University of Dhaka

Curriculum for Bachelor of Science (BS)
in
Biochemistry and Molecular Biology

Sessions: 2020-21 and onwards

Department of Biochemistry and Molecular Biology
Faculty of Biological Sciences
University of Dhaka, Dhaka-1000
Bangladesh

BACHELOR OF SCIENCE (BS)
IN
BIOCHEMISTRY AND MOLECULAR BIOLOGY
UNIVERSITY OF DHAKA

Introduction:

The discipline of Biochemistry and Molecular Biology deals with agricultural, environmental and health sciences. Together these form the core of modern life sciences. Advances in Biochemistry and Molecular Biology are leading the development of advanced technologies that are important in the different fields of biochemistry and biotechnology including agricultural and health sciences. This includes the diagnosis as well as cure of metabolic and other cellular dysfunctions and the management of infectious diseases on one hand and improvement in agricultural productivity and nutrition on the other.

This department works to provide a center of excellence that promotes the understanding of the molecular events that underlie normal and stress conditions in both plants and animals. In case of humans, this includes pathological functions in medicine and other allied health sciences and the biochemical pathways functional in plants. The Department is highly skilled in transferring such knowledge and education to change the basic concepts of life sciences and the environment together with a better understanding of life at the molecular level.

The Department of Biochemistry and Molecular Biology is committed to develop and enhance an optimal academic environment in order to provide outstanding teaching in biochemical, molecular and immunological sciences on the basis of a demanding curriculum which allows both quality teaching and excellent research of international repute. It is our mission to produce competent biochemists, molecular biologists, biotechnologists and immunologists with the knowledge, skills and values required to address the need for high-level manpower in biological sciences with international reputation.

Vision:

The vision of biochemistry and molecular biology is to unravel life's molecular complexities, integrate multidisciplinary approaches, and advance personalized medicine, synthetic biology, global health, and the biochemical pathways functional in plants. Through ethical practices and public engagement, these disciplines will transform our understanding of life and benefit diverse industries and populations.

Mission:

The department of Biochemistry and Molecular Biology is committed to develop and enhance an optimal academic environment in order to provide outstanding teaching in biochemical, molecular and immunological sciences on the basis of a rigorous curriculum which allows both quality teaching and excellent research of international repute. The department provides a healthy learning environment for the students which encourage them for creative thinking, innovation, and leadership. It is our mission to produce competent biochemists with the knowledge, skills and values required to address the need for high-level work force in biological sciences with international reputation here, at the University of Dhaka, Bangladesh.

Objectives:

To fulfill its mission, the department is committed to:

- Provide high-quality academic programs with a healthy learning environment in biochemistry and molecular biology.
- Provide graduates with a sound knowledge of the fundamental principles and practice of biochemistry, molecular biology and immunology.
- Encourage students for creative thinking, innovation and leadership.
- Encourage students to participate in cutting-edge research creating a community of faculty and students excited by biological science.
- Participate in intramural and extramural collaborations in teaching and research that provides students' interdisciplinary educational and training opportunities.
- Provide career path counseling to our students in their academic programs.
- Maintain a motivated and committed teaching staff.
- Actively maintain contact with our alumni to enrich our current academic program.

BS Program Learning outcomes

Upon completion of the Bachelor of Science program, students will be able to:

1. Core knowledge

a) Demonstrate knowledge on the fundamentals of chemistry and biology and the key principles of biochemistry, molecular biology, immunology, microbiology, nutrition and biotechnology.
b) Gain awareness of the major issues at the forefront of the discipline.

2. Problem solving and analytical/critical thinking

a) Apply the core knowledge to dissect scientific problems into its key features by thinking in an integrated manner and examining problems from different perspectives.
b) Provide clear rationale for solving a problem and draw conclusion by using problem solving, critical thinking, and analytical reasoning skills.

3. Laboratory and Research skills

a) Implement standard safety procedures and regulations for safe handling and use of chemicals**.**
b) Design and conduct biochemical and molecular biological experiments independently with special emphasis to proper laboratory documentation.
c) Use practical knowledge to handle cutting edge instruments to obtain and record data for biochemical and chemical experiments.
c) Demonstrate good quantitative skills such as the ability to prepare reagents and buffers accurately and reproducibly for all experimental procedures.
e) Design experiments and understand the limitations of the experimental approach and follow-up experiments.
f) Interpret experimental data and identify consistent and inconsistent components.
g) Work safely and effectively in the laboratory and collaborate with other researchers

4. Teamwork and communication skills

a) Collaborate effectively as part of a team to solve problems, debate different points of view, and interact productively with a diverse group of team members.
b) Present scientific reports with clear, concise language using oral, written and visual modes to the audiences.
c) Communicate the problem and the results to diverse audiences.

5. Career, Research and Preparation

Students approaching the end of their course of study will be able to make informed choices among post-graduate opportunities for work or further education.

Student Admission:

Students will be admitted to the undergraduate program in the department under the Faculty of Biological Sciences as per the existing rules of the University of Dhaka.

Duration of the Program:

The duration of BS (Honors) Program under the Faculty of Biological Sciences will be of 4 (four) academic years divided into 4 (four) sessions, so that there will be one session in each academic year.

The duration of each session will be 42 - 44 working weeks, which will be distributed as follows:

Classes	30 weeks
Preparation Time for Course Final Examination, 1st, 2nd & 3rd years	4 weeks
Preparation Time for Course Final Examination, 4th year	6 weeks
Course Final Examination (Theory + Practical)	8 weeks
Total	42/44 weeks

Assignment of Credits:

The entire undergraduate program is covered by a set of theoretical, practical (laboratory), seminar/project courses.

Theoretical Courses:

A minimum of 15 class hours per session constitutes 1 (one) credit hour.

Practical courses:

For laboratory work, students will have to complete 3-4 experiments per credit that consists of theory lecture for experiments and hands-on-training. To complete an experiment, approximately 4-6 hours are required.

A student must have to earn a minimum of **140** credits for successful completion of his/her graduation program.

Distribution of credits in four years will be approximately as follows:

Year	Departmental			Extra-departmental	Total
	Theory	Laboratory work	Viva-voce		
1st	13	4	2	9	**28**
2nd	18	4	2	8	**32**
3rd	24	8	2	6	**40**
4th	30	8	2	0	**40**
Total	**85**	**24**	**8**	**23**	**140**

Evaluation of Students' Performance:

The total performance of a student in a given course (departmental or extra-departmental) will be evaluated on the basis of a scheme of continuous assessment and course final examinations.

For theory courses the continuous assessment will be made through a set of in-course examinations and class attendance.

Continuous assessment of laboratory work will be made through observation of the student at work, *viva-voce*, assignments and evaluation of practical reports.

The scheme of continuous assessment for the laboratory work will be announced by the teacher on the first day of classes.

An extra-departmental course includes laboratory work based on the course materials, the assessment on the practical part will be done only by a final examination.

The distribution of marks for a theoretical courses and laboratory work will be as follows:

Class attendance	5%
In-course assessment	35%
Course Final Examination	60%

The distribution of marks for an extra-departmental course will be as follows:

Class attendance	5%
In-course assessment	15%
Practical examination	20%
Course Final Examination	60%

Basis for awarding marks for class attendance will be as follows:

Attendance (% of total class held)	Marks (%)
95 and above	5
90 to less than 95	4
85 to less than 90	3
80 to less than 85	2
75 to less than 80	1
Less than 75	0

In-course Assessment (Theory courses):

i. In-course assessment of minimum one hour duration shall be conducted and evaluated by the course teacher. There will be at least 2 (two) written tests for 4/3- credit courses and at least 1(one) written test for 2- credit courses. Questions for in-course tests should preferably be of the objective type. Schedule of the summative tests will be determined by the chairperson of the department.

ii. No make-up test will be arranged for a student who fails to appear in in-course test/tests. Absence in any in-course test will be counted as zero for calculating the average in in-course test for that course. However, student can apply to the Chairman of the relevant department for make-up test. The Chairman will place the application before the academic committee if the particular student has met with an accident or his/her parents has expired or he/she has gone through a surgical procedure or any other such situation which the Academic Committee feels can be considered. The make-up test must be held during the course period.

iii. The course teacher will show the assessed in-course scripts to the students.

The Course Final Examination (Theory Courses):

i. The course final examination will be conducted centrally by the Controller of Examinations as per existing system.

ii. The course final examinations will be of 3 hours duration for 4-credit courses, 2½ hours for 3-credit courses and 2 hours for 2-credit courses.

iii. For evaluation of the course final examination there will be two examiners: one internal (will be the course teacher/teachers) and the other external (will preferably be within the department provided that he/she was not a course teacher for the course paper to be examined).

iv. Under double-examiner system and in caser of difference of more than 20% of marks, there will be a 3rd examiner. Marks of nearest two examiners will average out as final marks. If difference between 3rd examiner and other examiners become equal than 3rd examiners mark will be the final mark.

Assessment of Seminar/Project/Assignment/Internship Courses:

Respective course teachers can provide students assignments, seminar on a specific topic and can ask for feedback from the students within a definite time frame. For internship programs, a student or a group of students can visit related industries, research laboratories/institutes and then, students will prepare a report on their experiences according to the guidelines set by the teacher(s).

Viva-voce:

A four-member examination committee including an external member will be formed by the academic committee of the department which will be authorized to conduct the Viva-voce on the basis of the contents of each course of the respective academic year at the end of final examination.

The Grading System:

Marks obtained for each course will be converted to grades. A basic four-point (4.00) grading scale will be followed.

The following letter grades and corresponding grade points will be used to determine the student's grade point average (GPA) as approved by the University of Dhaka.

Marks Obtained	Corresponding Letter Grade	Grade Point
80% or above	A+	4.00
75% to less than 80%	A	3.75
70% to less than 75%	A-	3.50
65% to less than 70%	B+	3.25
60% to less than 65%	B	3.00
55% to less than 60%	B-	2.75
50% to less than 55%	C+	2.50
45% to less than 50%	C	2.25
40% to less than 45%	D	2.00
Less than 40%	F	0.00

Earned Credits:

A course in which a student has obtained 'D' or higher grade will be counted as credits earned by the student. Any course in which a student has obtained 'F' grade will not be counted for calculation of credits earned.

Promotion:

Promotion from 1st year to 2nd year

(i) A student must earn a minimum Grade Point Average (GPA) of 2.0 and must have passed all the courses taken for promotion.
(ii) Students who failed in courses (maximum 8 credit hours) but have earned the required GPA 2.0 will be promoted on probation.
(iii) Those on probation shall appear in a retake examination as detailed below and must pass the failed courses to be allowed to continue studies in the 2nd year.

Promotion from 2nd year to 3rd year:

(i) A student must have earned a minimum Cumulative Grade Point Average (CGPA) of 2.25 and must have passed all the courses for promotion.
(ii) Students who failed in courses (maximum 8 credit hours) but have earned the required CGPA 2.25 will be promoted on probation.
(iii) Students who earned CGPA less than 2.25 but equal to or more than 2.0 without any 'F' grade will also be promoted on probation.
(iv) Those on probation shall appear in a retake examination as detailed below and pass the failed courses to be allowed to continue studies in the 3rd year.

Promotion from 3rd year to 4th year:

(i) A student must have earned a minimum Cumulative Grade Point Average (CGPA) of 2.5 and must have passed all the courses for promotion.
(ii) Students who failed in courses (maximum 8 credit hours) but have earned the required CGPA 2.5 will be promoted on probation.
(iii) Students who earned CGPA less than 2.5 but equal to or more than 2.25 without any 'F' grade will also be promoted on probation.
(iv) Those on probation shall appear in a retake examination as detailed below and pass the failed courses to be allowed to continue studies in the 4th year.

Retakes (Course final examination only):

Students who have been promoted on probation for failing in course(s) must sit for retake examination of the failed courses, within 6 weeks after publication of results, conducted by the respective original examination committee for the year. Expenses of the retake examinations (as determined by the University) must be borne by the student/students. After the retake examination, if a student achieves the required credits, he/she will be considered promoted, but his/her transcript will be marked to identify the courses retaken. If any student fails to earn the required credits, his/her promotion on probation will be deemed cancelled.

Students who have been promoted on probation for failing to earn requisite CGPA without any 'F' will be allowed to sit for retake examination for maximum 8 credits (including practical course and viva-voce), within 4-6 weeks after publication of results, conducted by the respective original examination committee for the year. Expenses of the retake examinations (as determined by the University) must be borne by the student/students. After the retake examination, if the student succeeded to earn required CGPA he/she will be considered promoted, but his/her transcripts will be marked to identify the courses retaken. If any student fails to achieve the required CGPA, his/her promotion on probation

will be deemed cancelled.

Students who failed in maximum of 8 credits of the 4th year, he/she must sit for retake examination of the failed courses, within 4-6 weeks after publication of results, conducted by the respective original examination committee for the year. Expenses of the retake examinations (as determined by the University) must be borne by the student/students. After the retake examination, if a student achieves the required credits, he/she will be considered for graduation, but his/her transcript will be marked to identify the courses retaken.

Readmission:

A student failing to earn the requisite credits and/or GPA/CGPA (see above) for promotion or graduation may seek readmission with the next batch. For readmission, a student will have to apply within one month after announcement of the result of the concerned year. Readmission will be allowed only after the approval of the departmental academic committee.

On readmission, a student may choose, subject to approval of the Academic Committee of the respective department, to keep grades and credits earned earlier or choose to take all or any course(s) again. Student must clearly indicate his/her choice on the application for readmission.

On readmission, a student may be allowed by the departmental Academic Committee to retain his/her in-course marks, earned earlier as chosen by him/her.

Readmission shall not be allowed more than twice during the entire program. A student will have to complete the B.S. program within a period of maximum six years, including readmission.

A student attending less than 60% classes will not be allowed to take readmission. Therefore, he/she will be dropped out of the program forever.

Drop Out:

A student failing to earn the required minimum GPA/CGPA and/or to earn requisite credits after retakes, he/she may take readmission, with the approval of the Academic Committee of the respective department, to appear in the course final examinations with the next batch. If he/she fails again to earn the required minimum GPA/CGPA and/or to earn requisite credits he/she will be dropped out of the program.

Improvement of earned credits:

To improve GPA/CGPA, a student may appear in the course final examination (theory courses, practical courses and viva-voce), only once, with the following next batch in a maximum 8 credits in each year. Improved grade point will be used for GPA/CGPA calculation. For improvement of

grade in a course the student shall apply to the chairman of the department at least 8 weeks before the start of the final examination.

If a student likes to improve the grade point earned in a course of 4th year, he/she must apply for such improvement examination before the award of the degree (i.e., before issuance of certificate). Improvement shall not be allowed once the degree is awarded.

Requirements for Graduation:

To graduate with a Bachelor's degree, a minimum total of 140 credits must be earned by a student within 4-6 academic years after his/her first admission in the graduation program. He/she must also have earned the minimum required CGPA (2.5 on a 4.00 scale).

A student who has fulfilled all the academic requirements for Bachelor's degree will have to file with the Controller of Examinations, an application for Graduation. Provisional degree will be awarded on completion of credit and CGPA requirements. Such provisional degree will be confirmed by the Academic Council.

Time Limits for Completion of Bachelor's Degree:

A student must fulfill all the requirements for a Bachelor's degree within a maximum period of six academic years, starting from the year of registration.

Teaching Methodologies:

Problem-based learning (PBL) strategies will be followed to ensure maximum participation of all students attending the classes. Student-centered teaching will be the primary distinguishing feature of PBL. The strategy will include carefully selected and designed problems, achievement of critical knowledge, problem-solving proficiency, self-directed learning strategies, and team-participation skills. In this regard, lectures will be delivered and hands out as well as available books/research/review articles will be distributed and/or cited so that learners can have easy excess to the contents of each class. Emphasis will be given on solutions based on the knowledge and skills acquired rather than on right or wrong answers.

The course teacher at the beginning of the course will explain among the following methodologies which methods will be followed for the course:

☐ lectures ☐ discussions ☐ homework ☐ text book ☐ problem based ☐ case studies
☐ presentation ☐ Other teaching method.

For any matter not covered in this curriculum the existing rule of the Faculty of Biological Sciences, University of Dhaka will be applicable.

