Cytometry; Principle and design of flow cytometer, cell sorting. Detection strategies in flow cytometry and parameters measured by flow cytometry.

8 hrs

Radio-isotopic methods of analysis: Atomic stability and radiation, types of decay, rate of radioactive decay, half-life, units of radioactivity. Detection and measurement of radioactivity, Design and applications of Geiger-Muller Counter, and types of scintillation counters. Disadvantages of scintillation counters, quenching, Chemiluminescenceand phospholuminescence counting efficiency, channel ratio, sample preparation, scintillation cocktails, Cerenkov counting. Autoradiography; principle and applications. Radio tracer techniques; radio-labeled nucleotides, metabolites. Pulse chase experiments, application of radio tracers in diagnosis (PET scanning).

5 hrs

UNIT-III

Microscopic techniques: Microscopy: Fluorescence microscopy, FRET, Biomolecular fluorescence complementation assay, FRAP (Fluorescence recovery after photobleaching); Confocal microscopy, Electron microscopy, CE Microscopy; Specialized techniques: Patch clamp, Metal shadowing, design and applications of scanning electron microscopy (SEM), Transmission electron microscopy (TEM), and cryo-electron microscopy. 3-D images, negative staining, single particle reconstruction.

9 hrs

Manometry: Instrumentation, types of manometry; Warburg constant volume manometer, Gilson's differential respirometer, applications.

4 hrs

UNIT-IV

Electrophoresis: Historical developments, principle, effect of applied voltage on the velocity of charged molecules, relationship between power generated in medium and resistance and current. Support media for electrophoresis- agarose, polyacrylamide gels. non-denaturing PAGE, activity staining for enzymes, zymogram, denaturing electrophoresis (PAGE), SDS-PAGE, SDS-PAGE in reducing conditions, determination of sub unit mass of proteins by SDS-PAGE. Buffer systems for native and denaturing electrophoresis. 2-D PAGE, urea electrophoresis, iso-electrofocusing.

Protein western blotting, immunodetection by enzyme-linked antibodies, fluorescentlabled antibodies.

*Electrophoresis of Nucleic acids:*Electrophoresis in DNA sequencing, Sanger- deoxynucleotide sequencing. Methodology, instrumentation and applications of Pulse-field electrophoresis, Foot-printing of DNA. RNA electrophoresis, principle and applications of capillary electrophoresis, microchip electrophoresis

13 hrs

References

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)
2. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
3. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
4. Biochemical Techniques 87thEdn., John F. Roby& Bernard J White Waveland Press Inc. (1987).
5. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland,(1969).
6. Principles of Protein Structure, Function, & evolution, Dickerson & Geis, 2nd Ed. Benjamin-Cummings (1983).
7. Basic Mathematics for Biochemists; Cornish Bowden, Oxford University Press(1998).
8. Biophysical Tools for Biologists*In Vivo* Techniques; John CorreiaH. Detrich, III Elsevier (2008).
9. Recent Advances in Electron Microscopy- Part-A; B.V. Venkartarmaprasad, and Steve Ludtke, Academic Press (2010).
10. Recent Advances in Electron Microscopy- Part-B; B.V. Venkartarmaprasad, and Steve Ludtke, Academic Press (2011).
11. Introduction to Electron Microscopy for Biologists; Terry Allen, Academic Press (2008).
12. Fluorescence Microscopy; AndaCarnea and P. Michael Conn; Academic Press (2014).

BCHT –04: Protein structure and Enzymology

4 units (52hrs)

UNIT-I

Structural properties of Proteins: Review of classification and structure of amino acids, acid – base properties of amino acids. Ionic properties of peptides and proteins. Peptide synthesis– reactive ester method and modified Merrifield solid phase synthesis.

Primary structure: Elucidation of primary structure of proteins– Determination of amino acid composition, end-group analysis, cleavage by enzymes and chemicals, Manual and modern methods of sequencing and reconstructing the protein sequence. Assignment of disulphide bonds.

Secondary structure: Peptide bond – structure and conformation, Ramachandran plot. Regular α – helix and other types of helices, β– pleated sheet, irregular, turns, loops and triple helical structures. Helix stabilizing and destablizing amino acids. Structure of fibrous proteins: α-keratin, and silk fibroin. Motifs (super secondary structure– triose phosphate isomerase, concanavalin-A and Rossmann fold) and domain structure (glyceraldehyde-3-phosphate dehydrogenase). Secondary structure of insulin, ribonuclease, lysozyme, myoglobin and chymotrypsin.

Tertiary structure: Forces stabilizing tertiary structure of proteins. Protein denaturation and renaturation.

Quaternary structure and symmetry: Structure and function of myoglobin and hemoglobin. Cooperative and allostery mechanism of oxygen binding to hemoglobin. Fibrous and Globular proteins, Structural Features of Membrane proteins; Protein Folding and its biotechnological applications: The "protein folding problem" Anfinsen's classical experiment; Folding curves and transitions; Models of protein folding; Assisted protein folding (Chaperones); misfolding and diseases; Abnormal hemoglobin– sickle-cell hemoglobin.

13 hrs

UNIT-II

Introduction to Enzymes

A short history of the discovery of enzymes. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups. Classification and Nomenclature, Specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemicalspecificity. Active site, Identification of amino acids at the active sitetrapping of ES complex, identification using chemical modification ofamino acid side chains and by site-directed mutagenesis. Enzyme assay– enzyme units, Katal, IU, coupled kinetic assay, immobilized enzymes. Enzyme localization. Criteria of purity of enzymes. Serine proteases, zymogen activation, multifunctional enzymes, oligomeric enzymes ,and multi- enzyme complexes.

4hrs

Enzyme kinetics

Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics & pre-steady-state kinetics. Initial velocity studies, rapid reaction techniques and relaxation technique.Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation. Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of Km, Vmax, kcat, and their physiological significance, Importance of kcat/Km.

Effect of pH & temperature on enzymatic reactions, Arrhenius plot, determination of activation energy.

Enzyme inhibition: Irreversible inhibition, Reversible inhibition-Competitive, uncompetitive,non-competitive, mixed and substrate inhibition. Graphical analysis- Diagnostic plots for the determination of inhibition type. Therapeutic use of enzyme inhibitors- Aspirin,

(irreversible inhibitors), Methotrexate (competitive inhibitor), camptothecin (uncompetitive inhibitor).

9 hrs

UNIT-III

Kinetics of bi- substrate reactions: Sequential mechanism, compulsory order and random order mechanism, non-sequential mechanism, ping pong mechanism, distinction between different kinetic pathways using primary and secondary plots. Inhibition studies in the characterization of bi-substrate reactions. Investigations of reaction mechanisms using isotopic exchange at equilibrium.

6hrs

Allostery of enzyme action:

Allosteric enzymes: Binding of ligands to proteins, Co-operativity, the Hill equation, Adair equation, Scatchard plot and equilibrium dialysis techniques. MWC and KNF models of allosteric enzymes, Sigmoidal kinetics taking ATCase as an example.. Regulation of amount and catalytic activity by pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Feedback inhibition-sequential, concerted, cumulative, enzyme multiplicity with examples.

7 hrs

UNIT-IV

Chemical nature of enzyme catalysis

General acid-base catalysis, electrostatic catalysis, covalent catalysis, intra-molecular catalysis and enzyme catalysis. Mechanisms of actions; lysozyme, ribonuclease, lactate dehydrogenase, serine proteases (chymotrypsin), sulfhydryl enzymes (papain), and multi-enzyme complexes (pyruvate dehydrogenasecomplex). Metal– activated and metallo-enzymes (mechanism of action of pyruvate kinase, carboxypeptidase – A).

Coenzymes and Cofactors – Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with specific examples.

9hrs

Enzyme Technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method. Designer enzymes- ribozymes and abzymes. Therapeutic use of streptokinase. Application of enzymes in industry- rennin, lipases, lactases, invertase, pectinases.

4 hrs

References

1. Fundamentals of Ezymology; 3rdEdn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012).
2. Fundamentals of Biochemistry Donald Voet John Wiley & Sons (2016).
3. Enzyme Kinetics and Mechanism. P. F. Cook and W. W. Cleland, Garland Science(2007).
4. Enzymes; Trevor Palmer, East – West Press Pvt. Ltd., Delhi(2004).
5. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland , Wiley-VCH Publishers(2000).
6. Enzyme Kinetics; Irwin H.Segel (1976) Interscience-Wiley.
7. Enzyme Kinetics; the Steady state approach; Engel, P.C. 2ndEdn. Champman and Hall(1981).
8. An Introduction to Enzyme and Coenzyme Chemistry; 2ndEdn., Tim Bugg, Blackwell(2004)
9. Protein Bioinformatics, Michael, G. M. Elsevier(2010).
10. Lehninger- Principles of Biochemistry; D. L. Nelson and M.M. Cox 8thEdn. WH Freeman & Co., (2021).
11. Biochemistry, Berg JM, Stryer L, Gatto,G, 8thedn,WH Freeman & Co., (2015).

BCHSCT –05:Plant Biochemistry

3 units (39 hrs)

UNIT-I

Introduction

Introduction to Plant Cells, Plant classification, phylogenetic tree of green plants, eukaryotic plant cell- molecular aspects of cell wall, cellular organelles with emphasis on mitochondria and plastids, microbodies, peroxisomes, and glyoxysomes.

5 hrs

Photosynthesis

Structure of chloroplasts, photosynthetic pigments, light energy utilization to produce ATP and NADPH. Photochemical property of chloroplasts, light harvesting and energy transfer. Components of photosystem-I and II structure and functions, regulation of light energy utilization,. Photo-inhibition, mechanism of ATP synthesis, Bason-Calvin cycle; working and regulation, photorespiration, enzymes, C4 photosynthesis- subtypes and regulation. Gas exchange in C3 and C4 plants. Crassulacean acid metabolism (CAM), diurnal changes in gas exchange, regulation of CAM.

8 hrs.

UNIT-II

Metabolism of storage carbohydrates

Sucrose- synthesis, mobilization, sucrose as regulator , transport, carriers, α, α trehalose-synthesis, catabolism, other oligosaccharides- trehalose. Tri-saccharides and tera-saccharides, raffinose, stachyose. Fructans- structure, biosynthesis, mobilization. Sucrose-starch interrelationship, other reserve polysaccharides- mannans, xyloglucans, α-glucan and β-glucans.

5 hrs

Nitrogen metabolism

Pathways of nitrogen assimilation, enzymes of nitrate assimilation- nitrate and nitrite reductases, regulation of nitrate assimilation. Factors affecting enzymes of nitrate assimilation,. Inter-convertible forms of nitrate reductase. Biological nitrogen fixation, properties of N2 fixing organisms, biochemistry of N_2 reduction, properties of nitrogenase- components, mode of action, active site. Ammonia assimilation and transport, nitrogenase protection against oxygen in different species. Role of leghaemoglobin, regulation of nitrogenase by NH4, O2, hydrogen evolution and uptake. Energetics of biological nitrogen fixation. Regulation of *nif* genes in *Klebsiellapneumonia*.

8 hrs

UNIT-III

Secondary metabolism

Structure, functions, classification and biosynthesis of alkaloids.Structure and functions of phenolics.Shikimate/arogenate pathway, phenyl propanoid pathway, hydroxyl cinnamate conjugates, hydroxyl coumarins, hydroxyl benzoates, flavonoids, lignins, lignans, and neolignans, tannins, and quinones. Isoprenoid metabolism; nomenclature, classification and occurrence, general pathway of biosynthesis. Monoterpenoids, biosynthesis, biological activity. Sesquiterpenoids, biosynthesis and functions-ABA. Diterpenoids- gibberellins- biosynthesis, and function. Triterpenoids- biosynthesis and function. Saponins- carotenoids, distribution, biosynthesis, regulation in higher plants. Polyterpenoids-degraded terpenoids.

7 hrs

Plant stress physiology

Plant stress, plant responses to abiotic and biotic stresses, salinity, water, heat, chilling, anaerobiosis, heavy metals, radiations and their impact on plant growth and metabolism, mechanisms of resistance to biotic stress and abiotic stress, antioxidative defence mechanism.

