

**Learning Outcomes-Based Curriculum Framework
(LOCF)**



**Scheme and Syllabus of
B. Voc. (BIOMEDICAL SCIENCES)
(Three-Year Bachelor's Degree Programme)**

w.e.f. 2025-26

**DEPARTMENT of VOCATIONAL Studies and
Skill Development**

**School of Life-long Learning
Central University of Haryana
Mahendergarh, Haryana**

BACKGROUND

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of “Comprehensive Roadmap for Implementation of NEP-2020” in the 32nd meeting of the Academic Council of the University held on April 23, 2021. The roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on ‘creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills’ for the ‘development of an enlightened, socially conscious, knowledgeable, and skilled nation’.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasizing upon— integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness;

Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with industry and businesses; closer collaborations between industry and higher education institutions for technical, vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course.

In case of UG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NCrF, NHEQF, NSQF, International Standard Classification of Occupations, Sector Skill Council, Industry and other relevant agencies/sources. The University has also developed a consensus on the adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of B.Voc. Biomedical Sciences program has been devised with concerted efforts of the faculty, Heads of the Departments, Industry experts and members of Life Sciences Sector Skill Development Council (LSSSDC). Curriculum is aligned with National Skill Qualification Framework (NSQF) and has adopted job roles corresponding to NSQF level-4.5, 5 and 5.5 from the LSSSDC. These job roles are *Production Machine Operator* (NSQF Level-4.5),

Quality Control-Chemist (NSQF Level-5), and *Quality Control- Microbiologist* (NSQF Level-5.5).

The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

PROGRAMME OUTCOMES

After successful completion of the programme, the students shall be able to:

- PO1. Scientific knowledge:** Apply the knowledge of science and industrial technology to the solution of scientific problems in the industry.
- PO2. Problem analysis:** Identify, formulate, research literature, and analyze complex scientific problems reaching substantiated conclusions using first principles of biological sciences, and chemical sciences.
- PO3. Design/development of solutions:** Design solutions for complex problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- PO4. Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- PO5. Modern tools usage:** Create, select, and apply appropriate techniques, resources, and modern computing and IT tools including prediction and modeling to complex scientific activities with an understanding of the limitations.
- PO6. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the scientific practice.
- PO7. Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- PO8. Communication:** Communicate effectively on complex activities with the scientific community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- PO9. Project management:** Demonstrate knowledge understanding of the scientific and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- PO10. Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES

On completing B.Voc. Biomedical Sciences, the students shall be able to:

- PSO-1.** Perform manufacturing activities and carry out post manufacturing outcomes.
- PSO-2.** Conduct quantitative and qualitative analysis to ensure specified quality of the manufactured products.
- PSO-3.** Manages the work of licensing team in order to ensure that the appropriate licenses are in place for carrying out the life sciences facility operations.
- PSO-4.** Perform routine analysis in the laboratory while ensuring compliance to good manufacturing processes (GMP) and good laboratory practices (GLP).
- PSO-5.** Carry out reporting and documentation to meet quality standards.
- PSO-6.** Coordinate with supervisors and colleagues within and outside the department.
- PSO-7.** Maintain a healthy, safe and secure working environment in the life science facility.
- PSO-8.** Use individual judgment to determine if results or processes comply with regulations and approved standards
- PSO-9.** Make team decisions rather than individual decisions
- PSO-10.** Listen effectively and orally communicate information accurately

LEARNING OUTCOME INDEX:

Mapping of Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

PSOs→ POs↓	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
PO1	√	√	X	√	√	X	√	√
PO2	√	√	X	√	√	X	X	√
PO3	√	√	√	√	√	X	√	√
PO4	√	√	√	√	√	X	X	√
PO5	√	√	√	X	√	√	√	√
PO6	X	√	√	X	√	√	√	√
PO7	X	√	X	√	X	√	√	√
PO8	√	√	√	√	√	√	√	√
PO9	X	√	√	√	√	X	X	√
PO10	√	√	√	√	√	√	√	√

Mapping of general education component courses with PSOs

PSOs→ Core Course Number↓	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CC-1	√	X	X	X	√	X	X	√
CC-2	√	√	√	√	√	X	X	√
CC-3	X	X	X	√	X	X	√	√
CC-4	√	√	√	√	√	√	√	√
CC-5	√	√	√	√	√	X	X	√
CC-6	√	√	√	√	√	√	√	√
CC-7	√	√	√	X	√	√	X	√

TEACHING LEARNING OUTCOME

METHODOLOGIES

Learning based curriculum designed for various courses under B. Voc. (Biomedical Sciences) Programme aim for dissemination of up-to-date knowledge, development of student's capability to use ideas and information, and their ability to test those ideas and evidence. The courses also aim for facilitating the personal development and capacity of students to plan and manage their own learning. Instead of using traditional teaching methods, new teaching methods and pedagogical tools are required to ensure the achievement of desired learning outcomes for each of the courses. In view of the programme outcomes, following teaching methodologies will be used:

- Class room lectures
- Use of up-to-date textbooks, other learning resources
- Use of internet to support and explore the knowledge
- Use of case studies
- Practical exercises for each course to augment the learning
- Work experience through internship and fieldwork
- Projects
- Demonstrations
- Group working
- Simulations (e.g., computer based)
- Problem solving
- Discussion and debate
- Role play
- Quizzes
- Seminar presentations
- Class presentations
- Tutorials
- Examination papers

ASSESSMENT OUTCOME MEASUREMENT METHODS

Methods of measuring student learning are often characterized as summative or formative assessments:

Summative assessments: It includes case study analysis, assessment and evaluation of internship reports, project report evaluation, tests, quizzes, and other graded course activities that are used to measure the performance of learner. These assessments are cumulative and often reveal what students have learned at the end of a unit or the end of a course. Within a course, summative assessment includes the system for calculating individual student grades.

Formative assessment: It includes any means by which students receive input and guiding feedback on their relative performance to help them improve. It can be provided face-to-face in office hours, in written comments on assignments.

An array of direct and indirect methods should be used based upon the above-mentioned methodologies and assessment tools to assess the level of learning outcome(s) under each course with more weightage on 'Formative Assessment' to ensure that the learner improves during the teaching learning process. Direct measures require a learner to present or demonstrate their learning or produce work so that observers can assess how well students' work or responses fit institution-or program-level expectations of outcomes. It includes examinations, field experience, internship, lab reports, case studies, etc. as mentioned under Teaching Learning Outcome Methodologies and Summative Assessment. Through the indirect measures, the observer would be able to infer student abilities, knowledge, and values based on an analysis of reported perceptions about student mastery of outcomes using the indirect measures.

BLENDED LEARNING

B.Voc. Biomedical Sciences is focused to provide quality skill education. Success of skill education requires direct interaction of students with the industrial experts and hands-on-industrial training. Learning at B.Voc. Biomedical Sciences program in CUH involves regular expert lectures of the industrial experts. With the online classes being the option in NEP-2020, department will be conducting online expert classes from the industry for the skill enhancement of the students.

Scheme and Syllabus

Bachelor of Vocation (B.Voc.) in Biomedical Sciences



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CENTRAL UNIVERSITY OF HARYANA

School of Life-long Learning

Department of Vocational Studies and Skill Development

B. Voc. (BIOMEDICAL SCIENCES)

(Three-Year Degree Programme)

(Semester-wise Course Structure)

(w.e.f. 2025-26)

SEMESTER – I

GENERAL EDUCATION COMPONENT								
Type of Course	Course Code	Course Name	L	T	P	Credit	Marks	
CC	VSB 101 DM 30	Human Physiology	3	0	0	3	100	
CC	VSB 103 DM 30	Physical Chemistry	3	0	0	3	100	
CC	VSB 105 DM 20	Biomolecules	2	0	0	2	100	
SEC	VSB 107 SE 20	Practical	0	0	4	2	100	
Total						10	400	
SKILL EDUCATION COMPONENT*								
VET	Specific Job Role defined by SSCs as per the guidelines of					15		
Total Credits						25		

* Skill education component also includes an internship

SEMESTER – II

GENERAL EDUCATION COMPONENT								
Type of Course	Course Code	Course Name	L	T	P	Credit	Marks	
CC	VSB 102 DM 30	Metabolism of Biomolecules	3	0	0	3	100	
CC	VSB 104 DM 30	Organic Chemistry	3	0	0	3	100	
AEC	VSB 106 AE 20	English Communication	2	0	0	2	100	
SEC	VSB 108 SE 20	Practical	0	0	4	2	100	
Total						10	400	
SKILL EDUCATION COMPONENT*								
VET	Specific Job Role defined by SSCs as per the guidelines of					15		
Total Credits						25		

* Skill education component also includes internship

B. Voc. (BIOMEDICAL SCIENCES)

SEMESTER – III

		GENERAL EDUCATION COMPONENT							
		Type of Course	Course Code	Course Name	L	T	P	Credit	Marks
III (200)	CC	VSB 201 DM 30	Cell Biology	3	0	0	3	100	
	CC	VSB 203 DM 30	Pharmacology	3	0	0	3	100	
	VAC	VSB 205 VA 20	Environmental Sciences	2	0	0	2	100	
	SEC	VSB 207 SE 20	Practical	0	0	4	2	100	
	Total							10	400
	SKILL EDUCATION COMPONENT								
VET	Specific Job Role defined by SSCs as per the guidelines of						15		
Total Credits							25		

* Skill education component also includes internship

SEMESTER – IV

		GENERAL EDUCATION COMPONENT							
		Type of	Course Code	Course Name	L	T	P	Credit	Marks
IV (200)	CC	VSB 202 DM 30	Molecular Biology	3	0	0	3	100	
	CC	VSB 204 DM 30	Applied Organic	3	0	0	3	100	
	CC	VSB 206 DM 20	Medical Biotechnology	2	0	0	2	100	
	SEC	VSB 208 SE 20	Practical	0	0	4	2	100	
	Total							10	400
	SKILL EDUCATION COMPONENT								
VET	Specific Job Role defined by SSCs as per the guidelines of						15		
Total Credits							25		

* Skill education component also includes internship

B. Voc. (BIOMEDICAL SCIENCES)

SEMESTER-V

		GENERAL EDUCATION COMPONENT							
		Type of Course	Course Code	Course Name	L	T	P	Credit	Marks
V (300)	CC	VSB 301 DM 30	Introduction to Microbiology	3	0	0	3	100	
	CC	VSB 303 DM 30	Advanced Organic Chemistry	3	0	0	3	100	
	CC	VSB 305 DM 20	Enzymology	2	0	0	2	100	
	SEC	VSB 307 SE 20	Practical	0	0	4	2	100	
	Total							10	400
	SKILL EDUCATION COMPONENT								
VET	Specific Job Role defined by SSCs as per the guidelines of NSQF.						15		
Total Credits							25		

* Skill education component also includes internship

SEMESTER-VI

		GENERAL EDUCATION COMPONENT							
		Type of Course	Course Code	Course Name	L	T	P	Credit	Marks
VI (300)	CC	VSB 302 DM 30	Immunology	3	0	0	3	100	
	CC	VSB 304 DM 30	Medical Genetics	3	0	0	3	100	
	CC	VSB 306 DM 20	Medicinal Chemistry	2	0	0	2	100	
	SEC	VSB 308 SE 20	Practical	0	0	4	2	100	
	Total							10	400
	SKILL EDUCATION COMPONENT								
VET	Specific Job Role defined by SSCs as per the guidelines of						15		
Total Credits							25		

* Skill education component also includes internship

L: Lectures T: Tutorial P: Practical CC: Core Course

SEC: Skill Enhancement Course AEC: Ability Enhancement Course

VAC: Value Added Course VET: Vocational Education and Training

GENERAL
EDUCATION
COMPONENT

SEMESTER- I

Semester I

Human Physiology

Course code: VSB 101 DM 30

Course Credit- 3; Total hours: 45

Course Objective: *The objective of the course in human physiology is to provide a comprehensive study of the molecular and cellular mechanisms that govern the integrative working and regulation of the various organ systems in the human body. The course will provide a foundation of the physiological principles and the application of the same in real life situations. It also outlines the factors and biochemical events that disrupt homeostasis leading to various diseases. The course will prepare students for higher education in any field related to molecular medicine.*

Course Learning Outcomes

Unit 1: Organization of Human Body and Blood Physiology

After completion of the unit, students will be able to:

- Identify the main tissue types and discuss their roles in the human body
- Identify the four types of tissue membranes and the characteristics of each that make them functional
- Explain the functions of various epithelial tissues and how their forms enable their functions
- Explain the functions of various connective tissues and how their forms enable their functions
- Describe the characteristics of muscle tissue and how these enable function
- Discuss the characteristics of nervous tissue and how these enable information processing and control of muscular and glandular activities
- Identify the primary functions of blood, its fluid and cellular components, and its physical characteristics
- Identify the most important proteins and other solutes present in blood plasma
- Describe the formation of the formed element components of blood
- Discuss the structure and function of red blood cells and hemoglobin
- Classify and characterize white blood cells
- Describe the structure of platelets and explain the process of hemostasis
- Explain the significance of AB and Rh blood groups in blood transfusions

- Discuss a variety of blood disorders

Unit 2: Skeletal system and Nervous system

After completion of the unit, students will be able to:

- List and describe the functions of bones
- Describe the classes of bones
- Discuss the process of bone formation and development
- Explain how bone repairs itself after a fracture
- Discuss the effect of exercise, nutrition, and hormones on bone tissue
- Describe how an imbalance of calcium can affect bone tissue
- Name the major divisions of the nervous system, both anatomical and functional
- Describe the functional and structural differences between gray matter and white matter structures
- Name the parts of the multipolar neuron in order of polarity
- List the types of glial cells and assign each to the proper division of the nervous system, along with their function(s)
- Distinguish the major functions of the nervous system: sensation, integration, and response
- Describe the components of the membrane that establish the resting membrane potential
- Describe the changes that occur to the membrane that result in the action potential
- Explain the differences between types of graded potentials
- Categorize the major neurotransmitters by chemical type and effect

Unit 3: Gastrointestinal and Hepatic Physiology

After completion of the unit, students will be able to:

- List and describe the functional anatomy of the organs and accessory organs of the digestive system
- Discuss the processes and control of ingestion, propulsion, mechanical digestion, chemical digestion,
- Absorption, and defecation
- Discuss the roles of the liver, pancreas, and gallbladder in digestion
- Compare and contrast the digestion of the three macronutrients

Unit 4: Endocrine system and Renal Physiology

After completion of the unit, students will be able to:

- Identify the contributions of the endocrine system to homeostasis

- Discuss the chemical composition of hormones and the mechanisms of hormone action
- Summarize the site of production, regulation, and effects of the hormones of the pituitary, thyroid, parathyroid, adrenal, and pineal glands
- Discuss the hormonal regulation of the reproductive system
- Explain the role of the pancreatic endocrine cells in the regulation of blood glucose
- Identify the hormones released by the heart, kidneys, and other organs with secondary endocrine functions
- Discuss several common diseases associated with endocrine system dysfunction.
- Describe the composition of urine
- Label structures of the urinary system
- Characterize the roles of each of the parts of the urinary system
- Illustrate the macroscopic and microscopic structures of the kidney
- Trace the flow of blood through the kidney
- Outline how blood is filtered in the kidney nephron
- Provide symptoms of kidney failure
- List some of the solutes filtered, secreted, and reabsorbed in different parts of the nephron
- Describe the role of a portal system in the kidney
- Explain how urine osmolarity is hormonally regulated
- Describe the regulation of major ions by the kidney

Course Content:

Unit 1: Organization of Human Body and Blood Physiology (12h)

Tissues of the Human Body: Types and embryonic origin of tissues, epithelial, connective tissue, muscle tissue and nervous tissue; tissue membranes **Tissue Disorders:** Aging injury and cancer. **Blood Composition and Function:** Blood plasma, erythrocytes haemoglobin and life cycle of erythrocytes. **Blood Disorders:** Anemia and erythrocytes related disorders, **Leukocytes and Platelets:** Structure and function, **Haemostasis and Blood Clotting:** Mechanism and disorders

Unit 2: Skeletal system and Nervous system (13h)

Skeletal System: Bone classification, and structure, bone cells and tissues, bone formation and development, **Disorders:** Fractures and effects of exercise, nutrition, hormones and Calcium homeostasis **Nervous system:** Basic structure and function of the central and peripheral

nervous system, functional division, **Nervous Tissue:** Neurons structure, types and functions, Synapse, Neurotransmitters and Action potential

Unit 3: Gastrointestinal and Hepatic Physiology (6h)

Overview of digestive system: Processes of digestion and absorption in mouth, pharynx, oesophagus, stomach, small and large intestine, **Accessory organs:** Liver, gall bladder and pancreas - structure and function, **Chemical Digestion and Absorption:** Enzymes and nutrient uptake

Unit 4: Endocrine system and Renal Physiology (14h)

Endocrine System: Hormones and signaling mechanisms, Regulation of hormone secretion. Function and regulation of the hormones secreted by following glands: Pituitary, hypothalamus, thyroid, parathyroid, adrenal, pancreas, gonads and placenta and secondary endocrine organs. **Anatomy of the Urinary System:** Gross and microscopic structures of kidney and urinary tract, **Urine formation:** Filtration, reabsorption, and secretion processes, Physical Characteristics of Urine, Endocrine regulation of urine function

Suggested Textbook:

1. Fox, S.I. (2018) Human Physiology 15th ed., McGraw Hill International Publications, (New York) ISBN 978-1259864629.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2019) Vander's Human Physiology 15th ed., McGraw Hill International Publications (New York), ISBN: 978-1259903885.
3. OpenStax College, Anatomy & Physiology. OpenStax College. 25 April 2013. <http://cnx.org/content/col11496/latest/>

Suggested References:

1. Guyton, A.C. and Hall, J.E., (2016) Reed Textbook of Medical Physiology 13th ed., Elsevier India Pvt. Ltd. (New Delhi). ISBN: 9781455770052
2. Sherwood, L. (2012) Introduction to Human Physiology 8th edition; Brooks/Cole, Cengage Learning. ISBN-13: 978-1133104544.