Structure of Curriculum

1st Year BS (Honors)

Course No.	Name of the course	Credits
Departmental courses:		
BMB-101	Biophysical Chemistry	3
BMB-102	Bioorganic Chemistry	4
BMB-103	Cells and Biomolecules	2
BMB-104	Peptides and Proteins	2
BMB-105	Molecular Biology-I	2
BMB-106	Laboratory Work	4
BMB-107	Viva-voce	2
Extra-departmental courses:		
BMB-151	Foundation Course in English	2
BMB-152	Basic Microbiology	2
BMB-153	Basic Biology and Biodiversity	2
BMB-154	Introduction to Applied Biology	3
	Total	**28**

2nd Year BS (Honors)

Course No.	Name of the course	Credits
Departmental courses:		
BMB-201	Enzymes	4
BMB-202	Carbohydrate Metabolism	4
BMB-203	Biological Membrane and Lipid Metabolism	3
BMB-204	Endocrinology	3
BMB-205	Molecular Biology-II	4
BMB-206	Laboratory Work	4
BMB-207	Viva-voce	2
Extra-departmental courses:		
BMB-251	Human Physiology	4
BMB-252	Computer Basics and Data Analysis	4
	Total	**32**

3rd Year BS (Honors)

Course No.	Name of the course	Credits
Departmental courses:		
BMB-301	Metabolism of Nitrogenous Compounds	4
BMB-302	Biochemistry of Natural Products	2
BMB-303	Human Nutrition	4
BMB-304	Molecular Biology-III	2
BMB-305	Molecular Genetics	4
BMB-306	Plant Biochemistry	2
BMB-307	Basic Immunology	2
BMB-308	Laboratory Science and Clinical Biochemistry	4
BMB-309	Laboratory Work	8
BMB-310	Viva-voce	2
Extra-departmental courses:		
BMB-351	Applied Biostatistics	4
BMB-352	Microbiology	2
	Total	**40**

4th Year BS (Honors)

Course No.	Name of the course	Credits
Departmental courses:		
BMB-401	Cell Biology	4
BMB-402	Plant Biotechnology	2
BMB-403	Pharmaceutical and Food Biotechnology	4
BMB-404	Molecular Biology-IV	2
BMB-405	Biochemistry of Cancer	2
BMB-406	Virology	2
BMB-407	Immunology	4
BMB-408	Biochemistry of Drugs	2
BMB-409	Neurobiochemistry	2
BMB-410	Applied Human Nutrition	2
BMB-411	Basic Bioinformatics	2
BMB-412	Research Methodology	2
BMB-413	Laboratory Work	8
BMB-414	Viva-voce	2
	Total	**40**

Grand total for BS (Honors) program: 140 Credits

1st Year BS (Honors)

Total Credits in 1st Year BS (Honors): 28 Credits

Course No.	Name of the course	Credits
Departmental courses:		
BMB-101	Biophysical Chemistry	3
BMB-102	Bioorganic Chemistry	4
BMB-103	Cells and Biomolecules	2
BMB-104	Peptides and Proteins	2
BMB-105	Molecular Biology-I	2
BMB-106	Laboratory Work	4
BMB-107	Viva-voce	2
Extra-departmental courses:		
BMB-151	Foundation Course in English	2
BMB-152	Basic Microbiology	2
BMB-153	Basic Biology and Biodiversity	2
BMB-154	Introduction to Applied Biology	3
	Total	**28**

BMB-101: Biophysical Chemistry 3 Credits

Introduction:

The fundamental principles that govern life are the same as those that govern all of chemistry (e.g., thermodynamics, chemical equilibrium, kinetics, molecular forces, buffer etc.) and systems requires a rigorous understanding of the physicochemical properties that define their structure and function. This course is designed to introduce students to the principles of physical chemistry with a focus on their application to biochemical processes and biophysical interactions.

Objectives:

The objectives of the course are to:

- Understand the fundamental concepts of the first, second and third laws of thermodynamics.
- Comprehend different thermodynamic processes, such as isothermal and adiabatic expansion, and solve mathematical problems related to them.
- Explore the nature of heat and work, including PV work and maximum work, and apply the first law of thermodynamics to determine internal energy, enthalpy, and molar heat capacities.
- Analyze thermochemical equations, standard enthalpy of formation, and the dependence of reaction enthalpy on temperature and bond energy.
- Apply thermodynamics concepts to open systems and explore the relevance of classical thermodynamics in biochemistry.
- Analyze the applications of chemical equilibrium principles in living systems.
- Investigate catalysis, including its definition, types, characteristics of catalysts, and the concept of activation energy.
- Understand the Bronsted-Lowry and Lewis concepts of acids and bases.
- Differentiate between strong and weak acids and bases and evaluate their strengths.
- Apply the concept of pH and solve numerical problems related to pH calculations.
- Grasp the principles of buffer solutions and the Henderson-Hasselbalch equation.
- Understand the Beer-Lambert law and its application in spectrophotometry.
- Construct and analyze standard curves in spectrophotometry.

Contents:

1. **Thermodynamics:**

   i) First law of thermodynamics: Introduction, system, boundary, surroundings, intensive and extensive properties, thermodynamic processes, nature of heat and work, PV work, maximum work, first law of thermodynamics - internal energy, enthalpy, molar heat

capacities, isothermal and adiabatic expansion, mathematical problems.

ii) Thermochemistry: Exothermic and endothermic reactions, standard enthalpy of formation, thermochemical equations, reaction enthalpy - dependence on temperature, bond energy.

iii) Second law of thermodynamics: Thermodynamics-reversibility and irreversibility, spontaneous processes, entropy, thermodynamic efficiency and Carnot's theorem, statements of second law, entropy changes - phase transition, heating, irreversible processes. Third law of thermodynamics.

iv) Free energy: Variation with temperature and pressure, Gibbs-Helmholtz equation, applications of thermodynamics in biochemistry, biochemical relevance of classical thermodynamics, open systems.

2. **Chemical equilibrium:** Nature of chemical equilibrium, law of mass action, equilibrium constant, equilibrium constant for different reactions, calculating equilibrium constant of reactions, predicting the direction of a reaction, calculating equilibrium concentrations, relationship between ΔG and Keq, effect of temperature and pressure, Le Chatelier's principle, equilibrium reaction involving protons, coupling of reactions. Applications in living systems.

3. **Chemical kinetics:** Definition, reaction rate, rate laws, zero-, first- and second-order reactions, molecularity of a reaction, pseudo-first order reaction, half-life, determination of order and rate constant, effect of temperature on reaction rates. Theories of reaction rates – the collision theory, the activated complex theory. Catalysis - definition, types, characteristics of catalysts, activation energy and catalysis.

4. **Acids and bases:** Bronsted-Lowry concept, Lewis's concept, strengths of acids, strong and weak acids and bases, pH, numerical problems based on pH, buffer solutions. Henderson-Hasselbalch equation, numerical problems based on buffers, buffering against pH changes in biological systems, maintaining the pH of blood, acid-base titration, indicators: types of indicators, choice of suitable indicators.

5. **Properties of liquids (brief treatment):** Introduction – kinetic molecular description, intermolecular forces in liquids, dipole-dipole forces, ion-dipole forces, dispersion forces, hydrogen bond, dielectric constant, surface tension, viscosity, diffusion and osmosis, osmotic pressure, isotonic solutions, reverse osmosis, phase rule, components, degrees of freedom, phase diagram of one component system, phase diagram of water, ionization of water, water as a reactant.

6. **Spectrophotometry:** Beer-Lambert law, standard curves, working principle of a spectrophotometer.

Intended Learning Outcome:

After a successful completion of this course student should be able to:

- State and interpret thermodynamic terms, system, properties and processes
- State, explain and apply the laws of thermodynamics
- Calculate pressure-volume wok heat gain or lost, internal energy and work done by system/processes.
- Explain and calculate enthalpy of reactions.
- Relate ΔH and ΔE and calculate the values for different reactions.
- Interpret calorimetry, specific heat and heat capacity to calculate values of food.
- Discuss, interpret and calculate entropy and Gibbs free energy changes for spontaneity of a process.
- Predict chemical equilibrium and spontaneity of reactions by using thermodynamic principles.
- Interpret ΔG for molecular reactions.
- Interpret concept and characteristics of equilibrium and equilibrium law,
- Write the equilibrium constant expression.
- Calculate the equilibrium constant from concentration data.
- Predict the direction of a reaction using equilibrium constant and initial concentrations of reactants and products.
- Relate chemical kinetics with chemical equilibrium and relate chemical equilibrium with free energy changes.
- Interpret, explain and calculate how living things deliver the need energy to bodybuilding chemical reactions by coupling between exergonic and endergonic reactions.
- Interpret effect of catalyst on equilibrium constant.
- Relate the equilibrium constant for differently balanced equations.
- Explain and interpret rate of reaction, rate law and order of reactions.
- Distinguish between molecularity of a reaction and order of a reaction.
- Calculate rate of reaction, rate law and order of reactions.
- Discus the effect of catalyst on a chemical reaction.
- Explain, interpret and calculate half-life of a reaction.
- Explain and interpret concept of acid and base, relative strength of acid and bases, pH of a solution and pH scale.
- Solve problems using ionization constant, concentration, and pH or pOH for weak acids and weak bases.
- Describe the preparation of buffer solutions and buffer capacity.
- Explain and interpret how buffer solutions wok.
- Calculate the pH of a buffer solution and buffer solution after adding small amount of acid or base.

- Explain and interpret use of buffer to maintain pH of blood and body fluids during normal metabolism, during exercise, during acidosis and during alkalosis.
- Describe the use of acid-base indicators.
- Plot titration curves and label the midpoint, the buffering region and the equivalence point.
- Identify major species present for and calculate pH for any point along the titration curve.
- Explain, identify and interpret different types of intermolecular forces between molecules and between ions and molecules.
- Explain, identify and interpret hydrogen bonds and its significance in biological systems.
- Explain and interpret structure and properties of water.
- Explain and interpret properties of liquids – surface tension and viscosity in terms of intermolecular forces.
- Explain and interpret phase rule and draw phase diagram of water.
- Explain and interpret working principle of spectrophotometer.
- Explain and interpret absorption measurements and their application to quantitative analysis.
- Explain and interpret diffusion, osmosis, osmotic pressure and reverse osmosis.
- Explain and interpret isotonic, hypertonic and hypotonic solution.
- Explain and interpret osmotic effects on animal and plant cells.
- Explain and interpret laws of osmotic pressure and calculation of osmotic pressure.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Thermodynamics	8
02.	Chemical equilibrium	8
03.	Chemical kinetics	8
04.	Acids and bases	7
05.	Properties of liquids (brief treatment)	7
06.	Spectrophotometry	7
Total classes		**45**

Recommended Books and Readings:

1. Essential of Physical Chemistry by Arun Bahal, BS Bahl and GD Tuli.
2. Chemistry by Raymond Chang.
3. Principles of Biochemistry by Nelson, D. L. and Cox, M.M. Lehninger.
4. Physical Chemistry for the Biosciences by Raymond Chang.

BMB 102: Bioorganic Chemistry 4 credits

Introduction:

This course is a brief discussion on different types of organic compounds like aliphatics, aromatics, heterocyclics, their physical and chemical properties, their importance in biochemistry and molecular biology, their mechanisms of reaction, their uses. Uses of different organic reactions to synthesize biologically and medicinally important compounds like drugs and to understand the mechanisms of biochemical reactions occurring in the biological systems. Without organic chemistry it is not possible to learn biochemistry and molecular biology.

Objectives:

This course has been designed in such a way so that students will

- Learn to synthesize chemical compounds using various chemical reactions.
- Acquire knowledge on various types of bonds to understand properties of different types of biochemicals.
- Know important biological, biochemical and medicinal properties about various compounds
- Apprehend mode or mechanism of action of different compounds in different types of reactions.

Contents:

1. **Physico-chemical parameters for biomolecules:** Inter- and intra-molecular interactions: covalent bond, ionic bond, dative (coordinate covalent) bond, hydrogen bonding, hydrophobic interactions, Van der Waals interaction (London forces) with special references to their presence in biomolecules, hybrid orbitals, polarity of bonds, electronegativity, dipole.

2. **Nature of bonding in organic molecules and in relation to biomolecules:** Delocalized chemical bonding-conjugation, resonance, tautomerism hyperconjugation, bonding in fullerenes.

3. **Aliphatic hydrocarbon:** Homologous series. Alkanes, alkenes, alkynes-their synthesis and properties (briefly). The S_N2, S_N1 reactions mechanisms with references to biological systems, single electron transfer (SET) reactions. Mechanisms of addition reactions, mechanisms of elimination reactions with special references to biological systems.

4. **Aromaticity and aromatic reaction mechanisms:** Structure of benzene, sources of aromatic hydrocarbons, industrially important aromatic compounds, nomenclature of benzene derivatives, electrophilic and nucleophilic aromatic substitution, chemistry of aromatic aliphatic compounds**.** Mechanisms of aromatic electrophilic substitution reactions, mechanisms of aromatic nucleophilic substitution reactions: bimolecular displacement mechanism, elimination-addition mechanism (benzene).

5. **Dienes:** Structure and properties of 1, 3-butadiene, addition reactions, polymerization, different types with examples. Natural polymer-rubber (composition and mechanism of formation). Diels-Alder and other reactions of dienes.

6. **Stereochemistryand stereoisomerism:** Chirality, chiral centre, polarimeter, plane polarised light and optical activity, specific rotation, enantiomers, diastereoisomers, meso compounds, racemic mixtures, racemic modifications, chiral biological molecules, biological importance of chirality, the R-S (rectus-sinister) system.

7. **Alcohols, ethers, epoxides and diols:** Occurrence, nomenclature, structure, synthesis, physical and chemical properties and their uses.

8. **Aldehydes and ketones:** Nomenclature, important biochemical carbonyl compounds, synthesis, mechanisms of carbonyl compound reactions: nucleophilic addition, addition-elimination, enolization-ketonization. Oxidation and reduction of carbonyl compounds, haloform reaction, enolisation in biological system, α-halocarbonyl compounds, aldol condensation, benzoin condensation, Claisen condensation, crossed aldol condensation, Perkin condensation, Mannich condensation, Claisen-Schmidt condensation. Wittig reaction, Reformatsky reaction.

9. **Rearrangement reactions**: Wagner-Meerwein rearrangement, pinacol-pinacolone rearrangement, Hoffman rearrangement, Beckmann rearrangement. Biological rearrangements.

10. **Carboxylic acids and their derivatives:** Nomenclature, synthesis, classification, properties, reactions, uses, decarboxylation reactions, dicarboxylic acids, acid chlorides, esters, acid amides, imides and acid anhydrides, soaps and detergents, biodegradable detergents.

11. **Aromatic and aliphatic nitro-compounds and amines:** Occurrence,nomenclature, synthesis, classification, properties, reactions, uses, diazonium compounds. Mechanism of diazotization and Sandmeyer reactions.

12. **Phenols:** Occurrence, nomenclature, synthesis, properties and reactions, polyhydric phenols.

13. **Heterocyclic compounds:** Chemical nature, classification and synthesis, with special reference to pyrroles, pyridines, pyrimidines and purines by mentioning their roles in biochemistry and biological systems.

Intended Learning Outcome:

After a successful completion of this course student should be able to:

- Explain chemical properties of various types of compounds
- Illustrate presence of compounds in various biochemicals
- Demonstrate their chemical synthesis
- Describe mechanism of reactions and their applications in synthesizing biologically important natural compounds

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Physico-chemical parameters for biomolecules	4
02.	Nature of bonding in organic molecules and in relation to biomolecules	4
03.	Aliphatic hydrocarbon	8
04.	Aromaticity and aromatic reaction mechanisms	7
05.	Dienes	2
06.	Stereochemistry and stereoisomerism	4
07.	Alcohols, ethers, epoxides and diols	3
08.	Aldehydes and ketones	8
09.	Rearrangement reactions	2
10.	Carboxylic acids and their derivatives	6
11.	Aromatic and aliphatic nitro-compounds and amines	5
12.	Phenols	3
13.	Heterocyclic compounds	2
Total Classes		**60**

Recommended Books and Readings:

1. A text book of organic chemistry by Arun Bahl, B.S Bahl.
2. Organic chemistry by Robert Thomton Morrison and Robert Neilson Boyd.
3. Advanced Organic Chemistry. Reactions, Mechanisms and Structure. Jerry March. *Johm Willey & Sons, Inc.*
4. Organic Chemistry. Stereochemistry and Chemistry of Natural Products. I.L. Finar. *English Language Book Society/ Longman.*
5. Organic Chemistry. TW Fraham Solomons and Craig B Fryhle. John Wiley & Sons.