Plant defence:Genetic basis of plant-pathogen interactions, anti-R-Avr gene interactions and isolation of R genes, hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR). **6 hrs**

References

1. Introduction of Plant Biochemistry, by Goodwin T. W. and E.I. Mercer, Pergamon Press, Oxford, (1983).
2. Plant Physiology, 5thEdn, Lincoln Taiz and Eduardo Zeiger, Amazon press, (2012)
3. Biochemistry and Molecular Biology of Plants. 2ndEdn, Buchanan BB, Gruissem W & Jones RL. Ed. John Wiley (2000).
4. Plant Physiology and Development, Taiz, L., Moller, IM, & Murphy, A 7thEdn. Sinauer Associates (2023).
5. Lehninger- Principles of Biochemistry; D. L. Nelson and M.M. Cox 8thEdn. W H Freeman & Co., (2021).
6. Plant Biochemistry; 5thEdn. Heldt, H.W. &Piechulla, B. Academic Press (2021).
7. Plant Biochemistry and Molecular Biology,Heldt HS, Oxford University Press (1997)

BCHP – 06:Metabolism and Cell biology– I (4 Credits)

List of Experiments

1. Preparation of buffers; Acetate, phosphate and tris buffer.
2. Determination of pKa of weak acids and amino acids by pH metric titration.
3. Estimation of uric acid
4. Estimation of pyruvate
5. Estimation of creatinine
6. Determination of phytic acid.
7. Determination of catalase activity from liver/serum
8. Estimation of vitamin -C by dichlorophenol indophenol method.
9. Mammalian Cell culture (demonstration and report only)
10. Isolation of lymphocytes from blood cells.
11. Estimation of iron by Wongs method
12. Cell viability test by Trypan blue/MTT assay
13. Cell counting and viability (yeast/bacteria).

References

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011).
2. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
3. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology, 8thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
4. Biochemistry LabFax, Ed. J.A.A. Chambers and D. Rickwood,, Blackwell Science, (1993).
5. Protein Purification Applications, S.L.V. Harris and Angal IRL Press, (1990)
6. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
7. Biochemical Techniques 87thEdn., John F. Roby,& Bernard J White Waveland Press Inc. (1987).

BCHP – 07:Bioanalytical Techniques(4 Credits)

List of Experiments

1. Absorption spectra of proteins and nucleic acids and determination of molar extinctioncoefficient.
1. Estimation of reducing sugars (lactose in milk) by DNS method.
2. Estimation of protein by Lowry's method.
3. Estimation of inorganic phosphate by Fiske-Subbarao method.
4. Estimation of tyrosine by Millon's method.
5. Isolation of nucleic acid from cauliflower / sheep liver.
6. Estimation of DNA by Diphenylamine method.
7. Ascending descending and circular paper chromatography of amino acids /carbohydrates/purines and pyrimidines.
8. Two-dimensional chromatography of amino acid / carbohydrates.
9. Thin layer chromatography of carbohydrates / amino acids.
10. Gel–permeation chromatography of pigments/proteins.
11. Separation of proteins by non-denaturing PAGE.
12. Determination of molecular weight of Proteins by SDS–PAGE
13. Separation of isoenzymes by isoelectric focusing
14. Ion exchange chromatography of nucleic acids / proteins.
15. Effect of solvent system on the Rf value of solutes using TLC.

References

1. Biochemical Calculations, Irwin H.Segel (1976) 2nd Ed. Jhon Wiley and Sons.
2. Methods in Enzymology; Colowick , S.P. et al., [Eds.] (1987) Vol. 152, Academic Press.
3. Modern Experimental Biochemistry R.F.Boyer [Ed.] (1986) Addition Wesley.
4. Methods of Enzymatic Analysis; Berg Meyer (1974) Vol. 1-X,
5. Basic Biochemical Laboratory Procedures and Computing, R. Cecil Jack, Oxford University(1995).
6. Analytical Biochemistry; D.J.Holme and H. Pick Longman(1983).
7. Biochemical Techniques 87thEdn., John F. Roby& Bernard J White, Waveland Press Inc. (1987).
8. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
9. Bioanalytics, Friedrich Lottspeich, Wiley-VCH (2018).

SECOND SEMESTER

BCHT – 08: Molecular Biology

4 units (52 hrs)

UNIT-I

Introduction: Central dogma of molecular biology, its modification,Relationship between genes and proteins. Nature of genetic material, experiments confirming DNA as genetic material. RNA as genetic material. Variation in size and shape of genomes; ultracentrifugation and electron microscopic methods to study the shape and size of genomes. Size of genome and genetic capacity; C-value paradox. Organelle genomes, Genome sequence and gene numbers, *Topological problems;*Topo-isomerases, gyrases and helicases- assay, mechanism and classification.

6hrs

Prokaryotic DNA Replication: Replicon, linear and circular replicons, unidirectional and bidirectional replication, experimental methods, mapping origin of replication, semi-conservative and semi-discontinuous replication; experimental demonstrations.

Priming DNA synthesis in bacteria; experimental evidence, components of primosome, Initiation at origin (*oriC*) of *E. Coli*. Isolation of replication intermediates. Regulation of initiation at origins, sequestration of origins after replication, role of helicase.

Enzymology of DNA replication; DNA polymerases, chemistry ofnucleotide polymerization and in vitro assay. Properties and functions of DNA polymerase-I, Korenberg enzyme. Hand-palm structure of DNA polymerases. Processivity and fidelity of replication. Conditional lethal mutants, identification of replicative polymerase. Subunit composition of polymerase –III holoenzyme, functional characterization of subunits. Mechanism of replication of *E. coli* DNA-trombone model, termination of replication. Bacterial replication and its connection to cell cycle. Replication of DNA ϕX174 in *E.coli.*

7 hrs

UNT-II

Eukaryotic DNA replication

Replicative and repair enzymes of eukaryotes. Initiation, elongation by eukaryotic DNA polymerases.SV-40 replication using eukaryotic replicative machinery. Isolation of ARS of yeast, ORC, Licensing factors and control of eukaryotic DNA replication, role of MCM proteins. Replication of organelle genomes, maintenance of ends of linear DNAs; telomeric DNA and telomerase. Regulation of eukaryotic DNA replication and inhibitors of DNA replication.

3hrs

DNA repair: Experimental demonstration of repair in prokaryotes,Weigle reactivation, damaging agents and damage recognition, direct repair, Miss-match repair assay for mismatch repair, Base excision repair (BER), Nucleotide excision repair (NER) systems; components and mechanism of repair, error prone/SOS repair, *umu* genes and Rec-A. Eukaryotic BER and NER, controlling direction of mismatch repair, DNA damage in chromatin, molecular basis of xeroderma pigmentosa.

4 hrs

Transcription in prokaryotes: Prokaryotic RNA polymerase; molecular composition, and mechanism of transcription. Initiation of prokaryotic transcription; Structure and function of sigma factor, sigma cycle, FRET assay for sigma movement. Promoter clearance, role of α-subunit in upstream element recognition. Foot-printing of upstream elements with α-subunit. *Elongation:* Role of β-subunit in phosphodiester bond formation. Structure of elongation complex and core polymerase. Termination of transcription: Rho- dependent and independent, termination, RNA product under Rho dependent termination.

6 hrs

UNIT-III

Transcription in eukaryotes: Nuclear RNA polymerases- rat liver RNA pol. Sensitivity to α-amanitin and metal ions. Subunits of RNA pol-II (yeast pol-II). Heterogeneity of Rpb1 subunit. Formation and maintenance of transcription bubble.

Eukaryotic promoters: Class-II core promoter, modular organization, SV40 early promoter. Linker-scanning mutagenesis, TATA Box, downstream promoter elements, proximal promoter elements, TATA-less promoters and initiators. Class-I and Class-III promoters, Enhancers and silencers.

Class-II pre-initiation complex, foot-printing DAB. Components of TFIID, TBP and associated factors (TAFs). Phosphorylation of CTD of RNA pol-II, Mediator complex and RNA pol-II. Elongation factors: Effect of TFIIS, reversal of transcription arrest, proof reading of transcripts. Composition and working of transcription units at class-I and class-III promoters.

RNA processing: split genes, RNA splicing: R-looping experiments, splicing signals, effect of splicing on gene expression. Splicing of nuclear mRNA precursors. Mechanism of RNase T_1 and T_2, direct evidence for a branched nucleotide.

Spliceosomes: snRNPs, detection of spliced product by RNase protection assay. Spliceosome assembly and function. Alternative splicing, exon-intron definition. Commitment of precursor RNA to splicing, role of SR protein. Yeast two hybrid assay. Role of RNA pol-II in splicing, control of splicing. Self-splicing RNase. Group-I introns, demonstration of exon ligation, Group-II introns.

Post transcriptional modification of mRNA: Structure of cap, purification of caps, capping substrate. Cap structure of Reovirus, functions of cap.

Polyadenylation: Function of poly A, mechanism and signals for polyadenylation. Cleavage and Polyadenylation for mRNA elongation of poly-A, poly-A binding protein (PABP),turnover of poly-A. Coordination of mRNA processing with Coupling termination and mRNA 3' end processing.

13 hrs

UNIT-IV

Genetic code

Breaking the code, experimental results leading to deciphering genetic code, coding properties of mRNA, Co-linearity of genes and proteins, Coding properties of tRNA, triplet binding assay, use of synthetic oligo nucleotides (works of Khorana and Nierenberg), base pairing between codon and ani-codon, Wobble base pairing. Properties of genetic code, deviation from universal genetic code.

5 hrs

Ribosomes and Translation

Prokaryotic ribosomes; molecular components, *in vivo* assembly, dissociation of subunits, and polysomes. Eukaryotic components and their assembly, organelle ribosomes.

Initiation of protein synthesis in prokaryotes, Shine-Dalgarno sequence, formation of 30 S and 70 S initiation complexes; effect of GTP hydrolysis by IF2. exchange of ribosomal subunits. Eukaryotic translation initiation-scanning model, eukaryotic initiation factors, role of eIF4E, F, and G. Formation of stable 48S initiation complex, role of eIF1 and eIF1A, toeprint assay, direction of polypeptide synthesis and mRNA translation. Control of translation in bacteria and eukaryotes. Amino acyl-tRNA synthetases, formation of ternary complex among amino-acyl tRNA, EF-T, and GTP, three site model of ribosome, peptide bond formation, G-protein and translation, stop codon suppression, release factors, aberrant termination, non-stop mRNAs, termination codon, no-go-decay of mRNA. Inhibitors of prokaryotic and eukaryotic translation. Post-translational modifications of proteins. Mechanism of translational control.

8 hrs

References

1. Lehninger Principles of Biochemistry; D. L. Nelson and M.M. Cox 8thEdn. W H Freeman & Co., (2021).
2. The Bacteriophages; Richard Calendar, 2nd Edition, Oxford University Press (2005).
3. Basic Virology; Wagner and Hewlett; Blackwell Science, (2004)
4. Lewin's Gene XII; Krebs, Jocelyn E. Burlington, MA: Jones & Bartlett Learning, (2018).
5. Molecular Biology of the Cell, Alberts et al., Garland Publications, (2012).
6. Molecular Biology, David Freifelder, Narosa Publishers, (1997).
7. Molecular Biology 5thEdn.,Robert F. Weaver, McGraw Hill (2018).
8. Microbial Genetics; Maloy et al., Jones and Bartlett Publishers, (1994).
9. Principles of Developmental Genetics; S.A. Moody, Academic Press (2007).
10. Molecular Biology of Gene; Watson, J.D. et al.,7thEdn. Pearson Education; (2004).
11. Principles of Virology; S.J. Flint et al., ASM Press (2000).
12. Biochemistry and Molecular Biology; 5thEdn. D. Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott Oxford University Press (2014)
13. Biochemistry 5thEdn. Jeremy M. Berg, John L. Tymoczko, LubertStryer (2011).
14. Genome Stability: DNA Repair and Recombination; James Haber, Garland Science (2013)

BCHT –09: Molecular Genetics

4 units (52hrs)

UNIT-I

Introduction to Genetics

Molecular Evolution: History of Genetics and Evolutionary biology, Neutral evolution, molecular divergence and molecular clocks; Molecular tools in phylogeny, classification and identification; origin of new genes and proteins; Gene duplication and divergence. Mendelian and non-Mendelian principles: Laws of Inheritance, autosomal inheritance, Chi square analysis, Phenocopy, Inheritance of mitochondrial and chloroplast genes, X- linked Inheritance, Morgan's discovery and Maternal Effect - Sex influenced and sex determined traits.