Semester I
Physical Chemistry
Course code: VSB 103 DM 30
Course Credit- 3; Total hours: 45

Course Objective: *This course aims to provide students with a foundational understanding of physical chemistry concepts including thermodynamics, chemical kinetics, catalysis, chemical equilibrium, ionic equilibrium, and the behavior of solutions and disperse systems. It will also develop analytical thinking through problem-solving and encourage understanding of applications in pharmaceutical and biological contexts.*

Course Learning Outcomes

Unit 1: Thermodynamics

- Explain the fundamental laws of thermodynamics and their pharmaceutical significance.
- Apply the concepts of enthalpy, bond energy, and resonance energy to calculate heat changes in reactions.
- Use Kirchhoff's equation to determine enthalpy change with temperature.
- Explain the third law of thermodynamics and calculate absolute entropies of substances.

Unit 2: Chemical Kinetics and Catalysis

- Describe factors affecting the rate of chemical reactions.
- Derive and apply rate laws for zero, first, and second order reactions.
- Determine reaction order using experimental methods and interpret half-life data.
- Calculate activation energy using the Arrhenius equation.
- Compare collision theory and transition state theory qualitatively.
- Define catalysis and differentiate between homogeneous and heterogeneous catalysis.
- Explain the mechanisms of acid-base, enzyme, and biocatalysis.
- Discuss the industrial and pharmaceutical applications of various catalytic systems.

Unit 3: Chemical Equilibrium, Ionic Equilibrium and Buffers

- State the law of mass action and derive the equilibrium constant expression.
- Analyze how temperature, pressure, and concentration affect equilibrium.
- Use Van't Hoff isotherm and equation to study equilibrium shifts.
- Define pH and calculate it for strong and weak acids/bases.
- Prepare buffer solutions and determine their buffer capacity.
- Apply buffer systems in pharmaceutical preparations and adjust isotonicity.

Unit 4: Solutions and Disperse Systems

- Describe the physical properties of liquids and their pharmaceutical importance (surface tension, viscosity, etc.).
- Explain colligative properties and partition coefficients.
- Classify colloids, gels, emulsions, and suspensions with examples.
- Discuss the preparation and applications of disperse systems in drug formulations.

Course Content:

Unit 1: Thermodynamics

(7h)

Review of thermodynamics and the laws of thermodynamics, important principles and definitions of thermochemistry, concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, variation of enthalpy of a reaction with temperature – Kirchoff's equation., statement of third law of thermodynamics and calculation of absolute entropies of substances.

Unit 2: Chemical Kinetics and Catalysis

(15 h)

Chemical Kinetics: The concept of reaction rates, effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction, derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants), half-life of a reaction, general methods for determination of order of a reaction, Concept of activation energy and its calculation from Arrhenius equation.

Theories of reaction rates: Collision theory and activated complex theory of bi-molecular reactions. Comparison of the two theories (qualitative treatment only)

Catalysis: Classification and applications, Catalysis, type of catalysis, Theory and applications of Homogenous and Heterogeneous catalysis, mechanism of catalysis, Acid Base catalysis Enzyme catalysis, biocatalysis, phase transfer catalysis transition metal catalysis and organo catalysis

Unit 3: Chemical equilibrium, Ionic Equilibrium and Buffers (14 h)

Chemical equilibrium: Reversible reactions, law of mass action, equilibrium constant, factors influence equilibrium states, relation between K_p and K_c , Van't Hoff reaction isotherm, Van't Hoff Equation.

Ionic Equilibrium and Buffers: Acids, bases, pH scale, buffer solutions, indicators, buffer equations and buffer capacity in general. Buffers in pharmaceutical systems: Preparation, stability, buffered isotonic solutions, measurements of tonicity, calculations, and methods of adjusting isotonicity

Unit 4: Solutions and Disperse Systems (9h)

Solutions: Physical properties of Liquids (surface tension, viscosity, refractive index). Ideal and real solutions, solutions of gases in liquids, colligative properties, partition coefficient, conductance, and its measurement, Debye-Huckel theory.

Disperse System: Colloids: Size, Shape, and types of colloidal systems, Optical Properties, Kinetic Properties, Electrical Properties, Stability of colloidal systems, Sensitization, protective colloidal Action, Solubilization, Pharmaceutical Applications of colloids. **Gels and Emulsions:** Gels and its types, Emulsions, Types of emulsions, Preparation of Emulsion. **Suspensions:** Classification and Properties, Formulations and Pharmaceutical Applications.

Suggested Textbooks:

1. Puri, B.R., Sharma, L.R. & Pathania, M.S. – *Principles of Physical Chemistry*, Vishal Publishing.
2. Atkins, P. & De Paula, J. – *Atkins' Physical Chemistry*, Oxford University Press.
3. Lachman, L., Lieberman, H.A., Kanig, J.L. – *The Theory and Practice of Industrial Pharmacy*, CBS Publishers.
4. Connors, K.A. – *A Textbook of Pharmaceutical Analysis*, Wiley.

Suggested References:

1. Remington – *The Science and Practice of Pharmacy*, Pharmaceutical Press.
2. Patrick, G.L. – *An Introduction to Medicinal Chemistry*, Oxford University Press.
3. Manavalan & Ramasamy – *Physical Pharmaceutics*, Vignesh Publishers.
4. Vogel, A.I. – *Quantitative Chemical Analysis*, Pearson.

Semester I

Biomolecules

Course code: VSB 105 DM 20

Course Credit- 2; Total hours: 30

Course Objective: *The objective of this course is to offer detailed knowledge about the fundamentals of structure and classification of biomolecules present inside the cell. The course also focuses on the diversity and functions of biomolecules.*

Course Learning Outcome:

Unit 1: Carbohydrate

- Define carbohydrates and classify them into monosaccharides, disaccharides, oligosaccharides, and polysaccharides based on their structure and complexity.
- Describe the structure, types, and functions of monosaccharides, including isomerism and functional group classification (aldoses and ketoses).
- Explain the formation and structure of disaccharides (e.g., maltose, lactose, sucrose) and their biological roles.
- Differentiate among various types of polysaccharides (e.g., starch, glycogen, cellulose) and explain their structural and storage functions in plants and animals.
- Discuss the biological importance and functions of proteoglycans, glycoproteins, and glycolipids, including their roles in cellular communication, structure, immunity, and molecular recognition.

Unit 2: Lipids

- Define lipids and classify them based on their structure and biological functions (simple, compound, and derived lipids).
- Classify fatty acids into saturated, unsaturated (mono- and polyunsaturated), essential and non-essential types.
- Describe the physico-chemical properties of fatty acids, including melting point, solubility, saponification, iodine number, and cis-trans isomerism.

- Explain the structure and biological functions of cholesterol, including its role in membrane fluidity and as a precursor of steroid hormones and bile acids.
- Describe the structure and function of phosphoglycerides, highlighting their amphipathic nature and role in membrane structure.
- Explain the structure and significance of sphingolipids, including sphingomyelin, and their role in nerve tissue and signal transduction.
- Differentiate between sphingolipids and glycosphingolipids, and describe the role of glycosphingolipids in cell recognition and signaling.
- Discuss the structure, synthesis, and biological role of eicosanoids, including prostaglandins, thromboxanes, and leukotrienes in inflammation and other physiological processes.

Unit 3: Proteins

- Define and classify amino acids based on their chemical nature (polar, non-polar, acidic, basic, aromatic, etc.) and nutritional requirement (essential vs. non-essential amino acids).
- Explain the concept of zwitterions, and relate it to the acid-base behavior of amino acids in different pH conditions.
- Interpret titration curves of amino acids and calculate pKa and isoelectric point (pI) to understand buffering action and charge states at various pH levels.
- Describe the formation of peptide bonds and explain the significance of peptide linkage in protein structure.
- Differentiate between the four levels of protein structure—primary, secondary (α -helix, β -sheet), tertiary, and quaternary—with examples.
- Identify and describe the types of bonds and interactions (hydrogen bonds, ionic bonds, disulfide bridges, hydrophobic interactions) that stabilize protein structures.
- Explain the principles and mechanisms of protein folding, including the role of chaperones in assisting proper folding.

- Discuss the processes of protein denaturation and renaturation, and their relevance in biological systems and laboratory applications.
- Relate protein structure to its function and stability, including the consequences of misfolding or structural alterations.

Unit 4: Nucleotides

- Identify and describe the structure and function of nucleotides, including the components nitrogenous bases (purines and pyrimidines), pentose sugars, and phosphate groups.
- Differentiate between purines and pyrimidines, and explain the concept of tautomerism in nitrogenous bases and its biological significance.
- Classify and explain the roles of nucleotide derivatives (e.g., ATP, cAMP, NAD⁺) in cellular processes.
- Explain how nucleotides function as regulatory molecules in metabolic pathways and signal transduction.
- Distinguish between the various structural forms of DNA (A-DNA, B-DNA, Z-DNA) and RNA types (mRNA, tRNA, rRNA, etc.) and describe their respective roles in the cell.
- Describe and interpret the process of DNA denaturation and renaturation, including the principles behind hyperchromic and hypochromic effects as observed in UV absorption spectra.
- Apply knowledge of nucleic acid properties to experimental contexts, such as DNA melting temperature analysis and base-pairing dynamics.

Course Content:

Unit 1. Carbohydrates (8h)

definition, classification, structure and functions of carbohydrates; Monosaccharides, Disaccharides and Polysaccharides Biological importance of Proteoglycans, Glycoproteins, and Glycolipid;

Unit 2. Lipids (7h)

Definition and classification of lipids. Classification of fatty acids, physio-chemical properties of fatty acids, Structure and function of cholesterol, Phosphoglycerides, Sphingolipids, Glycosphingolipids and Eicosanoids.

Unit 3. Proteins (8h)

Definition and classification of amino acids based on chemical nature and nutritional (essential and nonessential) requirement, Zwitterions, pKa, pI, Titration of amino acids, Peptide bonds; Structure of protein-Primary, secondary, tertiary and Quaternary structure; Protein stability, Bonds and interaction stabilizing the protein structure, Protein folding, Denaturation and Renaturation;

Unit 4. Nucleotides (7h)

Nucleic acids- Nucleotides, Nitrogenous Bases- Purines and Pyrimidines; tautomers of bases, nucleotide derivatives, nucleotides as regulating molecules, different types of DNA and RNA, Denaturation of DNA Hyperchromic and hypochromic effect

Suggested Textbooks:

1. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations*. John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116/ISBN:10-1464126119.

Semester I

Practical

Course code: VSB 107 SE 20

Course Credits: 2; Total hours: 60

Course Objective: *The objective of this course is to provide knowledge of basic laboratory preparation and sensitize them towards the necessity of good laboratory practices and Standard Operating Procedures. This course introduces students to the basic human physiology experiments where students learn to prepare slides and counts cells use the microscope. The course also covers the preparation of different volumetric and buffer solutions, evaluating how various factors affect the rate of reaction.*

Course Learning Outcomes:

After completing the course, student will be able to:

- Count the RBC, WBC, different types of leukocytes present in an individual.
- Estimate the amount of hemoglobin in an individual
- Identify type of blood group of an individual
- Measure the blood pressure using sphygmomanometer
- To perform experiments using good laboratory practices
- To report observations and result of the experiments
- Learn different ways of expressing the concentration of solution
- Convert one form of concentration to another, e.g., Molarity to g/L.
- Accurately prepare standard solutions using analytical balance and volumetric glassware.
- Understand the importance of precision in solution preparation.
- Perform acid-base titration and calculate the unknown concentration using stoichiometric principles.
- Apply endpoint detection techniques effectively.
- Prepare buffer solutions and measure their pH using a pH meter or indicator.
- Investigate how changing reactant concentrations affects reaction rate.
- Evaluate the influence of temperature on reaction rate.

- acquire knowledge of how intermolecular forces influence physical properties like viscosity and surface tension.
- Determine the relative and absolute viscosity of dilute solutions using an Ostwald's viscometer, and interpret the results in terms of molecular interactions and concentration effects.
- Measure surface tension accurately using a stalagmometer and explain how temperature, solute type, and concentration affect surface tension.
- Apply theoretical knowledge to practical techniques, enhancing precision in measurements and calculation of physical constants.
- Develop laboratory skills including careful sample handling, timing, calibration of instruments, and error minimization.
- Analyze and report experimental data systematically, drawing valid conclusions and relating findings to physicochemical principle
- Perform specific chemical tests to identify mono-, di-, and polysaccharides.
- Interpret results based on color changes and reaction principles.
- Use Biuret, Millon's, and other protein-specific tests to detect proteins in samples.
- Explain the chemical basis of each test.
- Accurately estimate protein concentration using Lowry's colorimetric assay.
- Prepare standard curves and analyze unknown samples quantitatively.
- Detect the presence of lipids using Sudan III staining technique.
- Interpret lipid solubility and staining properties.
- Conduct saponification to identify fats and understand soap formation.
- Explain the chemistry of fat hydrolysis and its practical applications.

Course Content:

1. Introduction to Good laboratory practices

Human Physiology

2. Introduction to the Microscope
3. Estimation of haemoglobin
4. Determination of bleeding time and clotting time of blood.
5. Determination of total erythrocyte count.

6. Determination of total leukocyte count.
7. To perform differential leukocyte count of blood.
8. Blood Pressure recordings in humans.
9. Determination of blood group

Physical Chemistry

10. Preparation of volumetric solutions
11. Determination of the concentration of an unknown solution by using titration.
12. Preparation of buffer solutions and determination of pH
13. Experiment to study the effect of concentration on the rate of reaction.
14. Experiment to study the effect of temperature on the rate of reaction.
15. Determination of the relative and absolute viscosity of a liquid dilute solution using an Ostwald's viscometer.
16. Determination of surface tension using stalagmometer.

Biomolecules

17. Qualitative tests for Carbohydrates
18. Qualitative tests for Proteins
19. Quantitative estimation of proteins by Lowry's method.
20. Qualitative Tests: Sudan III
21. Qualitative analysis of fat through saponification test

Suggested Textbooks:

1. Ghai, C.L. (Latest ed.), *A Textbook of Practical Physiology*, Jaypee Brothers Medical Publishers, New Delhi.
2. Joshi, V.D. (Latest ed.), *Clinical Physiology Made Ridiculously Simple*, Medmaster Inc.
3. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (Latest ed.), *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Edn., John Wiley and Sons Inc.
4. Puri, B.R.; Sharma, L.R.; Pathania, M.S. (Latest ed.), *Principles of Physical Chemistry*, Vishal Publishing Co., Jalandhar.
5. Marr, J.B.; Rockett, R.W. (Latest ed.), *Practical Physical Chemistry*, Van Nostrand Reinhold Company.
6. Ahluwalia, V.K.; Dhingra, S. (2004), *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press.