BMB-103: Cells and Biomolecules 2 Credits

Introduction:

This course aims to offer a fresh and stimulating approach to the molecular logic of life in which the students will be introduced that the living organisms are composed of numerous lifeless molecules; there are a set of principles that characterize all living organisms. From a single-celled bacterium to a multi-cellular human, each cell is constructed from the same kinds of macromolecules (DNA, RNA, proteins) made up of the same monomeric subunits (nucleotides, amino acids), using the same pathways for synthesis, and the same genetic code, and how these molecules interact with each other.

Objectives:

This course has the following objectives:

- To give the students in-depth understanding that all living organisms possess extraordinary attributes not shown by any random collection of molecules.
- To present the structures of amino acids and explain how the properties and reactions of amino acids influence the functions of proteins.
- From the structures of various lipids which are molecules containing hydrocarbons and polar groups, the students will be made aware about the biological functions of these molecules in storing energy, signaling, and acting as structural components of cell membranes.
- To introduce the students with the structures of different carbohydrates, their reactions and explain how they play important roles as energy source of the body, rigid component of cell walls, in extracellular spaces, cellular recognition processes, and other functions.

Contents:

1. **History, scope and future of biochemistry**: The molecular logic of life; understanding the science of biochemistry; role of biochemistry in medicine, health and agriculture; application of biochemistry based on recombinant DNA technology in immunology, industry, diagnostics.

2. **Cells and organelles and their composition:** Isolation, identification and functional characteristics of organelles; comparison of prokaryotic and eukaryotic cells, common structural features of bacterial cells.

3. **Amino acids:** Classification, structural features, physico-chemical properties involving titration, buffering capacity, acid-base properties, characteristic chemical reactions, optical behavior, essential amino acids, nonstandard amino acids, synthesis of important biomolecules.

4. **Carbohydrates:** Monosaccharides and their biological properties, color reactions of carbohydrates, important derivatives of monosaccharides, sugar acids, important reactions of carbohydrates. Disaccharides and oligosaccharides of biological importance - maltose, lactose, sucrose and other disaccharides. Polysaccharides –storage and structural polysaccharides; structures and function of starch, glycogen and cellulose; other polysaccharides of biological interests – chitin, peptidoglycan; biological degradation of storage polysaccharides; artificial sweeteners; dextrans. Glycosaminoglycans and proteoglycans - structures and functions.

5. **Lipids:** Chemical nature, biological functions, classification with representative examples, fatty acids - nomenclature, saturated and unsaturated fatty acids and fats, essential fatty acids; triacylglycerol, phospholipids, sphingolipids, cerebrosides, gangliosides, action of phospholipases on membrane phospholipids; saponification value, iodine number, acid number, rancidity etc. with their significance, steroids and their importance (in brief); very brief idea about prostaglandins, prostacyclines, thromboxanes and leukotrienes along with their physiological importance.

Intended Learning Outcome (ILOs):

After successful completion of the course, students will be able to:

- Explain general scientific skills in understanding the biomolecules involved in constructing and functioning of a cell.
- Explicate the structure-function relationship of the various biomolecules.
- Discuss and interpret factual information of the biological system.
- Demonstrate the knowledge of biomolecules in biochemistry, medicine, agriculture, nutrition and industry.

Required number of classes):

No	Title of the unit	Number of classes
01.	History, scope and future of biochemistry	3
02.	Cells and organelles and their composition	4
03.	Amino acids	7
04.	Carbohydrates	10
05.	Lipids	6
	Total Classes	**30**

Recommended Books and Readings:

1. Lehninger Principles of Biochemistry by David L. Nelson, Michael M. Cox
2. Text Book of Biochemistry with Clinical Correlations, 4th Edn., by Thomas M. Devlin.
3. Molecular Biology of the Cell. Bruce. Alberts, Denneis Bray, Julian Lewis, Martin Raff, Keith, Roberts, James, D. Watson. *Garland Publishing Inc.*

BMB-104: Peptides and Proteins 2 Credits

Introduction:

Proteins are the 'doers' of the cell. They are huge in number and variety and diverse in structure and function, serving as both the structural building blocks and the functional machinery of the cell. Just about every process in every cell requires specific proteins. The basic principles of protein structure and function, which are reviewed in this course, are crucial to understanding how proteins perform their various roles.

The huge diversity in the functions of proteins is reflected in the specialization of these molecules. As you will see in this course, every protein optimally performs a particular job and the key to how it does so is its structure. The refinement of protein structure and optimization of protein function are driven by evolutionary pressures. Mutations at the DNA level that result in a change in protein structure and function will persist if they enhance survival or are not detrimental to the organism.

Proteins come in as many different shapes and sizes as they have functions. A broad distinction is made between globular proteins and fibrous proteins. Globular proteins are a particularly diverse group that includes enzymes, receptors and transport proteins, and are characterized by a roughly spherical compact shape. Fibrous proteins are elongated and rod-like (e.g. collagen, represented in and often have a structural role.

Objectives:

The objective of this course is to make students understand:

- Different aspects of the structure of proteins and how, through their interactions with other cellular components, they can function as dynamic molecular machines.
- Three-dimensional nature of proteins, their biochemistry and the biophysical rules that determine their structure.
- The relationship between protein structure and function using a variety of different proteins as examples, including enzymes, signaling proteins and transport proteins.
- Some of the techniques employed in studying protein characterization and protein–protein interactions.

Contents:

1. **Peptides:** Characteristic properties, peptides of biological importance.
2. **Protein:** General introduction, classification of proteins based on biological functions and nutritional values.
3. **Protein structure:**

i) Primary structure of proteins: Sequencing of proteins, sequence homology.

ii) Fibrous proteins: Secondary structure of proteins, protein conformation, planar peptide

bonds, α-helix, helix forming and destablizing amino acids, α- and β-keratins – conformation and structure, structures of collagen and elastin, filamentous proteins – actin, myosin and microtubules.

iii) Globular proteins: Tertiary and quaternary structures of proteins, distinctive tertiary structures of myoglobin and ribonuclease, renaturation of ribonuclease, factors maintaining the tertiary structure of globular proteins, oxygen-binding curves of hemoglobin and myoglobin, cooperative binding of oxygen by hemoglobin, factors contributing to oxygen saturation curve of hemoglobin, sickle-cell anemia and its relation to hemoglobin.

iv) Protein denaturation: denaturing agents and their mode of action, measure of denaturation processes using Anfinsen experiment.

4. **Exploring proteins**: protein isolation, purification and characterization:

i) Salting-in and salting out, isoelectric precipitation, dialysis, gel filtration, chromatography - ion-exchange and affinity chromatography, HPLC, electrophoresis – SDS-polyacrylamide gel electrophoresis, isoelectric focusing.

ii) Molecular weight determination by ultracentrifugation, SDS-PAGE, 2-D gel electrophoresis.

Intended Learning Outcome (ILOs):

After successful completion of the course, students will be able to:

- Explain basic concepts of protein biotechnology, protein folding and engineering.
- Delineate chromatographic techniques in the separation of proteins.
- Explicate various methods for testing protein activities.
- Describe the different levels of protein structure and their interdependence.
- Describe, using examples, the relationship between protein structure and function.
- Demonstrate significance of domains in protein function and how their evolution.

Required number of classes):

No	Title of the unit	Number of classes
01.	Peptides	2
02.	Protein	3
03.	Protein structure	13
04.	Exploring proteins - protein isolation, purification and characterization	12
Total Classes		**30**

Recommended Books and Readings:

1. Lehninger Principles of Biochemistry by Nelson, D. L. and Cox, M.M.
2. Text Book of Biochemistry with Clinical Correlations, by Thomas M. Devlin.
3. Text of Biochemistry. ES West, WR Todd, HS Mason and JT Van Bruggen.

4. Biochemistry (Lippincott Illustrated Reviews) by Richard A. Harvey, Denise R. Ferrier.

BMB-105: Molecular Biology-I 2 Credits

Introduction:

BMB-105 is a 2-credit course intended for understanding and appreciating basic molecular biology through an introduction to its fundamental principles which will establish the basics of gene structure and functions and the relationship between genotype and phenotype. The central dogma of life as the process of building up a protein from the code in the genes will be outlined through an emphasis of the molecular mechanisms of DNA replication, transcription, protein synthesis, and gene regulation in prokaryotes. This course will also briefly describe biotechnological methods through an introduction of the basics of recombinant DNA technology while describing its various applications.

Objectives:

The objectives of this course are to introduce students to the:

- basic concepts of heredity and DNA structure
- the general principles of DNA replication
- gene expression and protein synthesis in an prokaryotic organism
- some techniques used in molecular biology
- applications of the current techniques used in recombinant DNA technology

Contents:

1. **Heredity:** Mendel's laws of inheritance, gene concept, conceptual relationship between gene and chromosomes, and gene and enzymes.
2. **DNA as genetic material:** Griffith's experiment to prove the presence of a transforming principle, Avery, MacLeod and McCarty's experiment to determine that DNA and not RNA or protein was the transforming principle, further validation by Hershey and Chase.
3. **Chemistry of nucleic acids:** Classification and composition of nucleic acids, bases, sugars, nucleosides, nucleotides and polynucleotides.
4. **DNA structure:** Watson and Crick model and its characteristics, isolation of DNA from natural sources, its physicochemical properties.

5. **Gene expression:**

i) Replication as continuity of transfer of genetic information.
ii) Transcription, types of RNAs, their characteristics and function.
iii) Translation leading to functional protein synthesis, colinearity of genes and proteins.

6. **Application of Molecular Biology:** Concept

i) Recombinant DNA technology – isolation of genes, restriction endonuclease, vectors, cloning and expression of cloned genes.
ii) Agricultural and industrial applications with examples.
iii) Application in medical and related fields – forensic studies, detection of molar diseases, pharmaceutical production, gene therapy.
iv) Some molecular biology techniques – polymerase chain reaction, DNA fingerprinting, DNA mapping, use of genetic markers, DNA sequencing.

7. **Recombinant DNA technology:** Concept and controversies of genetically modified organisms (GMOs).

Intended Learning Outcome (ILOs):

After successful completion of the course, students will be able to:

- Demonstrate and understanding of classical/Mendelian genetics
- Elucidate experiments conducted to prove that DNA is the genetic material
- Explain the Watson Crick model of the DNA structure
- Explain and summarize molecular structures of DNA and RNA
- Explain relationships between DNA/RNA/Proteins
- Describe the process of DNA replication (plasmids and chromosome) in a bacterial cell
- Explain how proofreading and repair occurs during DNA synthesis
- Illustrate the principle behind the polymerase chain reaction and how this differs from DNA synthesis in a cell
- Describe the process of transcription at the molecular level including transcription termination
- Explain the concept of promoter
- Describe how the *lac* and *ara* operons are regulated
- Develop a basic understanding of functional protein biosynthesis in the living organisms
- Delineate the concept of application of recombinant DNA technology and genetic engineering

- Describe cloning, DNA fingerprinting, and molecular markers and their applications
- Provide examples of current applications of molecular biology and advances in the different areas like pharmaceutical, medical, microbial, agricultural, plant, animal, and forensic.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Heredity	2
02.	DNA as genetic material	3
03.	Chemistry of nucleic acids	3
04.	DNA structure	3
05.	Gene expression	11
06.	Application of Molecular Biology: Concept	6
07.	Recombinant DNA technology	2
Total Classes		**30**

Recommended Books and Readings:

1. Molecular Biology made simple and fun, by David P. Clark; Lonnie D. Russell.
2. Lehninger Principles of Biochemistry, by David L. Nelson and Michael M. Cox.
3. Genetics: A Conceptual Approach, by Benjamin A. Pierce.
4. Principles of Genetics, by D. Peter Snustad, Michael J. Simmons.
5. Molecular Biology of the Cell. Bruce. Alberts, Denneis Bray, Julian Lewis, Martin Raff, Keith, Roberts, James, D. Watson. *Garland Publishing Inc.*
6. Cell and Molecular Biology. E.D.P. DeRobertis and E.M.F. DeRobertis. *Wavertev.*

BMB-106: Laboratory Work 4 Credits

Introduction:

This course is designed to introduce students with good laboratory practices that include biosafety and biosecurity rules and few fundamental experiments like estimation of different organic and inorganic elements present in various samples, familiarization students with laboratory apparatus, instruments, and reagents. This also includes preparation of standard solutions and establishes reference concentrations for accurate measurements. Techniques such as titration and spectrophotometry are utilized to estimate the content of substances like acetic acid, calcium, iron, ascorbic acid, and glucose. Identification of organic compounds and determination of saponification and iodine numbers also included. These topics provide a foundation for practical skills for the beginners.

Objectives:

- Understand the importance of biosafety and biosecurity measures in the laboratory to ensure personal and environmental safety during experiments.
- Familiarize students with a wide range of laboratory apparatus, instruments, and reagents used for various analytical techniques.
- Learn the process of preparing standard solutions with known concentrations for calibration and accurate measurements.
- Gain proficiency in the titrimetric method and standardize hydrochloric acid (HCl) to determine its exact concentration.
- Develop skills in estimating the acetic acid content of vinegar using a titrimetric method, which is a common application of acid-base titrations.
- Perform titrimetric analysis to estimate the calcium content in milk, contributing to nutritional assessment and quality control.
- Gain hands-on experience in Bessel's titrimetric method to estimate the ascorbic acid content in biological samples and vitamin C tablets, providing insights into vitamin C levels.
- Learn the Molisch test and identification techniques to identify organic compounds based on elements and functional groups, expanding your understanding of their chemical properties.
- Acquire knowledge and skills to determine the saponification number, iodine number, lactose, protein and glucose content.

Contents:

1. Introduction to biosafety and biosecurity.
2. Familiarization of the laboratory apparatus, instruments and the reagents.
3. Preparation of standard solutions.
4. Standardization of HCl by titrimetric method.
5. Estimation of acetic acid content of vinegar by titrimetric method.
6. Estimation of calcium from milk by titrimetric method.
7. Estimation of iron from Mohr’s salt and commercial iron tablets by dichromate method.
8. Estimation of ascorbic acid content of biological samples and vitamin C tablets by Bessel’s titrimetric method.
9. Identification of organic compounds (elements and functional groups including Nitrogen, Sulphur, Halogen, aldehydes, ketones, carboxylic acids, phenols, amines and amides); Molisch test.
10. Determination of saponification number of fat or oil.
11. Determination of iodine number of fat or oil.
12. Determination of lactose content of milk by Benedict’s method.

13. Determination of λ-max and verification of Beer-Lambert law by using Spectrophotometer.
14. Determination of serum protein content by the biuret method.
15. Determination of glucose content of serum by Nelson - Somogyi method.
16. Estimation of copper content of a solution by iodometric method.

Intended Learning Outcome:

After a successful completion of the course, students will be able to:

- Understand the principles of biosafety and biosecurity and apply them in laboratory settings to ensure personal and environmental safety.
- Familiarize students with a wide range of laboratory apparatus, instruments, and reagents and demonstrate the ability to handle them safely and effectively.
- Demonstrate proficiency in preparing standard solutions with known concentrations to calibrate and validate analytical techniques.
- Apply the titrimetric method to standardize hydrochloric acid (HCl) and other solutions, ensuring accurate measurements in subsequent experiments.
- Perform the titrimetric estimation of acetic acid content in vinegar, calcium content in milk, iron content in Mohr's salt and commercial iron tablets, and ascorbic acid content in biological samples and vitamin C tablets.
- Apply identification techniques, such as the Molisch test, to identify organic compounds based on their elements and functional groups.
- Determine the saponification number and iodine number of fats or oils to assess their quality and suitability for various applications.
- Apply Benedict's method to determine the lactose content in milk, contributing to the evaluation of its nutritional composition.
- Utilize spectrophotometry to determine the -max and verify the Beer-Lambert law, enhancing understanding of the relationship between absorbance and concentration.
- Perform the Biuret method to determine serum protein content and the Nelson-Somogyi method to estimate glucose content in serum.
- Additionally, conduct the iodometric method to estimate the copper content in a solution, providing deeper insights in various estimating procedure.