6 hrs

Genome Mapping

Mapping in Bacteria, bacteriophages and yeast:- Mapping genes by interrupted mating, deletion mapping Chromosomal Mapping in Eukaryotes: G/Q banding, FISH, comparative genome hybridization, long range restriction mapping, high resolution mapping STS/EST/MS/SNP/sequencing; Linkage maps, - Physical Mapping- restriction mapping, Linkage analysis (RFLP/MS/SNP), Chromosome mapping based on recombination frequency datamapping with molecular markers, somatic cell hybrids.

7 hrs

UNIT-II

Developmental Genetics

Genetics of drosophila embryo development, axes and pattern formation in drosophila, Homeotic induction, Floral development in plants, Sex determination, Dosage compensation and X-inactivation in human female, Genomic imprinting. Epigenetic regulation and inheritance – Chromatin modification, Euchromatin, HeterochromatinDNA methylation, histone acetylation, histone methylation, non-coding RNAs in chromosomal remodelling and gene activity.

6 hrs

Human Genetics: Genome organization, Structure of chromosome, Pedigree analysis-Pedigree analysis- Mendelian inheritance and exceptions; Chromosomal analysis (in vitro, in vivo), gene mapping, physical mapping, mapping markers,

Genetic disorders- Autosomal Dominant, Recessive and X- Linked and other

Maternally inherited Diseases- Pedigree analysis- Genetic testing –Direct testing, –Karyotyping,

Prenatal diagnosis - Gene tracking, Detection of Single Nucleotide Polymorphism. Haplotype andLinkage Equilibrium, Quantitative genetics: Polygenic inheritance, heritability and its measurements,QTL mapping, LOD score for Linkage testing.

7 hrs

UNIT-III

Quantitative Genetics: Human quantitative traits, discontinuous traits and continuous traits,X-linked traits in humans. Identification of sex chromosomes, XX,XY, mechanism of sex determination. Breeding analysis, genetics basis of quantitative variation, Multiple factor hypothesis and analysis of polygenes. Genotype-Environment Interaction and models for their measurement, estimation of Heritability Index. Human genetic diversity- Methods of study – Biochemical/molecular genetic markers.

7 hrs

Population Genetics

Populations, Gene pool, Gene frequency; Hardy-Weinberg Law; Adaptive radiation, Isolating mechanisms, Speciation,Allopatricity and Sympatricity; Convergent evolution. Sexual selection; Human Impact in Genetic Variation, Co-evolution.

Mutations- molecular & phenotypic perspective. Chromosomal mutations- deletion, duplication, inversion, translocation, ploidy and their genetic implications.

6 hrs

UNIT-IV

Bacterial genetics

Transformation; Discovery of Transformation, Competence, Regulation of competence in B. subtilis, Experimental evidence for models of natural transformation, Plasmid transformation and phage transfection of naturally competent bacteria, Role of natural transformation, Importance of natural transformation for forward and reverse genetics, artificially induced competence.

4 hrs

Conjugation:Classification of self-transmissible plasmids, Mechanism of DNA transfer during conjugation in Gram negative bacteria, Chromosome transfer by plasmids, Formation of Hfr strains, Transfer of chromosomal DNA by integrated plasmids, Chromosome mobilization, Prime factors, mapping genes by interrupted mating, fine structure analysis of genes, Transfer system of Gram positive bacteria, Plasmid attracting pheromones.

4 hrs

Viral genetics

Basics concepts of bacteriophage growth and assay methods. Classical concepts of gene structure and function derived from bacteriophage genetics. Host-phage interaction mechanisms. Understanding gene regulatory circuits using bacteriophages as model systems.Decision making modules that control fate of lysogenic bacteriophages such as re-appropriation of host metabolism by bacteriophages using T4 as the model system.

Evolution of host immune responses against bacteriophages. Innate immunity and the role of altruism in host defensive mechanism. Acquired immunity against bacteriophages – CRISPr-Cas based immunity.Horizontal gene transfer mediated by bacteriophages.Specialized and generalized transduction. Applications of phages in control of Antibiotic resistance, Phage therapy and its potential.

5 hrs

References

1. Genetics, Analysis and Principles, 7thEdn, Robert Brooker, McGraw Hill (2021)
2. Human Molecular Genetics. Strachan, T. and Read, A. Garland Science (2018)
3. Introduction to Genetic Analysis, Griffiths, A.J.F., Wessler, R.S., Carroll, S.B., Doebley, J. W.H. Freeman and Company, (2015)
4. Genetics, Strick Berger, M.W. (1990) 3rdedn. McMillan.
5. Human Molecular Genetics; Peter Sudbery, (2002) Prentice Hall.
6. Genetics,; From Gene to Genomes, 8thEdn., M.L. Goldberg and J.A. Fischer, McGraw Hill (2023)
7. Discovering Genomics, Proteomics andBioinformatics, Campbell AM &Heyer LJ, 2ndEdn. Benjamin Cummings,(2007).
8. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011).
9. Principles of Developmental Genetics; S.A. Moody, Academic Press (2007).
10. Human Molecular Genetics, T. Strachan, Garland Science (2019).
11. Essential Genetics: A Genomics Perspective; Daniel L. Hartl, 6th Edition, Jones and Barlett Learning (2012).
12. Bacterial and Bacteriophage Genetics; Edward A. Birge, 5th Edition, Springer (2006).
13. Nucleosome Histone, and Chromatin; Part-A; Carl Wu and C. Allis, Academic Press (2012).
14. Evolution of the Human Genome I, Saitou, The Genome and Genes**,** Naruya (Ed.) Springer (2017).

BCHT – 10: Analytical Biochemistry – II

4 units (52hrs)

UNIT-I

Chromatography: Introduction, partition coefficient phase systems, liquid and solid phases, principle procedure and application of paper chromatography, column chromatography; retention, resolution, physical basis of peak broadening, plate height equation, capacity factors, peak symmetry.

Modes of chromatography: Ion exchange, ion exchange matrices, examples of cation and anion exchangers, chromate-focusing. Gel filtration: fractionation range and matrices, determination of native mass of protein.

Hydrophobic interactions and affinity chromatography: Affinity ligands, immobilization of ligands. Activation of matrices, coupling affinity ligands (example–GSH). Metal affinity chromatography, His tag, open column chromatography, hydroxylapatite chromatography.

HPLC: Instrumentation, injectors, mobile phases in HPLC, two dimensional HPLC, factors affecting resolution in HPLC chromatography. Separation modes: normal and reverse, gradient reverse phase, ion suppression and ion pairing. Chiral-HPLC, chiral columns. Detectors: UV, visible fluorescence, electrochemical detectors. Fast protein liquid chromatography (FPLC).

*Thin layer chromatography:*Introduction; phases used in TLC preparative TLC, metabolic profiling, solvent systems for TLC. Detection of compounds on TLC plates.

13hrs

UNIT-II

Spectroscopic techniques

Wave particle duality of light, electromagnetic spectrum, transition in spectroscopy. Principle, design and application of UV-Vis spectrophotometry. Principle, design and application of fluorescence spectroscopy. Measurement of fluorescence and chemiluminescence, use of fluorescence in binding studies. Spectroscopy techniques using plane polarized light, circular dichroism (CD), equipment for CDmeasurement, CD of biomolecules (proteins) and LD (linear dichroism)of biomolecules.

IR spectroscopy:Physical basis of IR spectroscopy. Instrumentation, use of IR in structure determination, Fourier transfer, IR spectroscopy, Raman IR spectroscopy.

ESR:Principle, measurement of ESR spectra uses of ESR in chemistry.

NMR:Principle, effect of atomic, identity on NMR, chemical shift, spin coupling NMR, measurement of NMR spectra, biochemical application of NMR.

Mass spectroscopy:Principle, overview of MS- experiment, ionization modes, equipments in MS analysis (Identification of metabolites) MS of protein/ peptides. Interfacing MS with other methods; MS/MS, LC/MS, GC/MS, electrophoresis/MS. MS and heterogeneity in proteins, peptide mapping, post translation modification analysis, determination of disulphide bridges, analysis of DNA compounds.

13 hrs

UNIT-III

Gas chromatography: Principle and design of instrument. Factors affecting GC, stationary phase, mobile phase, column length, diameter, film thickness, flow rate temperature, sample introduction. Detectors: flame ionization, thermal ionization, electron capture, mass selective detection. GLC; principle and application.

6 hrs

Biocalorimetry: Arrhenius equation, determination of energy of activation from Arrhenius plots. Main thermodynamic parameters; enthalpy, and entropy. Isothermal titration calorimetry, design of experiments, determination of change in heat capacity, eg., oligomerization of valinomycin, DNA duplex. Determination of specific heat from enthalpy. Differential scanning

calorimetry; design of experiment, application of DSC, microcalorimetry. Determination of thermodynamic parameters by non-calorimetric data.

7 hrs

UNIT-IV

Animal Cell Culture techniques

History, biology of cultured cells, culture media-composition, preparation and development,cell isolation, establishment and evaluation of cell culture, sterilization techniques for ATClab. Animal cell lines: Establishment, properties and use of cell lines, cultures of tumor cells;Cryopreservation of animal cells. Culture and scale up: Monolayer culture-surfacerequirements, gas phase requirements, capillary culture units, suspension culture scale up.

Somatic cell fusion: Methods of somatic cell fusion, selection, properties of cell hybrids and their applications.

Cell-Based Assays- Proliferation assays, Apoptosis assays Reporter gene assays. Clinical Applications- Stem cell culture and regenerative medicine. Cell therapy and personalizedmedicine. Current Trends and Emerging Technologies- 3D cell culture, Organoids andmicrofluidics

13 hrs

References

1. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)
2. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology 8thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
3. Biochemistry and Molecular Biology; 5thEdn. D.Papachristodoulou, A. Snape, W.H. Elliott, and D. C. Elliott, Oxford University Press (2014)
4. Discovering Genomics, Proteomics andBioinformatics, Campbell AM &Heyer LJ, 2ndEdn. Benjamin Cummings,(2007).
5. Culture of animal cells: A manual of Basic Technique, 5thedn.,Freshney RI, Willey Liss Publisher (2005).
6. Tissue Engineering: Essential for DailyLaboratory Works, Minuth WW, Strehl R, Schumacher K, Willey Publisher (2005).
7. Principle and Practice of Bioanalysis; Richard F. Venn (Ed.)Taylor and Francis (2000).
8. Hydrophobic interaction Chromatography, Principles and Methods, Stuart E. Builder,Amarsham-Pharmacea Biotech(1993).
9. Biochemical, Physiological, and Molecular Aspects of Human Nutrition, StipanukElseveir (2012).
10. Protein Bioinformatics; M. Michael Gromiha, Academic Press (1983).
11. The Physical Basis of Biochemistry: The Foundations of Molecular Biophysics, 2ndedn. R. R. Bergethon, Springer, NY(2010).
12. Isoelectric Focusing; Theory, Methodology and Applications; P.G. Righetti , Elsevier (2013).
13. Fluorescence Spectroscopy; Ludwig Brand and Michael Johnson, Academic Press (2008).

BCHT – 11: Immunology and Microbiology

4 units (52hrs)

UNIT-I

Infection: Types of infection and the nature of infective agents. Nonspecific host defence mechanisms including anatomical barriers, lysozyme, and other antimicrobial agents. Phagocytosis and phagocytic cells, such as neutrophils, monocytes and macrophages.

Immunity:States of immunity; innate and acquired immunity, naturally and artificial acquired passive and active immunity. Immunization practices, use of toxoids, killed and attenuated organisms. Surface components and newer vaccines, production of vaccines.

Cellular basis of immunity: immunological memory, specificity, diversity, discrimination between self and non self, primary and secondary lymphoid organs, cell mediated and humoral immune responses involving T and B lymphocytes, mechanism underlying autoimmune reactions.

Antigen and antibody*:*antigen, antigenic determinant, immune-potency, structure of antibody,constant and variable regions, Fab, F(ab2) and Fc fragments, different classes of antibodies and their functions, fine structures of antibodies,X- ray diffraction studies, isotypes, allotypes and idiotypes.