7. . Chatterjee, C.C. (Latest ed.), *Human Physiology*, Vol. 1 & 2, Medical Allied Agency, Kolkata
8. Plummer, D.T. (Latest ed.), *An Introduction to Practical Biochemistry*, 3rd Edn., McGraw-Hill Education.
9. Jayaraman, J. (Latest ed.), *Laboratory Manual in Biochemistry*, New Age International Publishers.
10. Wilson, K.; Walker, J. (Latest ed.), *Principles and Techniques of Biochemistry and Molecular Biology*, Cambridge University Press.
11. Sawhney, S.K.; Singh, Randhir (Latest ed.), *Introductory Practical Biochemistry*, Narosa Publishing House, New Delhi.

Suggested References:

1. Indian Pharmacopoeia (Latest Edition)

SEMESTER- II

Semester II

Metabolism of Biomolecules

Course code: VSB 102 DM 30

Course Credit- 3; Total hours: 45

Course Objective: *The objective of this course is to offer detailed knowledge about the fundamentals of structure and function different biomolecules present inside the cell. The objective of this course is to focus on metabolism of these molecules with respect to health diseases in addition to providing overview of inhibitors of metabolism for treating the diseases of metabolic disorders. The course also offers detailed and comprehensive knowledge about the synthesis and degradation pathways of amino acids and nucleotides and their importance in the proper functioning of the cells.*

Course Learning Outcomes:

Unit 1. Metabolism and Bioenergetics

After completion of the unit, students will be able to:

- After completion of the unit, students will be able to:
- Explain energy production and the principles of metabolic regulation.
- classify coenzymes as either metabolite-derived or vitamin-derived
- structures and functions of NAD⁺, NADP⁺, FAD, and FMN in redox reactions.

Unit 2: Carbohydrate Metabolism

After completion of the unit, students will be able to:

- Understand and describe the central carbohydrate metabolic pathways.
- Explain energy production and the principles of metabolic regulation.
- Relate biochemical processes to associated metabolic disorders.

Unit 3: Lipid Metabolism

After completion of the unit, students will be able to:

- Describe lipid catabolic and anabolic pathways and their regulation.
- Understand the bioenergetics of fatty acid metabolism.
- Analyze the biochemical basis of lipid metabolic disorders.

Unit4: Amino acids and Nucleic acids Metabolism

After completion of the unit, students will be able to:

- Describe amino acid degradation pathways and nitrogen excretion.
- Explain urea cycle regulation and interconnection with central metabolism.
- Identify and interpret key metabolic disorders of amino acid metabolism.
- Understand nucleotide biosynthesis, salvage, and degradation.
- Explain regulatory mechanisms and their clinical implications.
- Describe metabolic defects associated with nucleotide metabolism.

Course Content:

Unit 1: Metabolism and Bioenergetics

(9h)

Coenzymes- Classifications (metabolite derived/vitamin derived) function of various types, structure of NAD⁺, NADP⁺, FAD & FMN, Principles of bioenergetics-Standard free energy change, experimental measurement of ΔG , ATP and other reaction molecules, metabolic roles of ATP-Phosphoryl group transfer, nucleotidyl group transfer, biological oxidation-reduction reactions.

Unit 2: Carbohydrate Metabolism

(13h)

Glycolysis, Entry of galactose, Mannose and fructose into glycolytic pathway. Anaerobic fate of pyruvate: ethanol and lactic acid fermentation, Gluconeogenesis, Hexose Monophosphate Pathway, Coordinate Regulation of glycolysis and gluconeogenesis, futile cycle; Glycogen metabolism: Synthesis and breakdown of glycogen and its coordinate regulation. Aerobic fate of pyruvate, Pyruvate dehydrogenase complex enzyme and TCA cycle, Amphibolic nature, Anaplerotic reactions, Regulation of TCA cycle, Glyoxylate cycle; Electron transport chain and Oxidative phosphorylation: Component and sequence of electron, Proton motive force, Chemiosmotic theory of ATP synthesis, Role of uncouplers and thermogenesis; Disorders associated with defects in carbohydrate metabolism: Lactose intolerance, fructose intolerance, Glycogen storage disorders.

Unit 3: Lipid Metabolism

(12h)

Transport of fatty acids to mitochondria, β -Oxidation of even chain saturated fatty acid. β -Oxidation of odd chain saturated fatty acid, Omega and Alpha oxidation of fatty acids.

Bioenergetics for complete oxidation of fatty acid to acetyl CoA and CO₂, Coordinate regulation of fatty acid synthesis and breakdown, Ketone bodies synthesis and degradation (Ketosis). Relationship of ketone bodies production with Diabetes mellitus and starvation; Disorders associated with defects in Lipid metabolism: Tay sach's disease, Gaucher disease

Unit4: Amino acids and Nucleic acids Metabolism

(11h)

Assimilation of Ammonia: its incorporation in glutamate, glutamine and alanine as nitrogen carrier, regulation of glutamate dehydrogenase and glutamine synthetase, transamination reactions-role of pyridoxal phosphate, nitrogen excretion and urea cycle. An overview of degradation pathways of amino acids with detailed pathway of phenylalanine and branched chain amino acids. Disorders associated with defects in protein and amino acid metabolism: disorder associated with deficiency of Urea cycle enzymes, Phenylketonuria, Alcaptonuria, Maple syrup urine disease, tyrosinemia Nucleic acid synthesis Denovo and salvage pathway Degradation of purines and pyrimidines, nucleotide analogs as chemotherapeutic agents. Disorders associated with defects in nucleotide metabolism- Gout, Lesch Nyhan

Suggested Textbooks:

1. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations*. John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116/ISBN:10-1464126119.

Semester II

Organic Chemistry

Course code: VSB 104 DM 30

Course Credit- 3; Total hours: 45

Course Objective: *This course aims to introduce students to fundamental principles of organic chemistry including electronic effects, bond cleavage, stereochemistry, and the structure and reactivity of hydrocarbons and alkyl halides. Emphasis is placed on understanding organic reaction mechanisms, structural representations, and stereochemical considerations. This course serves as the foundation for advanced organic chemistry and its applications in chemistry and allied disciplines.*

Course Learning Outcomes

Unit 1: Fundamentals of Organic Chemistry

After completion of the unit, students will be able to:

- Explain the electronic effects such as inductive, resonance, electromeric, and hyperconjugation.
- Differentiate between homolytic and heterolytic bond cleavage.
- Identify and describe reactive intermediates: carbocations, carbanions, and free radicals.
- Define electrophiles and nucleophiles and illustrate their roles in organic reactions.
- Understand the concept of aromaticity and apply Hückel's rule to classify aromatic and non-aromatic compounds.

Unit 2: Stereochemistry

After completion of the unit, students will be able to:

- Analyze conformations of ethane, butane, and cyclohexane using Newmann, Sawhorse, Wedge, and Fischer projections.
- Understand the concept of chirality and identify chiral centers (up to two carbon atoms).
- Distinguish between geometrical and optical isomerism, including enantiomers, diastereomers, meso compounds, threo/erythro isomers, and D/L forms.
- Apply CIP (Cahn-Ingold-Prelog) rules for assigning R/S and E/Z configurations (up to two chiral centers or double bonds).

Unit 3: Aliphatic and Aromatic Hydrocarbons

After completion of the unit, students will be able to:

- Describe methods for preparation of alkanes including Wurtz reaction, Kolbe synthesis, catalytic hydrogenation, and use of Grignard reagents.
- Explain free radical substitution mechanisms, especially halogenation in alkanes.
- Analyze the preparation and reactions of alkenes including elimination (Saytzeff rule), catalytic hydrogenation, Birch reduction, and electrophilic addition (Markovnikov and anti-Markovnikov).
- Describe oxidation (e.g., ozonolysis, hydroxylation) and addition reactions of alkenes.
- Illustrate preparation methods of alkynes and analyze their characteristic reactions such as acidity, metal acetylide formation, oxidation, and hydration to carbonyl compounds.
- Explain the aromatic character and structure of benzene.
- Describe the methods of benzene synthesis from various precursors.
- Understand mechanisms of electrophilic aromatic substitution (EAS) including nitration, halogenation, sulphonation, and Friedel-Crafts reactions.
- Predict products of side-chain oxidation reactions in alkylbenzenes.
- Analyze the stability and reactivity of intermediate carbocations involved in EAS.

Unit 4: Alkyl Halides (up to 5 carbon atoms) and Haloarenes

After completion of the unit, students will be able to:

- Describe the structure and classification of primary, secondary, and tertiary alkyl halides.
- Illustrate preparation methods of alkyl halides from alcohols and alkenes with mechanisms.
- Differentiate between S_N1 , S_N2 , and S_Ni mechanisms with examples.
- Analyze factors affecting substitution vs. elimination competition.
- Explain specific nucleophilic substitution reactions like hydrolysis, nitrile formation, and Williamson ether synthesis.
- Explain the structure and resonance of haloarenes.
- Describe methods of preparation from benzene via electrophilic substitution and from phenols and anilines via nucleophilic substitution (Sandmeyer and Gattermann reactions).
- Understand reactivity patterns of haloarenes in comparison to haloalkanes.

- Predict the orientation and reactivity of electrophilic and nucleophilic substitutions on the aromatic ring.

Course Content:

Unit 1: Fundamentals of Organic Chemistry (5h)

Electronic displacements: Inductive effect, electromeric effect, resonance, hyperconjugation. Cleavage of bonds: homolysis and heterolysis. Reaction intermediates: carbocations, carbanions and free radicals. Electrophiles and Nucleophiles, Aromaticity: Benzenoids and Hückel's Rule.

Unit 2: Stereochemistry (8h)

Conformations with respect to ethane, butane and cyclohexane, interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations, concept of chirality (upto two carbon atoms). configuration: geometrical and optical isomerism, enantiomerism, diastereomerism, and meso compounds). Threo and erythro; D and L; cis-trans nomenclature: CIP Rules: R/S (for upto 2 chiral carbon atoms) and E/Z nomenclature (for upto two C-C systems).

Unit 3: Aliphatic and Aromatic Hydrocarbons (15 h)

Aliphatic Hydrocarbons: Functional group approach for the following reactions: preparations, physical properties, and chemical reactions to be studied with mechanism in context to their structure.

Alkanes:

Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, Grignard reagent. Reactions: Free radical substitution: Halogenation

Alkenes:

Preparation: Elimination reactions: Dehydration of alcohols and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction).

Reactions: cis-addition (alk. KMnO_4) and trans-addition (bromine), addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration. Ozonolysis, oxymercuration-demercuration. Hydroboration-oxidation.

Alkynes:

Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides.

Reactions: formation of metal acetylides and acidity of alkynes, addition of bromine and alkaline KMnO_4 , ozonolysis and oxidation with hot alk., KMnO_4 . Hydration to form carbonyl compounds

Aromatic Hydrocarbons: Structure and aromatic character of benzene.

Preparation: methods of preparation of benzene from phenol, benzoic acid, acetylene and benzene sulphonic acid.

Reactions: electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side chain oxidation of alkyl benzenes.

Unit 4: Alkyl Halides (up to 5 carbon atoms) and Haloarenes: (15 h)

Alkyl halides: Structure of haloalkanes and their classification as primary, secondary and tertiary (1° , 2° & 3°).

Preparation: starting from alcohols (1° , 2° & 3°) and alkenes with mechanisms.

Reactions: Nucleophilic substitution reactions with mechanism and their types ($\text{S}_{\text{N}}1$, $\text{S}_{\text{N}}2$ and $\text{S}_{\text{N}}i$). competition with elimination reactions (elimination vs substitution), nucleophilic substitution reactions with specific examples from: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation and Williamson's ether synthesis

Haloarenes: Structure and resonance

Preparation: Methods of preparation of chloro, bromo & iodobenzene from benzene (electrophilic substitution), from phenols (nucleophilic substitution reaction) and from aniline (Sandmeyer and Gattermann reactions).

Suggested Textbooks:

1. Morrison, R.T., & Boyd, R.N. (2010). *Organic Chemistry* (7th ed.). Pearson Education.

2. Solomons, T.W.G., Fryhle, C.B., & Snyder, S.A. (2022). *Organic Chemistry* (12th ed.). Wiley India.
3. Paula Yurkanis Bruice. (2016). *Organic Chemistry* (8th ed.). Pearson Education.

Suggested References:

1. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic Chemistry* (2nd ed.). Oxford University Press.
2. Bahl, A. & Bahl, B.S. (2014). *Advanced Organic Chemistry*. S. Chand & Co.
3. Smith, J.G. (2020). *Organic Chemistry* (6th ed.). McGraw-Hill Education.

Semester II
English Communication
Course code: VSB 106 AE 20
Course Credit- 2; Total hours: 30

Course Objective: *Effective communication is an essential skill for success in any sphere of activity, from leadership responsibilities, teamwork, interviews, presentations, and inter-personal relations. This is a skill that needs to be taught in a systematic manner so that students imbibe the fundamentals of communication.*

The ability to think critically is crucial for a good communicator and involves an understanding of the communicative process. Therefore, we need to study every stage of this process systematically in order to be much more effective at communicating successfully – interviews, public speaking, letter writing, report writing, presentations, and inter-persona debates and conversations.

Course Learning Outcomes:

Unit 1:

After completion of the unit, students will be able to

- Understand the importance of effective communication
- Describe the barriers for effective communication
- Apply the rules of effective communication to improve their communication skills.

Unit 2:

After completion of the unit, students will be able to

- Identify the styles of communication
- Describe different elements of communication
- Understand the role of body language in communication
- Describe factors built our perspectives

Unit 3:

After completion of the unit, students will be able to

- Describe and practice the elements of active listening to become active listener.
- Express the concepts through writing.
- Organize the message, lecture and practice brief and conscience writing.

Unit 4:

After completion of the unit, students will

- Have the knowledge of dos and don'ts of an interview
- Be able to deliver effective presentations
- Be able to draft email, C.V.'s and reports for business purposes.
- Develop communication skills for group discussion.

Course Content:

Unit 1: (6h)

Communication Skills: Introduction, Definition, The Importance of Communication, The Communication Process – Source, Message, Encoding, Channel, Decoding, Receiver, Feedback, Context; **Barriers to communication:** Physiological Barriers, Physical Barriers, Cultural Barriers, Language Barriers, Gender Barriers, Interpersonal Barriers, Psychological Barriers, Emotional barriers; **Perspectives in Communication:** Introduction, Visual Perception, Language, Other Factors affecting our perspective – Past Experiences, Prejudices, Feelings, Environment.

Unit 2: (6h)

Elements of Communication: Introduction, Face to Face Communication – Tone of Voice, Body Language (Non-verbal communication), Verbal Communication, Physical Communication; **Communication Styles:** Introduction, The Communication Styles Matrix with example for each –Direct Communication Style, Spirited Communication Style, Systematic Communication Style, Considerate Communication Style

Unit 3: (7h)

Basic Listening Skills: Introduction, Self-Awareness, Active Listening, Becoming an Active Listener, Listening in Difficult Situations; **Effective Written Communication:** Introduction, When and When Not to Use Written Communication – Complexity of the Topic, Amount of Discussion' Required, Shades of Meaning, Formal Communication; **Writing effectively:** Subject Lines, Put the Main Point First, Know Your Audience, Organization of the Message.

Unit 4: (11h)

Interview Skills: Purpose of an interview, Do's and Don'ts of an interview; **Giving Presentations:** Dealing with Fears, planning your Presentation, Structuring Your Presentation, Delivering Your Presentation, Techniques of Delivery; **Group Discussion:** Introduction, Communication skills in group discussion, Do's and Don'ts of group discussion; **Correspondence:** Personal, official and Business, Report writing, drafting an email, Writing of C.V.

Suggested Textbooks:

1. Interview skills and Group discussion, Praveen Joe I.R. Laxmi Publication.
2. Group discussion, job interview skill, Nitin Sharma, Unicorn books pvt Ltd.
3. Adair, John effective communication, London: Pan Macmillan Ltd.
4. Basic communication skills, Sonu Marwah.