Required Number of Classes:

For laboratory work, students will have to complete 3-4 experiments per credit that consists of theory lecture for each experiment and laboratory work. To complete an experiment, approximately one hour of theory lecture and 4-6 hours of laboratory work are required.

No.	Name of experiments	No of experiments
1.	Introduction to biosafety and biosecurity.	1
2.	Familiarization of the laboratory apparatus, instruments and the reagents.	1
3.	Preparation of standard solutions.	1
4.	Standardization of HCl by titrimetric method.	1
5.	Estimation of acetic acid content of vinegar by titrimetric method.	1
6.	Estimation of calcium from milk by titrimetric method.	1
7.	Estimation of iron from Mohr's salt and commercial iron tablets by dichromate method.	1
8.	Estimation of ascorbic acid content of biological samples and vitamin C tablets by Bessel's titrimetric method.	1
9.	Identification of organic compounds (elements and functional groups including Nitrogen, Sulphur, Halogen, aldehydes, ketones, carboxylic acids, phenols, amines and amides); Molisch test.	2
10.	Determination of saponification number of fat or oil.	1
11.	Determination of iodine number of fat or oil.	1
12.	Determination of lactose content of milk by Benedict's method.	1
13.	Determination of λ-max and verification of Beer-Lambert law by using Spectrophotometer.	1
14.	Determination of serum protein content by the biuret method.	1
15.	Determination of glucose content of serum by Nelson - Somogyi method.	1
16.	Estimation of copper content of a solution by iodometric method.	1
Total experiments		**17**

Recommended Books and Readings:

1. Laboratory manuals and protocol sheets.
2. Essential of Physical Chemistry by Arun Bahal, BS Bahl and GD Tuli.

BMB-107: Viva-voce 2 Credits

Introduction:

This course is designed to assess the overall depth and clarity of knowledge gained in relevant courses during the current academic session. This course will provide a platform for the students to showcase their basic understanding of the overarching goals and approaches of different

courses taught during the academic session.

Objectives:
The objective of the viva-voce exam is to:

- assess the overall knowledge of a student on a particular academic topic.
- enable them the platform to develop their interpersonal communication skills.
- provide a foundation for formal discussion on an academic topic with the current peers (in this case, the examiners of the examination committee).

Contents:
The content of the viva-voce exam includes all the topics taught in the theory and practical courses, throughout the academic year.

Intended Learning Outcome:
By participating in the Viva-voce exam, the students will be able to –

- Develop basic communication skills
- Express their depth and clarity of knowledge on an academic topic.
- Showcase and improve on their scientific discussion skill.

Extra-departmental courses:

BMB-151: Foundation Course in English 2 Credits

Introduction:
The course aims at developing the four basic skills of English i.e. Speaking, Writing, Reading, and Listening with a special emphasis on the development of oral and written communication skills. It focuses on the strategies of speaking including IPA (International Phonetic Alphabet) symbols which will help students to overcome their inhibition and stage fright in speaking and interact with others with accuracy and fluency. The course teaches the students the processes and strategies of writing both for academic and professional purposes. In addition, it covers the strategies of reading and helps students to read and interpret variety of texts critically. Besides, the course reviews basic English grammar and makes students aware of its proper use in context. Thus, the course helps students to become independent and confident users of English through building a strong foundation of English in them.

Objectives:
The objectives of the course are:

- To introduce the students to the basic English language skills

- To help students speak English with accuracy and fluency in various contexts
- To help students understand the processes and organization of writing of different genres for academic and professional purposes
- To enhance students' academic reading skills and develop them as effective readers of English
- To develop students' confidence in using four skills of English both in and outside the classroom

Contents:

1. **Speaking:** This segment is aimed at improving students' speaking ability so that they can communicate freely in a good range of situations. This course will also help students reduce their shyness, nervousness and inhibition in speaking. This segment will include, but will not be limited to, the following functions/items:

- Introducing yourself and others.
- Expressing likes and dislikes, personal experiences, past habits, requests and offers, apologies and excuses, inviting, comparison and contrast.
- Describing people/place/things, narrating action and events, saying numbers and time.
- Giving and following instructions, asking for and giving direction.
- Reporting, complaining, suggesting.
- Role-plays in various authentic situations.
- Participating in debates, making extempore speech.
- Seminar presentations and interviews.
- Phonetics (IPA symbols; using a dictionary for pronunciation; phonetic transcriptions; intonation and stress).

2. Reading: This segment is mainly designed to provide the students an opportunity for reading, and understanding variety of texts and improving their communication skills and analytical capability, especially through effective reading. Reading should also involve activities and discussions that finally lead to effective writing.

- Strategies of reading: Predicting, skimming, scanning, inferencing, and analyzing selected texts.
- Variety of texts reflecting common interests.
- Special texts related to students' major courses.

3. Writing: Students will learn the principles of and practice effective writing of different lengths. They should be able to write well-organized paragraphs and essays along with other types. They are expected to gain an understanding of the underlying principles of effective writing styles, to gain an understanding of the importance of the organization techniques of writing adapting to a variety of audiences and occasions and to demonstrate an ability to prepare and deliver effective written responses.

Item/Activities:

- Teaching the writing process - brainstorming, outlining, drafting and editing/proofreading. Paragraph development - paragraph structure, transitional devices/connectives.
- Paragraph types - descriptive, narrative, process analysis, cause and effect, argumentative etc.
- Essay writing - essay structure, thesis statement, introduction and conclusion, and different essay types.
- Writing formal letters.
- Report writing - academic reports, newspaper reports, lab reports etc. Miscellaneous - combining sentences, summary/paraphrase writing.

4. Listening: This segment will introduce students to diverse speakers and types of English. Listening comprehensions focusing on varying elements of vocabulary and structures will be practiced. Students will be taught how to be an active listener to obtain information and understand the key ideas. Class practice will include listening to tapes suitable for students' needs.

5. Grammar: Grammar teaching will involve remedial work. Much of the language will be contextualized and will encourage students to study meaning as well as form. The grammar exercises and editing works will help students overcome all sorts of grammatical problems.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Use IPA symbols and speak English accurately and fluently in various contexts
- Interact with others and give speeches in English without nervousness and fear
- Plan, organize and write paragraphs and long essays in English with accuracy
- Write for both academic and professional purposes with purpose and clarity
- Use various reading strategies to understand and interpret English texts critically
- Improve their listening skills in English and understand key ideas in English conversations and lectures
- Develop as confident and independent users of English

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Speaking skills	7
02.	Reading skills	5
03.	Writing skills	8
04.	Listening skills	5
05.	Grammar	5
Total Classes		**30**

Recommended Books and Readings:

1. Intermediate English Grammar by Raymond Murphy.
2. From Paragraph to Essay by Imhoof M. & Herman H.
3. Practicing Faster Reading by Mosback G & Mosback V.
4. Writing a College Handbook by Hefferman AWJ.
5. Effective Reading by Simon G.& Swan M.
6. English Phonetics and Phonology by Peter Roach.
7. Ship Or Sheep? by Ann Baker.

BMB-152: Basic Microbiology 2 Credits

Introduction:

Microbiology deals with the study of small living microorganisms for instance bacteria, virus, fungus, protozoa and algae that are too small to see with the naked eye. Studying of these microbes are very crucial because they are not only responsible for causing various diseases of humans and animals but also play an important role in ecological equilibrium, climate change, nutrient cycling, large scale production of food and beverage, biofuels, and drugs. Therefore, the course Basic Microbiology (BMB-152) has been designed for 1st year undergraduate students of Biochemistry and Molecular Biology (Major) to provide preliminary ideas of the above microorganisms including their invention, culture, structure, life cycle, disease pathogenesis and treatment. Finally, this course connects both theoretical knowledge and hands on experience to enable students for culturing, visualization/identification of microbes using microscope and designing new projects for solving problems in field of Microbiology.

Objectives:

This course intents to let the students to:

- Know briefly the discovery of technological advancement and scientific contribution in the field of Microbiology.

Contents:

Theory: 40 Marks

1. **Overview of History of Microbiology:** Definition and scope of microbiology, naming and classifying microorganisms (Bacteria, Fungus, Protozoa, Algae and Virus) – binomial nomenclature, five kindom concept and eight kindom concept, general characteristics and functions of microbes; history of microbiology; theories of spontaneous generation; contributions of scientists in microbiology - Robert Hooke, Antonie van Leeuwenhoek, Francisco Redi, Lazzaro Spallanzani, John Needham, Louis Pasteur, John Tyndall, Joseph Lister, Alexander Fleming, Edward Jenner; the germ theory of diseases - Koch's postulates, applications of microbiology and the future.

2. **Microscopes**: Microscopy and different types of microscopes - light microscope, phase contrast microscope, fluorescence microscope, electron microscope.

3. **Stains and staining techniques:** Definition of different types of stain and classification of stains; Gram staining; acid fast staining; negative staining; staining capsule, flagella and endospore.

4. **Bacteria**: Bacterial cell structure, classification of bacteria, nutritional requirement of bacteria; classification based on requirements of nutrients, oxygen, temperature, pH; growth media types and composition; inoculation and bacterial growth in nutrient broth and agar media; bacterial growth curve; F^+, F' and Hfr; factors affecting bacterial growth; isolation of bacteria from natural sources, preparing pure culture; enumeration of bacteria and maintenance of pure culture.

5. **Viruses (basic concepts):** Importance of viruses; chemical and physical characteristics of viruses; classification of viruses; virus cultivation and enumeration through plaque assay; structure of viruses – capsid symmetry, enveloped and non-enveloped viruses; lytic and cycle and lysogeny; concepts of viroids; cytopathic effect and host cell transformation by viruses; importance of bacterial virus e.g., λ-phage, T-phages; plant viruses e.g., TMV and animal viruses e.g., HBV, HSV, HIV, polio virus.

6. **Parasitology (brief understanding)**: Characteristics of protozoa, structure, life cycle, epidemiology, pathogenesis, diagnosis and treatment involving *Plasmodium sp*, *Trypanosoma sp*, *Leishmania sp*.

Practical: 10 Marks

1. Learning safety rules and uses of equipments in common microbiology laboratory.
2. Learning the techniques of sterilization.
3. Practical uses of microscope.
4. Preparation of bacterial culture media (agar/ broth).

5. Isolation of bacteria by: streak / spread/ pour plate methods from water, food and others natural samples.
6. Identification of bacteria through biochemical tests – (i) acid production (ii) starch hydrolysis (iii) indole production.
7. Gram staining of gram-positive and gram-negative bacteria
8. Test for phenol sensitivity

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Attain basic knowledge on microbes specially bacteria, fungus, virus, algae and protozoan.
- Acquire detail knowledge regarding important contribution of renowned scientists in the development of different concepts/hypothesis and their proofs in the field of microbiology.
- Illustrate the basic concepts of microscope, their types and application in various fields.
- Identify/visualize the component of bacteria using different stains and staining techniques.
- Demonstrate the mechanism of staining, advantages and disadvantages of various staining techniques.
- Explain the characteristics of bacteria, fungus, virus, algae, and protozoan including their classification.
- Discuss on nutritional requirements for the growth of microbes, and reproduction of bacteria, fungi.
- Explain briefly about the benefits of microbes and also, about their disease causing effects in human and in plants.
- Discuss epidemiology, pathogenesis, diagnosis and treatment of some protozoan diseases involving *Toxoplasma sp. Plasmodium sp, Trypanosoma sp.* and *Leishmania sp*.
- Delineate theoretical and practical knowledge on preparation of different culture media, maintenance and preservation.
- Explain how to set and perform microbiology related experiments both for routine works and/or research activities along with safety precautions where applicable.
- Demonstrate their engagement in the field of microbiology by sub-culturing microbes, identifying bacteria, performing biochemical analyses.
- Communicate their laboratory-based knowledge both verbally and in writing.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Overview of History of Microbiology	3
02.	Microscopes	4
03.	Stains and staining techniques	5
04.	Bacteria	5
05.	Viruses (basic concepts):	5

06.	Parasitology (brief understanding):	5
07	Laboratory Work	4
Total Classes		**30**

Recommended Books and Readings:

1. Microbiology by Chan ECS, Pelczar MJ. Jr., Krieg NR.
2. Prescott's Microbiology by Joanne Willey, Linda Sherwood, Chris Woolverton.
3. Fundamentals of Microbiology. IE Aleamo. Addison-Wesley Publishing Company

BMB-153: Basic Biology and Biodiversity 2 Credits

Introduction:

The course is designed to generate interest on different aspects of biology, biodiversity and evolutionary process. This course encompasses the basic concepts of various biological systems including plants and animals with special emphasis on evolutionary process that drives the biodiversity of all living systems on earth. Furthermore, general concepts of pathological conditions that are associated with plant and animal diseases will also be covered. Through a series of combined lecture/discussion and practical classes, this course will help the students to understand how evolutionary processes accelerates biological diversity of the living systems (plants and animals) and the impact of plant and animal diseases on economy and ecology systems. Lastly students will gain knowledge about the danger of bio-extinction and endangered species along with the concept of bio-preservation as an intervention strategy to cope with bio-extinction.

Objective:

- The course is designed with the aim to enable students to conceptualize the basic concepts of biological systems including various plants and animals.
- Students will be familiarized with various diseases that commonly affect plants and animals and the impact of these diseases on economy and ecology. In addition students will gain an understanding of various intervention strategies for these diseases.
- Students should be given an overview of the concepts of biodiversity and evolution. Moreover students will be introduced to the basics of ecosystems and habitats and their importance on biodiversity.
- Students will learn the danger of bio-extinction and endangered species along with the concept of bio-preservation as an intervention strategy to cope with bio-extinction.

Contents:

Theory: 40 Marks

1. **Plants and animals**: Economic importance, ecological and future importance.

2. **Plant pathology**: Definition of diseases in plants, plant diseases, their causes, diagnosis and control. Major pests - concept, modes of damage. Control of insects and pests in prevention and control of diseases, integrated pest management (IPM), biochemical defenses in plants.

3. **Animal pathology**: Feed, diseases, maintenance and health.

4. **Evolution and biodiversity**: Evolution -tree of life (TOL), scientific basis of TOL, explanation of TOL, genetic basis of TOL, story of the first cell and the energy source, evolution of eukaryotic cells,RNA world hypothesis. Biodiversity - concept, types, values and conservation in plants and animals. Ecosystem and habitats in plants - ecological features of hydrophytes, xerophytes and halophytes (mangroves). Ecosystem and habitats in animals - adaptations in arctic, temperate and tropical zones.

Practical: 10 Marks

1. **Plant pathology**:Major world-wide fungal diseases and examination of prepared slides.
2. **Plant breeding technologies**:Stomatal size and density as a function of different plants - simple sections and microscopic observations
3. **Animal physiology**:Collection of animal blood; **s**imple dissections of mice and collection of muscle tissues, brain, heart and liver; slide observations.

Intended Learning Outcome:

- Students should be able to outline the general features of biological systems including animals and plants.
- Students should be able to identify pathological conditions associated with various plant and animal diseases.
- Students should be able to identify the impact of plant/animal diseases on economy and ecology.
- Students should be able to propose intervention strategies for various plant/animal diseases.
- Students should be able to summarize the concept of evolution and link evolution as underlying mechanism for biodiversity.
- Students should be able to illustrate why different ecosystems such as arctic, temperate and tropical zones are important to sustain biodiversity.

- Students should be identify the causes of bio-extinction and endangered species and propose intervention strategy to stop the extinction of endangered animals and plants.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Plants and animals	6
02.	Plant pathology	9
03.	Animal pathology	5
04.	Evolution and biodiversity	10
	Total classes	30

Recommended Books and Readings:

1. Plant Pathology by Agrios GN.
2. Bangshagatibidhya by Akhtaruzzaman M.
3. Introduction to Plant Breeding by Chaudhary RC.
4. Vascular Plant Taxonomy by Dirk RW, David JK and Zack EM.
5. Plant Anatomy by Esau K.
6. Environment and Plant Ecology by Etherington.
7. BangshagatiBidyarMulkatha by Islam AS.
8. Parasitology by Chatterjee KD.
9. Biodiversity and Conservation by Jeffries MJ.
10. Modern Textbook of Zoology: Invertebrates by Kotpal RL.
11. Protozoology by Kudo.
12. A Textbook of Vertebrate Zoology by Prasad SN and Kashypap V.
13. Foundations of Parasitology by Schmidt GD and Roberts LS.
14. General Zoology by Storer TI, Usinger, RL, Stebbins RC and Nybakken JW

BMB-154: Introduction to Applied Biology 3 Credits

Introduction:

This course deals with the impact of the knowledge of Biochemistry and Molecular Biology in broad areas of Agriculture, Health and Disease, Industry and the Environment.