13 hrs

UNIT-II

Molecular Immunology

Theories of antibody formation including clonal selection and network theory, Genetics of antibody diversity with reference to germ line and somatic mutation theories.Immunoglobulin genes, monoclonal and polyclonal antibodies, poly reactive antibodies, catalytic antibodies, abzymes.

MHC: Organization, MHC molecules and genes, cellular distribution, regulation of MHC and immune responsiveness, class switch of Ig genes. MHC and susceptible deficiency diseases. Antigen processing and presentation.

T-cell: Receptor complex structure, T-cell maturation, activation and differentiation. Cell death and T-cell population.

B-cell: Receptor complex structure, T-cell maturation, activation and differentiation.

Complement activation: Pathways, regulation of complement system, Biological consequences of complement activation, complement deficiencies.

Antigen- Antibody interactions: In vivo - cross reactivity, In vitro: precipitants, agglutinants, Dot blotting and immuno-diffusion tests with antibodies, immune-electrophoresis, . Rocket electrophoresis, counter immune-electrophoresis,RIA, ELISA- techniques and applications, western blotting. FACS.

13 hrs

UNIT-III

Cytokines: Structure and function of IL, IFN, TNF, CSF, cytokines receptors, cytokine antagonists, cytokines related diseases.Cell mediated immunity: CTL mediated cytotoxicity, NK cell mediated toxicity, delayed type hypersensitivity. Immunological tolerance.

Leukocyte mediated immune response: Cell adhesion molecule, Lymphocyte and neutrophils, extravasation, mediators of inflammation, inflammatory process.

Hypersensitivity reactions: Type- I, II, III and IV. Hypersensitivity diseases. Immunity to infectious diseases : viral - influenza, bacteria – tuberculosis, parasite – *Plasmodium falciparum*, Helminthes.

Autoimmunity : Autoimmune diseases in human, animal models, mechanism of induction of autoimmunity, therapy.

Transplantation: Types, Genetics of transplantation, Graft versus host reaction, tissue matching and immunosuppressive agents, clinical manifestation, therapy and bonemarrow transplants, organ- transplants. Immunodeficiency diseases: B-cell, T-cell, SCID, Pathogenesis, diagnosis and treatments of AIDS.

Vaccines*:* Active and passive immunization, whole organism vaccines, recombinant vector vaccines, DNA vaccines, synthetic peptide vaccine, multivalent sub-unit vaccines.

Cancer immunology: Tumor antigens, immune response to tumors, tumor evasion, cancer Immunotherapy-chimeric antigen receptorCAR-T cell therapy.

13 hrs

UNIT-IV

Microbial Biochemistry; Morphology and structure of bacteria, gram positive and gramnegative organisms. Sterilization, nutritional requirements and growth characteristics of bacteria, media for growing bacteria and fungi.Enrichment culture techniques for isolation of chemoautotrophs, chemoheterotrophs and photosynthetic microorganisms.

3 hrs

Foodand Diary Microbiology:Food spoilage, food preservation, fermented foods, exotoxins produced by bacteria. Contamination of milk by microbes,Bacterial count, reactions occurring in milk, Pasteurization and sterilization. Fermented milk products, cheese

3 hrs

Viruses: –General structure, and classification of plant, animal and bacterial viruses.

Bacteriophages; one step growth experiment, single burst and premature lysis experiments, productive cycles of λ and ϕx-174 viruses, RNA phages, isolation and cultivation of bacterial viruses.Plant viruses- transmission, effect on plants, common diseases, TMV. Slow viruses and DI viruses- discovery and importance.Animal viruses- productive cycle of DNA viruses- parvo, adeno. RNA viruses- polio, Influenza Retrovirus (RSV). Persistent chronic and acute viral infections. Inhibition and inactivation of viruses by physical and chemical agents.

Interferon- types, nomenclature and classification, induction, antiviral effect, antiviral proteins-ds RNA dependent and independent pathways. **7 hrs**

References

1. Antibodies– A Laboratory Manual; E. D. Harlow, David Lane, 2nd Edn. CSHL Press (2014).
2. Primer to the Immune Response, TakMak Mary Saunders Bradley Jett, Elsevier (2014).
3. Cellular and Molecular Immunology (8th Edn.), A. Abbas, A. Lichtman, S. Pillai, Saunders, Elsevier, USA(2014).
4. Roitt's Essential Immunology; Ivan, M. Rohitt&Petrer J Delves (2001) Blackwell Science.
5. Immunology: Roitt et al., Mosby(2001),
6. Kuby's Immunology; Oven, Punt, Stranford, 8th Edn. W. H. Freeman (2022).
7. Immunology at a Glance: J.H.L. Playfare [ed.] Blackwell Science, (1987).
8. Immunology; Jan Klein [Ed.], Blackwell Science (1990).
9. Microbiology; Prescott, Harley and Klein, McGraw-Hill(2003).
10. Understanding Immunology (Cell and Molecular Biology in Action); Peterwood, Pearson Education Ltd. (2006).
11. Microbial physiology, 4th Edn. Albert G. Moat, John W. Foster and Michael P. Spector, Wiley-Liss (2002).
12. Microbiology; Lansing M. Prescot, Hartley and Klein, 5th Edn.McGraw Hill (2002).
13. Applied Microbial Physiology: A practical approach Rhodes and Stanbury (1997) IRL Press.
14. Microbiology, Pelczer, Reid and Kreig Tata McGraw Hill (1996).
15. Biology of Microorganisms, Brock Prentice Hall (1996).

BCHSCT – 12: Biostatistics and Research Methodology

3 units (39 hrs)

UNIT-I

Probability Theory Data Representation

Probability Theory: Concept of probability, probability theorems, permutations and combinations, conditional probability, Bayes theorem, Concept of Prior and Posterior in Baysian statistics, Contingency Table analysis, ROC curves, Applications to Biological data.

Data representation: Qualitative and quantitative data types, tabulation and visual display ofdata, Plotting line plot, scatter plot, frequency plot, frequency histograms, pie-chart, heat map and 3-D plots.

9 hrs

Descriptive Statistics

Measures of central tendency, Measures of variability, concept of probability distributions, Concept of populations and random samples, Binomial, Poisson, Hypergeometric, Gaussian distributions and their properties.

4 hrs

UNIT-II

Hypothesis testing and error analysis

Random sampling, central limit theorem, confidence intervals and p-value.Testing of hypothesis: Fundamentals of hypothesis testing, Distributions of difference inmeans, rations and ratios of variances, t-distribution, F-distribution, Parametric tests for one,two and many samples: Z-test, t-tests and ANOVA. Nonparametric tests for one, two and manysamples: Wilcoxon tests, Mann-Whitney test and Kruskal-Wallis test. Chi-square goodness offit test, Hypergeometric and Chi-square tests on contingency tables.

Error Analysis: Error analysis and error estimates for formulas, Type-I and Type-II errors,power of statistical test. Error bars on plots. Hypothesis testing of data from biologicalexperiments with examples.

13 hrs

UNIT-III

Regression analysis

Linear regression, least square fit to a linear, polynomial and exponential curves, regression analysis of few data sets from biological experiments

4 hrs

Research methodology

Research Basics: definition, purpose and types; Process of Research and Dimensions of research, research problem, research questions, Research design, tools of research; methods of research, systematic review of literature, preparation of research proposal/ synopsis. Mechanics and precautions of writing research reports for scientific journals, popular magazines, seminars/symposia/conferences/workshops, poster session. Research Ethics (Issues relating to referencing and documentation, copyrights, plagiarism), Impact Factor, H-Index, Citation Index, references/bibliography, structuring the thesis, use of software in thesis writing.

6 hrs

Funding Agency (National and International), Fellowships at national and international levels, conferences and symposium, testimonial, reference letter, preparation of manuscript and its submission, writing of innovative project proposal and its submission.

3 hrs

References:

1. Practical Biostatistics; Mendel Suchmacher and Mauro Geller, Academic Press (2012).
2. Choosing and Using Statistics; A Biologist Guide, ClavinDythan, Blackwell Scientific (1999).
3. The Statistical Analysis of Experimental Data' by, John Mandel, ISBN: 0486646661, ISBN13: 9780486646664
4. Research Methodology and Scientific Writing' by C. George Thomas, ISBN 978-3-030-64864-0
5. Research Methods for Science' by Michael Marder, Online ISBN:9781139035118
6. Research Methodology: An Introduction - Stuart Melville and Wayne
7. Practical Research Methods - Catherine Dawson
8. Research Methodology –Methods and Techniques, C. R. Kothari, 5thEdn., New Age international (2023).
9. Essential Bioinformatics, Jin Xiong,Cambridge University Press,(2006).
10. Choosing and Using Statistics;A Biologists Guide, Calvin Dytham Blackwell Science (2011).

BCHP – 13:Immunochemistry and Microbiology(4 Credits)

List of Experiments

1. Precipitin reaction by double immune-diffusion and radial immune-diffusion (Ouchterlony and Mancini's methods)
2. Detection of antibodies or antigen by ELISA (Indirect and Sandwich ELISA)
3. Detection of antigens by immune-blotting techniques
4. Demonstration of indirect agglutination reaction-latex agglutination.
5. Purification of antibodies; conventional (isolation of IgY from Egg yolk).
6. Rocket electrophoresis.
7. Safety measures and Good Laboratory Practices in microbiology laboratory
8. Sterilization, Culture and inoculum preparation.
9. Staining of bacteria – Gram Staining
10. Isolation of pure culture from contaminated sources,
11. Measurement of growth of bacteria.

References

1. Methods in Immunology and Immunochemistry; Curtis Williams, Academic Press (1971).
2. Immuno Assay Hand Book; David Wild, Elsevier (2013).
3. Basic Methods for the Biochemical Lab; Martin Holtzhauer, Springer, (2007).
4. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology8thEdn. Andreas Hoffman and Samuel Clockie, Ed., Cambridge University Press, (2018).
5. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland, (1969).
6. Principle and Techniques of Practical Biochemistry; Keith Wilson and John M. Walker, Cambridge University Press (2000).
7. Laboratory Techniques in Biochemistry and Molecular Biology, Work and Work Vol. I & II, North Holland,(1969).
8. Basic and Practical Microbiology, Ronald L. Atlas (1986) McMillan Publication Co.
9. Microbes in Action, A Laboratory Manual of Microbiology Seley et al., (19) W.H. Freeman.
10. Biophysical Tools for Biologists*In Vivo* Techniques; John CorreiaH. Detrich, III Elsevier (2008).

BCHP – 14: Enzymology (4 Credits)

List of Experiments

1.Determination of total activity of pea esterase.
2. Determination of K_M and Vmax of pea esterase.
3. Determination of optimum pH of pea esterase.
4. Determination of pH stability of pea esterase.
5. Determination of optimum temperature and activation energy of pea esterase.
6. Determination of temperature stability of pea esterase.
7. Determination of type of inhibition (reversible or irreversible) of pea esterase.
8. Determination of I_{50} of pea esterase using organophosphate inhibitor.
9.Determination of total activity of salivary α-amylase /β-amylase (sweet potato or germinated ragi).
10. Determination of Km and Vmax of α-amylase / β-amylase.
11.Determination of Km and Vmax of alkaline phosphatase (potato).
12. Determination of type of inhibition (reversible or irreversible) of alkaline phosphatase.
13. Determination of I_{50} of alkaline phosphatase.
14. Determination of inhibitor constant, Ki of alkaline phosphatase.
15. Determination of optimum temperature and activation energy of urease (horsegram).

References

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry:Trevor Palmer, Horwood, (2001).
2. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis:Robert A. Copeland, by Wiley-VCH Inc. (2000).
3. *Enzymes: A Practical Introduction to Structure, Mechanism and Data Analysis*: Robert A. Copeland , John Wiley & Sons (2000).
4. Enzyme Kinetics: *A Modern Approach*: Alejandro G. Marangoni, John Wiley & Sons (2002)
5. Enzyme Kinetics: *Principles and Methods:* Hans Bisswanger, Wiley–VCH (2002).
6. Fundamentals of Enzyme Kinetics:4thedn. Athel Cornish-Bowden, Wiley-Blackwell (2012).
7. *Fundamentals of Enzyme Kinetics*: Athel Cornish-Bowden, Portland Press (2004)
8. Contemporary Enzyme Kinetics and Mechanism, D. L. Purich3rdEdn., AP(2009).
9. Practical Enzymology, Second Revised Edtion [StormRG]:Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)

THIRD SEMESTER

BCHT – 15:Gene Regulation and Gene Editing

4 units (52 hrs)

UNIT-I

Gene Expression in Prokaryotes: Bacterial transcription control; Discovery and structure of lac operon, induction and diauxy. Utility of merodiploids in understanding regulation of operon. Molecular basis of repression. Isolation of repressor, assay of binding of *lac* operator and repressor. Positive control of *lac* operon; mechanism of action of CRP/CAP, transcription activation by recruitment, characterization of binding of cAMP-CAP-DNA. Catabolite repression, inducer exclusion and prevention mechanism. Anatomy and regulation of tryptophan operon. Riboswitches; discovery and models of action.

