Fourth Semester (IV)

SN	Course Code	Subject
1	BSB 2201	Molecular Biology -I
2	BSB 2202	Immunotechnology
3	BSB 2203	Clinical Biochemistry
4	BSB 2204	Developmental Biology
5	BSB 2205	Biophysics and Bioinstrumentation

MOLECULAR BIOLOGY-I

Semester: Fourth (IV)
Code: BSB2201
Credit: 3 (Theory) +1(Practical)
Lecture Hours: 45

Objective:

The course is intended to introduce the students to basic molecular biology and its applied fields in microbes

Course Description:

Unit 1: Structure and properties of nucleic acids of bacteria ***(4 Hours)***

Models of DNA structure; RNA structure, Physical, chemical properties of NA ; Spectroscopic and thermal properties of NA; The bacterial chromosome: structure, plasmid DNA, Models of replication in bacteria, Start replication, replication, termination, and segregation of the bacterial chromosome; cellular division, and the bacterial cell cycle.

Unit 2: Gene Expression in Prokaryotes I ***(4 Hours)***

Structure of bacterial promoters. Monocistronic and polycistronic RNAs; Start and elongation of the bacterial transcript, Bacterial transcription terminators. Degradation of the mRNA. Transcription in archaea. Transcriptional attenuation and regulation of transcription-

Unit 3: Gene expression in prokaryotes II. ***(5 Hours)***

Global modulators of gene expression. Multigenic networks. Stressful response. Repression by catabolite. Positive and negative transcriptional regulation. Transcriptional regulators. Bacterial operons. Posttranscriptional regulations. Regulones. Regulatory RNAs

Unit 4: Mutagenesis and DNA repair systems in bacteria. ***(5 Hours)***

Conditional lethal mutations. Suppressor mutations. Mismatch repair. Photoreactivation. Reparation by excision. Adaptive response to alkylating agents. Emergency repair response or SOS system

Unit 5: Mobile genetic elements in bacteria. ***(6 Hours)***

Insertion sequences. Transposons. Transposition mechanisms and their regulation. Mutagenesis with transposons. Mobile pathogenicity islands. Integrones. Other Mobile genetic elements.

Unit 6: Bacteriophages and Transduction ***(3 Hours)***

Attenuated and lytic bacteriophages. Lambda and P22 bacteriophages as attenuated bacteriophage models. Restricted, generalized, and lateral transduction. Phage conversion.

Unit 7: Defense systems in prokaryotes *(3 Hours)*

Innate immunity in prokaryotes: Prevention of Phage Attachment and Entry. Superinfection Exclusion Systems. Abortive Infection. Restriction-Modification Systems. Adaptive immunity in prokaryotes: CRISPR

Unit 8: Plasmids *(4 Hours)*

Molecular structure and property of plasmids. Mechanisms of maintenance. Aggregation and cointegration of plasmids. Replication. Incompatibility groups

Unit 9: Conjugation and Transformation *(5 Hours)*

Plasmid conjugation in Gram-negative and Gram-positive cells. Mobilization of the bacterial chromosome. Other conjugative elements (ICEs). Importance of the conjugative elements in the evolution of the microbial world. Natural transformation. Competence state. Molecular mechanisms associated with natural transformation. Induced transformation

Unit 10: Mechanisms of antimicrobial resistance *(6 Hours)*

Plasmid resistance. Chromosomal resistance. Mechanisms of antimicrobial inactivation. Synthesis of alternative enzymes. Resistances by alternative metabolic pathways. Modifications of cellular structures by plasmid enzymes. Mechanisms of distribution of plasmid resistances

PRACTICALS

Hours: 30

1) Isolation of genomic DNA from Bacteria
2) Agarose Gel Electrophoresis
3) Isolation of plasmid DNA
4) Plasmid profiling
5) Blue-white screening

REFERENCES

1. Tina M. Henkin, Joseph E. Peters. Snyder and Champness Molecular Genetics of Bacteria (5th Edition). Wiley-Blackwell (ISBN: 978-1-555-81975-0)
2. Jeremy W. Dale & Simon F. Park. Molecular Genetics of Bacteria, (5th Edition) Wiley-Blackwell (ISBN: 978-0-470-74184-9)
3. Gene VII by B. Lewin.
4. Essentials of Molecular Biology, Malacinski and Freifelder Jones and Bartlett Publishers.
5. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd.
6. Cell and Molecular Biology, Concepts and experiments Gerald Karp, John Wiley, and Sons.
7. The Cell - A molecular approach, Gm Cooper Asm Press.