Reference Books:

1. Personality development and communication skills, Dr. S.S. Narula, Taxmann publications pvt ltd.
2. Listening skills, Master the art of listening and communication skills, Michele Gilbert.
3. Communication skills, Sanjay kumar, Pushplata, Oxford University Press.
4. Active listening, the forgotten skill, Corbison, Nitor publication.

Semester II

Practical

Course code: VSB 108 SE 20

Course Credits: 2; Total hours: 60

Course Objective: *This course aims to provide hands-on experience with biochemical and organic chemistry laboratory techniques. It emphasizes understanding key metabolic biomolecules and their estimation from biological fluids, along with practical exposure to stereochemistry, software-based molecular analysis, and basic organic functional group identification.*

Course Learning Outcomes:

After completion of this course, students will be able to:

- Extract and estimate biological macromolecules and metabolites from physiological samples
- Analyze and interpret titration curves and biochemical parameters
- Visualize and construct stereochemical molecular models
- Draw and predict organic structures and spectra using Chemdraw
- Detect unsaturation and halogenated hydrocarbons using standard qualitative methods

Course Content:

Metabolism of Biomolecules

1. Estimation of urea
2. Creatinine estimation
3. Determination of cholesterol in blood
4. Determination of ketone bodies in urine
5. Estimation of blood sugar

Organic Chemistry

6. Introduction and preparation of stereo models for:
 - Butane
 - Butene

- Butyne
 - Cis/trans alkene
 - Cyclohexane conformers (chair/boat)
7. Structure drawing and spectral prediction using ChemDraw:
 - Drawing of organic molecules
 - Mechanisms of representative reactions
 - Prediction of ^1H and ^{13}C NMR spectra
 8. Detection of unsaturation using Baeyer's test (alkaline KMnO_4)
 9. Functional group test for halogenated hydrocarbons using silver nitrate tests

Suggested Textbooks:

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C. (Latest ed.), *Vogel's Textbook of Quantitative Chemical Analysis*, 5th Edn., John Wiley and Sons Inc.,
2. Ahluwalia, V.K.; Dhingra, S. (2004), *Comprehensive Practical Organic Chemistry: Qualitative Analysis*, University Press
3. Plummer, D. T. (1987). *An Introduction to Practical Biochemistry*, Tata McGraw-Hill
4. Mann, F. G. & Saunders, B. C. (2009). *Practical Organic Chemistry*, Pearson
5. Wilson, K. & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, Cambridge University Press
6. ChemDraw User Guide and Tutorials from PerkinElmer

SEMESTER- III

Semester III

Cell Biology

Course Code: VSB 201 DM 30

Course Credits: 3; Total Hours: 45

Course Objective: *The course aims to provide advanced knowledge of the function of cellular organelles, the structure and function of cytoskeleton and its role in mobility. The course will also provide details of cellular interaction with cells and tissues round and the molecular regulation of cell growth and cell death. The course will outline the molecular details of the origin of cancer and the diagnosis and treatment.*

Course Learning Outcome:

Unit 1: Introduction to cell Biology

- Compare and contrast the structural organization of prokaryotic and eukaryotic cells, highlighting differences in cellular complexity and compartmentalization.
- Describe the structural characteristics and biological significance of acellular entities such as viruses, viroids, mycoplasma, and prions.
- Identify and explain the structure and functions of major cell organelles, including the nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, and others.
- Relate the size and structure of cells and organelles to their specific functions and roles in maintaining cellular homeostasis.

Unit 2: Membrane Structure Protein Transport and Cell Communication

- Explain the mechanisms of protein transport across cellular compartments, including the nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, and mitochondria.
- Describe the process of vesicular transport, including vesicle formation, targeting, docking, and fusion in intracellular trafficking.
- Compare various models of plasma membrane structure, such as the fluid mosaic model, and explain their relevance to membrane function.

- Differentiate between active and passive transport mechanisms and explain how substances are selectively moved across biological membranes.
- Describe the processes of endocytosis and exocytosis, and explain their role in nutrient uptake, signaling, and waste removal.
- Explain the structure and function of the extracellular matrix (ECM) and its role in cell-matrix interactions and signaling.
- Describe different types of cell-cell interactions, including tight junctions, desmosomes, gap junctions, and their significance in tissue integrity and communication.

Unit 3: Cell Signaling and Cell Cytoskeleton

- Identify major types of signaling molecules and explain how they interact with specific cell surface receptors to initiate cellular responses.
- Describe the functions and mechanisms of cell surface receptors, with a focus on G-protein coupled receptors (GPCRs) and receptor tyrosine kinases (RTKs).
- Explain the steps of intracellular signal transduction pathways, including amplification, regulation, and integration into signaling networks.
- Interpret how signaling networks coordinate cellular activities and respond to internal and external stimuli.
- Describe the structure and organization of the cytoskeleton, including actin filaments, intermediate filaments, and microtubules.
- Explain the molecular basis of cell movement, highlighting the roles of actin, myosin, and cytoskeletal remodeling.
- Relate cytoskeletal components to their specific functions in maintaining cell shape, division, transport, and motility.

Unit 4: Cell Cycle and Cell death

- Describe the phases of the eukaryotic cell cycle and explain the molecular mechanisms regulating cell cycle progression.
- Explain the key events of the mitotic phase, including chromosomal segregation and cytokinesis.
- Compare mitosis and meiosis, and explain the significance of meiosis in gametogenesis and fertilization.

- Differentiate between types of cell death, including programmed cell death (apoptosis – intrinsic and extrinsic pathways), necrosis, and autophagy, and explain their physiological relevance.
- Describe the properties and roles of stem cells, including embryonic and adult stem cells, in tissue maintenance, regeneration, and development.
- Discuss the potential of stem cells in therapeutic applications and their role in maintaining homeostasis in adult tissues.

Course Content:

Unit 1: Introduction to cell Biology (9h)

Cell size and structure -Prokaryotic and Eukaryotic cells, Virus, Viroids, Mycoplasma, Prions, structural organisation and functions of cell organelles

Unit 2: Membrane Structure Protein Transport and Cell Communication (13h)

Protein Transport across Nuclear Envelope, Endoplasmic reticulum, Golgi apparatus, Lysosomes, Peroxisomes and Mitochondria; Mechanism of Vesicular Transport.

Various models of plasma membrane structure, Active and Passive Transport, Endocytosis, Extracellular Matrix and Cell Matrix Interactions; Cell-Cell Interactions.

Unit 3: Cell Signaling and Cell Cytoskeleton (12h)

Signaling Molecules and their Receptors; Functions of Cell Surface Receptors; Intracellular Signal Transduction Pathway (GPCR, RTKs); Signaling Networks.

Structure and Organization of Actin Filaments; Actin, Myosin and Cell Movement;

Intermediate Filaments; Microtubules.

Unit 4: Cell Cycle and Cell death (11h)

Eukaryotic Cell Cycle, Regulation of Cell Cycle Progression, Events of Mitotic Phase,

Meiosis and Fertilization. Programmed Cell Death (Extrinsic and Intrinsic Pathways, Necrosis and Autophagy, Stem Cells and Maintenance of Adult Tissues, Embryonic Stem Cells.

Suggested Textbooks:

1. Cooper, G.M. and Hausman, R.E., (2009). *The Cell: A Molecular Approach*. (7th ed.). ASM Press & Sunderland (Washington DC), Sinauer Associates, MA. ISBN:978-0- 87893-30.
2. Karp, G., (2010). *Cell and Molecular Biology: Concepts and Experiments* (8th ed.). John Wiley & Sons. Inc. ISBN: 978-1-118-65322-7.
3. Kleinsmith, L. J., Hardin, H., Wayne G., Becker, M. (2009). *The World of the cell* (7th ed.). ISBN-13: 978-0805393934 / ISBN-10: 0805393935.

Semester III

Pharmacology

Course code: VSB 203 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *This course aims to provide a comprehensive understanding of the fundamental principles of pharmacology, including drug classification, nomenclature, and essential drug concepts. Students will explore the mechanisms of drug absorption, distribution, metabolism, and excretion (pharmacokinetics), along with the molecular and physiological effects of drugs on the body (pharmacodynamics). The course introduces pharmacotherapy and clinical pharmacology, emphasizing rational drug use, dosage determination, and personalized medicine approaches such as pharmacogenomics. Special attention is given to the autonomic nervous system, including cholinergic and adrenergic pharmacology, as well as commonly used therapeutic classes such as antimicrobials, anticancer agents, NSAIDs, and diuretics. Through this course, students will gain foundational knowledge essential for clinical applications, drug development, and evidence-based healthcare practice.*

Course Learning Outcomes:

Unit 1: Introduction to pharmacology

Students will have the knowledge of basic concepts of pharmacology, types of drug nomenclature, prescription drugs, criteria of selection of essential drugs and types of routes of drug administration.

Unit 2: Pharmacokinetics, Pharmacodynamics, Pharmacotherapy and clinical pharmacology

Students will be able to determine the route(s) of administration, dose, latency of onset, time of peak action, duration of action and frequency of administration of a drug. Students will be able to describe the principle and mechanism of drug action in the terms of dose-response relationship, drug potency and therapeutic efficacy. Students will be able to explain the various phases and types of clinical trails used in clinical studies.

Unit 3: Autonomic Nervous System, Adrenergic System and drugs

Students will be able to name cholinergic and anticholinergic drugs while explaining pharmacokinetics, pharmacodynamics and toxic effects of these drugs. Students will be able to name adrenergic and antiadrenergic drugs while explaining pharmacokinetics, pharmacodynamics and toxic effects of these drugs

Unit 4: Antimicrobial, Anticancer drugs, NSAIDs and diuretic drugs

Students will be able to describe various classes of antibacterial and anticancer drugs, their mechanism of action along with their pharmacokinetics, pharmacodynamics and toxicological profiles. Students will be able to describe various classes of non-steroidal anti-inflammatory and antidiuretic drugs, their mechanism of action along with their pharmacokinetics, pharmacodynamics and toxicological profiles.

Course Content:

Unit 1: Introduction to pharmacology (5h)

Basic concepts in pharmacology, Drug nomenclature, Drug Compendia, Concept of Essential medicines, Routes of drug administration.

Unit 2: Pharmacokinetics, Pharmacodynamics, Pharmacotherapy and clinical pharmacology (15h)

Pharmacokinetics: Transport across Biological membranes: Passive diffusion, filtration and specialized transport; Principle of absorption, bioavailability, bioequivalence, distribution, Plasma protein binding, metabolism, excretion, kinetics of elimination

Pharmacodynamics: Principles of drug action, Dose-response relationship, Drug potency and efficacy, Therapeutic index.

Pharmacotherapy and clinical pharmacology: Drug dosage, factors modifying drug action, pharmacogenomics, rational uses of medicines, Expiry date of pharmaceuticals: Clinical studies: Clinical trials, Cohort studies and case control studies.

Unit 3: Autonomic Nervous System, Adrenergic System and drugs (13h)

Autonomic Nervous System and drugs: Mechanism in autonomic nervous system and cholinergic transmission; **Cholinoreceptors:** Muscarinic receptors and Nicotinic receptors,

Muscarinic and nicotinic actions; **Cholinergic drugs:** Cholinergic agonists (Pilocarpine), Anticholinesterases (physostigmine), Anticholinergic drugs (Atropine)

Adrenergic System and drugs: Adrenergic transmission, Adrenergic drugs (Noradrenaline, Adrenaline, Salbutamol) Antiadrenergic drugs (Atenolol)

Unit 4: Antimicrobial, Anticancer drugs, NSAIDs and diuretic drugs (12h)

Antimicrobial and anticancer drugs: General consideration, Antibacterial (tetracyclines, penicillins), antiviral (acyclovir, Zidovudine), Classification of anticancer drugs (Methotrexate, Imatinib).

NSAIDs and diuretic drugs: Pharmacological actions and pharmacokinetics of Aspirin. Thiazide diuretics

Suggested Textbook:

1. Rang and Dale's Pharmacology by James M. Ritter, Rod J. Flower, Graeme Henderson, Yoon Kong Loke, David MacEwan
2. Essentials of Medical Pharmacology by K.D. Tripathi
3. Basic and Clinical Pharmacology by Bertram G. Katzung
4. Principles of Pharmacology: The Pathophysiologic Basis of Drug Therapy by David E. Golan et al.

Suggested References:

1. Goodman & Gilman's The Pharmacological Basis of Therapeutics by Laurence Brunton, Bjorn Knollmann
2. Clinical Pharmacology by P.N. Bennett and Morris J. Brown
3. WHO Model List of Essential Medicines – World Health Organization (latest edition)
4. Pharmacology for Health Professionals by W.C. Bowman and M.J. Rand
5. British National Formulary (BNF) – for practical drug information and prescribing guidance
6. Research papers and clinical guidelines from reputed journals like The Lancet, BMJ, and Journal of Clinical Pharmacology

Semester III

Environmental Sciences

Course code: VSB 205 VA 20

Course Credits: 2; Total hours: 30

Course Objective: *This course introduces students to environment concerns. Students are expected to learn about environment, factors affecting it, environmental ethics and its protection through lectures, presentations, documentaries and field visits.*

Course Learning Outcomes:

- Understand the relationship between humans and their environment, predict the consequences of human actions on the environment, global economy and quality of human life
- Gain in-depth knowledge on natural processes that sustain life.
- Develop critical thinking for environmental protection and conservation of biodiversity, social equity and sustainable development
- Acquire values and attitudes towards understanding complex environmental-socioeconomical challenges, knowledge of pollution and environmental degradation.
- Understand the fundamental concepts of various ecosystems.
- Adopt sustainability as a practice in life, society and industry.

Course Content:

Unit 1: Introduction to Environmental Science

(5h)

Multidisciplinary nature of environmental studies; components of environment – atmosphere, hydrosphere, lithosphere and biosphere. Scope and importance; Concept of sustainability and sustainable development; **Ecosystems:** What is an ecosystem? Structure and function of ecosystem; Energy flow in an ecosystem: food chain, food web and ecological succession. Case studies of the following ecosystems: a) Forest ecosystem b) Grassland ecosystem c) Desert ecosystem d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

Unit 2: Natural resources, Biodiversity and conservation

(10h)

Natural Resources: Renewable and Non-renewable Resources Land Resources and land use change; Land degradation, soil erosion and desertification; Deforestation: Causes and impacts due to mining, dam building on environment, forests, biodiversity and tribal populations; Water: Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state); Heating of earth and circulation of air; air mass formation and precipitation; Energy resources: Renewable and non-renewable energy sources, use of alternate energy sources, growing energy needs, case studies; **Biodiversity and Conservation:** Levels of biological diversity: genetic, species and ecosystem diversity; Biogeography zones of India; Biodiversity patterns and global biodiversity hot Spots; India as a mega-biodiversity nation; Endangered and endemic species of India; Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity; Ecosystem and biodiversity services: Ecological, economic, social, ethical, aesthetic and Informational value.

Unit 3: Environment pollution, policies and practices

(9h)

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

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

Unit 4: Human Communities and the Environment

(6h)

Human population and growth: Impacts on environment, human health and welfares; Carbon foot-print, Resettlement and rehabilitation of project affected persons; case studies; Disaster management: floods, earthquakes, cyclones and landslides; Environmental movements: Chipko, Silent valley, Bishnios of Rajasthan; Environmental ethics: Role of Indian and other religions and cultures in environmental conservation; Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi, Swachh Bharat Abhiyan).

Field work:

- Visit to an area to document environmental assets; river/forest/flora/fauna, etc.
- Visit to a local polluted site Urban/Rural/Industrial/Agricultural.
- Study of common plants, insects, birds and basic principles of identification.
- Study of simple ecosystems-pond, river, ridge, etc.