6hrs

Gene Expression in Eukaryotes:

Analysis of gene expression; mapping and quantifying transcripts; Northern blots; S1 mapping of 5' and 3' ends of transcripts. Primer extension, Runoff transcription and G-less cassette transcription, measuring *in-vivo* transcription rate- nuclear run on transcription.

Chromatin structure and its effect on transcription. Effect of histones on transcription activation. Nucleosome positioning; SV-40 mini chromosome, experimental location of nucleosomal positions; DNase hypersensitive sites and mapping. Locus control regions.

Histone modifications; Acetylation of histone tails. Identification of histone acetyl transferases (HATs). Properties and roles of P_{55} and Gcn-5 HATs. Histone deacetylases; experimental demonstration of HDACs in repressor complexes. Histone methylation, histone methyl transferases (HMTs) and their role in gene regulation,Histone code.

7 hrs

UNIT-II

Chromatin remodelling

Major classes of remodelling complexes; assay of remodelling; ChIP. Composition of SWI2/SNF2 and ISWI complexes. Model of SWI2/SNF2 mechanism. Remodelling in yeast HO gene and human IFN-β promoter. Heterochromatin silencing; chromo and bromo domains, SFR and RAP-proteins.

Transcriptional activators

Classification, structure and function, domains of activators. DNA binding motifs; Zn fingers-Gal 4 activator of yeast. Nuclear receptor- structure and function of glucocorticoid, thyroid and orphan receptors. Domains of nuclear receptors; homeo, bZIP and bHLH domains. Modularity of domains of activators; chimeric transcription factors- Gal4-LexA, two hybrid assay. Dimerization of activators, modular arrangement of enhanceosomes. Recruitment of TFIID and holoenzyme; evidence, role of enhancers, interaction between enhancer and promoter-control region of human metallothionine gene. Insulators-working, insulator bodies, working of imprinting control region (ICR). Transcription factories, detection. Co-activators and mediators; mediators factors; activation of CRE-linked gene model for nuclear receptor activation. Regulation of transcription factors; modification of activation by ubiquitination, sumoylation and acetylation.

13 hrs

UNIT-III

Regulation of gene expression via stability of mRNA

Casein mRNA and transferring-receptor mRNA, gel mobility shift assay for IRE binding protein, model for TFR mRNA destabilization by iron. Gene Expression and Gene Regulation Networks RNA-seq analyses. Differential expression, stochasticity, and FDR. Alternate splicing, ENCODE. Epigenomic analyses and cancer/ diseases. Bisulfite sequencing

RNA interference; post transcriptional gene silencing (PTGS) and quelling. Definition, mechanism of RNAi. Classical experiments with petunia and *C. elegans.* Simplified model, composition and function of Dicer and RISC. Role of *Argonaute*. siRNAs, role of RNAi machinery in heterochromatin formation and gene silencing- EF1A gene. miRNAs; control of gene expression by miRNAs example and experimental proofs, pathways of gene silencing by miRNA. Stimulation of translation by miRNAs. Translation repression; processing bodies.

13 hrs

UNIT-IV

Gene Editing

Basis of gene editing, Nonhomologous End-Joining (NHEJ), Homologydirected repair, Programmable nucleases for gene editing, Meganucleases, Zinc-Finger nucleases, Transcription Activator-Like Effector Nucleases (TALEN), CRISPR-Cas systems, gene editing using CRISPR-Cas, drawbacks and major challenges to present gene editing techniques, gene editing for human disease therapy

5 hrs

Gene and cell therapy: Basics of Gene and cell therapy, types of gene therapy, gene therapy strategies, therapeutic targets for gene therapy, choice of the therapeutic target, administration routes, delivery systems, expression of transgene, persistence of the gene therapy, cell targeting, immunological response to the therapy, ethical and legal issues, concerns about gene and cell therapy.

4hrs

Vectors for Gene therapy: Non-viral and viral vectors for gene therapy, Physical methods of gene delivery, Polymer, Lipid and inorganic material based chemical systems for gene delivery, Viral vectors, Lentiviral, Adenoviral, Adeno-associated virus for gene delivery, choice of viral vector and oncolytic virus. Gene therapy applications, Gene therapy for cancer.

4 hrs

References

1. Molecular biology and Biotechnology; 4thEdn., J.M. Walker and R. Rapley, RSC (2000).
2. Molecular Biology of Gene; Watson, J.D. et al., 5thEdn. Pearson Education; (2004).
3. LEWINS Gene XII; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and Barlett Publishers (2018).
4. Molecular Biology; 5thEdn., Robert F. Weaver, Mc Graw-Hill (2018).
5. Epigenetics and Epigenomics; Christopher J. Payne, INTECH, (2014).
6. Gene Control; David Latchman, Garland Science (2010).
7. Molecular Cell Biology; Harvey Lodish, Arnold Berk, Chris A. Kaiser, 7th Edition, W. H. Freeman (2012).
8. An Introduction to Molecular Medicine and Gene Therapy 1stEdn, Thomas F. KresinaUpadhyay, S. K. (Ed.) (2021).
9. Molecular Biology of the Cell; 7thEdn. Bruce Alberts et al., (2008), Garland Publications
10. Long Range Control of gene Expression; Veronica van Heyningen and Robert Hill, Academic Press (2008).
11. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press (2001).
12. Stem cell biology and gene therapy, Booth C., Cell Biology International, Academic Press
13. An Introduction to Molecular Medicine and Gene Therapy 1st Edition by Thomas F. KresinaUpadhyay, S. K. (Ed.). (2021).

BCHT – 16: Biochemistry of Cell signalling

4Units(52 hrs)

UNIT-I

Signal transduction

Introduction, basic model of signal transduction pathways, Extracellular signals acting locally or at a distance, major types of signalling mechanisms, cell-cell contact, Cell surface receptors, major class of cell surface receptors, evolutionary origin, Diversity of Cellular responses, mechanisms of signal transduction; major components of a hypothetical signalling pathway, second messengers, signalling proteins, Signalling proteins as molecular switches Localization of signalling proteins.

6hrs

Signalling in prokaryotes

Microbial signal transduction; quorum sensing (QS)- auto-inducers, receptors, signal transduction.Biofilm formation, stages, molecules of adhesion, physiological significance, changes in gene expression. Two-component signal transduction systems- HPKs, response regulators and physiological significance.Nutrient sensing nutrients as signalling molecules,L-arginine as a Pleiotropic Nutrient.g, chemotaxis -methyl-accepting chemotaxis proteins (MCPs), horizontal gene transfer stress response- physical and chemical sensors, antibiotic resistance.

7 hrs

UNIT-II

Experimental Approach to Cell Signalling:

Study of protein translocation, Cell-Cell adhesions, monitoring signal transduction by blocking specific kinases, assessing physiological and biochemical changes, behaviour of cells. Visualization/measurementof differences of cytoskeletal elements- shape, of cells, spreading, adhesion and migration.

Confocal and electron microscopic methods to visualize the signal transduction- Intracellular fluorescent indicators- tracking specific proteins (4FP), plasma membrane lipids. Measurement of Calcium (calcium chelators fluorescent EGTA, APTRA, BAPTA), and pH. Immunohistochemistry; GFP-tagged proteins-myelin basic protein, FRET and FRAP to study signal transduction with examples. Biochemical analysis in signal transduction; Western blotting, immunoprecipitation, GST-pulldown assay, activity assays- ICE and caspase.

Use of pharmacological agents which interfere with signalling proteins, transfection/ microinjection with plasmid that express either inactive or constitutively active proteins, blocking the synthesis by antisense technology.

7 hrs

G-protein coupled receptor system: Transmembrane Receptors, Domains of Transmembrane (TM) receptors, and Regulation of Receptor Activity. GTPase Superfamily: General Functions and Mechanism, G-domain as Common Structural Element of the GTPases.General mechanism of the activation of effectors molecules associated with G-protein-coupled receptors, G-protein coupled that activate or inhibit adenylate cyclase, stimulate phospholipase-C, or regulate ion channels. Signalling via arrestin and its regulatory roles in GPCR pathways.

6hrs

UNIT-III

Ser/Thr-Specific Protein Kinases and Protein Phosphatases

Classification, Structure, and Characteristics, regulation of Protein kinases, The Protein Kinase Reaction, Control of Protein Kinase Activity, regulation of Protein Phosphorylation. Structure, substrate specificity, and regulation of Protein kinase–A (PKA), A-Kinase Anchor Proteins (AKAPs); The PI3 Kinase/Akt Pathway, Signalling by Akt Kinase. Classification, Structure, functions, and substrates of PKC, activation and regulation of PKC, Receptors of PKC.

6hrs

Intracellular Messenger Substances:"Second Messengers": General Properties, Cyclic AMP,cAMPSignalling.cGMP-GuanylylCyclases, Targets of cGMP, Inositol Phospholipid Messengers, PLC, PtdIns(3,4,5)P3, PtIns (4,5)P2 and Diacylglycerol. Ceramide, sphingosine, and Lysophosphatidic Acid as signalling molecules. InsP3 Receptor, Storage and Release of Ca^{++} . Ryanodine Receptor, cADP-Ribose and NAADP. Ca^{++}as a Signal Molecule, the EF Hand: A Ca-Binding Module, Calmodulin as a Ca^{++} Sensor, Target Proteins of Ca/Calmodulin, other Ca^{++} Sensors.

NO Signaling; NO and NOS, Physiological Functions of Nitrosylation, Nitrosylation of Metal Centers, NO-Sensitive GuanylylCyclase, Regulatory functions of Nitrosylation and Denitrosylation, Toxic Action of NO and Nitrosative Stress.

7hrs

UNIT-IV

Intracellular signalling proteins

adaptors, activators, bifurcators, integrators and effectors; Downstream cascades of Receptor Tyrosine Kinase, Extracellular-signal-regulated kinases, MAPK-Ras–Raf, SOS signalling pathways; Effectors of intercellular signalling- Adenylatecyclase, Phospholipase–C, Nitricoxide synthase, guanylatecyclase and their activation. Mechanisms of modulation of signalling cascades, including positive and negative regulation.

6hrs

Cytokines- Interferon family: Major proteins/protein families that constitute the cytokine group of regulatory molecules; Structural classification of cytokines; Cytokine receptor superfamilies; Human interferons (IFNs) and the cells that produce interferons; Interferon signal transduction; Interferon receptors; JAK–STAT pathway; Interferon JAK–STAT pathway; Biological effects of interferons. **7 hrs**

References

1. Biochemistry of Signal Transduction and Regulation, Gerhard Krauss, 5thEdn.Wiley-VCH Verlag GmbH & Co (2014).
2. Bacterial Signalling , ReinhardKrämer, Kirsten Jung (Eds), Wiley, (2009)
3. The Biochemistry of Cell signaling; Ernst J.M. Helmreich, OUP, (2001).
4. Signal transduction and human disease; TorenFinkel, and J. Silvio Gutkind, John Wiley & Sons, Inc. (2003)
5. Greenspan's Basic and Clinical Endocrinology; 9thEdn. David Gardner and Dolores Shoback Lange Clinical Medicine (2012).
6. Elements of Molecular Neurobiology; 3rdEdn. C. U. M. Smith, John Wiley & Sons Ltd, (2002).
7. G-Proteins coupled Receptors; P. Michael Conn Academic Press (2013).
8. Molecular Biology of the Cell;6thEdn. Bruce Alberts, Alexander Johnson, Julian LewisDavid Morgan, Martin Raff, Keith Roberts, Peter Walter; Garland Science (2014).
9. Molecular Cell Biology; Lodish et al., 7thEdn. W.H. Freeman and Co. (2012).
10. Cell Signaling; Wendell Lim, Bruce Mayer, Tony Pawson; Garland Science (2014).
11. Electrochemical methods for neuroscience; Michael AC, Borland LM, editors.Boca Raton (FL): CRC Press(2007).
12. Cell Signaling, J. Hancock, 3rdedn, Oxford University Press, (2010).
13. Signal Transduction; Lewis Cantley, CSHL Press (2014).