Unit 7: Defense systems in prokaryotes *(3 Hours)*

Innate immunity in prokaryotes: Prevention of Phage Attachment and Entry. Superinfection exclusion Systems. Abortive Infection. Restriction-Modification Systems. Adaptive immunity in prokaryotes: CRISPR

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2. Jeremy W. Dale & Simon F. Park. Molecular Genetics of Bacteria, (5th Edition) Wiley-Blackwell (ISBN: 978-0-470-74184-9)
3. Gene VII by B. Lewin.
4. Essentials of Molecular Biology, Malacinski and Freifelder Jones and Bartlett Publishers.
5. Genomes, T. A. Brown, John Wiley and Sons PTE Ltd.
6. Cell and Molecular Biology, Concepts and experiments Gerald Karp, John Wiley, and Sons.
7. The Cell - A molecular approach, Gm Cooper Asm Press.

IMMUNOTECHNOLOGY

Semester: Fourth (IV)
Code: BSB2202
Credit: 3(Theory) + 1(Practical)
Lecture hours: 45

Objectives:
Upon completion of the course, students will possess a thorough understanding of the immune system's components, mechanisms, and functions, including innate and adaptive immunity, antigen recognition, and immune cell interactions. Students will also build an understanding about immunodeficiency, autoimmunity, immunotherapy and vaccination.

Course Description:

Unit 1: Basic Concept of Immunology *(4 Hours)*
Overview of immunology, Historical perspectives, Innate (non-specific) and adaptive (specific) immunity, Humoral and cell mediated immune response.

Unit 2: Cells and Organs of immune system *(4 Hours)*
Lymphocytes, Granulocytes, Antigen presenting cells, NK cells, Mast cells, Dendritic cells, Anatomy of the immune system: Bone marrow, thymus, lymph node, spleen, lymphoid tissues.

Unit 3: Antigens *(3 Hours)*
Immunogenicity and antigenicity, Factors influencing immunogenicity, Types and characteristics of antigens: Mitogens, haptens, immunogens, Epitopes.

Unit 4: Humoral immunity and Immunoglobulins *(6 Hours)*
Activation and differentiation of B cell, B cell receptor, Structure, Classification and function of antibodies, Synthesis, assembly and expression of immunoglobulin molecules, Genetic basis of antibody diversity.

Unit 5: Cell Mediated Immunity *(6 Hours)*
T cell activation, differentiation and maturation, T cell receptors, T cell types (cytotoxic, helper, suppressor), Role and structure of MHC molecules, Antigen processing and presentation.

Unit 6: Immune responses *(8 Hours)*
Complement system, Phagocytosis. Opsonization of antigens, Cell mediated effecter responses, Inflammatory responses, Hypersensitivity reactions, Autoimmunity, Immune tolerance.

Unit 7: Immunological techniques *(7 Hours)*
Antigen-antibody reactions-Precipitation, Agglutination, Enzyme linked immunosorbent assay (ELISA), Radioimmunoassay (RIA), Immunofluorescence, Immunohistochemistry, Immunoblotting, Immunoelectrophoresis.

Unit 8: Vaccines and Immunotherapy *(4 Hours)*
Overview of vaccine and vaccination, Types of vaccines, Adverse events following immunization, Introduction to immunotherapy.

it 9: Antibody techniques *(3 Hours)*

duction of monoclonal and polyclonal antibodies-techniques and applications, Purification of bodies, Antibody engineering.

CTICALS

s: 30

1. Collection of venous blood from healthy volunteer and separation of serum and plasma.
2. Differential blood count for identification of granulocytes and agranulocytes.
3. Blood grouping
4. Delayed hypersensitivity test: Mantoux test
5. Antigen antibody reaction: agglutination test (ASO/RPR), double diffusion (Ouchterlony), ELISA, Rocket immunoelectrophoresis
6. Immunochromatographic techniques
7. Handling of laboratory animals and inoculation techniques using different routes
8. Production of polyclonal antisera in animals.