Objectives:

This course was designed to provide broad theoretical knowledge of biochemistry and its applications.

- It will provide understanding the pathology of diseases such as communicable and non-communicable diseases and possible approaches for the development of innovative drugs and vaccines against the infections.
- The agriculture and environment part of the course will provide an overview of the impact of green revolution, climate change as well as urbanization on agriculture and the need to improve crops, crop management and make the best use of resources, without altering the ecological balance and at the same time sustain crop productivity. The topics include recycling of resources by waste management, mitigation of CO_2 build-up by use of biofuels in minimal lands as well as management of nutrient cycles by reducing anthropogenic activities.
- It will also give an understanding about white biotechnology that focuses on the technical acquisition of tailor-made products from microbial and cellular sources and their industrial applications.

Contents:

Theory: 60 Marks

1. **Health and Diseases:** Human diseases, infectious and non-infectious**;** etiology of disease, strategies and technologies for pathogen detection. Understanding disease prevention: immunity, vaccination, nutrition and role of gut microbiomes. Molecular basis of disease (basic aspect): diabetes, cholera, Parkinson disease.
2. **Agriculture:** Impact of urbanization and natural calamities on agriculture**;** green revolution vs. sustainable agriculture; minimizing the impact on the natural environment. Sustainable agricultural practices such as conservation agriculture and ecological intensification. Soil health and Rhizosphere. Role of endophytes in plant resilience. Soil health: conservation agriculture, ecological intensification, fertilizer and PGPRs. Food chains, food web and pyramids of biomass and energy and their effect on human preferences. Biotechnology in animal improvement.
3. **Food Security:** Population growth and the food crisis; basic plant physiology; adaptation to the environment in plants; evolutionary principles in crop plants and their applications; seed banks, gene banks and databases; designing the crops for the future; marker-assisted plant breeding, genetically modified plants and gene-edited plants. Biosafety oversights and compliance.
4. **Energy for a sustainable world**: Renewable energy, biofuels, waste management, reduction green-house gases.
5. **Industrial Biotechnology and Therapeutics:** Application of microbes and enzymes in food, textile and tannery industries. Sources, uses of drugs**;** search for new drugs; lead compound, major steps in drug development**,** development of new vaccines. Artificial blood development, re-engineering of artificial blood.

6. **Ecology and Environment:** Effect of anthropometry on geochemical cycles; environmental and industrial pollution - air, water, thermal, sound; biochemical and molecular approach to control environmental pollution, bioremediation. Genetic rearrangement of microbes to clean up environment.

Practical: 15 Marks

1. Assignment/Field Visit

Intended Learning Outcome:

On successful completion of the course students will be able to:

- Get fundamental knowledge in Biochemistry and Biotechnology to enable them to understand its applications.
- Gain a solid background in core areas of Biochemistry including health and diseases, agriculture, drugs, ecology and environment etc.
- Learn why resilient crops, resistant to both biological and environmental stresses are needed, particularly in view of climate change. They will also get an idea about how such crops can be produced using principles of Biochemistry and Molecular Biology. How the best nutrients can be ensured for crops, how they can be protected and re-cycled without causing imbalance in the environment.
- Get an idea about the principles of the production of superior and disease-free animals, and ensuring the best kind of feed for them and for human consumption.
- Get basic ideas on environment, and nutrient cycles, their re-cycling and the effect of human intervention, such as pollution and ways to mitigate these effects. They will learn about renewable energy such as biofuels, waste management and bioremediation.
- Understand medicinal biochemistry and drug development.
- Understand social issues involved with current biotechnological and molecular biology applications.
- Apply their knowledge to the area of 'White Biotechnology' to improve our overall quality of life.

Required Number of Classes

No	**Title of the unit**	**Number of classes**
01.	Health and Diseases	6
02.	Agriculture	6
03.	Food Security	5
04.	Energy for a sustainable world	5
05.	Industrial Biotechnology and Therapeutics	7
06.	Ecology and Environment	7
	Total Classes	**36**

Recommended Books and Readings:

1. Applied Biochemistry and Bioengineering by Lemuel Wingard.
2. Biology by Peter Raven, George Johnson, Kenneth Mason, Jonathan Losos, Susan Singer.
3. Environmental Biology by Allan M. Jones.
4. Biotechnology for Green Energy: Biofuels (Pocket K No. 24).
5. Evolution in Health and Disease by Stephen C. Stearns.
6. Industrial Biotechnology by Varun Shastri.
7. Drugs-From Discovery to Approval 1st Edition by Rick Ng.
8. Adaptation to climate change in agriculture in Bangladesh: The role of formal institutions by Md Torikul Islam, Melissa Nursey-Bray.
9. Nothing left to waste: The prospects for faecal sludge-based organic fertiliser in Bangladesh by Digbijoy Dey, AT M Ridwanul Haque, Babar Kabir, Elisabeth Kvarnström, Peter McIntyre, Sharmin Farhat Ubaid.

****

2nd Year BS (Honors)

Total Credits in 2nd Year BS (Honors): 32 Credits

Course No.	Name of the course	Credits
Departmental courses:		
BMB-201	Enzymes	4
BMB-202	Carbohydrate Metabolism	4
BMB-203	Biological Membrane and Lipid Metabolism	3
BMB-204	Endocrinology	3
BMB-205	Molecular Biology-II	4
BMB-206	Laboratory Work	4
BMB-207	Viva-voce	2
Extra-departmental courses:		
BMB-251	Human Physiology	4
BMB-252	Computer Basics and Data Analysis	4
	Total	**32**

BMB-201: Enzymes 4 Credits

Introduction:

Enzymes are protein molecules that function by triggering chemical reactions in cells throughout the body. Each of these molecules has its own characteristic shape and affects only certain types of materials. Enzymes are highly selective catalysts, meaning that each enzyme only speeds up a specific reaction. Without the effects of enzymes, the body would be unable to transform its internal chemicals fast enough to sustain life. Some enzymes help break large molecules into smaller pieces that are more easily absorbed by the body. Other enzymes help bind two molecules together to produce a new molecule.

Objectives:

The aim of the module is to provide students with a detailed understanding of enzyme structure, synthesis, function, and use, with a particular focus on metabolic enzymes. The course will cover a wide range of subjects such as vitamins and coenzyme, classification of enzyme, mechanism and kinetics of the enzyme-catalyzed reaction. The final part will deal with the production, extraction, purification, characterization, and application of enzymes.

The objectives of this course are to:

- Introduce students to various theoretical and practical aspects of enzymology.
- Stimulates their interest in learning the structure, function and kinetics of enzyme and their role as catalyst and regulator of cell metabolism.
- Serve as a foundation for more advanced courses.

Contents:

1. **Enzymes:** Basics concepts – characteristics, classification, catalytic properties, lowering of activation energy, prosthetic group, coenzyme, cofactor, concept of specificity of enzyme, identification of residues at active sites and effect of substrate concentration, temperature and pH on enzyme activity; activity unit, specific activity, turnover number. Different methods for enzyme assay.

2. **Enzyme kinetics:** Michaelis-Menten equation, K_m and V_{max} determination and their significance; enzyme inhibition – reversible and irreversible, determination of nature of enzyme inhibition, using Line weaver Burk curve and citing examples, use of specific enzyme inhibitors as drugs.

3. **Coenzymes*:*** Roles of coenzymes in enzyme catalyzed reactions with reference to the following coenzymes: NADH, FADH, CoA, TPP, pyridoxal phosphate, biotin and tetra hydrofolate.

4. **Enzyme regulation:** Specific examples be cited in each category of regulation, Importance of enzyme regulation, covalent modification for enzyme regulation; *de novo* synthesis and enzyme breakdown as regulatory means, allosteric regulation showing concept of cooperativity; Hill equation, models of cooperation, isoenzymes, their distribution, regulatory role in metabolic flux, if any; zymogen, and their significance in metabolism, substrate cycles.

5. **Enzyme catalytic mechanisms:** To understand that enzymes bind substrates at the active site, stabilize transition state and provide functional groups that make and break bonds required - specific examples: (i) Ribonuclease, (ii) Carbonic anhydrase.
(iii) Chymotrypsin. (iv) Lysozyme (v) Carboxypeptidase

6. **Novel enzymes*:*** Characteristics and their utility, examples like Ribozymes, abzymes.
Novel enzymes for the degradation of cellulose.

7 **Membrane bound enzymes*:*** Characteristic properties biological importance, representative examples with their functional aspects including ATPases and retinol dehydrogenases.

8. **Enzymes in industries:** Brief idea about present use and future prospect. Enzymes in biofuel production.

9. **Enzymes in cell signaling:** Classification of signal transducing receptors with special reference to the following:
(i) Receptor tyrosine kinases
(ii) Receptor serine / threonine kinases (RSKS).

Intended Learning Outcome:

- Explain the essential principles of enzyme reaction mechanisms.
- Demonstrate mechanisms of action of several major enzyme classes to illustrate key catalytic strategies.
- Explain the key structural and energetic factors which give rise to increased enzyme stability, and the contribution of kinetic and physical experiments to the understanding of these properties.
- Outline specific interactions between enzymes and substrates are determined by protein structure and how preferential binding of the transition state by enzymes leads to catalysis.
- Describe the basic biochemical techniques for enzyme characterization.
- Identify factors affecting enzyme activity and reactions.
- Explain the essential principles of enzyme kinetics and mechanisms.
- Explain the quantitative determination and significance of enzyme steady-state kinetic

parameters.

- Formulate the basic assays to interpret and analyze enzymatic data.
- Explain how does one can calculate K_M and V_{max} from a graph.
- Explain how can one identify a competitive inhibitor and a noncompetitive inhibitor
- Describe kinetic parameters that explain allosteric regulation.
- Explain the importance of coenzymes in different types of biological
- reactions.
- Identify the structure-function relationship of different enzyme-cofactors and can explain their mode of action.
- Explain how proteases facilitate a fundamentally difficult reaction.
- Describe how carbonic anhydrases make a fast reaction even faster.
- Illustrate how aspartate transcarbamoylase is allosterically inhibited by the end product of its pathway.
- Explain how isozymes provide a means of regulation specific to distinct tissues and developmental stages.
- Evaluate how covalent modification is used as a means of regulating enzyme activity.
- Explain the mechanisms of catalysis.
- Collect the information to design experiments required for carrying research related to enzymology.
- Describe the mechanism to determine the essential amino acid residues of an enzyme.
- Predict the functions of different proteins located in biological membrane knowing it's different domains.
- Discuss the clinical applications of enzymes.
- Summarize current processes involved in industrial enzyme production, from protein production to purification and formulation.
- Describe methods for selection and optimization of industrial enzymes using genetic and biochemical techniques.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Enzymes	7
02.	Enzyme kinetics	7
03.	Coenzymes	6
04.	Enzyme regulation	8
05.	Enzyme catalytic mechanisms	8
06.	Novel enzymes	4
07.	Membrane bound enzymes	6
08.	Enzymes in industries	7
09.	Enzymes in cell signaling	7
Total classes		**60**

Recommended Books and Readings:

1. Principles of Biochemistry by Nelson, D. L. and Cox, M.M. Lehninger, (2017)
2. Textbook of Biochemistry by Donald Voet, Judith G. Voet. (2012)
3. Biochemistry by Lubert Stryer, John L. Tymoczko, Jeremy Mark Berg. (2012)
4. Enzymes. M Dixon and EC Webb. Associated Press. (1979)

BMB-202: Carbohydrate Metabolism 4 Credits

Introduction:

The course describes the thermodynamics of energy metabolism. This course also integrates an introduction to the glucose metabolism that includes glycolysis, citric acid cycle and electron transport chain as well as their regulation along with major metabolic pathways and their interconnection into tightly regulated networks. Topics addressing glycogen metabolism will include glycogenesis and glycogenolysis with their reciprocal regulation. An exploration of gluconeogenic pathways will discuss about the complex mechanism of biosynthesis of glucose from non-carbohydrate sources along with the biosynthesis of di- and oligo-saccharides, biosynthesis of glycoproteins, proteoglycans, and interconversion of saccharides. Students will briefly discuss about the disorders of carbohydrate metabolism.

Objectives:

This course was designed to:

- provide knowledge on the steps of ATP synthesis by glycolysis
- deliver information about the process of fermentation to glycolysis
- distribute facts how glycolytic intermediates impact oxygen binding, and protect red blood cells against reactive oxygen species
- convey knowledge on the production of reduced electron carrier during the citric acid cycle
- identify each step of the production of ATP by oxidative phosphorylation
- understand how the number of ATP molecules produced with the point of entry of electrons in the electron transport chai
- compare the yield of ATP synthesis by substrate level phosphorylation and oxidative phosphorylation
- explain the role of allosteric enzymes as valves controlling the flux of intermediates in a pathway
- determine how transient covalent modification affects enzymes controlling key steps in metabolic pathways
- explain the hormonal regulation of metabolic pathways
- predict how changes in blood glucose level affect the biochemical and hormonal regulations of metabolic pathways including glycolysis, gluconeogenesis, glycogen synthesis and, glycogen degradation
- explain glycogenesis, glycogenolysis, gluconeogenesis, di and tri-carbohydrate biosynthesis

- provide information on disorders related to carbohydrate metabolism

Contents:

1. **Bioenergetics:** Bioenergetics and thermodynamic principle, high energy compounds, ATP cycle, ATP in metabolism
2. **General aspects of metabolism:** Characteristics, study of metabolic intermediates to determine metabolic pathway
3. **Carbohydrate metabolism:** Digestion and absorption of carbohydrates, availability of glucose to cells, receptor mediated glucose entry and involvement of hormone in entry process, types of GLUTs.
4. **Glycolysis and pentose phosphate pathway:** The pathway showing individual steps, aerobic and anaerobic aspects, energetics, regulation of glycolysis, anaerobic glycolysis and its physiological importance, glucose metabolism in premature babies, feeder pathways – entry of other mono- and di-saccharides in glycolytic pathway. Pentose phosphate pathway.
5. **TCA cycle:** Overview of tricarboxylic acid cycle, the cyclic pathway and its regulation, energetics of the total oxidation of glucose, anapleorotic pathways, amphibolic nature of TCA cycle, futile cycle. The glyoxylate cycle.
6. **Electron transport and oxidative phosphorylation:** Shuttles across mitochondrial membrane, mitochondrial structure and compartmentalization of respiratory metabolism, the evolution of electron transport chain, oxido-reduction and electron transport; oxidative phosphorylation, inhibitors and uncouplers of oxidative phosphorylation, disorders due to deficiencies of mitochondrial enzymes/proteins.
7. **Glycogen metabolism:** Biosynthesis and coordinated regulation of glycogen synthesis and breakdown, role of insulin and glucagon in glycogen metabolism.
8. **Biosynthesis of carbohydrates:** Gluconeogenesis and its regulation, biosynthesis of di- and oligo-saccharides, biosynthesis of glycoproteins, proteoglycans, interconversion of saccharides (sugars); glucuronic acid pathway; pathway for ascorbic acid biosynthesis.
9. **Carbohydrate metabolism disorders:** glycogen storage diseases; galactosemia; fructose intolerance; lactose intolerance, pyruvate metabolism disorders, hypoglycemia; hyperglycemia and diabetes (brief outline).