BCHT – 17:Bioinformatics

(52 hrs, 4 credits)

UNIT-I

Biological sequences

Bioinformatics: Introduction and Scope. DNA and protein sequences, genome, transcriptome proteome and Glycome. Gene structure in prokaryotes and eukaryotes, coding and noncoding genes open reading frames, Retrieval, submission and storing sequences; various file formats for bio-molecular sequences: GenBank, FASTA, and FASTQ

6 hrs

Database resources

NCBI, EMBL, DDBJ, OMIM, UCSC browser and their retrieval system; SRS, GetEntry, NTREZ, File formats, utilities of metadata across GEO, TCGA, Array Express, 1000 genome, dbSNPs, COSMIC; Pfam, SCOP, KEGG and UNIPROT databases navigation for protein sequence analysis.

7 hrs

UNIT-II

Sequence Alignment Tools and molecular phylogeny

Basic concepts of sequence similarity, identity and homology, definitions of homologues, orthologues, paralogues, scoring matrices. Sequence analysis of biological data - Pairwise sequence alignment - Local and Global alignment; Dot plot, FASTA and BLAST programs, types of BLAST, primer BLAST, Statistics of alignment score – P value and E value. Multiple sequence alignment – Introduction, Methods - Progressive method, iterative method, genetic algorithm and applications. Tools for multiple sequence alignment- Clustal W, T-Coffee, DIALIGN, Clustal Omega. Phylogenetic analysis- Phylogenetic tree and terminology, Phylogram v/s. cladogram. Methods for phylogenetic tree construction; Distance matrix methods- UPGMA, NJ, Character based methods- Maximum parsimony, Maximum likelihood

13 hrs

UNIT-III

Biological networks and pathways

Pathway and Molecular Interaction Databases: Reactome, KEGG, EcoCyc, Molecular Interaction Databases: BioGRID, IntAct, STRING, STITCH, GeneMANIA .Pathway Visualization and Analysis: Network Visualization and Analysis, Cytoscape

7 hrs

Gene Prediction Tools

Gene prediction methods: Ab Initio ,neural networks and homology based in prokaryotic and eukaryotic;GENSCAN, GRAIL, FGENES- SMART.Genomes- genome annotations.

6 hrs

UNIT-IV

Structural bioinformatics

Molecular structures – visualizing and graphical representations.Calculation of geometric parameters (bond distance, bond angle, dihedral angle). Identifying intramolecular and inter molecular interactions from crystal structures (using GUI). **6 hrs**

Computer-aided drug design

CADD: concepts and principles, applications – success – limitations. Small molecule databases: Pubchem, ChEMBL, Drugbank and NIST, Protein structural databases: PDB and MMDB. Lipinski rule of five, ADMET prediction - ADMET prediction methods and tools.
Drug design ;structure-based drug design, protein modelling, molecular docking -virtual screening. Ligand based drug design – pharmacophore modelling SAR and QSAR

7 hrs

References

1. N. Gautham; Bioinformatics: Databases and Algorithms; Alpha Science, (2006).
2. D. W. Mount; Bioinformatics Sequence and Genome Analysis; Cold Spring Laboratory Press, (2001).
3. Essential Bioinformatics, Jin Xiong, Low Price Edition, Cambridge Press, (2019).
4. Practical Bioinformatics. Agostino, Michael, Garland Science, (2012)
5. Bioinformatics a Practical Guide to the Analysis of Genes and Proteins,Baxevanis, A.D. and Francis Ouellellette, 3rdEdn,B.F.,Wiley India Pvt Ltd (2009).
6. Molecular Modeling – Principles and Applications; Second Edition, Leach, AR (2001) Prentice Hall, USA.
7. Structural Bioinformatics An Algorithmic Approach F. J Burkowski; CRC Press, (2009).

A. Introduction to Bioinformatics; M Lesk; Oxford University Press, (2002).

8. BLAST J. Bedell, I. Korf and M. Yandell;; O'Reilly Press, (2003).
9. Biological sequence analysis R. Durbin, Cambridge University Press, (1998).
10. A cell biologists' guide to modeling and bioinformatics; R. M. Holmes; Wiley Interscience, (2007)

10. Algorithms in Bioinformatics, Practical introduction. Sung Wing-Kin, CRC Press, (2010)

BCHT OE−304: Open Elective

Student can choose from other disciplines

4 units (52 hrs)

BCHP – 19: Molecular Biology (4 credits)

List of Experiments

1. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from bacteria (E. *coli*).
2. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of genomic DNA from plant.
3. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of plasmid DNA from bacteria.
4. Isolation, quantification and characterization (Spectrophotometric and agarose gel electrophoresis) of total RNA, mRNA from plant and microbial sources.
5. Restriction digestion and ligation of DNA.
6. Spectroscopic determination of melting temperature(Tm) of calf thymus DNA.
7. Amplification of desirable gene by Polymerase chain reaction.
8. Rapid amplification of polymorphic DNA.
9. Reverse transcriptase- Polymerase chain reaction RT-PCR
10. Southern blotting
11. Phage Titration.

References

1. Molecular Biology Techniques; Sue Carson, Heather Miller and D. Scott Witherow, Academic Press (2011).
2. Principles and Techniques of Biochemistry and Molecular Biology; 7thEdn. Keith Wilson and John Walker (2012).
3. Principles of Gene Manipulations; 6thEdn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
4. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell (2006).
5. Laboratory methods in Enzymology; Part-A; Jon Lorsch, Academic Press (2014).
6. Gene Cloning Laboratory Manual 4thEdn. Michael R. Green and Joseph Sambrook, CSHL Press (2014).
7. Current Protocols in Molecular Biology; S Gallaghar, Wiley Interscience (2008).

BCHP – 20: Gene Regulation and Bioinformatics(4 credits)

List of experiments

Gene Regulation

1. Demonstration of induced expression of prokaryotic gene
2. Quantification of transcripts; Northern blot, RT-PCR

Bioinformatics

3. Biological Databases and Computational Tools
4. Exploring the integrated database system at EMBL-EBI server
5. Exploring tools on ExPASY
6. Exploring & querying UniProtKB and other protein sequence databases.
7. Nucleic acid sequence analysis: Sequence alignment, substitution Matrices
8. Protein sequence analysis: Sequence alignment, substitution matrix, secondary structure elements, motifs
9. Phylogenetic tree construction using Distance-based, Maximum parsimony and maximum likelihood methods;
10. RCSB PDB database, Protein tertiary structure prediction using homology modelling and threading
    a) Protein Data Bank
    b) Nucleic Acid Databank
    c) Visualization of structures (SWISS-PDB Viewer, Discovery Studio)
    d) Calculation of structural parameters of Proteins & Ramachandran Plot
    e) Calculation of structural parameters of DNA & RNA
11. Understanding macromolecular interactions through visualization and structure analysis
    a) Protein – Protein
    b) Protein – Nucleic acids
12. Energy minimization and molecular docking

References

1. Molecular biology and Biotechnology; 4thEdn., J.M. Walker and R. Rapley, RSC (2000).
2. Molecular Biology of Gene; Watson, J.D. et al., 5thEdn. Pearson Education; (2004).
3. Lewin's Gene XII; J.E. Krebs, E.S. Goldstein, and S.T. Kilpatrick, Jones and Barlett Publishers (2018).
4. Molecular Biology; 5thEdn., Robert F. Weaver, Mc Graw-Hill (2018).
5. Epigenetics and Epigenomics; Christopher J. Payne, INTECH, (2014).
6. Gene Control; David Latchman, Garland Science (2010).
7. Bioinformatics: Databases and Algorithms; N. Gautham; Alpha Science, (2006).
8. Bioinformatics Sequence and Genome Analysis; D. W. Mount; Cold Spring Laboratory Press, (2001).
9. Essential Bioinformatics, Jin Xiong, Low Price Edition, Cambridge Press, (2019).
10. Practical Bioinformatics. Agostino, Michael, Garland Science, (2012)
11. Bioinformatics a Practical Guide to the Analysis of Genes and Proteins, Baxevanis, A.D. and Francis Ouellellette, 3rdEdn, B.F., Wiley India Pvt Ltd (2009).
12. Molecular Modeling – Principles and Applications; Second Edition, Leach, AR Prentice Hall, (2001).

FOURTH SEMESTER

BCHT – 21:Developmental Biology

4 units (52 hrs)

UNIT-I

Introduction to Developmental Biology

Principles of Developmental Biology- Potency, commitment, specification, induction, competence. Determination and differentiation; morphogenetic gradient, cell fate and cell lineages. Cell to cell communication during early development. Environmental control of gene regulation, Epigenetic regulation of developmentally relevant genes.

6hr

Gametogenesis

Production of gametes, Formation of zygote, fertilization and early development: molecules in sperm-egg recognition in animals; cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis. Drosophila Developmental biology- Axis formation, Genes & mutation.

7 hrs

UNIT-II

Morphogenesis & Organogenesis

Metamorphosis and organogenesis in model organisms- Drosophila: Axes, compartment and pattern formation, polarity determination of embryo, formation of body segments, Homeotic and HOX gene and their regulation. *Caenorhabditis elegans*: Early development mosaic development, and vulva formation. *Xenopus:* Organizer formation, mesoderm specification. Zebra fish: Cell movement and signal during early development, Patterning, polarity and regionalization of nervous system. *Mouse:* Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
Limb development.

8 hrs

Regeneration Developmental Biology Stem cells

Definition, Classification, Embryonic and adult stem cells, properties, identification, Culture of stem cells, Differentiation and dedifferentiation, Stem cellmarkers, techniques and their applications in modern clinical sciences. 3-D culture and transplantation of engineered cells. Tissue engineering - skin, bone and neuronal tissues.

5 hrs

UNIT-III

Stem cells and tissue regeneration

Stem cells in development: Definition, types and properties of stem cells, cultivation of stem cells, cancer stem cells, stem cell markers, role of stem cells in development and applications of stem cells.

Adult and foetal stem cells, embryonic stem cells, cell reprogramming, induced pluripotent stem cells (iPSC), Chemically induced pluripotent stem cells (CiPSC), reprogramming factors, iPSC derived progenitors cells, Organoids, 3-D bioprinting, organogenesis. Cancer stem cells, stem cell markers, role of stem cells in development and applications of stem cells. Environmental & evolutionary influences – teratogens, maternal effects, evolutionary developmental biology.
Molecular events of embryogenesis:Nieuwkoopcenter, Spemann-Mangold organizer theory and Mesodermal induction.

13 hrs

UNIT-IV

Ageing

Replicative and chronological ageing, ageing theories, telomeres & telomerase. Mechanism and physiology of ageing, genomic instability, telomeric attrition, epigenetic alterations, dysregulated nutrient sensing, mitochondrial dysfunction, stem cell exhaustion, altered intercellular communications. Hallmarks of aging their classification, advanced glycation end products, Age-related diseases – Progeria (HGPS, Werner syndrome), neurodegenerative (Alzheimer's, Parkinson's), metabolic (diabetes, obesity, mitochondrial dysfunction). Ageing of stem cells – programmed cell death. Brain ageing, skin ageing

Interventions:

Anti-ageing approaches, Nutrients regulations, calory restrictions, senolytics, mTOR and sirtuin modulators, epigenetic reprogramming, stem cells and regeneration therapy.

13hrs

References

1. Principles of Developmental Genetics; SA Moody, Academic Press(2007).
2. Developmental Biology; S. P. Gilbert, 8thEdn. Sinauer Associates Inc. (2006).
3. Developmental Biology; Scott F. Gilbert, 13thEdn, Sinauer Associates, (2013).
4. Caenorhabditis Elegans: Molecular Genetics and Development, 2ndEdn. Joel H. Rothman Academic Press, (2011)
5. Manipulating the mouse embryo: a laboratory manual, Nagy, M. Gertsenstein, K Vintersten, R. Behringer. Cold spring Harbor Press, (2003).
6. Stem cell biology edited by Daniel R. Marshak, Richard L. Gardner, David Gottlieb, Cold Spring Harbor Laboratory Press (2001).
7. Essentials of Stem Cell Biology, 3rdEdn, Lonza and Atla, (ed), Academic Press, (2013)
8. Aging Hallmarks and Progression and Age-Related Diseases: A Landscape View of Research Advancement; RumianaTenchov et al., ACS Chemical Neuroscience, Vol.15 (1), 2023.