ERENCES

1. Abbas AK and Lichtman AH (2008), *Basic Immunology: Functions and Disorders of the Immune System*, 3rdEdition, W B Saunders Co
2. Abbas AK, Lichtman AH and Pillai S (2007), *Cellular and Molecular Immunology*, 6 th Edition, Elsevier
3. Kindt BA (2006), *Kuby Immunology*, 6th TJ, Goldsby RA and Osborne Edition, W. H. Freeman
4. Roitt IM and Delves PJ (2001), *Roitt's Essential Immunology*, 10th Edition, ELBS, Blackwell Scientific Publications
5. Janeway, C.A., Travers, P., Walport, M., Capra, J.D. (2005). Immunobiology (6th Edition). Garland Science, New York.
6. Harlow, E.D. and Lane, D. (1999). Using Antibodies. A Laboratory Manual. CSH Laboratory Press. NY.
7. Hay, F.C., Westwood, O.M.R. (2002). Practical Immunology (4th Edition). Blackwell Publishing
8. Sambrook, J. and Russell, D. (2001). Molecular Cloning. A Laboratory Manual Vol. I, II & III CHSL Press, USA.
9. Multhukkaruppam, VR (2001). Hubridoma Techniques. A Laboratory courses.
10. Walker, J.M. (Editor) (1996). The protein protocols handbook. Humana press, NJ

CLINICAL BIOCHEMISTRY

Semester: Fourth (IV)
Code: BSB2203
Credit: 3 (Theory) +1(Practical)
Lecture Hours: 45

Objective:

- To understand the fundamental principles of bioenergetics and thermodynamics, and the importance of enzymes in biochemical pathways and the laws of thermodynamics in biological systems
- To empowering students to critically analyses various metabolic processes and their implications in health, disease, and biotechnological advancements.

Course Description:

Unit 1: Introduction to Clinical Biochemistry *(2 Hours)*
Definition, scope, and significance of clinical biochemistry in healthcare; Role of clinical biochemists in diagnostics and patient care; Overview of laboratory procedures, quality control, and ethics in clinical biochemistry.

Unit 2: Bioenergetics *(3 Hours)*
Bioenergetics and thermodynamic principle, high energy compounds, ATP cycle, ATP in metabolism, biotechnological applications of bioenergetics.

Unit 3: Carbohydrate Metabolism and Related Disorders *(6 Hours)*
Metabolism- Digestion and absorption of carbohydrates, availability of glucose to cells.; Glycolysis pathway: aerobic and anaerobic aspects, energetics, regulation of glycolysis, anaerobic glycolysis and its physiological importance; Pentose phosphate pathway. Feeder pathway for glycolysis.
Glycogen metabolism: Biosynthesis and coordinated regulation of glycogen synthesis and breakdown, role of insulin and glucagon in glycogen metabolism; Gluconeogenesis and its regulation, glucuronic acid pathway, Cori cycle (Lactic acid cycle), futile cycle, glyoxylate cycle; Glycogen storage diseases.
Clinical Disorders-Diabetes mellitus: biochemical basis, HbA1c, oral glucose tolerance test (OGTT), and insulin resistance; Hypoglycemia: causes and diagnostic approaches; Glycogen storage diseases: biochemical features and diagnostic markers.
Diagnostic Tools- Blood glucose analysis, estimation of ketone body, and enzymatic assays

Unit 4: TCA cycle *(3 Hours)*
Overview, the cyclic pathway and its regulation, detailed steps of the TCA Cycle, energetics of the total oxidation of glucose, anapleorotic pathways, amphibolic nature, interconnections with other metabolic pathways. TCA Cycle in Bioenergetics.

Unit 5: Protein Metabolism *(6 Hours)*
Metabolism- Decarboxylation, transamination, deamination, Urea cycle, amino acid metabolism, Metabolic disorders. Regulations and clinical aspects; Metabolism- Protein turnover, urea cycle, and amino acid metabolism; Clinical Applications-Phenylketonuria, maple syrup urine disease, and urea cycle defects; Diagnostics-Plasma amino acid profiling, urea, and ammonia levels.

Unit 6: Lipid Metabolism and Dyslipidemias *(6 Hours)*

Metabolism- Digestion, absorption, and transport of dietary lipids, Bile acid and salt, chylomicrons. Beta-oxidation of fatty acids, lipogenesis, ketone bodies, Lipid disorders and diseases. Clinical Diagnosis; Role of lipoproteins (chylomicrons, VLDL, LDL, HDL); Apolipoproteins and their clinical significance; Exogenous and endogenous lipid transport pathways; Clinical Applications- Dyslipidemia, metabolic syndrome, lipid storage disorders; Atherosclerosis, Fatty liver disease; Diagnostics- Lipid profile, apolipoproteins, lipid testing.

Unit 7: Nucleic Acid Metabolism *(6 Hours)*

Metabolism-Biosynthesis, Salvage and de-novo Pathway, and catabolism of nucleotides. Clinical Applications- Gout, Lesch-Nyhan syndrome, and purine-pyrimidine disorders. Diagnostics-Uric acid levels, genetic testing.