Suggested Textbooks:

1. Carson, R. 2002. *Silent Spring*. Houghton Mifflin Harcourt.
2. Gadgil, M., & Guha, R.1993. *This Fissured Land: An Ecological History of India* Univ. of California Press.
3. Gleick, P.H. 1993. *Water in Crisis*. Pacific Institute for Studies in Dev., Environment & Security. Stockholm Env. Institute, Oxford Univ. Press.
4. Groom, Martha J. Gary K. Meffe, and Carl Ronald carroll. *Principles of Conservation Biology*. Sunderland: Sinauer Associates, 2006.
5. Grumbine, R. Edward, and Pandit, M.K. 2013. Threats from India's Himalaya dams. *Science*, 339: 36-37.
6. McCully, P.1996. *Rivers no more: the environmental effects of dams* (pp. 29-64). Zed Books.
7. McNeil, John R. 2000. *Something New Under the Sun: An Environmental History of the Twentieth Century*.
8. Odum, E.P., Odum, h.T. & Andrews, J.1971. *Fundamentals of Ecology*. Philadelphia: Saunders. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2011. *Environmental and Pollution Science*. Academic Press.
9. Rao, M.N. & Datta, A.K. 1987. *Waste Water Treatment*. Oxford and IBH Publishing Co. Pvt. Ltd.
10. Raven, P.H., Hassenzahl, D.M. & Berg, L R. 2012. *Environment*. 8th edition. John Wiley & Sons.

11. Rosencranz, A., Divan, S., & Noble, M.L. 2001. *Environmental law and policy in India*. Tripathi 1992.
12. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*. S. Chand Publishing, New Delhi.
13. Sodhi, N.S., Gibson, L. & Raven, P.H. (eds). 2013. *Conservation Biology: Voice from the Tropics*. John Wiley & Sons.
14. Thapar, V. 1998. *Land of the Tiger: A Natural History of the Indian Subcontinent*.
15. Wilson, E.O. 2006. *The Creation: An appeal to save life on earth*. New York: Norton.

Suggested References:

1. Basu, M., Xavier, S. (2016). *Fundamentals of Environmental Studies*, Cambridge University Press, India
2. Bharucha, E. (2013). *Textbook of Environmental Studies for Undergraduate Courses*. Universities Press.
3. De, A.K., (2006). *Environmental Chemistry*, 6th Edition, New Age International, New Delhi.
4. Masters, G. M., & Ela, W. P. (1991). *Introduction to environmental engineering and science*. Englewood Cliffs, NJ: Prentice Hall.
5. Kaushik A. and Kaushik C.P., (2011) *Perspectives in Environmental Studies*, New age International Publishers, New Delhi, India.

Semester III

Practical

Course code: VSB 207 SE 20

Course Credits: 2; Total hours: 60

Course Objective: *This course aims to develop hands-on skills in cell biology techniques, including the study of mitosis, meiosis, osmosis, and X-chromosome inactivation using microscopy. In pharmacology, it enables students to understand drug analysis, animal handling, and drug delivery techniques. It also introduces students to basic environmental assessment tools and sustainable development frameworks through field and laboratory-based activities.*

Course Learning Outcomes:

- Students will learn to operate microscope and see different phases of cell division cycle under microscope.
- Understand the concept of X-inactivation and differentiate between male and female cells based on the presence or absence of the Barr body.
- Relate the experimental observations to the osmotic behavior of cells in living organisms
- Observe and identify cell structures such as the cell wall, nucleus, and cytoplasm and understand the importance of staining in highlighting cellular components for microscopic examination
- Safely handle laboratory animals following ethical and regulatory norms (e.g., CPCSEA guidelines).
- Understand and compare different routes of drug administration, particularly oral and intramuscular, and demonstrate their procedures using models or virtual tools.
- Detect the presence of acetaminophen in a sample using simple qualitative analysis.
- Describe and interpret the different stages of general anesthesia and their physiological implications.

- Determine and interpret the partition coefficient of drugs (Aspirin and Salicylic Acid) and understand its significance in drug absorption.
- Analyze the progress of a country toward the Sustainable Development Goals (SDGs) using qualitative and quantitative approaches.
- Identify ecosystem components and biodiversity through field visits to terrestrial and aquatic environments.
- Understand the functioning of eco-friendly technologies (e.g., paper recycling, rainwater harvesting, biogas, solar, wastewater treatment) through field observations.
- Assess the quality of water using rapid test kits and interpret the results in terms of pollution and potability.
- Measure and evaluate the Air Quality Index (AQI) using real-time environmental data and correlate with public health impacts.

Course Content:

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

Cell Biology

1. Study of Barr Body in human cheek epithelial cell
2. Demonstration of osmosis in egg
3. To study the stages of Mitosis and Meiosis from permanent slides
4. To prepare stained temporary mounts of onion peels
5. Study of cell division in onion root tip

Pharmacology

6. Handling of laboratory animals.
7. Routes of drug administration (Oral, I.M.)

8. To study the presence of acetaminophen in given sample.
9. To study the stages of general anesthesia.
10. Determination of Partition coefficient of Aspirin
11. Determination of partition coefficient of salicylic acid.

Environmental Sciences

12. Analysis of achievements of Sustainable Development Goals of any country.
13. Field visit to terrestrial and aquatic ecosystems (a) forest, (b) grasslands, (c) wetlands, (d) Biodiversity Parks, etc.
14. Visit to paper recycling unit/ rain water harvesting plant/ biogas plant/ solar plant/ wastewater treatment plant.
15. Determine water quality of a given location using rapid pollution monitoring Kits.
16. Assess air quality Index (AQI) of any location using real-time air quality parameters.

Suggested Textbooks:

1. Alberts, B. et al. *Molecular Biology of the Cell*, Garland Science.
2. K.D. Tripathi, *Essentials of Medical Pharmacology*, Latest Edition.
3. Trivedi, R.K. & Goel, P.K., *Chemical and Biological Methods for Water Pollution Studies*, Environmental Publications.

Suggested References:

1. Indian Pharmacopoeia (Latest Edition)
2. WHO Guidelines on Water and Air Quality
3. United Nations SDG Report (Latest Edition)

SEMESTER- IV

Semester IV

Molecular Biology

Course code: VSB 202 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *The objective of the course is to introduce to the students, the basic concepts of genome, DNA structure, genes, chromatin and chromosomes. It provides comprehensive understanding of DNA replication, transcription and translation processes in a way that students can apply this knowledge in understanding the life processes and develop an interest to pursue high quality research.*

Course Learning Outcome

Unit 1: Introduction to Molecular Biology and DNA Structure

After completion of the unit, students will be able to:

- Define and differentiate between fundamental molecular biology terms.
- Explain DNA structure, genome organization, and chromatin packaging.
- Understand the principles of DNA denaturation and renaturation kinetics.

Unit 2: DNA Replication and Transcription Mechanism

After completion of the unit, students will be able to:

- Describe different models of DNA replication and identify the role of key enzymes.
- Compare and contrast transcription mechanisms in prokaryotes and eukaryotes.
- Explain the step-by-step processes of replication and transcription.

Unit 3: Transcriptional Regulation and RNA Processing

After completion of the unit, students will be able to:

- Describe gene regulation mechanisms at the transcriptional level in prokaryotes.
- Explain RNA processing events such as splicing, editing, and shuffling.
- Understand how mRNA is transported and regulated post-transcriptionally

Unit 4: Genetic Code and Protein Synthesis

After completion of the unit, students will be able to:

- Explain the structure and significance of the genetic code.
- Describe the mechanism of translation and protein synthesis.
- Compare translation processes in prokaryotic and eukaryotic systems.

Course Content:

Unit 1: Introduction to Molecular Biology and DNA Structure (9h)

Basic concepts: DNA, gene, genome, and chromatin, Organization of the genome, DNA denaturation and renaturation kinetics, Structure and functional roles of chromatin

Unit 2: DNA Replication and Transcription Mechanism (13h)

Models of DNA replication, Mechanism of replication in prokaryotes and eukaryotes, Enzymes involved in replication (DNA polymerases, helicase, ligase, etc.), Mechanism of transcription, Transcription machinery in prokaryotic and eukaryotic cells, Differences in transcription processes between prokaryotes and eukaryotes

Unit 3: Transcriptional Regulation and RNA Processing (12h)

Gene regulation in prokaryotes (lac operon and other regulatory systems), Mechanisms of transcriptional regulation at the gene level, Post-transcriptional RNA modifications, RNA splicing, editing, and shuffling mRNA transport and stability

Unit 4: Genetic Code and Protein Synthesis (11h)

Concept and properties of the genetic code, Mechanism of translation in prokaryotes and eukaryotes, Components involved in translation (ribosomes, tRNA, initiation/ elongation/ termination factors), Comparison of translation between prokaryotes and eukaryotes.

Suggested Textbooks:

1. Nelson, D. L. and Cox, M. M (2017) *Lehninger: Principles of Biochemistry* (7thed.) W. H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7th ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781/ISBN-13:9780321762436

Semester IV

Applied Organic Chemistry

Course code: VSB 204 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *The objective of this course is to provide students with an in-depth understanding of modern organic synthesis with a focus on sustainability and pharmaceutical relevance. It aims to introduce the principles and goals of green chemistry, emphasizing atom economy, waste prevention, and environmentally benign synthetic methods such as solvent-less reactions, microwave, and ultrasound-assisted synthesis. The course explores the chemistry of natural products including alkaloids, terpenes, steroids, and antibiotics, highlighting their extraction, structure, and therapeutic significance. Students will gain hands-on knowledge of synthetic reagents and modern techniques including oxidation-reduction strategies, protection-deprotection of functional groups, and solid-phase peptide synthesis. Additionally, the course offers detailed insights into the mechanisms and applications of important name reactions and coupling reactions used in advanced organic synthesis. Overall, this course equips students with the conceptual tools and practical approaches needed to design efficient, sustainable, and bio-relevant chemical syntheses.*

Course Learning Outcomes:

Unit 1: Basics of Green Chemistry

After completion of the unit, students will be able to:

- Explain the principles and goals of green chemistry.
- Illustrate the concepts of atom economy and waste minimization in chemical synthesis.
- Identify and compare different green solvents and solvent-free methodologies.
- Describe the role of microwave and ultrasound-assisted synthesis in green chemistry.
- Discuss the green synthesis of drugs like ibuprofen, paracetamol, and aspirin.
- Evaluate the challenges and limitations in implementing green chemistry practices.

Unit 2: Chemistry of Natural Products

After completion of the unit, students will be able to:

- Describe the occurrence, extraction methods, and properties of key alkaloids and terpenes.
- Explain the structure and classification of steroids and their biological relevance.
- Identify important therapeutic alkaloids and their sources.

- Classify antibiotics based on their chemical structure and mode of action.

Unit 3: Reagents and Their Application

After completion of the unit, students will be able to:

- Classify and apply various oxidizing and reducing agents in organic synthesis.
- Use synthetic reagents like NBS, DCC, and diazomethane for specific transformations.
- Explain the importance of protection and deprotection strategies in multistep synthesis.
- Describe solid-phase peptide synthesis and its pharmaceutical significance.

Unit 4: Organic Name Reactions

After completion of the unit, students will be able to:

- Describe the mechanism and synthetic applications of major organic name reactions.
- Apply reactions such as Aldol, Grignard, and Diels-Alder in designing synthetic routes.
- Compare various coupling reactions like Suzuki, Stille, and Sonogashira in complex molecule synthesis.
- Demonstrate the role of rearrangement reactions in the development of pharmaceuticals.

Course content:

Unit 1: Basics of Green Chemistry

(10h)

Introduction and Green Chemistry, Goals and Principles of Green chemistry, Designing a Chemical synthesis, Prevention of waste or by-products, Atom Economy, Prevention/minimization of hazardous/toxic products, Green Solvents, Solvent less Processes, Immobilized solvents and ionic liquids, Examples of green synthesis/reactions, Microwave assisted reaction, Ultrasound assisted reactions; **Green Synthesis:** Ibuprofen, Paracetamol, Aspirin, limitations and obstacles in the pursuit of the goals of green chemistry

Unit 2: Chemistry of natural products

(10h)

Occurrence, extraction and properties of Alkaloids: Connine, Nicotine, Atropine, Therapeutically Important alkaloids; **Terpenes:** Isoprene Rule, Classification, Isolation, Properties, Geraniol, Pinene, Camphor, **steroids,** Cholesterol, and Classification of Antibiotics

Unit 3: Reagents and Their Application

(12h)

Synthetic Reagents: NBS, Diazomethane, **Amide Coupling Reagents:** DCC, **Oxidizing Reagents:** Peracids, Dess-martin Periodinane, OsO₄, KMnO₄, PCC, PDC, Peroxides;

Reducing Agents: LAH, DIBAL, NaBH₄, **Borane Reagents and Hydrogenation Reactions:** Homogenous Catalysis, Heterogenous Catalysis, **Role of protection/ deprotection in organic synthesis:** Protection for Hydroxyl group, Protection of 1,2- and 1,3- diols, Protection for the carbonyl group, Protection for the carboxyl group, Protection for the amino group and amino acids. Solid phase peptide synthesis

Unit 4: Organic Name Reactions: (13h)

Synthetic Applications of Organic Name reactions: Aldol reaction, Cannizzaro reaction, Diels-Alder reaction, Grignard reaction, Michael addition, Mannich reaction, Reformatsky Reaction, Wittig Reaction, Baeyer-Villiger Oxidation, Claisen Schmidt reaction, Dieckmann condensation, Knoevenagel condensation, Mitsunobu reaction, Suzuki coupling, Stille coupling, Sonogashira coupling, Beckman rearrangement

Suggested Textbooks:

1. Jerry March, *Advanced Organic Chemistry: Reactions, Mechanisms and Structure*, Wiley-Interscience.
2. Morrison and Boyd, *Organic Chemistry*, Prentice Hall.
3. C. N. R. Rao, *New Directions in Solid State Chemistry*, Cambridge University Press.
4. P. S. Kalsi, *Organic Reactions and Mechanisms*, New Age International.

Suggested References:

1. M. C. Carruthers, *Some Modern Methods of Organic Synthesis*, Cambridge University Press.
2. T. W. Greene and P. G. M. Wuts, *Protective Groups in Organic Synthesis*, Wiley.
3. V. K. Ahluwalia and M. Kidwai, *New Trends in Green Chemistry*, Springer.
4. R. K. Bansal, *Organic Reaction Mechanism*, New Age International.
5. L. G. Wade, *Organic Chemistry*, Pearson.

Semester IV

Medical Biotechnology

Course code: VSB 206 DM 20

Course Credits: 2; Total hours: 30

Course Objective: *The objective of the course is to learn basics of theory and practical aspects of recombinant DNA technology and other techniques of DNA manipulation in the microorganisms and mammalian cells which can be used for the development of diagnostic kits and therapeutics interventions in biotech industry.*

Course Learning Outcomes:

Unit 1: Tools and Methods of Recombinant DNA Technology

After completion of the unit, students will be able to:

- Describe the nature of the biochemical tools used in DNA technology and recognize why microorganisms occupy an important place in the experiments of DNA technology.
- Describe the key discoveries and experiments that formed the basis for modern DNA technology.
- Identify some of the individuals whose work laid the foundations for DNA technology.
- Recognize some important terms and concepts used in DNA technology and broaden your vocabulary of this science
- Describe how genes are isolated from cells or synthesized in the laboratory for use in DNA technology.
- List some criteria for selecting vectors to carry foreign genes and host cells to produce the protein encoded by those genes.
- Conceptualize the biochemistry involved in gene expression, understand the problems that can arise in the process, and learn how DNA technologists resolve those problems.
- Explain the concept of the gene library, describe the process for establishing two types of gene libraries, and discuss how genes are recovered from the library.

Unit 2: Pharmaceutical products of DNA Technology

After completion of the unit, students will be able to:

- Explain how deficiencies of proteins, such as insulin, human growth hormone, and Factor VIII, contribute to ill health and how DNA technology can be used to produce these proteins.
- Appreciate some of the biochemical problems encountered in manufacturing pharmaceutical products by DNA technology and recognize how biochemists circumvent these problems.
- Discuss the synthesis and innovative uses of therapeutic drugs such as tissue plasminogen activator, interferon, and antisense molecules and summarize how they can be used to relieve disease.
- Understand the basis of vaccine activity in the body and conceptualize the role of DNA technology in the production of vaccines.