Intended Learning Outcome:

After successful completion of the course students are expected to be able to:

- Explain about bioenergetics, how bioenergetics is related with thermodynamics, Gibbs free energy, changes in free energy and standard free energy change.
- Know about ATP and other high energy compounds, how ATP provides energy, role of ATP in metabolism, ATP cycle.
- Discuss about the basic aspects of metabolism, features of metabolic pathways, interrelationship of different metabolic pathways.
- Describe the different approaches to study metabolism.
- Show the overview of metabolic pathways in selected tissues.
- Elucidate about different glucose transporters, their tissue distribution, mode of action.
- Describe the reactions involved in glycolytic pathway, regulations of glycolytic pathway, feeder pathway of glycolysis.
- Explicate how 2,3 BPG is formed and its role in fetal development, about the glycolysis in tumor cells.
- Illustrate the reactions (with mechanism) involved in pentose phosphate pathway, importance of this pathway in metabolism.
- Explain TCA cycle with its regulation, energetics of the total oxidation of glucose, anapleorotic pathways, amphibolic nature of TCA cycle, and futile cycle.
- Discuss Glyoxylate cycle and its importance.
- Describe shuttle systems in mitochondrial membrane mitochondrial structure and compartmentalization of respiratory metabolism.
- Explain evolution of electron transport chain, electron transport proteins, chemiosmotic hypothesis.
- Describe structure of FoF1 ATPase and its role in ATP synthesis.
- Explore differentiation between inhibitors and uncouplers of oxidative phosphorylation.
- Comprehend the disorders due to deficiencies of mitochondrial enzymes/proteins.
- Demonstrate glycogen synthesis, role of glycogenin in glycogen synthesis, and regulation of glycogen synthesis.
- Discuss dietary and endogenous glycogen breakdown and the reglgulation of glycogen breakdown.
- Describe gluconeogenesis and its regulation.
- Elucidate biosynthesis of di- and oligo-saccharides, biosynthesis of glycoproteins, proteoglycans, interconversion of saccharides (sugars). glucuronic acid pathway; pathway for ascorbic acid biosynthesis.
- Explain glycogen storage diseases. galactosemia; fructose intolerance; lactose intolerance, pyruvate metabolism disorders.
- Demonstrate a basic idea about blood sugar level, hypo and hyperglycemia and diabetes.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Bioenergetics	5
02.	General aspects of metabolism	5
03.	Carbohydrate metabolism	10
04.	Glycolysis and Pentose phosphate pathway	7
05.	TCA cycle	8
06.	Electron transport and oxidative phosphorylation	8
07.	Glycogen metabolism	7
08.	Biosynthesis of carbohydrates	5
09.	Carbohydrate metabolism disorders	5
Total classes		**60**

Recommended Books and Readings:

1. Principles of Biochemistry by Nelson, D. L. and Cox, M.M. Lehninger, (2017)
2. Textbook of Biochemistry by Donald Voet, Judith G. Voet. (2011)
3. Biochemistry by Lubert Stryer, John L. Tymoczko, Jeremy Mark Berg. (2012)

BMB-203: Biological Membrane and Lipid Metabolism 3 Credits

Introduction:

This course will cover basic concepts and technologies in membrane and lipid metabolism in human. The technical approaches and experimental strategies used in studies that have contributed significantly to advancing the basic understanding of important aspects of membrane biochemistry and membrane biology will be emphasized. The goal of the course is to provide the student with an understanding of the role of lipid metabolism in normal and dysfunctional growth and metabolism.

Objectives:

- The objective of the course is to provide an understanding of
- The molecular and cellular features of biological membranes and functions,
- Lipid metabolism and their biological significance,
- Diseases associated with lipid metabolism.
- Structure and Membrane transport, digestion, absorption, mobilization, and transport of fatty acids.
- Utilization and storage of energy in lipid form, lipoprotein metabolism, metabolic pathways of fatty acids and regulations,

- Pathways of metabolism of special Lipids such as phospholipids, cholesterol, sphingolipids, prostaglandins, thromboxanes.
- Clinical correlations**:** obesity, respiratory distress syndrome, atherosclerosis, lipid storage dieses and many more.

Contents:

1. **Biological membranes:** Membrane **s**tructure - chemical composition of membranes, micelles, lipid bilayers and liposomes, structure of biological membranes. Movement of molecules through membranes, ion channels and carriers, the membrane potential, K^+, Na^+ and Ca^{++} channels and their biological functions, aquaporins, uniporters, symporters and antiporters, specific transporters - the Na^+ transporter, the Ca^{++}-ATPase and the F_1F_O-ATPase.

2. **Lipid metabolism:** Brief overview of lipid metabolism, digestion; absorption; transportation of lipids; plasma lipoproteins - compositions and metabolism, fatty acid oxidation, ketone body formation and utilization, fatty acid biosynthesis, regulation of fatty acid metabolism, storage of fatty acids as triglycerides, utilization of fatty acids for energy production, metabolism and functional role of polyunsaturated fatty acids, cholesterol metabolism, arachidonate metabolism, prostagladins, prostacycline, thromboxane and leukotrienes, phospholipid metabolism, sphingolipid metabolism, bile acid metabolism.

3. **Disorders of lipid metabolism:** Stress, fatty acids and myocardial infarction, genetic deficiencies in carnitine or carnitine palmitoyl transferase, sudden infant death syndrome (SIDS), Refsum's disease, respiratory distress syndrome, sphingolipidoses, Gaucher's disease, diseases associated with lipoproteins and cholesterol metabolism.

Intended Learning Outcome:

After completion of the course students are expected to be able to:

- Identify chemical composition and structure of biological membranes.
- Describe how lipids are distributed in cell membrane and explain their functions.
- Describe how carbohydrates are distributed in cell membrane and explain their functions.
- Describe how proteins are distributed in cell membrane and explain their functions.
- Identify and explain the interactions between lipids, proteins and carbohydrate in biological membrane and roles.
- Identify and interpret common features underlie of biological membranes
- Explain and interpret micelles, lipid bilayers, liposome, and their significance.
- Identify abnormalities of cell membrane fluidity in disease.

- Membrane transport processes – simple diffusion, facilitated diffusion, osmosis, active transport, exocytosis, endocytosis, phagocytosis, pinocytosis, and filtration:
- Outline and explain the mechanisms of Na^+ pump, Ca^{2+} translocation by active transportation and proton pump.
- Describe the process of digestion and absorption of fatty acids, cholesterol and triglycerides, as well as the medical ramification of lipid malabsorption, in particular, with respect to vitamins and apolipoproteins.
- Explain and interpret how lipids are involved in generation and storage of energy. This involves liberation of fatty acids, activation, transfer and oxidation.
- Explain and interpret regulation of fatty acid metabolism
- Outline and explain the overall scheme of cholesterol synthesis via isoprene units.
- Explain and interpret regulation of cholesterol metabolism.
- Explain excretion of cholesterol as bile acids.
- Illustrate and explain synthesis, storage and mobilization triacylglycerol.
- Illustrate and explain synthesis of phospholipids and remodeling of phospholipids.
- Illustrate and explain synthesis and degradation of sphingolipids.
- Identify and explain sphingolipid storage disease of human.
- Describe some abnormalities in lipid metabolism.
- Outline and explain biosynthesis of eicosanoids (prostaglandins, thromboxanes, leukotrienes and lipoxins and identify their functions.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Biological membranes	15
02.	Lipid metabolism	15
03.	Disorders of lipid metabolism	15
Total classes		45

Recommended Books and Readings:

1. Text Book of Biochemistry with clinical correlation by Thomas M Devlin. (2010)
2. Principles of Biochemistry by Nelson, D. L. and Cox, M.M. Lehninger, (2017)
3. Textbook of Biochemistry by Donald Voet, Judith G. Voet. (2011)
4. Biochemistry by Lubert Stryer, John L. Tymoczko, Jeremy Mark Berg, (2012)
5. Fundaments of Biochemistry (Life at the molecular level) by Donald Voet, Judith G. Voet & Charlotte W. Pratt. (1997)
6. Biochemistry (Lippincott Illustrated Reviews) by Richard A. Harvey, Denise R.

Ferrier. (2011)

BMB-204: Endocrinology 3 Credits

Introduction:

This course aims to provide a broad overview of mammalian endocrine systems with special emphasis on human. The course is designed with the aim to generate appreciation for the elegant concepts of regulatory and functional features of hormones in respective target organs. The course is subdivided in five segments covering all the major endocrine systems including pituitary, hypothalamic, thyroid, adrenal cortex, pancreatic and gastrointestinal hormones. The segments dedicated to different endocrine systems will cover the structure, biosynthesis, regulation, transport and mode of actions of the above mentioned hormones. In addition the students will gain an understanding of various endocrine disorders; in particular they should be able to interpret the clinical symptoms and diagnostic measurements to understand the pathophysiology of various endocrine disorders. The last segments deals with the cutting edge diagnostic techniques to measure hormones levels in order to give the students a broad overview of the current techniques and importantly to make them understand the application of the techniques by comparing their strengths and weaknesses.

Objectives:

- The course is designed with the aim to enable students to conceptualize the intricate concepts of regulatory and functional features of hormones in respective target organs.
- In addition, the students will gain an understanding of various endocrine disorders.
- Students should be given an overview of Pituitary, hypothalamic hormones, thyroid and parathyroid hormones including structure, synthesis, physiological and biochemical actions.
- Students should be given an overview of the Hormones of the adrenal cortex, adrenal medulla, gonads and pancreas including structure, synthesis, physiological and biochemical actions.
- Students will be introduced to the concept of different Gastrointestinal hormones and their production site and functionality.
- This segment deals with the cutting-edge diagnostic techniques to measure hormones levels Students will be introduced to the concept of different assays that are routinely used to determine the hormone levels in clinical practice including enzyme immunoassay (EIA), enzyme multiplied immunoassay (EMIT), enzyme-linked immunosorbent assay (ELISA), fluorescence immunoassay (FIA).

Contents:

1. **Characteristics of the hormone system:** Introduction, overview of the endocrine system, chemical nature of hormones, classification and functions of hormones, endocrine glands, target-gland concept, negative and positive feedback, hormone receptors and its classifications, hormone-mediated intracellular signaling and intracellular messengers.

2. **Pituitary and hypothalamic hormones:** Anatomical location of hypothalamus and pituitary gland, hypothalamic-pituitary axis and portal system, biosynthesis, physiological and biochemical actions of hypothalamic, posterior-pituitary and anterior-pituitary hormones.

3. **Thyroid and parathyroid hormones:** Structure of thyroid stimulating hormones (TSH) and TSH-receptors, TSH signaling, structure and classification of thyroid hormones, biosynthesis of thyroid hormones, negative feed-back mechanism and function of thyroid hormones, pathological complications of thyroid hormones, Graves' disease. Physiological effects of parathyroid hormone, control of parathyroid hormone secretion, disease states associated with parathyroid hormone.

4. **Hormones of the adrenal cortex, adrenal medulla, gonads:** The hypothalamic-pituitary-adrenal axis, structure, classification, regulation, and functions of adrenal cortex and adrenal medulla hormones, hyperfunction of adrenal cortex, Cushing's syndrome, aldosteronism, gonadotropins, signaling pathways, regulations, and interactions of gonadotropins, hormonal regulation of male and female reproductive functions.

5. **Pancreatic hormones:** Structural features of pancreatic cells, sources and physiological functions of pancreatic hormones. Insulin biosynthesis, secretion and function, insulin signal transduction pathway. Pathophysiology and treatment of Type I and II diabetes mellitus. Glucagon biosynthesis, signaling pathway, and functions.

6. **Gastrointestinal (GI) hormones:** Cellular architecture of stomach and GI tract, secretion, regulation, signaling pathways and functions of gastrin, cholecystokinin (CCK), secretin, gastric inhibitory polypeptide (GIP), vasoactive intestinal polypeptide (VIP), glicentin, neurotensin, substance P and somatostatin, feedback mechanisms of GI hormones, Zollinfer-Ellison syndrome, impact of infection on GI hormones.

7. **Hormone assay techniques:** Assay of peptide and steroid hormones by radioimmunoassay (RIA), nonisotopic immunoassay - enzyme immunoassay (EIA), enzyme multiplied immunoassay (EMIT), enzyme-linked immunosorbent assay (ELISA), fluorescence immunoassay (FIA), fluorescence polarization immunoassay (FPIA)

Intended Learning Outcome:

After completion of the course students are expected to be able to:

- Outline the general mechanism of hormone actions
- Classify the hormones based on their structure and functionality

- Distinguish various type of hormone receptor and their structure and function
- Delineate the concept of positive and negative feed-back regulation with appropriate example
- Interpret the clinical symptoms and diagnostic measurements to understand the pathophysiology of various endocrine disorders.
- Demonstrate their ability to relate Pituitary, and hypothalamic hormones with their functions.
- Identify the targets organs of pituitary and hypothalamic hormones.
- Outline the physiological and biochemical actions of Pituitary, and hypothalamic hormones
- Differentiate between thyroid and parathyroid hormones in terms of their structure and functions
- Identify possible abnormality of thyroid and parathyroid hormones by assessing clinical symptoms.
- Determine the structure and functions of the hormones of adrenal cortex, adrenal medulla, gonads and pancreas.
- Outline the physiological and biochemical actions of the hormones of adrenal cortex, adrenal medulla, gonads and pancreas.
- Identify possible abnormality of hormones of the adrenal cortex, adrenal medulla, gonads and pancreas by assessing clinical symptoms.
- Distinguish the site of production of different gastrointestinal hormones.
- Determine the individual, synergistic and antagonistic functions of different gastrointestinal hormones.
- Differentiate various hormonal assays based on their principles.
- Evaluate the strength and weakness if each of the hormonal-assay methods.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Characteristics of the hormone system	5
02.	Pituitary and hypothalamic hormones, thyroid and parathyroid hormones	12
03.	Hormones of the adrenal cortex, adrenal medulla, gonads and pancreas	12
04.	Gastrointestinal hormones	9
05.	Hormone assay techniques	7
Total classes		**45**

Recommended Books and Readings:

1. Harrison’s Endocrinology by J. Larry Jameson. (2006)
2. Endocrinology - Basic and Clinical Principles by Shlomo Melmed and P. Michael Conn. (2005)
3. Text Book of Endocrinology. R H Williams. *W. B. Saunders Company.* (2011)

BMB-205: Molecular Biology-II 4 Credits

Introduction:

This course is designed for undergraduate students to introduce them with detailed structure and functions of nucleic acids, including DNA and RNA, and their sequence complexity. We will also discuss how nucleic acids are packaged within cells in association with nucleic acid binding proteins, of particular histones. Furthermore, this course is intended to elaborate mechanisms of replication, transcription and translation - both in prokaryotes and eukaryotes.

Objectives:

This course aims to let the students:

- Understand the structure, physicochemical properties and sequence complexity of DNA and RNA.
- Comprehend how genomes are packaged within cells in both prokaryotic and eukaryotic organisms.
- Understand the detailed mechanisms of replication, transcription, and translation both in prokaryotes and eukaryotes.

Contents:

1. **Structure and properties of DNA:** Different physicochemical properties; different conformations of DNA, tandem sequence, palindrome sequence, cruciform structure, hybridization kinetics, C_0t values, sequence complexity.

2. **Packaging of DNA:** Genome organization of prokaryotes and eukaryotes; role of histones, non-histone and histone-like proteins; genomes of organelles.

3. **DNA replication:** DNA replication: Basic mechanism of DNA replication involving helicases, topoisomerases, primase, polymerases, ligases and other proteins. Replication process: initiation, elongation and termination both in prokaryotes and eukaryotes. Bidirectional, unidirectional and rolling circle replication. Role of telomerase in replication. Regulation of replication in eukaryotes: cell cycle checks points and CDKs.

4. **Transcription:** RNAs and their characteristics. Major steps in prokaryotic and eukaryotic transcription: pre-initiation, initiation, elongation and termination. Role of Promoter sequences, transcription factors and RNA polymerase. Post-transcriptional modification of primary transcripts. RNA transport; inhibitors of transcription.
5. **Structure and function of ribosome:** Prokaryotic and eukaryotic ribosomes; ribosomal proteins and RNAs; ribosome as seat of protein synthesis; major sites of ribosome; recent findings on structure and function of ribosome.

6. **Genetic code:** Discovery; codons and anticodons; codon dictionary: salient features; effect of mutations: point mutation and frame shift mutation; Wobble hypothesis; variations to the standard genetic code; redundancy.

7. **Translation:** Steps in protein synthesis: Activation: activation of amino acids and its specificity; Initiation: initiation factors; difference in initiation in prokaryotes and eukaryotes; Elongation: factors involved; elongation process along with translocation; Termination: factors involved.