Unit 8: Endocrine Biochemistry and Hormonal Disorders *(7 Hours)*

Metabolism- Hormone (Steroid hormones (e.g., cortisol, aldosterone, sex hormones); Peptide hormones (e.g., insulin, glucagon, parathyroid hormone); Amine hormones (e.g., adrenaline, thyroxine) biosynthesis and regulation.; Clinical Applications- Thyroid disorders, adrenal insufficiency, diabetes (Type 1 and Type 2 diabetes); Diagnostics-Hormone assays (TSH, cortisol, insulin).

Unit 9: Electron Transport Chain (ETC) *(3 Hours)*

Shuttles across mitochondrial membrane, mitochondrial structure and compartmentalization of respiratory metabolism, the evolution of electron transport chain, substrate-level phosphorylation, oxidative phosphorylation, components of the ETC, ATP synthase complex, Proton Motive Force (PMF), Iron-sulphur proteins (ISPs), Q-cycle, chemiosmotic theory, inhibitors and uncouplers of oxidative phosphorylation, diseases and disorders related to ETC dysfunction (e.g., mitochondrial diseases).

Unit 10: Reactive oxygen species (ROS) **(3 Hours)**

Introduction, biochemical pathways and physiological roles of ROS. Oxidative Stress and Cellular Damage. Biological Roles of ROS. ROS and Human Diseases.

PRACTICALS

Hours: 30

1. Estimation of Reducing Sugars by the Dinitro Salicylic Acid (DNS) Method.
2. Determination of Blood Glucose by the enzymatic method.
3. Estimation of Protein by the Biuret Method.
4. Estimation of Protein by the FC-Method
5. Protein Assay by Bradford Method
6. Estimation of DNA by the Diphenylamine Method.
7. Analyse serum protein, total cholesterol, and uric acid levels

REFERENCES

1. Devlin, T.M. ed., 2010. Textbook of biochemistry with clinical correlations. John Wiley & Sons.
2. Voet, D., Voet, J.G. and Pratt, C.W. Principles of biochemistry.
3. Nelson, D.L., Lehninger, A.L. and Cox, M.M. Lehninger principles of biochemistry. Macmillan.
4. Harvey, R.A. and Ferrier, D.R., 2017. Lippincott's illustrated reviews: biochemistry. Lippincott Williams & Wilkins.
5. Lopez, J., 2015. Carl A. Burtis and David E. Bruns: Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics, Elsevier, Amsterdam, 1075 pp, ISBN 978-1-4557-4165-6.
6. Murray, K., Rodwell, V., Bender, D., Botham, K.M., Weil, P.A. and Kennelly, P.J., 2009. Harper's illustrated biochemistry. 28. *Citeseer, New York, United States*.
7. Palmer, T. and Bonner, P.L. Enzymes: biochemistry, biotechnology, clinical chemistry.

DEVELOPMENTAL BIOLOGY

Semester: Fourth (IV)
Code: BSB 2204
Credit: 3 (Theory)+1 (Practical)
Lecture hours: 45

Objective: The objective of the course is to provide latest findings about gamete structure, developments, assisted reproductive techniques (IVF, ICSI); make student understand embryonic development, gene regulating embryonic development and embryo manipulations.

Course Description

Unit 1. Basic Concept ***(5 Hours)***
Signaling in development and differentiation, Differential gene expression in development, Reprogramming genes of differentiated cells into embryonic state by animal cloning techniques (Somatic Cell Nuclear Transplantation, SCNT)

Unit 2. Model Systems for Studying Developmental Biology ***(5 Hours)***
Animal models: *Drosophila melanogaster, Caenorhabditis elegans, Xenopus laevis*, zebrafish, chicken, mouse. Plant model: *Arabidopsis thaliana.*

Unit 3. Gametes and Fertilization ***(4 Hours)***
Structure and development of mammalian male and female gametes, various steps of fertilization in mammalian.

Unit 4. Assisted Reproduction Techniques. ***(3 Hours)***
Human in vitro Fertilization (IVF) and Intracytoplasmic Sperm Injection protocols

Unit 5. Morphogenesis ***(4 Hours)***
Embryonic cell cycle, cleavage, blastula, gastrulation in mammalian proembryo, development of 3-chambered embryo, neural tube formation

Unit 6. Organogenesis ***(3 Hours)***
Imaginal discs, wing development in *Drosophila.*

Unit 7. Frog Metamorphosis. ***(2 Hours)***

Unit 8. Development in Nematodes and Slime Molds ***(6 Hours)***
Axes development in C. *elegans*, Cell-fate determination, larva and vulva development in *C. elegans*. Patterning of the slug in slime mold (*Dictyostelium*), cell differentiation, aggregation in slime mold.