BCHT – 22:Omics Technologies

4 units (52 hrs)

UNIT-I

Genomics

Introduction to Genomics, Structural genomics, Comparative genomics, Organelle genome: nuclear genome, mitochondria and chloroplast, Concepts of Metagenomics, Conservation, and diversity of genomes.

Sequencing projects for microbes, plants and animals, human genome structure andcomparative genomics.

*Sequencing technology;*Principle of and output from Sanger's dideoxy method;

Genome sequencing- whole genome shortgun sequencing and next-generation sequencing, sequencing platforms- Illumina (Solexa) sequencing, pyro sequencing, SOLiD sequencing, Human genome project overview.

Molecular markers in genome analysis**.** Tools for genome analysis- RFLP, RAPD, AFLP, SSLPs, STR, EST and SNPs, Disease monitoring, Linkage and Pedigree, Huntington disease, disease prognosis, genetic counselling.

13 h

UNIT-II

Metagenomics and population genomics

Overview of metagenomics principles, microbial and ecological aspects underlying metagenomic experiments, applications and limitations of metagenomics, differencesbetween metagenomics and single-cell genomics. Definition and principle of populationgenomics, difference between metagenomics and population genomics, applications ofpopulation genomics.

6hr

Transcriptomics

Transcriptome and techniques used fortranscriptomics; Sequencing (NGS) Technology, Whole genome - *de novo* sequencing or resequencing; exome sequencing; RNA sequencing; small RNA sequencing; metagenomics; NGS workflow, Ribosomal RNA depletion (RNA-Seq) and small RNA enrichment; 16S rRNA based sequencing for metagenomics, comparative genomics, personal genomics, minimal genome, barcode of life.

Concepts in microarray data analysis: gene expression analysis using RNA-seq data, statistical methods; relative merits of various platforms. Primers design for downstream validation; mapping algorithms such as Burrow-Wheeler. Measuring gene, lncRNA, siRNA from RNA-seq data.

7hr

UNIT-III

Functional genomics

Functional genomics of microbes, plants and animals; Microarray and microchips, SAGE, and CAGE, Whole Chromosome Transcriptional Mapping, genomic functional profiling, Genome-wide search for DNA–protein interactions in yeast by ChIP-chip analysis, mapping transcription factor bindingsite by ChIP, locating enhancers and promoters, in situ expression pattern,SNP and pharmacogenomics. Micro/siRNA technology and applications in studying gene functions. (Student seminar)

5 hrs

Proteomics

Human genome **-** Genomes to Proteomes - HUPO–Human ProteomeProject, Branches of proteomics - Protein extraction Methods: Subcellular fractionation, Density gradients, Ultrafiltration, - Protein fractionation - Affinity purification –Removal of interfering

compounds, salts, DNA, lipids, Protein solubilization methods, chaotropes, detergents, etc - Sample handling and storage .
Mass Spectrometry–Principles - MALDITOF - RP chromatography /Tandem mass spectrometry – Protein sequence analysis -Peptide mass finger printing- N-terminal determination methods- Protein modification – Protein microarrays – Tissue microarray – Infra red Protein array with Quantitative Readout (IPAQ)

8 hrs

UNIT-IV

Metabolomics

HPLC and FPLC based approaches in metabolomics. Criteria for the selection of chromatography methods and their importance in metabolomics. Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration. Metabolite profiling for infectious disease.Metabolite profiling in heart disease-application. Metabonomics in preclinical pharmaceutical discovery and development.

7hrs

Pharmacogenomics

Pharmacogenetics, cancer genomics, immunogenomics, somatic cell Genomics, biochemical genomics, single cell analysis, Genetics of globin triplet repeat Disorders, polygenic inheritance, Effects of drugs in individual and susceptibility, Personalized medicine, Synthetic Genomes. Ethics and issues of synthetic.

6 hrs

References

1. Bioinformatics and Functional Genomics Pevsner, John Wiley and Sons, Inc. (2015)
2. Concepts and Applications of DNA Technology. Dale, J.W., Schantz, M.V., Plant, N. John Wiley & Sons, (2012).
3. Introduction to Genomics, Lesk, A.M. Oxford University Press Inc., (2012).
4. Bioinformatics and Functional Genomics, Pevsner, J. John Wiley and Sons, Inc., (2015).
5. Genetics and Genomics in Medicine, 9th Eds Ronald Cohn, Stephen W. Scherer, and Ada Hamosh, Elsevier, (2023).
5. Concepts in Pharmacogenomics, Zdanowicz, M.MAmerican Society of Health-System Pharmacists, Bethesda. (2010)
6. Discovering Genomics, Proteomics and Bioinformatics, Campbell A M &Heyer L J, 2ndEdn. Benjamin Cummings, (2007).
7. Bioinformatics and Functional Genomics Pevsner, JJohn Wiley and Sons, Inc. (2015)
8. Protein Bioinformatics,Cathy H. Wu.C.H, Cecilia N. Arighi.C.N. and Karen E. Ross. K.E Humana Press (2017).
9. Proteomics, O'Connor C.D. and Homes. B. D. Scion Publishing Ltd. (2007).
10. From proteins to proteomics: Basic concepts. Techniques and application; SanjeevaSrivastava, CRC Press (2022).
11. Metabolome Analysis: An Introduction, S.G. Villas-Boas. Wiley-Blackwell, USA. (2007)
12. Concepts in Plant Metabolomics, B. J. Nikolau. Wurtele, Eve Syrkin, Springer, USA (2007).
13. The Handbook of Metabonomics and Metabolomics, J. Lindon, J. Nicholson, E. Holmes. Elsevier B.V., Netherlands (2006).

BCHT – 23:Genetic Engineering

4 credits (52 hrs)

UNIT-I

Restriction and modifying enzymes: Restriction enzymes Discovery, classification, properties, and applications. Reactions, application of the following modifying enzymes employed in rDNA technology; DNA- and RNA ligase, Phosphatases and kinases DNase (DNase-I) and RNases (RNase A, H), S1- and Micrococcal nuclease. DNA and RNA polymerases (Klenow fragment), template independent RNA polymerases.Linkersand adapters, TA-cloning.

6hrs

Cloning: Basic properties of plasmids vectors. Directional cloning in plasmid vectors, blunt end cloning in to plasmids. Bacteriophage lambda vectors; Insertional and replacement lambda vectors, transfection, *in vitro* packaging, screening recombinant phages. Cloning in M13 vector and COSMID vectors and their applications.

*Expression vectors:*Characteristics of expression vectors,expression vectors forcloning and expression in bacteria, yeast and mammalian cells. Super vectors; characteristic features and utility of BAC and YAC vectors.

Preparation of recombinant DNA, transformation of competent hosts.Screening colonies using X-gal and IPTG (α-complementation), screening by hybridization. Characterization of plasmid clones, restriction digestion.

7 hrs

UNIT-II

Genomic and cDNA libraries: Outline of methodology for genomic library construction using lambda and cosmid vectors. Evaluation and storage of genomic libraries. cDNA libraries; methodology, random arrayed and ordered cDNA libraries, screening cDNA libraries; probe selection, hybridization. Screening with antibodies, rescreening and sub-cloning. southern blot, PCR and sequence analysis.

4hrs

PCR: Discovery, principle and procedure, variants of PCR- RT-PCR. Application of PCR; Rapid amplification of cDNA ends (5'and 3' RACE), Cloning PCR products.Diagnostic application of PCR.

4 hrs

Gene transfer to animals cells: over view of strategies, transfection methods, phospholipids as delivery vehicles, electroporation and direct transfer, transient and stable transformation, Co-transformation and selection of stable transformants, selectable markers for animal cells. Mammalian plasmid expression vectors, reporter genes. Gene transfer by viral vectors; adeno baculovirus, and retroviral vectors. Gene therapy andGene editing; CRISPR.

5 hrs

UNIT-III

Gene transfer to plants: plant cell culture and protoplast, callus and their manipulations. *Agrobacterium*mediated transformation, Ti plasmid, mechanism of T-DNA transfer, Function of T-DNA genes, Ti-plasmid derivatives as plant vectors (disarmed T-DNA), cointegrate and binary vectors, high capacity binary vectors, selectable markers for plants, control of transgene expression in plants. Direct DNA transfer to plants; protoplast transformation, particle bombardment, *in-planta* and chloroplast transformation. Plant expression vectors; CaMV and TMV vectors.

7 hrs

Bioprocess technology: Fermentation: Fermentation process design, operation and characteristics of fermentation processes; batch, fed-batch and continuous culture systems, instrumentation and bioprocess control.

3hrs

Downstream process: Introduction to various downstream process operations in biopharmaceutical manufacturing such as centrifugation, filtration, tangential flow filtration, cell disintegration, solvent-solvent extraction, supercritical fluid extraction etc.

3 hrs

UNIT-IV

Industrial Biotechnology: Major areas of biotechnology in the pharmaceutical industry such as antibiotics, vaccines, diagnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF and therapeutic proteins etc.); commercial aspects, priorities for future biotechnological research.

3 hrs

Nanobiotechnology: Definition and methods of preparation of nano-bioparticles. Applications in drug designing, drug delivery & protein engineering.Biosensors – Construction, uses in industrial and environmental processes and medical applications.

3 hrs

Intellectual property: Concepts and fundamentals; Concepts regarding intellectual property (IP), intellectual property protection (IPP) and intellectual property rights (IPR);
Mechanisms for protection of intellectual property-patents, copyrights, trademark; Factors effecting choice of IP protection; Penalties for violation.WTO (World Trade Organisation), WIPO (World Intellectual Property Organization) GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS.

4hrs

Ethical values in IP: IP and ethics-positive and negative aspects of IPP; Societal responsibility; Avoiding unethical practices; Echo-responsibility-economic, social and environmental benefits of modern biotechnology.

3 hrs.

References

1. Molecular Cloning; A laboratory manual; Michael R. Green, CSHL Press (2012).
2. Molecular Biology of the Cell; 7thEdn. Bruce Alberts et al., (2008), Garland Publications
3. Molecular Biology; Robert F. Weaver, McGraw Hill (2018).
4. Principles and Techniques of Biochemistry and Molecular Biology; 7thEdn. Keith Wilson and John Walker (2010).
5. Principles of Gene Manipulations; 6thEdn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
6. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell Publishing (2006).
7. Molecular biology and Biotechnology; 4thEdn., J.M. Walker and R. Rapley, RSC (2000).
8. Plant Biotechnology and Agriculture; Arie Altman and Paul Hasegawa Academic Press (2011).
9. Law Relating to Intellectual Property by B.L.Wadhera
10. IPR Handbook for Pharma Students and Researchers by P.Bansal
11. Making Innovation Happen- A simple and Effective Guide to Turning Ideas into Reality Michael Morgan.

BCHT – 24:Biochemical Pharmacology

4 credits (52 hrs)

UNIT-I

Introduction: Source and nature of drugs, classification and nomenclature. Basic principles of drug action, Pharmacokinetics: Absorption, distribution and elimination of drugs, routes of drug administration. Drug–protein interactions. Pharmacogenetics; dose response curve - ED50 and LD50.Origin of Drug from plants and animals.

3 hrs

Drug targets: Enzymes, receptors, carrier proteins. Structural proteins, nucleic acids, lipids and carbohydrates. Forces involved in drug – receptor interaction, Receptor theories. Cholinergic and anticholinergic drugs, Adrenergic and adrenergic blockers, General anaesthetics, Local anaesthetics. Adverse reactions to drugs and common drug receptor interactions.

5 hrs

Drug metabolism: Drug metabolism: First pass metabolism – Elimination pathway – Entero–hepaticcycling of drugs. Drug biotransformation pathway – phase I – Hepatic cytochrome P450enzyme system; Cytochrome P450 cycle – induction and inhibition;– Oxidationcatalyzed by cytochrome P450 isoforms– all types of hydroxylation, Deamination;Dealkylation;– Dehalogenation. Oxidations: Microsomal and Non-microsomaloxidations.