Intended Learning Outcome:

- After completion of the course students are expected to be able to:
- Understand nucleic acid structures, their physicochemical properties and sequence complexity.
- Understand how nucleic acid are packaged within cells in association with histones.
- Discuss the process of DNA replication and its regulation.
- Understand the mechanism of transcription involving RNA polymerase and various transcription factors with special emphasis on promoter sequences.
- Understand the post transcriptional processing of RNA and how eukaryotic gene transcripts are spliced involving spliceosome. In addition, outline the mechanism of RNA transport from nucleus to cytoplasm following transcription.
- Understand post-transcriptional modifications of RNA.
- Conversant with structural components of prokaryotic and eukaryotic ribosomes with special emphasis on protein synthesis.
- Understand genetic code and its redundancy, and mutation.
- Familiar with the process of translation, its machineries, and end products.
- Distinguish translation process between prokaryotic and eukaryotic organisms.

Required Number of Classes:

No	Title of the unit	Number of classes
01	Structure and properties of DNA	9
02	Packaging of DNA	8
03	DNA replication	9
04	Transcription	9
05	Structure and function of ribosome	9
06	Genetic code	7
07	Translation	9
	Total classes	**60**

Recommended Books and Readings:

1. Lewin's GENES XII by Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick. (2017)
2. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox. (2017)
3. Textbook of Biochemistry with Clinical Correlations by Thomas M. Devlin. (2010)
4. Molecular Biology of the Cell. Bruce. Alberts, Denneis Bray, Julian Lewis, Martin Raff, Keith, Roberts, James, D. Watson. *Garland Publishing Inc.*(2008)
5. Cell and Molecular Biology. E.D.P. DeRobertis and E.M.F. DeRobertis. *Wavertev*.(1987)

BMB-206 Laboratory Work 4 Credits

Introduction:

This course is designed to anticipate a hands-on experience with the biochemical and molecular laboratory techniques of the students. The students will learn the principles of different techniques and then perform laboratory experiments as a part of their continuous laboratory skill development. It focuses on the rate and order of a chemical reaction, preparation and uses of buffer, determination of buffering capacity, and quantitative estimation of different biomarkers like bilirubin, glucose, inorganic phosphate, creatinine etc. from biological samples including blood and urine. The students will be able to practice how to estimate enzymatic activity like ALT and AST in serum. In addition, the students will also learn and perform how to estimate the activity of a commercial drug like antacid. This course will help students to improve their experimental result analysis and report writing ability.

Objectives:

This course has the following objectives:

- To perform laboratory experiments on organic chemistry.
- To provide practical training on buffer preparation and handling.
- To enable students safe handling and disposal of biological samples like blood.
- To introduce students to assessing quantitative estimation of compounds from biological samples.
- To give experience regarding the estimation of commercial drug's activity.
- To enable students to efficiently use and operate basic laboratory instruments.

- To enable students to analyze result and write laboratory reports.

Contents:

1. Determination of the rate and order of a chemical reaction using iodination of acetone.
2. Determination of the partition coefficient of ethanoic acid between water and 2-methylpropan-1-ol.
3. Determination of the equilibrium constant of the reaction $KI+I_2 = KI_3$ by the distribution method.
4. Preparation of buffer and demonstration of buffering capacity.
5. Determination of the pK_a of a weak acid-potentiometric titration and half-volume method.
6. Determination of serum total direct and indirect bilirubin by colorimetric method
7. Determination of creatinine content of a urine sample by colorimetric method.
8. Estimation of inorganic phosphate by colorimetric method.
9. Determination of the acid-neutralizing capacity of a commercial antacid tablet.
10. Estimation of chlorophyll content in the plant (*Basella alba*) leaves.
11. Measurement of microbial enzyme activity (i.e., dehydrogenase).
12. Determination of serum ALT and AST activity by colorimetric method.
13. Separation of serum and plasma from whole blood and determination of serum plasma glucose by glucose oxidase method.
14. Determination of pI of glycine or alanine.
15. Determination of pKa of a protein.
16. Determination of serum alanine aminotransferase by the enzymatic method.
17. Determination of serum HDL cholesterol by precipitation and the cholesterol oxidase method.
18. Isolation and determination of cholesterol from an egg.

Intended Learning Outcomes:

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

- Determine the rate and order of a chemical reaction
- Determine the partition coefficient.
- Determine the equilibrium constant of the reaction.
- Prepare buffer and determine buffering capacity.
- To quantitatively estimate different biomarkers like bilirubin, glucose, inorganic phosphate, creatinine etc. from biological samples
- Determine the pI, pK_a of amino acids and proteins.
- Analyze the enzymatic activity of different target enzymes.
- To efficiently use and operate basic laboratory instruments.

- To analyze experimental results, troubleshoot and write laboratory reports.

Required Number of classes:

For laboratory work, students will have to complete 3-4 experiments per credit that consists of theory lecture for each experiment and laboratory work. To complete an experiment, approximately one hour of theory lecture and 4-6 hours of laboratory work are required.

SL No.	Title of the unit	No. of Experiment
1.	Determination of the rate and order of a chemical reaction using iodination of acetone.	1
2.	Determination of the partition coefficient of ethanoic acid between water and 2-methylpropan-1-ol.	1
3.	Determination of the equilibrium constant of the reaction $KI+I_2 = KI_3$ by the distribution method.	1
4.	Preparation of buffer and demonstration of buffering capacity.	1
5.	Determination of the pK_a of a weak acid-potentiometric titration and half-volume method.	1
6.	Determination of serum total direct and indirect bilirubin by colorimetric method.	1
7.	Determination of creatinine content of a urine sample by colorimetric method.	1
8.	Estimation of inorganic phosphate by colorimetric method.	1
9.	Determination of the acid-neutralizing capacity of a commercial antacid tablet.	1
10.	Estimation of chlorophyll content in the plant (*Basella alba*) leaves.	1
11.	Measurement of microbial enzyme activity (i.e., dehydrogenase).	1
12.	Determination of serum ALT and AST activity by colorimetric method.	1
13.	Separation of serum and plasma from whole blood and determination of serum plasma glucose by glucose oxidase method.	1
14.	Determination of pI of glycine or alanine.	1
15.	Determination of pKa of a protein.	1
16.	Determination of serum alanine aminotransferase by the enzymatic method.	1
17.	Determination of serum HDL cholesterol by precipitation and the cholesterol oxidase method.	1
18.	Isolation and determination of cholesterol from an egg.	1
Total experiment		**18**

Recommended books and readings:

1. Laboratory manuals and handouts.

BMB-207: Viva-voce 2 Credits

Introduction:
This course is designed to assess the overall depth and clarity of knowledge gained in relevant courses during the current academic session. This course will provide a platform for the students to showcase their basic understanding of the overarching goals and approaches of different courses taught during the academic session.

Objectives:
The objective of the viva-voce exam is to:

- assess the overall knowledge of a student on a particular academic topic.
- enable them the platform to develop their interpersonal communication skills.
- provide a foundation for formal discussion on an academic topic with the current peers (in this case, the examiners of the examination committee).

Contents:
The content of the viva-voce exam includes all the topics taught in the theory and practical courses, throughout the academic year.

Intended Learning Outcome (ILOs):
By participating in the Viva-voce exam, the students will be able to –

- Develop basic communication skills
- Express their depth and clarity of knowledge on an academic topic.
- Showcase and improve on their scientific discussion skill.

Extra-departmental courses:

BMB-251: Human Physiology 4 Credits

Introduction:
This course provides fundamental knowledge of the major physiological systems of the human body. It includes topics on digestion, excretion, respiration, circulation, neurophysiology and reproduction. The course comprises of structural concepts of different body systems and physiological changes that lead to disease states. It also gives overviews of various physiological functions to maintain homeostasis.

Objectives:

After completion of the course students are expected to be able to:

- In this course, students will learn anatomical structure of various body systems.
- They will enrich knowledge on physiological functions of heart, blood cells, kidneys, lymphoid organs, digestive tract, liver, lung, brain and reproductive organs.
- They will have ideas about ABO blood typing, Rh incompatibility, specialized cardiac tissues, cardiac output, heart rate and blood pressure.
- They will learn filtration pressure, the role of hormones in salt and water retention, acidosis, alkalosis, role of digestive enzymes and hormones.
- They will have an understanding of respiratory mechanics, regulation of respiration, stages of reproduction along with hormonal regulation, nerve impulse conduction and neurotransmission.

Contents:

Theory (80 Marks):

1. **Blood: C**ompositions and components of blood and their functions, origin of blood cells: hematopoesis and erythropoesis, Hemostasis: vascular constriction, platelet plug, biochemistry of blood clotting, total count (TC), differential count (DC). Blood grouping: the ABO system and Rh-factor, transfusion reaction and Rh-incompatibility.

2. **Heart:** Heart, chambers of heart and its valves, their functions and locations, specialized cardiac tissues, sinoaortic node (SA node), atrioventricular node (AV node), bundle of His, Purkinjee's fibers, pace maker, artificial and natural cardiac output, blood pressure, systemic, pulmonary and coronary blood circulation.

3. **Kidneys:** Structures, physiology and functions of kidney. Nephrons - types, structures and functions of their different parts, the basic renal processes - glomerular filtration, tubular reabsorption, and tubular secretion, the glomerular membrane, the juxtaglomerular apparatus**,** transepithelial transport - sodium, water and urea reabsorption; ion secretion - potassium, hydrogen and bicarbonate ion secretion, urinary buffer system: composition, formation and excretion of urine, renal failure and its causes.

4. **Body fluid and acid-base balance:** Balance concept, body fluids: types and ionic composition, acid–base balance: acidosis and alkalosis in the body, different buffer systems and their roles in the body.

5. **Lymphatic and lymphoid system:** Lymph and lymph vessels and tissues, lymphatic circulation, outline of primary and secondary lymphoid organs and their functions, structure and function of lymph nodes, spleen, thymus and bone marrow in immunity, lymph nodes

and illness.

6. **Digestive system:** The gastrointestinal tract, digestive enzymes, digestion of food components and absorption of digested products, gut hormones.

7. **Hepatobiliary system:** Structural organization, functions and disorders of liver, gall bladder and pancreas, congenital anomalies and inflammation of gall bladder and bile duct.

8. **Respiratory System:** Mechanics of pulmonary ventilation, functions of respiratory passageways, blood flow through the lungs and its distribution, diffusion of gases through respiratory membrane, regulation of respiration, physiologic peculiarities of pulmonary abnormalities, artificial respiration.

9. **Reproductive system (male and female):** General structure and functions of the reproductive system, hormones and functions of the reproductive system, stages of reproduction, spermatogenesis and oogenesis and their hormonal control, the menstrual cycle and stages, pregnancy, placenta, lactation, menopause, hormonal factors in pregnancy, lactation and menopause, infertility.

10. **Nervous system:** Nerve cells, ionic basis of excitation and conduction, synaptic transmission, sense receptors, hypothalamus and temperature regulation.

Practical (20 Marks):

1. Total WBC count, differential count (DC).
2. Blood grouping.
3. Hemoglobin estimation.

Intended Learning Outcome:

After completion of the course students are expected to be able to:

- Identify different types of blood cells and demonstrate their functions
- Determine ABO blood typing, explain Rh-incompatibility in various situations
- Estimate hemoglobin content of the blood sample
- Recognize heart chambers, valves, pulmonary and coronary blood circulation
- Describe functions of specialized cardiac tissues (SA node, AV node, bundle of His, Purkinjee's fibers, pacemaker)
- Demonstrate cardiac output, heart rate, blood pressure
- Describe the excretion process through the urinary system
- Calculate filtration pressure

- Differentiate between tubular reabsorption and secretion process
- Demonstrate the role of hormones for salt and water retention
- Explain balance concept to maintain homeostasis
- Describe regulatory mechanisms to maintain fluid balance and acid-base balance of the body system
- Describe the structure and functions of lymphoid organs and lymph nodes
- Demonstrate the functions of different organs of the digestive system
- Describe mechanism of digestive juice secretion
- Explain the role of digestive enzymes and gut hormones in the digestion and absorption of carbohydrate, protein and fat components
- Demonstrate liver function, structure and disorder
- Explain the importance of bile in fat digestion and absorption
- Explain respiratory mechanics for inspiration and expiration
- Correlate air pressure with pulmonary pressure for gas exchange
- Describe lung behavior, spirogram (lung volume and capacity), regulation of respiration
- Demonstrate spermatogenesis and oogenesis along with regulation
- Describe the different stages of reproduction and explain hormonal function and infertility
- Demonstrate the structure and functions of neuron and glial cells
- Explain the ionic basis of nerve impulse conduction, process of neurotransmission

Required number of classes):

No	Title of the unit	Number of classes
01.	Blood	8
02.	Heart	5
03.	Kidneys	5
04.	Body fluid and acid-base balance	2
05.	Lymphatic and lymphoid system	2
06.	Digestive system	5
07.	Respiratory System	6
08.	Hepatobiliary system	2
09.	Reproductive system	5
10.	Nervous system	8
Total classes		**48**

Recommended Books and Readings:

1. Textbook of Medical Physiology by Guyton and Hall. (2008)
2. Ganong's. Review of. Medical Physiology by Kim E. Barrett, Susan M. Barman, Scott Boitano, Heddwen L. Brooks (2019)
3. Human Physiology from cell to system by Lauralee Sherwood (2015)
4. Human Biology by Sylvia S. Mader (2017)

BMB-252: Computer Basics and Data Analysis 4 Credits

Introduction:

This course provides a general introduction to computers, applications software, basic programming languages, hardware and computer information systems. Emphasis will be placed on computer literacy topics such as hardware, software, operating systems, programming languages, data communications, applications software and information systems along with networking and internet system.

Objectives:

The course has the following objectives:

- To meet the demand of the present age of information technology.
- To utilize information technology in research and education.

Contents:

Theory (50 Marks)

1. **Introduction to computers:** Computer basics and organization (general properties of memory devices, memory hierarchies, read only memory, random access memory, and cache memory), components of a computer system, importance and limitations of computers, classification of computer (based on purpose, signals, capacity), history of computers, computer generations.
2. **Computer software:** Software, classification of software, commercial software, freeware, advantages of package programs, popular package programs, programming languages, programs with simple input output operations, high level languages e.g., Perl as scripting language
3. **System software and operating system:** System software, the role of BIOS, language translators, text editor, the tasks of an OS, OS characteristics, types of OS, Linux, UNIX, MS DOS, Windows.
4. **Database concepts:** Basic concepts, database software, database structures, database management system, benefits and limitations of database management.
5. **Computer networks and the internet:** Introduction to computer network, network terminologies, LAN topology.
6. **Introduction to Python (lectures and demonstrations)**
   Basic concepts on programming, algorithm and scripting and its importance to biologists, Introduction to specific terms used in scripting e.g., variable, expression, statement, function, debugging, syntax etc., Installation, editing and running Python, Using text editors, manipulating texts, Running the first command “Hello World”, Working with files

input and output

Practical (50 Marks):

- Simple exercises on WINDOWS and UNIX operating systems.
- Power-point presentation.
- Python lists and loops
- Creating lists, working with list and retrieving elements, Using string, Iteration, Looping
- Conditions
- True and False, If, else, elif and while loop

Intended Learning Outcome:

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

- Elucidate basics on computer along with its different components
- Explain different hardware system of computer
- Demonstrate different devices of computers
- Illustrates operating system along with different softwares
- Explain and perform basics on programming languages
- Explicate computer network and interney

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Introduction to computers	3
02.	Computer software	5
03.	System software and operating system	6
04.	Database concepts	5
05.	Computer networks and the internet	5
06.	Introduction to Python (lectures and demonstrations)	6
Total classes		**30**

Recommended Books and Readings:

1. Introduction to Computer Science: A Textbook for Beginners in Informatics by Gilbert Brands**.** (2013)
2. Concepts in Programming Languages by John C. Mitchell (2013)
3. Basics of Computer Networking by Thomas G. Robertazzi (2013)

****

3rd Year BS Honors

Total Credits in 3rd Year BS (Honors): 40 Credits

Course No.	Name of the course	Credits
Departmental courses:		
BMB-301	Metabolism of Nitrogenous Compounds	4
BMB-302	Biochemistry of Natural Products	2
BMB-303	Human Nutrition	4
BMB-304	Molecular Biology-III	2
BMB-305	Molecular Genetics	4
BMB-306	Plant Biochemistry	2
BMB-307	Basic Immunology	2
BMB-308	Laboratory Science and Clinical Biochemistry	4
BMB-309	Laboratory Work	8
BMB-310	Viva-voce	2
Extra-departmental courses:		
BMB-351	Applied Biostatistics	4
BMB-352	Microbiology	2
	Total	**40**

BMB-301: Metabolism of Nitrogenous Compounds 4 Credits

Introduction:

The course will describe and explain the metabolic processes of nitrogenous macromolecules in detail. Oxidation, biosynthesis, and regulation of amino acids and nucleotides is main objective of this course. This course will also cover certain specific areas related to disorders of metabolic pathways.