Unit 3: DNA Analysis, Diagnosis and Gene Therapy

After completion of the unit, students will be able to:

- Understand the nature of DNA probe and appreciate how it identifies a segment of target DNA.
- Summarize the biochemistry of the polymerase chain reaction and understand how it amplifies a sample of DNA.
- Explain how DNA probes and polymerase chain reaction technology can be used to detect infectious diseases such as AIDS, tuberculosis, and Lyme disease.
- Conceptualize the genetic basis for such diseases as cystic fibrosis, Duchenne's muscular dystrophy, and Huntington's disease and recognize
- How DNA analysis can make the diagnosis of genetic diseases possible.
- Give a synopsis of how certain forms of diabetes, cancer, and hearing and vision loss can be identified through DNA technology.
- Outline several instances in which DNA probes and polymerase chain reaction technology can be useful for monitoring microorganisms in the environment.
- Explain how "foreign" genes can be delivered to the cells of a patient through the intervention of retroviruses.
- Explain the effects of deficiency of adenosine deaminase and conceptualize how gene therapy can resolve that deficiency.
- Appreciate the mechanism by which gene therapy can be used to treat certain

forms of cancer.

- Identify the molecular basis for cystic fibrosis and describe the uses of gene therapy to treat this disease.
- Explain several approaches to treating AIDS patients by using gene therapy.
- Name and explain several instances in which gene therapy will be useful in future years.
- Discuss the levels of review and oversight of gene therapy experiments to ensure the patient's safety and that of the public.

Unit 4: Transgenic Animals

After completion of the unit, students will be able to:

- Understand the nature of a transgenic animal and appreciate some of the technology in its development.
- Summarize the various transgenic animals that have been bred to date and indicate how each is genetically different from its unaltered counterpart.
- Explain some of the problems in adapting the methods used for laboratory animals to research in larger, barnyard animals.
- Describe a number of pharmaceutical products derived from transgenic animals and show how each is useful in medicine.
- Conceptualize how an animal can be made more resistant to infectious disease through transgenic DNA technology.
- Recognize methods by which transgenic animals can help interrupt the spread of disease in nature.
- Identify some of the major researchers who spurred the development of transgenic animals.

Course Content:

Unit I: Tools and Methods of Recombinant DNA Technology (9h)

Organisms as models, Restriction Enzymes, DNA ligase, Plasmids, Recombinant DNA experiments, Safety issues, Basic strategies for cloning. **Gene Libraries:** Construction and screening of a Gene library and cDNA Library. Selection of cloned genes.

Unit 2: Pharmaceutical products of DNA Technology (5h)

In medicine and Industry, **Human protein replacements:** Insulin, Human Growth hormone,

Factor VIII. **Human Therapies:** Tissue plasminogen Activator, Interferon, Antisense molecules, Hepatitis-B virus Vaccine.

Unit 3: DNA Analysis, Diagnosis and Gene Therapy (10h)

Methods of DNA Analysis: DNA Probes, PCR, DNA CHIP, RFLP, Analysis. **DNA Matching techniques:** DNA finger printing. Somatic cell therapy, Vectors in Gene Therapy. **Gene replacement therapy:** Retroviral Vectors, Adenoviral vectors, Adeno-associated viral vectors, lentiviral vectors, Challenges in viral gene therapy, nonviral vectors. **Gene-blocking therapies:** Antisense therapy, Ribozyme therapy, RNA interference.

Unit 4: Transgenic Animals (6h)

Techniques of Placing DNA in mammalian cells: Microinjection **Custom made animals:** Human mouse, oncomouse, Alzheimers mouse, knockout mouse. **Transgenic products:** Use of animals as bioreactors, Human hemoglobins from pigs, Lactoferrin, Pharm animals, vegetable vaccines, Examples of transgenic animals, improving animals for the production of transgenic products.

Suggested Textbooks:

1. Brown, T.A. (2010) *Gene Cloning and DNA Analysis* (6th ed.), Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Glick B.R., Pasternak, J.J. and Patten, C.L., (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.), ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
3. Michael R Green and J. Sambrook (2014) *Molecular Cloning: A laboratory manual*, (4th ed.), Cold Spring Harbor laboratory press (3vol.), ISBN: 978-1-936113-42-2
4. Primrose, S.B., and Twyman, (2006) *Principles of Gene Manipulation and Genomics* (7th ed.), R. M., Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.

Semester IV

Practical

Course code: VSB 208 SE 20

Course Credits: 2; Total hours: 60

Course Objective: *This course is designed to provide hands-on training in fundamental techniques of molecular biology, chemistry, and medical biotechnology. It aims to equip students with the skills necessary for preparing laboratory reagents, isolating and analyzing nucleic acids, and understanding gene manipulation techniques such as transformation and PCR. Through integrated experiments including classical organic synthesis and modern molecular techniques, students will gain a practical understanding of biomolecular separation, DNA handling, restriction digestion, and electrophoresis. The course also includes applications in green chemistry, such as biodiesel preparation, emphasizing sustainability and interdisciplinary knowledge critical for modern biosciences and biotechnology research.*

Course Learning Outcomes:

By the end of this course, students will be able to:

- Prepare standard laboratory solutions and buffers required for molecular biology experiments.
- Isolate genomic and plasmid DNA from *E. coli* and assess their quality and quantity.
- Determine the absorption characteristics of nucleic acids using spectrophotometry.
- Perform agarose gel electrophoresis to separate and visualize DNA fragments.
- Synthesize organic compounds such as dibenzal acetone and umbelliferone using classical named reactions (Claisen-Schmidt and Pechmann reactions).
- Separate binary mixtures of organic compounds based on acidity and neutrality.
- Prepare biodiesel, demonstrating application of green chemistry principles.
- Carry out bacterial transformation using plasmid DNA and confirm success through plasmid isolation.
- Perform restriction digestion of plasmid DNA and understand the mechanism of site-specific cleavage.
- Understand and demonstrate the working principle of Polymerase Chain Reaction (PCR).

Course Content:

Molecular Biology

1. Preparation of various stock solutions required for Molecular Biology Laboratory.
2. Isolation of genomic DNA from *E.coli*
3. Determination of absorption maxima of nucleic acids
4. Agarose gel electrophoresis for separation of DNA fragments

Applied Organic Chemistry

5. Dibenzal acetone from benzaldehyde by Claisen Schmidt reaction
6. Preparation of umbelliferone by Pechhman reaction
7. Separation of solid binary mixture of organic compounds- neutral and acidic
8. Preparation of biodiesel

Medical Biotechnology

9. Isolation of plasmid DNA from *E. coli*.
10. Transformation of *E. coli* cells with plasmid DNA.
11. Digestion of plasmid DNA with restriction enzymes.
12. Demonstration of Polymerase Chain Reaction (PCR) technique.

Suggested Textbooks:

1. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
2. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
3. Boyer, R. (2012). *Modern Experimental Biochemistry*. Pearson Education.
4. Kapoor, K. L. (2008). *A Textbook of Physical Chemistry* (Vol. 1–5). McGraw Hill Education.
5. Mann, F. G., & Saunders, B. C. (2009). *Practical Organic Chemistry*. Pearson Education.
6. Sharma, B. K. (2004). *Industrial Chemistry*. Goel Publishing House.

Suggested Reference:

1. Brown, T. A. (2016). *Gene Cloning and DNA Analysis: An Introduction*. Wiley-Blackwell.
2. Ghosh, A. (2013). *Introduction to Proteomics and Genomics*. Oxford University Press.

3. Nelson, D. L., & Cox, M. M. (2017). *Lehninger Principles of Biochemistry*. W.H. Freeman.
4. Vogel, A. I. (2000). *Vogel's Textbook of Practical Organic Chemistry*. Longman Scientific & Technical.
5. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
6. Sharma, R. C., & Sharma, B. K. (2010). *Practical Chemistry*. Krishna Prakashan Media.

SEMESTER- V

Semester V

Introduction to Microbiology

Course code: VSB 301 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *The objective of the course is to trace the history of development of the discipline of Microbiology and to emphasize the existence of the immense diversity in the microbial world. The course has been formulated to impart basic and medically relevant information on the microbes and provide knowledge about various microbial infectious agents that cause diseases in humans, the concepts of treatment and the biochemical basis of mechanism of action and drug resistance for various antimicrobial agents.*

Course Learning Outcomes

Unit 1: Foundations of Microbiology

Students will develop a good knowledge of the development of the discipline of Microbiology and the contributions made by prominent scientists in this field. Student will gain knowledge on various classes of microorganisms; their structure extracellular and intracellular components and describe characteristics of bacterial cells, cell organelles, cell wall composition and various appendages like capsules, flagella or pili.

Unit 2: Microbial Growth, Nutrition, and Control

Students will be able to explain the microbial nutrition and various microbiological techniques. Students will be able to apply the concept of culturing microorganisms aseptically and different sterilization techniques.

Unit 3: Viruses and Host Interaction

Student will develop knowledge of the chemical nature of viruses, different types of viruses infecting animals, and bacteria (bacteriophages) outcome and life cycles of viruses involved in causing human diseases like AIDS, Covid and influenza. Students will be able to explain the biology and life cycle of bacteriophages. Student will be able to explain the concept of

symbiosis and parasitism, and the significance pathogenicity in causing human and animal diseases while emphasizing viral and bacterial disease mechanisms.

Unit 4: Human Diseases caused by Bacteria, Viruses and Protozoans

Students will learn about pathogenic bacterial species (pneumonia, food poisoning, tuberculosis), viruses (Corona virus, Influenza virus, Dengue, Chikungunya, HIV) and protozoans (Malaria, Leishmania, Amoebiasis) causing the diseases to the humans and their mode of acquisition/transmission, clinical symptoms, detection and prevention.

Course Content:

Unit 1: Foundations of Microbiology (15h)

History and Scope: Microbial diversity - prokaryotes, eukaryotes, biological entities, Discovery of microorganisms: microscopes development, culture methods, Conflict over spontaneous generation: Contributions of Francesco Redi, John Needham, Lazzaro Spallanzani, Theodore Schwann, Theodor von Dusch, Louis Pasteur, John Tyndall; **Microorganisms and Disease:** Contributions of Louis Pasteur, Joseph Lister, Robert Koch **Prokaryotic Cell Structure and Function:** Shape, size and arrangement, **Cell Wall:** Gram-positive and Gram-negative bacteria, peptidoglycan structure, **Plasma Membrane:** Fluid mosaic model, **Cytoplasmic components:** Nucleoid, ribosomes, plasmids, inclusion bodies, endospores, **External Components to the Cell Wall:** Capsules, pili, and flagella

Unit 2: Microbial Growth, Nutrition and Control (5h)

Nutritional requirements: C, N, S and growth factors. Nutritional categories of microorganisms. **Culture media:** Types (liquid, semi-solid, solid, synthetic, and complex media), **Isolation of pure cultures:** streak, spread, and pour plate methods), Purification and preservation of microorganisms and their importance. **Sterilization methods:** Physical and chemical methods and their application in microbial control.

Unit 3: Viruses and Host Interaction (15h)

Structure of Viruses: Virion size, general structural properties (helical capsids, icosahedral capsids, viruses with capsids of complex symmetry, Viral envelopes and enzymes, viral genomes; **Bacteriophages:** General characteristics, Lytic and Lysogenic cycles **Pathogenicity:** Host-parasite relationships - Parasite, host, pathogen, and virulence, **Pathogenesis of Viral Diseases:** Maintaining a reservoir, Contact entry and primary

replication, Release from host cells, Viral spread and cell tropism, Virus host interactions, Virus shedding; **Pathogenesis of Bacterial Diseases:** Maintaining a reservoir, Transport to the host, Attachment and colonization, Invasion of host tissues, Growth and multiplication, Leaving the host; **Bacterial toxins:** Exotoxins, Endotoxins

Unit 4: Human Diseases caused by Bacteria, Viruses and Protozoans (10h)

Bacterial Pneumonia, Tuberculosis, Staphylococcal food poisoning, Gonorrhoea, **Life cycle and clinical symptoms of Respiratory Syndromes:** Coronaviruses and Human Respiratory Syncytial virus, **Acquired Immuno Deficiency Syndrome (AIDS):** HIV Virus, Influenza (Flu), **Arboviruses:** Dengue and chikungunya, **Protozoal Infections:** Malaria Leishmania and Amoebiasis.

Suggested Textbooks:

1. Prescott, Harley, Wiley, J.M., Sherwood, L.M., Woolverton, C.J. Klien's (2008). *Microbiology* (7th ed.). Mc Graw Hill International Edition (New York) ISBN: 978-007-126727
2. Chan, M. J., Krieg E. C. S., Pelczar, N. R. (2004) *Microbiology* (5th ed.). McGraw Hill International. ISBN 13: 9780094623206.
3. Willey, J., Sherwood, L., Woolverton, C. (2017). *Prescott's Microbiology* (10th ed.). McGraw Hill international. ISBN 13: 9781259657573.
4. Kenneth J. Ryan, C., George Ray (2010), Sherris Medical Microbiology: An introduction to infectious diseases. McGraw-Hill. ISBN-13: 978 0071604024 ISBN-10: 0071604022

Suggested References:

1. Cappuccino J. G., and Sherman N., *Microbiology: A Laboratory manual* (10th ed.). Benjamin/ Cummings. ISBN 13: 9780321840226.
2. Madigan, M. T., Martinko J. M., & Stahl D. A., (2010) *Brock Biology of Microorganisms* (13th ed.). Pearson Education International. ISBN 13: 9780321649638.

Semester V

Advanced Organic Chemistry

Course code: VSB 303 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *This course aims to provide an in-depth understanding of the chemistry of alcohols, phenols, ethers, carbonyl compounds, carboxylic acids, amines, and heterocyclic compounds along with their synthesis, properties, and mechanisms of reactions. The course also introduces the fundamental principles and applications of UV-Visible and IR spectroscopy in structural elucidation of organic molecules.*

Course Learning Outcomes:

Unit 1: Alcohols, Phenols, Ethers, Aldehydes, and Ketones

- Classify alcohols, phenols, and ethers based on structure and understand their methods of preparation.
- Explain and apply mechanisms for key reactions including oxidation, esterification, and rearrangements (e.g., Pinacol-Pinacolone).
- Understand the electronic effects and directing influence of functional groups in phenols and ethers.
- Describe the structure and reactivity of aldehydes and ketones and predict the products of nucleophilic addition and condensation reactions.

Unit 2: Carboxylic Acids, Amines, and Derivatives

- Explain the acidity of carboxylic acids and effect of substituents on acid strength.
- Compare reactivities of acid derivatives and understand mechanisms like Hell-Volhard-Zelinsky and Classen condensation.
- Describe the preparation and properties of aliphatic and aromatic amines.
- Understand the basicity and electrophilic substitution reactions of aniline.
- Explain diazotization and the synthetic utility of diazonium salts.

Unit 3: Polynuclear and Heteronuclear Aromatic Compounds

- Elucidate the structure and chemical behavior of naphthalene and anthracene.
- Identify the synthesis and key reactions of common heterocycles such as pyrrole, furan, thiophene, pyridine, indole, etc.
- Understand medicinal relevance and structure identification of heterocyclic cores in drug molecules.

Unit 4: UV-Visible and IR Spectroscopy

- Understand the principles of UV-Vis and IR spectroscopy and their relation to molecular structure.
- Apply Woodward-Fieser rules to predict λ_{max} for conjugated systems.
- Interpret IR spectra with respect to functional group identification and conjugation effects.

Course Content:

Unit 1: Alcohols, Phenols, Ethers, Aldehydes and Ketones (Aliphatic & Aromatic) (15h)

A) Alcohols (upto 5 Carbon):

Structure and classification of alcohols as 1^o, 2^o & 3^o. Preparation: Methods of preparation of 1^o, 2^o & 3^o by using Grignard reagent, ester hydrolysis and reduction of aldehydes, ketones, carboxylic acids and esters. Reactions: Acidic character of alcohols and reaction with sodium, with HX (Lucas Test), esterification, oxidation (with PCC, alkaline KMnO₄, acidic K₂Cr₂O₇ and conc. HNO₃), Oppeneauer Oxidation.

B) Diols (upto 6 Carbons):

Oxidation and Pinacol-Pinacolone rearrangement.

C) Phenols:

Acidity of phenols and factors affecting their acidity.

Preparation: Methods of preparation from cumene, diazonium salts and benzene sulphonic acid.