5 hrs

UNIT-II

Drug discovery and Development

Understanding Molecular Targets: Identification of potential drug targets, such as specificproteins, enzymes, or receptors. Validation of the biological relevance of these targets in thecontext of a particular disease. Hit discovery and lead optimization: Screening methods toidentify initial compounds High-throughput Screening (HTS) Techniques.

9hrs

Preclinical toxicology: General principles, Systemic toxicology (Single dose and repeat dose toxicity studies), Carcinogenicity, Mutagenicity, Teratogenicity, Reproductive toxicity, Local toxicity, Genotoxicity, animal toxicity requirements.

4 hrs

UNIT-III

Basic terminology used in clinical research: Types of clinical trials, single blinding, double blinding, open access, randomized trials and their examples, interventional study, ethics committee and its members, cross over design, Institution Ethics Committee / Independent Ethics Committee. Data Management in clinical Research

6 hrs

Clinical trials: New drug discovery process- purpose, main steps involved in new drug discovery process, timelines of each steps, advantages and purposes of each steps, ethics in clinical research, unethical trials, thalidomide tragedy,Various phases of clinical trialsSafety monitoring in clinical trials. Various regulatory requirements in clinical trials, Schedule Y, ICMR guidelines etc. Documents in clinical study. Introduction to regulatory agencies-DGCI, CIB, NBA, GEAC, FSSAI, CDSCO, ISO.Indian GCP guidelines (CDCSO guidelines), ICMR Guidelines - Ethical Guidelines for Biomedical Research on Human Subjects Schedule.

7 hrs

UNIT-IV

Bioavailability and Bioequivalence studies: Factors affecting bioavailability, types: absolute v/s relative, single v/s multiple dose studies, healthy volunteers vs patient studies, measurement

of bioavailability, drug dissolution rate and Bioavailability, *in vitro-in vivo* correlation, methods for enhancement of bioavailability.Bases for Determining Bioequivalence, Design and Evaluation of Bioequivalence Studies Analytical Methods, Reference Standard, Extended-Release Formulations, Combination Drug Products, Study Designs

6 hrs

Pharmacovigilance: Definition and aims of pharmacovigilance *Adverse drug reactions*– Classification, mechanism, predisposing factors and causality assessment. Role of clinical pharmacist in Reporting, evaluation, monitoring, prevention and management of ADR Adverse drug reaction reporting and monitoring Drug induced diseases. *Pharmacoepidemiology*-Epidemiological approach, Measurements in epidemiology, (rates, ratios, and proportions), Measurement of mortality, morbidity. Descriptive, analytical and experimental epidemiology.

7 hrs

References

1. Drug Discovery and Development, R.G. Hill and D Richards, Elsevier, (2021).
2. Modern Pharmacology with clinical correlations, 6thEdn., Charles R. Creig, and Robert E. Stitzel, Lippincott Williams & Wilkins.
3. Foye's Principles of Medicinal Chemistry, Williams,D.A. et al., 6thEdn.Lippincott Williams & Wilkins (2008).
4. Basic Pharmacokinetics and Pharmacodynamics: An Integrated Textbook and Computer Simulations, Sara E Rosenbaum2ndEdn, Wiley (2016).
5. Textbook of Clinical Trials edited by David Machin, SimonDayand Sylvan Green, MarchJohnWiley and Sons (2005)
6. Drugs: From Discovery to Approval, Rick, N.G. Wiley-Blackwell, (2015).
7. Applied Biopharmaceutics and Pharmacokinetics, Shargel,L. et al., 6th Edn., McGraw- Hill Medical, (2012).
8. Applied Biopharmaceutics & Pharmacokinetics, 5thEdn. Leon Shargel, Susanna Wu-Pong, Andrew B.C. Yu (2004)
9. Basic and Clinical Pharmacology, 12thEdn. Katzung, B.G., S.B. Masters, A.J. Trevor, McGraw-Hill (2012)
10. Remington The Science And Practice Of Pharmacy 23rdEdn, Academic Press, (2021)
11. Text Book of Therapeutics Drug and Disease Management,8thEdn., Richard A Helms, Lippincott Williams & Wilkins (2006).
13. Drug DiscoveryandDevelopment, James J. O'Donnell,J.Somberg,Vincent Idemyor,James T. O'Donnell, Taylor and Francis, (2021).

BCHP – 25: Genetic Engineering and Protein Chemistry (4 Credits)

Genetic Engineering

1. Preparation of Competent cells.
2. Transformation of DNA by $CaCl_2$ method (recombinant vectors – plasmids / phages).
3. Isolation and characterization of gene fragments for cloning
4. Restriction digestion of isolated plasmid DNA.
5. Expression of GFP in *E. coli*.
6. DNA Amplification (PCR).
7. Synthesis of cDNA.
8. Southern Blotting and Northern Blotting; Hybridization of DNA and RNA and detectionby specific probes (non-radioactive).
9. Characterization of clones by restriction digestion and agarose electrophoresis.
10. Expression, Isolation and purification of recombinant proteins.

Protein Chemistry

1. Extraction and isolation of enzymes (phosphatases / esterases / amylases) from Insect / Microbial / Plant sources.
2. Fractionation and purificationby conventional protein purification techniques (PAGE should be carried out at each step).
3. Ammonium sulfate, acetone and pH precipitation
4. Ion exchange chromatography.
5. Gel filtration.
6. Kinetic characterization of the enzyme

References

1. Nucleic Acid Blotting; D C Darling, P M Bricknell; Garland Science; (1994)
2. Principles and Techniques of Biochemistry and Molecular Biology; 7thEdn. Keith Wilson and John Walker (2012).
3. Principles of Gene Manipulations; 6thEdn. S.B. Primrose, R.M. Twyman, and R.W. Old, Blackwell Science (2012).
4. Gene Cloning and DNA analysis- An Introduction; T. A. Brown, 5th Edition, Wiley-Blackwell (2006).
5. Laboratory methods in Enzymology; Part-A; Jon Lorsch, Academic Press (2014).
6. Gene Cloning Laboratory Manual 4thEdn. Michael R. Green and Joseph Sambrook, (2014) CSHL Press.
7. Current Protocols in Molecular Biology; S Gallaghar, (2008) Wiley Interscience.
8. Wilson and Walker's Principles and Techniques in Biochemistry and Molecular biology; 8thEdn., Andreas Hofmann and Samuel Clokie; Eds. (2018), Cambridge University Press, New Delhi.

BCHPR – 26:Project Work (5 Credits)

Open elective for Non-Biochemistry PG students

BCHOET – 304.1: Biochemistry of Common Disorders

3 units (39hrs)

UNIT-I

Human Physiology: Introduction and brief description of cells, tissues and organs, their functions; Body fluids and their composition. Introduction to molecules as building blocks.Definition and differentiation of disease and disorder, types and causes. Relation between food, environment and illness. Analysis of various biochemical parameters in body fluids and specific tissues during disorders, diseases and forensics.

Diagnostic Techniques:Collection and storage of biological samples for clinical use. Commonly used tests fordiagnosis of various diseases and their interpretation.

13 hrs

UNIT-II

Blood analysis: Total blood count including ESR, Total serum proteins andtheir fractions. Blood glucose (GTT) (Fasting and postprandial), serum lipid fraction–cholesterol, triglyceride, LDL and HDL, blood urea, and serum calcium.

*Urine:*Creatinine, Glucose and protein (albumin).

*Enzymes:*SGPT, SGOT and isoenzymes as markers in various disorders and diseases.

6 hrs

Diseases and Disorders (common occurrence):

Aetiology; classification (if any); causative factors; incidence, symptoms and biochemical aspects and markers for-identification, monitoring, prevention and interventions; and nutritional aspects, overweight andobesity. **4 hrs**

Cardiovascular disease: Diabetes, diseases of Liver, Gall bladder & Pancreas-Hepatitis, (A, B, and C), Cirrhosis, alcoholic liverdisease, Gall stones, pancreatitis, pancreatic surgery- Causes, Prevention and dietarymanagement. **3 hrs**

UNIT-III

Renal disease: Nephrotic syndrome, Acute and Chronic renal failure- diagnostic proceduresand dietary management. Dialysis, medical and nutrition therapy. **4 hrs**

Gastrointestinal diseases/disorders: Gastro-oesophageal reflux and esophagitis, Gastritisand Peptic ulcer. Characteristics of and comparison of the stomach and duodenal ulcers.Diagnostic tests for malabsorption, sprue and tropical sprue, Crohn's disease, diarrhoea,constipation, ulcerative colitis, diverticular diseaseand colon cancer. **6 hrs**

Cancer and HIV/AIDS: Biochemistry of carcinogenesis, types, stages of cancer, diagnosis and existing medicines. Biochemistry of HIV infection, ART and social issues. **3 hrs**

References

1. Biochemistry; Donald Voet, Judith G. Voet, 4th Edition, John Wiley and sons (2010).
2. Lehninger- Principles of Biochemistry; David L. Nelson and Michael M. Cox, 6th Edition, W. H. Freeman (2013).
3. Biochemistry- The Chemical Reactions of Living Cells; David E. Metzler, 2nd Edition, Academic Press (2001).
4. Outlines of Biochemistry; Eric E. Conn, Paul K. Stumpf, George Breuning, Roy H. Doi, 5th Edition, John-Wiley and sons (2009).

5. Biochemistry- The Chemical Reactions of Living Cells; David E. Metzler, 2nd Edition, Academic Press (2001).
6. Hawk's Physiological Chemistry, ed. Oser, 14thEdn.(1976), Tata-McGrawHill.
7. Fundamentals of Practical Biochemistry. Mohanty and Basu, BI Publications, India. 2002.
8. 2. Clinical Biochemistry, 2ndEdn. W J Marshall, F I Biol and S K Bangert. Elsevier Health-Mosby Saunders. United States of America. ISBN: 9780443101861.

BCHOET – 304.2: Lifestyle Diseases

3 units (39 hrs)

UNIT-I

Lifestyle Diseases

General awareness: Definition - General introduction to lifestyle diseases - Risk factors: Lifestyle, food habits, Physiological stress, Free radicals and Oxidative stress- Preventive factors: Exercise, healthy food habits, antioxidants.

7 hrs

Atherosclerosis

Signs and symptoms, causes - modifiable and non-modifiable - Biochemical mechanisms of atherogenesis: including lipid peroxidation, plaque formation, and thrombosis - Diagnosis, Treatment and Prevention of Atherosclerosis.

6 hrs

UNIT-II

Alzheimer's and Parkinson's Disease

Dementia, Types of Dementia - Alzheimer's disease: stages of disease - causes: genetic, cholinergic hypothesis, amyloid hypothesis, tau hypothesis, pathophysiology and disease mechanism, disease Management - Parkinson's disease: causes, Symptoms, Molecular pathophysiology, prevention and disease management.

8 hrs

Hypertension

Characteristics, Causes, Risk factors - Obesity. Mechanism of obesity induced hypertension - Pathophysiology of hypertension in cardiovascular diseases (CVD) - Prevention and Management of hypertension.

5 hrs

UNIT-III

Diabetes mellitus

Classification – type 1, type 2, gestational - Complications of diabetes mellitus: Diabetic cataract, retinopathy, cardiomyopathy, nephropathy and neuropathy through advanced glycation end products - Role of glucose transporters in insulin resistance - Management of diabetes mellitus and treatment options.

6 hrs

Cancer

Overview Types, Causes, Genetic basis of cancer: tumor suppressor genes - oncogenes and gene expression. Molecular basis of cancer: dysregulation of cell cycle and mutation of p53 and Rb. Strategies for cancer treatment: immunotherapy, inhibition of cancer promoting proteins and inhibition of angiogenesis - prevention and management.

7 hrs

References

1. Textbook of Medical Physiology, by Arthur C Guyton, John E Hall Prism Saunders 9thEdn ISBN: 81-7286-034-X.
2. Molecular biology of the cell, by Alberts, Johnson, 5thEdn, Garland science (2016)
3. Cell and Molecular Biology by Gerald Karp, John Wiley & Son, Inc. New York ISBN 978, 5th Edition.
4. Disease and Drug consult: Neurologic Disorders, Lippincott, 1st edn, Lippincott Williams and Wilkins