Unit 9. Genes controlling Development ***(7 Hours)***
Role of maternal genes in polarization of body axes during oogenesis, patterning of early embryo & role of zygotic genes, segmentation and the role of pair-rule genes, body compartments and

ic role of segment polarity genes, role of homeotic genes in appendages development

Unit 10. Plant Development ***(6 Hours)***

Pattern of development in early embryogenesis of angiosperms. Juvenility and phase change, physiology of floral initiation and development. Development of fruits and seeds, Post harvest physiology fruits and seeds.

PRACTICALS

Hours: 30

1. To dissect male mouse. (a) study the male reproductive organs (b) Isolate spermatozoa from cauda epididymis and study live spermatozoa under microscope
2. To isolate spermatid cells by mincing seminiferous tubules of mouse testis and study various stages spermatogenesis
3. To dissect female mouse. (a) Study female reproductive organs. (b) Isolate mature, immature follicles and oocytes by tearing apart the ovaries and study them
4. To study chick embryo development in permanent slides
5. To study live, early-stage chick embryos
6. To study dicot and monocot embryos by dissecting water-soaked bean and maize seeds
7. To study development of flowering tree branch
8. To study development of garlic plant from clove
9. To study development of potato plant from tuber

REFERENCES

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

BIOPHYSICS AND BIOINSTRUMENTATION

Semester: Fourth
Code: BSB2205
Credit: 3 (Theory) +1(Practical)
Lecture Hours: 45

Objective:
The course focuses on understanding biophysics principles and instrumentation techniques essential for biotechnology applications.

Course Description:

Unit 1: Fundamentals of Biophysics *(6 Hours)*
Basic interactions- van der Waals, covalent bonds, hydrophilic and hydrophobic interactions, Cell membrane structure and Fluid Mosaic Model, Fick's Law of Diffusion and membrane permeability, Active and passive membrane transport mechanisms; Hodgkin-Katz Formula and theory of electro-diffusion.

Unit 2: Neurobiophysics *(7 Hours)*
Nerve cell structure and functions; Conducting properties of neurons; Generation and propagation of nerve impulses: Hodgkin-Huxley Model; Electrophysiological techniques (EMG, EEG, ECG); Blood flow and heart mechanics.

Unit 3: Microscopy and Spectroscopy *(7 Hours)*
Microscopy techniques: Optical, Atomic Force, TEM, SEM; Light scattering, optical activity, and spectroscopy (absorption, fluorescence, phosphorescence); Infrared and ultraviolet spectroscopy; Electron spin and resonance spectroscopy (NMR, mass spectroscopy).

Unit 4: Analytical Techniques *(6 Hours)*
Electrophoresis: Paper, gel, immuno, isoelectric focusing, 2D electrophoresis;
Chromatography: Paper, TLC, Gas Chromatography, Ion-Exchange, Affinity, HPLC.

Unit 5: X-Ray and Imaging Techniques *(8 Hours)*
X-ray interactions with tissues and materials (bones, muscles, cavities); Contrast agents (barium and iodine) and XRD technology; Imaging techniques: Gamma camera, CT, PET, SPECT, Ultrasonography, NMR imaging.

Unit 6: Radiation Biophysics *(5 Hours)*
Radiation types (ionizing and non-ionizing); Radiation dose units, Kerma, and dosimetry techniques; Radiation therapy (LINAC, Cobalt-60) and QA procedures; Cellular and subcellular radiation effects; Stochastic and non-stochastic effects of radiation.

Unit 7: Biomaterials and Tissue Engineering ***(6 Hours)***

Classification: Protein-based (collagen, gelatin), polysaccharides (cellulose, chitin), extracellular matrices, and synthetic biomaterials; Tissue engineering: Scaffolds, carbon nanotubes, and methods of application.

PRACTICALS

Hours: 30

1. To study the working principle of an optical microscope
2. To study the working principle of Centrifugal Technique
3. To study the working principle of Electrophoresis
4. To study the working principle of colorimeter
5. To study the working principle of UV- Spectrometer
6. To study the working principle of PH meter
7. Field visits for EMG, ECG, and EEG demonstrations.

REFERENCES

1. B.H. Brown, "Medical Physics and Biomedical Engineering."
2. Cotran R.S., Kumar V., Collins T., "Pathologic Basis of Disease."
3. Alberts B., "Molecular Biology of the Cell."
4. Hall J.E., "Guyton and Hall Textbook of Medical Physiology.