Reactions: Directive influence of OH group and Electrophilic substitution reactions, viz. nitration, halogenation, sulphonation, Reimer-Tiemann reaction, Gattermann-Koch

reaction, Houben-Hoesch condensation, reaction due to OH group: Schotten-Baumann reaction

D) Ethers (Aliphatic & Aromatic):

Williamson's ether synthesis, Cleavage of ethers with HI

E) Aldehydes and ketones (Aliphatic and Aromatic):

Preparation: from acid chlorides and from nitriles.

Reactions: Nucleophilic addition, nucleophilic addition – elimination reaction including reaction with HCN, ROH, NaHSO₃, NH₂-G derivatives. Iodoform test, Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemmensen reduction, Wolff Kishner reduction, Meerwein-Ponndorf Verley reduction.

Unit 2: Carboxylic acid, Amines and their derivatives

(10h)

A) Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and alkaline hydrolysis of esters. Reactions: Hell-Volhard Zelinsky reaction, acidity of carboxylic acids, effect of substitution on acid strength

Carboxylic acid derivatives (aliphatic):

Preparation: Acid chlorides, anhydrides, esters and amides from acids and their interconversion, Classen condensation. Reactions: Relative reactivities of acid derivatives towards nucleophiles, Reformatsky condensation.

B) Amines (aliphatic & aromatic) and Diazonium Salts

Amines

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs Saytzeff elimination, carbylamine test, Hinsberg test, reaction with HNO, Schotten-Baumann reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation, basicity of amines.

Diazonium salt

Preparation from aromatic amines, Reactions: conversion to benzene, phenol and dyes.

Unit 3: Polynuclear and heteronuclear aromatic compounds:

(10h)

Structure elucidation of naphthalene, preparation and properties of naphthalene and anthracene.

Synthesis, Properties, Reactions and Medicinal Uses of Heterocyclic Compounds: pyrrole, furan, thiophene, pyridine, Indole, pyrazole, imidazole, oxazole, thiazole, quinoline, isoquinoline, and acridine. Identification of Heterocyclic core in Drug molecules

Unit 4: UV-Visible and infrared spectroscopy

(10h)

Electromagnetic radiations and their properties; double bond equivalence and hydrogen deficiency.

UV-Visible spectroscopy (electronic spectroscopy): General electronic transitions, λ_{max} , chromophores & auxochromes, bathochromic & hypsochromic shifts. Application of Woodward rules for calculation of λ_{max} for the following systems: conjugated dienes alicyclic, homoannular and heteroannular; α , β -unsaturated aldehydes and ketones, charge transfer complex.

Infrared (IR) Spectroscopy: Infrared radiation and types of molecular vibrations, significance of functional group & fingerprint region. IR spectra of alkanes, alkenes, aromatic hydrocarbons (effect of conjugation and resonance on IR absorptions), simple alcohols (inter and intramolecular hydrogen bonding and IR absorptions), phenol, carbonyl compounds, carboxylic acids and their derivatives (effect of substitution on $>\text{C}=\text{O}$ stretching absorptions).

Suggested textbooks:

1. Morrison, R. T., & Boyd, R. N. (2011). *Organic Chemistry* (7th ed.). Pearson Education.
2. Clayden, J., Greeves, N., & Warren, S. (2012). *Organic Chemistry* (2nd ed.). Oxford University Press.
3. Solomons, T. W. G., & Fryhle, C. B. (2016). *Organic Chemistry* (12th ed.). Wiley.
4. Bahl, A., & Bahl, B. S. (2022). *Advanced Organic Chemistry*. S. Chand Publishing.
5. Eliel, E. L., Wilen, S. H., & Doyle, M. P. (2003). *Basic Organic Stereochemistry*. Wiley.
6. Y. R. Sharma (2020). *Elementary Organic Spectroscopy* (Revised edition). S. Chand Publishing.

Suggested References:

1. March, J. (2007). *Advanced Organic Chemistry: Reactions, Mechanisms, and Structure* (6th ed.). Wiley.
2. Carey, F. A., & Sundberg, R. J. (2007). *Advanced Organic Chemistry* (Parts A & B). Springer.
3. Pavia, D. L., Lampman, G. M., Kriz, G. S., & Engel, R. G. (2014). *Introduction to Organic Laboratory Techniques* (5th ed.). Cengage Learning.
4. Silverstein, R. M., & Webster, F. X. (2005). *Spectrometric Identification of Organic Compounds* (7th ed.). Wiley.
5. Mukherjee, S. M., & Singh, S. P. (2020). *Reaction Mechanism in Organic Chemistry*. Macmillan.

Semester V

Enzymology

Course Code: VSB 305 DM 20

Course Credits: 2; Total Hours: 30

Course Objective: *The objective of this course is also to provide a deeper insight into the fundamentals of structure, function and kinetics of enzymes. The course also aims to develop foundational knowledge in enzyme kinetics, regulation, and inhibition, while emphasizing the biological significance of coenzymes, catalytic mechanisms, and the influence of various physicochemical factors on enzymatic activity.*

Course Learning Outcome:

Unit 1: Introduction to Enzymes

Students will be able to describe the structural and functional components of enzymes, including apoenzymes and holoenzymes, classify enzymes based on IUBMB nomenclature, and explain the role of coenzymes, prosthetic groups, and metal ions. They will also understand enzyme activity units and the concepts of activation energy and binding energy.

Unit 2: Enzyme-Substrate Interaction Models

Students will be able to explain the lock-and-key and induced-fit models of enzyme-substrate interaction, discuss the catalytic roles of various coenzymes (e.g., NAD⁺, FAD, TPP), and describe the mechanisms of action of specific enzymes such as chymotrypsin and lysozyme. They will also interpret enzyme specificity, cooperativity, and binding analysis using Hill and Scatchard plots.

Unit 3: Enzyme kinetics

Students will be able to apply the principles of enzyme kinetics, derive and interpret the Michaelis-Menten equation, and use kinetic plots (e.g., Lineweaver-Burk) to calculate V_{max} and K_m. They will understand steady-state and rapid equilibrium assumptions and analyze bi-substrate reaction mechanisms.

Unit 4: Enzyme Regulation and Mechanisms of Inhibition

Students will be able to differentiate types of enzyme inhibition (competitive, non-competitive, uncompetitive), understand enzyme regulation via allosteric modulation, covalent modification, and zymogen activation. They will also explore the significance of isozymes, ribozymes, abzymes, and how pH, temperature, and other factors influence enzyme activity

Course Content:

Unit 1: Introduction to Enzymes (7h)

Apoenzyme, Holoenzyme, Role of coenzymes and prosthetic groups and vitamins as coenzymes precursors, Metal-activated and Metallo-enzymes; Classification and nomenclature of enzymes with example, Activation energy and Transition state theory, Binding energy; Unit of enzyme activity – definition of IU, Katal, enzyme activity, Specific activity; Significance of K_{cat} and specificity constant

Unit 2: Enzyme-Substrate Interaction Models (8h)

Lock-and-key hypothesis; Induced-fit hypothesis; Role of $NAD^+/NADP^+$, FMN/FAD, coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, lipoic acid, biocytin, Vitamin B12 Coenzyme, and tetrahydrofolate coenzymes in enzyme catalysis; Mechanism of action of chymotrypsin, ribonuclease, carboxypeptidase, and lysozyme, Specificity of enzymes (concept of active site); Negative and Positive Cooperativity; Hill plot; Scatchard plot;

Unit 3: Enzyme kinetics (8h)

Relationship between initial velocity and substrate concentration; Enzyme kinetics: Michaelis – Menten equation, Briggs and Haldane theory (rapid equilibrium and steady state theory), Lineweaver – Burk (L-B) plot, Determination of V_{max} & K_m from L-B plot and their significance, Bi-substrate reactions:

Unit 4: Enzyme Regulation and Mechanisms of Inhibition (7h)

Reversible enzyme inhibition—Competitive, Non-competitive and Uncompetitive; Suicide inhibitor, Transition state analogues, Catalytic antibodies, Isozymes and Ribozymes; Allosteric enzyme, Allosteric regulation with ATPase as an example, Covalent modification- glycogen phosphorylase, Zymogen activation by proteolytic cleavage with example of chymotrypsin and trypsin, Isoenzymes. Ribozyme and Abzyme Effect of pH, temperature, substrate concentration and metal ions on the activity of enzyme

Suggested Textbooks:

1. Nelson, D.L. and Cox, M. M. (2009). *Lehninger's Principles of Biochemistry*, W.H. Freeman and Company, New York
2. Berg, J. M., Tymoczko J. L. and Stryer L. (2006) 6th Edition. *Biochemistry*. New York, USA: W. H. Freeman and Co. ISBN-13: 978-0716787242

Semester V

Practical

Course code: SLLL BMS 35 04 C 0042

Course Credits: 2; Total hours: 60

Course Objective: *The objective of this course is to provide hands-on experience in fundamental techniques of microbiology, organic chemistry, and enzymology. Through practical exposure, students will gain essential laboratory skills including microbial culture methods, functional group analysis of organic compounds, and enzyme activity assays. The course aims to develop technical proficiency, analytical thinking, and experimental data interpretation in a multidisciplinary scientific context.*

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- To visualize and identify various microorganisms
- To culture microorganisms in aseptic conditions
- To prepare and sterilize different types of media
- To maintain different types of cultures
- To carry out research using microorganisms.
- To learn the principles behind and importance of sterilization while working in varied areas of biology in various laboratories.
- Identify functional groups in monofunctional organic compounds using characteristic chemical tests (alcohols, phenols, aldehydes, ketones, carboxylic acids).
- Prepare derivatives (oximes, semicarbazones, DNPs, etc.) to confirm the structure of organic compounds.
- Apply recrystallization techniques and determine melting points for compound purification.
- Calculate quantitative yields and interpret data from organic qualitative analysis experiments.
- Determine the temperature optimum for alkaline phosphatase and analyze enzyme stability.

- Examine the effect of pH on enzyme activity and interpret enzyme kinetics under different buffer conditions.
- Estimate total protein concentration and compute the specific activity of alkaline phosphatase to assess enzyme purity and function.

Course Content:

Introduction to Microbiology

1. Preparation of LA and LB media
2. Gram's staining
3. Pure culture techniques - Streak plate, Pour plate and Spread plate.
4. To analyze the samples from different sources for presence of microbes.

Advanced Organic Chemistry

Functional group test (including derivative preparation) for monofunctional compounds:

5. Alcohols: Ceric Ammonium Nitrate test and Lucas Test
6. Phenols: Ferric Ammonium test, Benzoylation or Bromination of phenol
7. Aldehydes: Tollen's and Fehling's test, Oxime, Semicarbazone or 2,4-dinitrophenylhydrazine formation.
8. Ketone: 2, 4- DNP test, Oxime, Semicarbazone or 2,4-dinitrophenylhydrazine formation.
9. Carboxylic acids: Sodium Bicarbonate test, Litmus test

(Recrystallization, determination of melting point and calculation of quantitative yields to be done in all cases)

Enzymology

10. To determine temperature optima for alkaline phosphatase
11. To examine effect of pH on activity of alkaline phosphatase
12. Estimate total protein content to calculate specific activity of the enzyme

Suggested Textbooks:

- Cappuccino, J.G., & Welsh, C. (2019). *Microbiology: A Laboratory Manual*. Pearson Education.
- Pelczar, M.J., Chan, E.C.S., & Krieg, N.R. (2001). *Microbiology: Concepts and Applications*. McGraw-Hill.

- Vogel, A.I. (2006). *Vogel's Textbook of Practical Organic Chemistry*. Pearson Education.
- Mann, F.G. & Saunders, B.C. (2009). *Practical Organic Chemistry*. Orient Blackswan.
- Price, N.C., & Stevens, L. (2011). *Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins*. Oxford University Press.
- Plummer, D.T. (1987). *An Introduction to Practical Biochemistry*. McGraw-Hill Education.

SEMESTER- VI

Semester VI

Immunology

Course code: VSB 302 DM 30

Course Credits: 3; Total hours: 45

Course Objective: *This course describes the molecular and cellular basis of the development and function of the immune system. The course will provide the basic framework in immunology that will cover the major topics including innate and adaptive immunity, antibodies and antigens, the molecular events leading to the generation of antibody, humoral and cell mediated adaptive immune response, hypersensitivity, self-tolerance, autoimmunity and vaccines.*

Course Learning Outcome:

Unit 1: Fundamentals of Immune System

Students will learn the overview of different types of immunity and will learn that all branches of immunity are interconnected. The students will be able to learn the basic concepts of different immune cells originate, mature and differentiate from haematopoiesis cell and organs related to immune system. They will also learn about the specialized functions of these immune cells in recognizing an antigen and provoking a response against them. Students will also understand the structure and function of various immune organs. Students will learn the basic difference between antigen, immunogen, haptens and adjuvant. They will also come across the structure and functions of different antibodies. Students will learn conventional method of monoclonal antibody production and its clinical uses.

Unit 2: Molecular and Cellular Basis of Immune Responses

Students will learn how different antigen is processed before an immune response is generated against it. They will also learn about major histocompatibility complex. Students will learn how an antigen is recognized by immune cell and generate humoral or cell mediated immune responses against pathogen. Students will learn about function, activation and regulation of various cytokines and other proteins in immune response.

Units 3: Immunological techniques and Vaccines

Students will learn various immunologic assays that will help them to measure or exploit antibody-antigen interaction in Laboratory. Students will learn basic concept of immunization. They will also understand designing of different types of vaccines and, type of response they generate.

Unit 4: Immune Dysfunctions and Disorders

Students will learn the consequences of dysfunction of immune system.

Course Content:

Unit 1: Fundamentals of Immune System

(13h)

Introduction to immunity: Types of immunity – innate and adaptive immunity, humoral and cell-mediated immune responses. **Cells and Organs of the Immune System:** Immune cells (Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell); primary (bone marrow and thymus) and secondary (lymph node, spleen, MALT, GALT) lymphoid organs. **Antigens and Antibody:** Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity), epitopes haptens and adjuvants. Antibodies - structure, classes, and function, antigenic determinants of Antibodies (isotype, allotype, idiotype). Production of monoclonal antibodies by hybridoma technology and its applications, Chimeric antibodies.

Unit 2: Molecular and Cellular Basis of Immune Responses

(12h)

Antigen processing and presentation: Role of antigen-presenting cells, endogenous antigens (cytosolic pathway), exogenous antigens (endocytic pathway). Major histocompatibility complex (MHC) organization, classes, structure and function. **Humoral Immune Response:** B-cell receptor, maturation, activation and differentiation. **Cell Mediated Immune Response:** T-cell receptor, maturation, activation and differentiation, Self MHC restriction, Co-stimulatory signals, Killing Mechanisms by CTL and NK cells. Introduction to tolerance. **Complement system:** components, function and activation pathways (classical, alternative and lectin)

Unit 3: Immunological techniques and Vaccines

(10h)

Precipitation, agglutination, immunodiffusion, immunoelectrophoresis, Radioimmunoassay (RIA), Enzyme-linked Immunosorbent Assay (ELISA). **Vaccines** - Concept of active and passive immunization, Designing Vaccines for active immunization; whole organism vaccines; purified macromolecules as vaccines; recombinant vector vaccines; DNA vaccines; multivalent subunit vaccines.

Unit 4: Immune Dysfunctions and Disorders

(10h)

Autoimmune Diseases: Organ-specific (Insulin Dependent Diabetes Mellitus, Myasthenia Gravis) and systemic (Systemic Lupus Erythematosus, Rheumatoid Arthritis) mechanisms and treatment. **Hypersensitivity Reactions:** Types I-IV with examples and mechanism. **Immunodeficiencies:** Overview and examples - SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, Chronic Granulomatous Disease (CGD).

Suggested Textbooks:

1. Coico, R and Sunshine, G. (2009) *Immunology: A Short Course (6thed.)*, John Wiley & sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
2. Kindt, T. L., Goldsby, R. A. and Osborne, B. A. (2007) *Kuby Immunology (6thed.)*, W. H Freeman and Company (New York), ISBN:13:978-0-7167-8590-3/ ISBN:10:0-7617-8590-0
3. Murphy, K., Mowat, A., and Weaver, C. T. (2012) *Janeway's Immunobiology (8thed.)*, Garland Science (London & New York), ISBN:978-0-8153-4243-4

Semester VI

Medical Genetics

Course Code: VSB 304 DM 30

Course Credits: 3; Total Hours: 45

Course Objective: *The aim of the course is to provide students with a comprehensive understanding of both classical and modern concepts in genetics with special emphasis on the areas of transmission genetics, molecular and chromosomal aberrations and population genetics in humans. The course will provide detailed knowledge of underlying causes and mechanisms of the genetic disease in humans.*

Course Learning outcome:

Unit 1: Foundations of Medical Genetics

- Explain the historical and clinical relevance of medical genetics.
- Describe Mendelian principles and their applications in inheritance patterns.
- Classify and interpret the clinical consequences of various genetic disorders.
- Analyze autosomal inheritance patterns and factors influencing gene expression.

Unit 2: Patterns of Inheritance and Genetic Variation

- Interpret various inheritance patterns including sex-linked, mitochondrial, and imprinting disorders.
- Describe the types, causes, and effects of genetic mutations and chromosomal abnormalities.
- Evaluate genetic disease mechanisms using examples like thalassemia and Down syndrome.

Unit 3: Genetic Analysis and Cytogenetics

- Apply population genetics principles to assess genetic variation.
- Describe key cytogenetic and molecular techniques used to detect chromosomal and DNA-level variations.
- Analyze genetic linkage and mapping methods used for disease gene identification.

Unit 4: Biochemical Genetics, Cancer Genetics, and Genomic Medicine

- Explain the genetic basis of metabolic and cancer-related disorders.
- Discuss molecular mechanisms and gene defects underlying inherited diseases.
- Evaluate methods used for prenatal diagnosis and personalized medicine approaches in clinical genetics.

Course Content:

Unit 1: Foundations of Medical Genetics

(9h)

Importance and history of medical genetics, Mendel's laws of inheritance, DNA as the basis of inheritance, Origins of medical genetics, Clinical impact of genetic diseases, Classification of genetic disorders: Single gene, chromosomal, polygenic, somatic cell, mitochondrial, Autosomal inheritance: Dominant and recessive, Reoccurrence risks and modifying factors: New mutations, germline mosaicism, reduced/age-dependent penetrance, variable expression, locus heterogeneity, pleiotropy

Unit 2: Patterns of Inheritance and Genetic Variation

(12h)

Sex-linked inheritance, X-linked (dominant & recessive), Y-linked, sex-influenced traits, Mitochondrial inheritance, Genomic imprinting: Prader-Willi, Angelman, Fragile X, Genetic mutations: Types, causes, molecular and clinical consequences (e.g., thalassemia, sickle cell disease) DNA repair mechanisms, Chromosomal abnormalities: Number (polyploidy, trisomy 21/18/13, Turner, Klinefelter), Structural (translocations, deletions, duplications, inversions)

Unit 3: Genetic Analysis and Cytogenetics

(13h)

Mutation rates, Detection and measurement of genetic variation: ABO, Rh system, protein electrophoresis, DNA-level techniques (brief), Genetic variation in populations: Probability, gene/genotypic frequencies, Hardy-Weinberg principle, Causes of variation, Cytogenetic techniques and nomenclature: Chromosome banding, FISH, CGH, Disease gene identification, Linkage analysis, LOD scores, physical mapping, Dosage mapping, gene expression testing, GWAS; Examples of Mendelian disease genes

Unit 4: Biochemical Genetics, Cancer Genetics, and Genomic Medicine

(11h)

Inheritance and prevalence of metabolic diseases, Defects in metabolic pathways:

Carbohydrate (e.g., glucose metabolism), Amino acid (e.g., phenylalanine), Lipid (e.g., cholesterol) Genetic basis of cancer, Inherited vs. somatic mutations, Oncogenes and tumor suppressor genes, Identification of inherited cancer genes, Prenatal diagnosis: Amniocentesis, Chorionic Villus Sampling, Genomics and medicine: Pharmacogenetics, individualized therapy, Genetic diagnostics and disease monitoring

Suggested Textbooks:

1. Medical Genetics, 5th Edition, Jorde, Carey, Bamshad
2. Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J. (2017) *An Introduction to Genetic Analysis*, (11th ed.), W.H. Freeman & Company (New York), ISBN: 1464109486
3. Pierce, B.A. (2012) *Genetics - A Conceptual Approach*, (6h ed.), W.H. Freeman & Co. (New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
4. Snustad, D.P. and Simmons, M.J. (2012) *Genetics* (6th ed.), John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.

Semester VI

Medicinal Chemistry

Course code: VSB 306 DM 20

Course Credits: 2; Total hours: 30

Course Objective: *The objective of this course is to learn the rational physiochemical approach to drug design and drug development and to appreciate the chemistry of drug action. This knowledge is of utmost importance for the understanding of how drugs function at the molecular level. The principles and fundamentals of drug design and drug action once understood; these concepts can be applied to the understanding of many classes of drugs. This basic understanding of the course can be the foundation for the future elucidation of drug action or the rational discovery of new drugs that utilize organic chemical phenomena.*

Course Learning Outcomes:

Unit 1: Principles of drug discovery

After completing this unit, students will be able to:

- Describe drugs discovered without rational drug design.
- Explain the approaches of modern rational drug design.
- Explicate the principle of target-based drug design.
- Rationalize steps involved in drug development.
- Clarify preclinical and phases of clinical trials.

Unit 2: Lead discovery

After completing this unit, students will be able to:

- Tell the sources and characteristics of lead molecules.
- Explain the approaches for screening of compounds for lead discovery.
- Describe the drug like properties of compounds.
- Describe modern tools to conduct rational drug design.

Unit 3: Lead Modification

After completing this unit, students will be able to:

- Elucidate the structural activity relationship.
- Describe the role of functional group modification.
- Identify the pharmacophore and auxophore in a given drug.

- Explain structural modifications approaches to increase the potency, therapeutic index, ADME properties, oral bioavailability and membrane permeability of a candidate drug molecule.

Unit 4: Proteins and Nucleic acids as drug targets

After completing this unit, students will be able to:

- Describe the classes interactive drugs
- Explicate the mechanism of action of DNA interacting drugs.
- Explain the binding of drug to a protein, receptor and enzymes
- Describe the principle of design of agonist and antagonists.

Course Content:

Unit 1: Principles of drug discovery (10h)

Drug discovered without rational design: Discovery of penicillin & Librium, drug discovered through metabolic studies; Modern rational drug design: Target based drug design, overview of drug targets; Drug development: Preclinical development, Clinical development

Unit 2: Lead Discovery (5h)

Basic concept of lead, Sources of Lead compounds, Endogenous ligands, Screening of compounds, desirable properties of compounds for screening.

Unit 3: Lead Modification (10h)

Identification of pharmacophore, Functional Group Modification, Structure–Activity Relationships, Structure Modifications to Increase Potency, Therapeutic Index, and ADME Properties, Structure Modifications to Increase Oral Bioavailability and Membrane Permeability.

Unit 4: Proteins and nucleic acids as drug targets (5h)

Drug receptor interactions: general principles, important forces involved in drug receptor complex Role of confirmation in affinity, Types of drug receptors, Design of agonist and antagonists, Concept of partial antagonism, desensitization, tolerance and dependence; **Classes of DNA interactive drugs:** Reversible DNA binders, Groove binders (netropsin), DNA intercalators (amsacrine), DNA alkylators (Mechlorethamine, Carmustine).

Suggested Textbooks:

1. Patrick G.I. (2017). 6th Edition. *Introduction to medicinal chemistry*. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691
2. Silverman, R.B. and Holladay, M.W. (2014). 3rd edition. *The organic chemistry of drug design and drug action*: San Diego, U.S.A: Elsevier, Academic press. ISBN-13: 9780123820303

Semester VI

Practical

Course code: VSB 308 SE 20

Course Credits: 2; Total hours: 60

Course Objective: *This course aims to provide practical exposure to core techniques in immunology, medical genetics, and medicinal chemistry. Students will perform key immunological assays to detect antigen-antibody interactions, study genetic traits and variations through classical and molecular methods, and synthesize or isolate medicinally important compounds from biological sources. The course strengthens foundational understanding of immune diagnostics, population genetics, molecular biology of nucleic acids, and the chemistry behind drug synthesis and extraction. By integrating biological, chemical, and genetic analyses, students gain interdisciplinary laboratory skills essential for careers in biomedical research and pharmaceutical sciences.*

Course Learning Outcomes:

Upon successful completion of this course, students will be able to:

- Detect antigen-antibody interactions using ring precipitin, single and double diffusion, and immunoelectrophoresis techniques.
- Perform and interpret diagnostic immunological assays such as Widal test and ELISA.
- Identify immune cells under the microscope based on morphology.
- Perform karyotyping for chromosomal analysis.
- Apply Hardy-Weinberg principle to evaluate gene and allele frequencies in a population.
- Conduct phenotypic tests such as color blindness and PTC tasting to study genetic inheritance.
- Determine human blood groups using haemagglutination and calculate allele frequencies.
- Isolate chromosomal DNA and determine its concentration and purity using spectrophotometry and DPA assay.

- Estimate the melting temperature of DNA and separate nucleotide bases by chromatography.
- Synthesize drugs such as aspirin and phenytoin and study their chemical properties.
- Extract bioactive compounds like caffeine and β -carotene from natural sources and analyze them.
- Perform Thin-Layer Chromatography of plant pigments and calculate the partition coefficient of compounds.

Course Content:

Immunology

1. To detect antigen-antibody complex by ring-precipitin test.
2. To detect antigen-antibody complexes by single diffusion method (Mancini)
3. To detect antigen-antibody complexes by double diffusion method (Ouchterlony)
4. To examine different immune cell under a microscope
5. To perform Widal test (antibody-antigen interaction/indirect agglutination)
6. To perform immunoelectrophoresis
7. To perform Rocket immunoelectrophoresis.
8. To perform ELISA.

Medical Genetics

9. Karyotyping
10. Hardy-Weinberg Genetic equilibrium: Study of gene & genotype frequencies. (PTC Tasters & nontasters)
11. To test for colour blindness using Ishihara charts and calculation of allele frequencies.
12. Blood group typing using haemagglutination tests and calculation of allele frequencies.
13. To hydrolyze DNA and separate nucleotide bases by paper chromatography
14. To plot ultraviolet absorption spectrum of DNA

15. Determination of DNA concentration by A260nm DNA estimation by Diphenylamine (DPA) method
16. Determination of the melting temperature of DNA Isolation of chromosomal DNA from E coli cells

Medicinal Chemistry

17. Preparation of phenytoin
18. Preparation of aspirin
19. Extraction of caffeine from Tea leaves and study its absorption properties.
20. Extraction of β - carotene from carrots.
21. Thin-Layer Chromatography of Chlorophyll a and b from Spinach.
22. Determination of partition coefficient in octanol water system.

Suggested Textbooks:

1. Kuby, J., Kindt, T. J., Goldsby, R. A., & Osborne, B. A. (2007). *Immunology*. W. H. Freeman.
2. Roitt, I., Brostoff, J., & Male, D. (2001). *Immunology*. Mosby.
3. Griffiths, A. J. F., et al. (2020). *Introduction to Genetic Analysis*. W.H. Freeman.
4. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A. (2020). *Concepts of Genetics*. Pearson.
5. Wilson, K., & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
6. Ghosh, M. N. (2005). *Fundamentals of Experimental Pharmacology*. Hilton & Company.
7. Foye, W. O., Lemke, T. L., & Williams, D. A. (2007). *Foye's Principles of Medicinal Chemistry*. Lippincott Williams & Wilkins.
8. Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Springer.

Suggested References:

1. Indian Pharmacopoeia (Latest Edition)

2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2022). *Cellular and Molecular Immunology*. Elsevier.
3. Alberts, B. et al. (2014). *Molecular Biology of the Cell*. Garland Science.
4. Lehninger, D. L. N. & Cox, M. M. (2021). *Lehninger Principles of Biochemistry*. W.H. Freeman.
5. Vogel, A. I. (2000). *Vogel's Textbook of Practical Organic Chemistry*. Pearson.
6. Rang, H. P., Dale, M. M., Ritter, J. M., & Flower, R. J. (2011). *Rang and Dale's Pharmacology*. Elsevier.
7. Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611
8. Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771

SKILL COMPONENT

Skill Education Component

Semester I & II

Skill Qualification pack

Sector Skill Council: **Life Sciences Sector Skill Development Council**

Job Role: **Production Machine Operator-Sterile Formulations**

NSQF Level: **4.5**

Qualification pack Code: **LFS/Q1203**

Applicable National Occupation Standards (NOS)

Compulsory NOS:

1. LFS/N1224: Discuss about Life Sciences Industry and basic of sterile Manufacturing
2. LFS/N0112: Adherence to Environment, health and safety guidelines in a production facility and GMP controlled area
3. LFS/N0265: Maintain compliance with current Good Manufacturing Practices (cGMP) and other regulations
4. LFS/N0113: Ensure a hygienic and clean work area to avoid contamination
5. LFS/N0268: Perform Reporting and documentation with Data Integrity
6. LFS/N0104: Coordinate and communicate with Supervisor/ production chemist, teams and auditors
7. DGT/VSQ/N0102: Employability Skills (60 Hours)

Electives (mandatory to select at least one):

Elective 1: Preparation

1. LFS/N1212: Prepare machines and perform pre-preparation checks and operation activities at preparation area of sterile dosage manufacturing

Elective 2: Filling

1. LFS/N1213: Prepare machines and perform Pre-Filling checks and operation activities at filling area of sterile dosage manufacturing

Elective 3: Cleaning and Disinfection

1. LFS/N1215: Perform cleaning & disinfection operations at cleaning area of sterile dosage manufacturing

Semester III & IV

Skill Qualification pack

Sector Skill Council: **Life Sciences Sector Skill Development Council**

Job Role: **Chemist-Quality Control**

NSQF Level: **5**

Qualification pack Code: **LFS/Q1301**

Applicable National Occupation Standards (NOS)

Compulsory NOS:

1. LFS/N0362: Discuss about Life Sciences industry and Basics of Quality Control
2. LFS/N1306: Perform laboratory investigations and analysis in compliance with current Good Manufacturing Practices (cGMP) and Good Laboratory Practices (GLP)
3. LFS/N0110: Ensure adherence to Environment, health and safety guidelines in GMP/GLP controlled areas and Lab
4. LFS/N0302: Coordinate with Manager, colleagues and auditors
5. LFS/N0314: To carry out reporting and documentation for Quality Control analysis in compliance with GDP, GLP and cGMP
6. LFS/N1307: Carry out process related checks in the quality control process
7. DGT/VSQ/N0103: Employability Skills (90 Hours)

Electives (mandatory to select at least one):

Elective 1: High-Performance Liquid Chromatography (HPLC)

1. LFS/N1301: Perform QC Analysis using High-Performance Liquid Chromatography

Elective 2: Gas Chromatography (GC)

1. LFS/N1302: Perform QC Analysis using Gas Chromatography

Elective 3: Ultraviolet-visible Spectroscopy (UV)

1. LFS/N1303: Perform QC Analysis using Ultraviolet visible spectroscopy

Elective 4: Fourier Transform Infrared Spectroscopy (FT-IR)

1. LFS/N1304: Perform QC Analysis using Fourier Transform Infrared Spectroscopy

Elective 5: Dissolution Test Apparatus

1. LFS/N1305: Perform QC Analysis using Dissolution Test Apparatus

Semester V & VI

Skill Qualification pack

Sector Skill Council: **Life Sciences Sector Skill Development Council**

Job Role: **Microbiologist-Quality Control**

NSQF Level: **5.5**

Qualification pack Code: **LFS/Q0308**

Applicable National Occupation Standards (NOS)

Compulsory NOS:

1. LFS/N0362: Discuss about Life Sciences industry and Basics of Quality Control
2. LFS/N0344: Perform checks in a microbiology lab before the start of the microbiological test
3. LFS/N0342: Perform test for microbial analysis in compliance with regulatory guideline
4. LFS/N0110: Ensure adherence to Environment, health and safety guidelines in GMP/GLP controlled areas and Lab
5. LFS/N0343: Perform reporting and documentation to meet quality and regulatory standards
6. LFS/N0302: Coordinate with Manager, colleagues and auditors
7. DGT/VSQ/N0103: Employability Skills (90 Hours)