Objectives:

The overarching goal of BMB-301 is to:

- Familiarize the students with the physiological pathways of how building blocks of proteins and nucleic acids are synthesized and degraded to maintain cell division, growth and health.
- Understand adaptation of cellular metabolisms and inter organ relationships during different states.
- Discuss the metabolisms of amino acids, nucleotides, heme, and their regulation.
- Describe the biochemistry involved in the regulation of cellular metabolism and common inborn errors of metabolism.
- Explore the metabolic interrelationships at different states of the body.
- Understand the clinical correlations of metabolic disorders and their significance
- Describe possible approaches for the modification of metabolic pathways for industrial uses.

Contents:

1. A**mino acid metabolism:** Overview, digestion and absorption of dietary proteins, degradation of endogenesis proteins, general reactions of amino acids, glucogenic and ketogenic amino acids, oxidative degradation of amino acids to specialized products, amino acid biosynthesis, metabolism of branched chain amino acids, regulation of amino acid metabolism, propionate and methylmalonate metabolism, nitrogen fixation, folic acid and one-carbon metabolism, glutathione metabolism, clinical correlations - phenylketonuria, alkaptonuria, folic acid deficiency, hyperammonemia and hepatic coma, urea cycle and deficiencies of the urea cycle enzymes.

2. **Nucleotide metabolism:** Overview, metabolic functions of nucleotides, synthesis of purine and pyrimidine nucleotides and deoxyribonucleotides, nucleotide degradation, uric acid formation, biosynthesis of nucleotide coenzymes, nucleotide metabolizing enzymes as a function of cell cycle and rate of cell division, anti-metabolites of purine and pyrimidine nucleotide metabolism, heme metabolism, regulation of nucleotide

metabolism, Lesch-Nyhan syndrome, gout, orotic acid urea.

3. **Metabolic interrelationships:** Overview, starved-fed cycle, mechanisms involved in switching the metabolism of the liver between well-fed states and starved state, metabolic interrelationships of tissues in various nutritional and hormonal states.

4. **Metabolic engineering:** Definition and applications. Different strategies of metabolic engineering, Use of microorganisms in metabolic engineering, modification of central metabolic pathways, modification of biosynthetic pathways, modification of transport systems, and metabolic engineering of bacteria for the production of organic acids.

Intended Learning Outcome:

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

- Describe the process of digestion and absorption of dietary proteins and transportation of amino acids.
- Describe the process of degradation of cellular proteins and regulation of the processes. Justify the requirement of degradation of endogenous proteins.
- Describe the processes of oxidation of amino acids.
- Describe the effect of protein metabolism on ammonia and urea cycle.
- Apply and evaluate the usefulness of various metabolic steps and disorders of amino acids metabolism for the benefit of the living world.
- Outlie, explain and interpret the biosynthetic and catabolic pathways of heme with required mechanisms and regulations. Explain and interpret the metabolic disorders associated with heme metabolism.
- Illustrate and explain metabolic steps of, both through the *de novo* pathway and salvage pathway, purine and pyrimidine nucleotides.
- Identify and explain unique metabolic profile of brain, heart, skeletal muscle, kidney, adpose tissue and the liver.
- Describe and interpret metabolic interrelationships to maintain acid-base balance of the body.
- Outline, explain and interpret modification of central and specific metabolic pathways and, if applicable, modification membrane permeability for the production of amino acids (lysine, histidine, tryptophan, threonine, methionine, and branched chain amino acids) and organic acids (acetic acid, lactic acid, pyruvic acid and succinic acid).
- Demonstrate their knowledge to modify different metabolic pathways in bacteria, yeast, fungus etc., for the production of industrially important products.

Required Number of Classes:

No	Title of the unit	Number of classes
1.	Amino acid metabolism	20
2.	Nucleotide metabolism	20
3.	Metabolic interrelationships	10
4.	Metabolic engineering	10
Total classes		**60**

Recommended Books and Readings:

1. Text Book of Biochemistry with clinical correlation by Thomas M Devlin.
2. Principles of Biochemistry by Nelson, D. L. and Cox, M.M. Lehninger,
3. Textbook of Biochemistry by Donald Voet, Judith G. Voet.
4. Biochemistry by Lubert Stryer, John L. Tymoczko, Jeremy Mark Berg,
5. Fundaments of Biochemistry (Life at the molecular level) by Donald Voet, Judith G. Voet & Charlotte W. Pratt

BMB-302: Biochemistry of Natural Products 2 Credits

Introduction*:*

Natural products are secondary metabolites of biological organisms. They have various physiological, pharmacological, biological and medicinal properties. This course consists of the uses of spectroscopic techniques to determine structure of various natural products, to understand their chemistry, their biological as well as chemical synthesis, mechanism of action, their medicinal uses. The important groups of natural products are alkaloids, antibiotics, steroids and flavonoids.

Objectives:

The main objective of this course is to

- familiarize spectroscopic techniques like UV, IR, Mass and NMR and their applications to determine the structures of natural products.
- study the chemical and biological properties of alkaloids, antibiotics, steroids and flavonoids,
- Describe the synthesis of medicinally important natural products.
- develop medicines from plant sources, which will be with low side effects.

Contents:

1. **Natural products:** Sources (plant, animal, microbial, marine), classification on chemical basis, role of natural products in development of medicinal chemistry.

2. **Spectroscopic techniques:** UV, IR, Mass Spectroscopy – principle, electron impact and

chemical ionization, mass fragmentations of some natural products, interpretation of mass spectrum, McLaferty rearrangement. NMR – principle, instrumentation, multiplicity and intensity, dehielding and shielding effects, couples constant, interpretation of NMR spectra of some important compounds and natural products.

3. **Alkaloids:** Classification, extraction, isolation and identification from plant sources, structures of some medicinally important alkaloids – ephedrine, atropine, morphine, quinine, vincristine and vinblastine. Taxol – anticancer agent, mechanisms of alkaloid actions, biosynthesis of some alkaloids.

4. **Antibiotics:** Classification of antibiotics on the basis of sources, spectrum and structure, structure determination of penicillin, chloramphenicol, tetracyclines, streptomycin, erythromycin, structure activity relationship, semisynthetic antibiotics, biosynthesis of penicillin and streptomycin.

5. **Steroids:** Functions of steroids, structure determination of some important steroids cholesterol and ergosterol.

6. **Flavonoids:** Biological functions, classification, structure determination of flavones, flavonol and isoflavonol, medicinal role of some important flavonoids as antioxidant, biosynthesis of flavonoids.

7. **Bioactive compounds:** Curacin A (from marine sources) and epibatidine (from animal sources).

Intended Learning Outcome:

At the end of this course students will be able to:

- familiarize themselves with different types of natural products and their biological functions,
- synthesize the natural products,
- determine their structure by the use of spectroscopic techniques like UV, IR, Mass and NMR.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Natural products	1
02.	Spectroscopic techniques	7
03.	Alkaloids	7
04.	Antibiotics	7
05.	Steroids	5
06.	Flavonoids	2
07.	Bioactive compounds	1
Total classes		**30**

Recommended Books and Readings:

1. Organic Chemistry. Stereochemistry and Chemistry of Natural Products. I.L. Finar. English Language Book Society/ Longman
2. Advanced Organic Chemistry. Reactions, Mechanisms and Structure. Jerry March. Johm Willey & Sons, Inc.

BMB-303: Human Nutrition 4 Credits

Introduction:

This course provides a comprehensive understanding of human nutrition, exploring the role of nutrients in maintaining optimal health. Students will delve into the functions of carbohydrates, proteins, fats, vitamins, minerals, and water in the human body. Additionally, they will explore topics such as energy metabolism, life cycle nutrition, and the assessment of nutritional status. This course aims to equip students with essential knowledge to make informed decisions regarding their own nutrition and contribute to promoting health and well-being in others.

Objectives:

The objective of this course is to:

- provide students with a solid foundation in human nutrition,
- comprehend the functions of various nutrients, their food sources, and their impact on health.
- provide insights into energy metabolism and life cycle nutrition.

Contents:

1. Overview of nutrition: Definition of nutrients, introducing nutrients - carbohydrates, lipids, proteins, vitamins, minerals and water. Balanced diet. Role of food toxins and food supplements in human nutrition

2. Carbohydrates in human nutrition: Nutritional function of carbohydrate and individual sugars, carbohydrate as dietary essential, fiber, glycemic effect of food. Carbohydrate and microflora. Different forms of starch in food, their changes during food processing and cooking. Recommended carbohydrate.

3. Proteins in human nutrition: Function of protein, nitrogen balance, essential amino acids, Protein metabolism. Quality of protein and its evaluation, limiting amino acids, mutual supplementation. Protein energy malnutrition – kwashiorkor and marasmus. Health effects of

excess protein, protein requirement.

4. Fats and oils in human nutrition: Chemistry of lipids, degree of unsaturation, rancidity, hydrogenation. Phospholipids and sterols. Lipid transport lipid metabolism, health implications of lipid, ω-3 and ω-6 fatty acids in health, essential fatty acids. Recommended intake of fat.

5. Vitamins: Fat soluble and water-soluble vitamins – sources, biological function, deficiency symptoms and RDA; coenzyme activities of vitamins.

6. Major minerals and trace elements: Importance of minerals and trace elements in a human body. Physiological roles, food sources, absorption, metabolism and excretion of major minerals (calcium, iron, potassium, magnesium, zinc, phosphorus and sodium) and trace elements (copper, selenium, manganese and iodine).

7. Energy metabolism: Energy balance, respiratory quotient, basal metabolic rate, energy requirement and energy expenditure, thermic effect of food, measurement of energy expenditure and requirement.

8. Life cycle nutrition: Pregnancy- Nutritional influence on fetal growth, Weight gains during pregnancy Nutritional requirements and toxemia of pregnancy. **Lactation**- Physiology of lactation, factors affecting lactation, quality and quantity of breast milk, nutritional requirement in lactation. **Infancy**- Nutritional requirement, breast feeding and artificial feeding, weaning food, **Childhood** -Nutritional problems of preschool child, growth and nutritional requirement. **The Teen years and adulthood**- Growth and nutritional requirement, food choice and eating habits of teenagers and adulthood. **The elderly**- Health problems and nutritional requirements, modification of adult diet for old age.

Intended Learning Outcome:

- Upon completion of this course, students will be able to:
- Define nutrients and describe the functions of carbohydrates, lipids, proteins, vitamins, minerals, and water in the human body.
- Explain the concept of a balanced diet and the role of food toxins and supplements in human nutrition.
- Analyze the nutritional function of carbohydrates, including individual sugars, fiber, glycemic effects, and the impact on gut microflora.
- Evaluate the importance of proteins in human nutrition, including nitrogen balance, essential amino acids, protein metabolism, and protein quality evaluation.
- Identify and discuss the chemistry of lipids, the degree of unsaturation, lipid transport, metabolism, and the health implications of different types of fatty acids.

- Examine the sources, functions, deficiency symptoms, and recommended dietary allowances (RDAs) of fat-soluble and water-soluble vitamins.
- Assess the significance of major minerals and trace elements in the human body, including their roles, food sources, absorption, metabolism, and excretion.
- Understand energy metabolism, including energy balance, basal metabolic rate, energy requirements, and measurement of energy expenditure.
- Evaluate the nutritional influence on fetal growth during pregnancy, nutritional requirements, and lactation physiology and nutritional requirements.
- Discuss nutritional requirements and challenges during infancy, childhood, teenage years, adulthood, and old age, including modifications for the elderly.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Overview of nutrition	5
02.	Carbohydrates in human nutrition	7
03.	Proteins in human nutrition	7
04.	Fats and oils in human nutrition	6
05.	Vitamins	8
06.	Major minerals and trace elements	7
07.	Energy metabolism	10
08.	Life cycle nutrition	10
Total classes		**60**

Recommended Books and Readings:

1. Human Nutrition and Dietetics by Davidson and Passmore
2. Lehninger Principles of Biochemistry by Michael M. Cox, David L. Nelson
3. Harper's illustrated Biochemistry by Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil.
4. Understanding Nutrition. Eleanor Noss Witney and Eva May Nunneley Hamilton. West Publishing Company.
5. Human Nutrition & Dietetics. Stanley Davidson, R. Passmore, J.F. Brock and A.S. Truswell. Churchill Livingstone.

BMB-304: Molecular Biology-III 2 Credits

Introduction:

Molecular biology is a field of science that explores and studies the structures and functions of cells on a molecular level. Most of the cell functions, which are incredibly complex and incompletely understood, take place on a molecular level. This means that the sophisticated interconnection and cooperation of biological molecules is what makes life possible, which is an intriguing subject that puzzles molecular biologists and motivates them to discover the secrets of cells. Consequently, in order to optimally exploit the biotechnical tools, knowledge about molecular biology is of great importance.

The course includes a short introduction to conventional assays used in molecular biotechnology, description of different methods for typing of genetic variations, a variety of techniques for multiplex amplification, advanced techniques and platforms for DNA sequencing.

Objectives:

The aim of this module is to:

- provide knowledge and understanding the basics in Molecular Biology techniques, which includes recombinant DNA technology and gene cloning, DNA sequencing as well as DNA markers.
- Make the students competent in designing and performing these experiments to address research questions.

Contents:

1. **Inhibition of protein synthesis:** Inhibition of protein synthesis: role of antibiotics and other chemicals.
2. **Post-translational modifications:** Different types of processing of nascent polypeptides; role of chaperons; synthesis of exportable proteins in eukaryotes.
3. **Assaying macromolecular interactions:** DNA-protein interactions (DNase footprinting, chromatin immunoprecipitation (ChIP), protein-protein interactions (in brief), interaction of RNA with other macromolecules (SELEX).
4. **Regulation of gene expression:** Chromatin remodeling and gene regulation, RNA interference, regulatory RNAs and gene expression, riboswitch and its function, Control of gene expression at transcriptional and translational levels (an overview); signal molecules like activators, insulators, inhibitors; steroids in regulation.
5. **Nucleic acid hybridization principles and application:** Principle and importance of hybridization, preparation of nucleic acid probes, blotting, hybridization using radioactive and non-radioactive probes and detection system.
6. **Recombinant DNA technology:** Concepts and importance; isolation of gene; restriction

endonucleases: their action and use; vectors: plasmids; λ-phage, cosmid, BAC and YAC; M13-based expression vectors for eukaryotic expression; use of expression vector and reporter genes. Genomic and cDNA library, cDNA as gene source. Conventional and real time PCR. Industrial application of recombinant DNA technology; recombinant DNA technology for diagnosis of genetic disorders, genome editing tools (in brief),

7. **DNA sequencing:** Sanger's method, Maxam and Gilbert's method, next generation sequencing methods.
8. **Application of DNA markers:** RFLP, AFLP, SSR, RAPD and SNP.

Intended Learning Outcome:

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

- Describe the mechanism of action, spectrum of activity, indications and usage for each of the pharmacologic categories of protein synthesis inhibitors.
- Explain the role of chaperones in protein folding
- Describe the ways by which proteins are modified post-translationally after synthesis
- Demonstrate principle of hybridization techniques and its types used in Molecular Biology.
- Outline the basics and skills of nucleic acid blotting in hybridization experiments.
- Identify the basic concept and limitation of Sanger's method, Maxam and Gilbert's method, and next-generation sequencing methods.
- Understand the detail concept of recombinant DNA technology.
- Outline definition, uses and importance of restriction enzymes in recombinant DNA technology. Manipulate DNA sequences with versatile DNA modifying enzymes.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Inhibition of protein synthesis	2
02.	Post-translational modifications	2
03.	Regulation of gene expression	6
04.	Nucleic acid hybridization principles and application	5
05.	Recombinant DNA technology	8
06.	DNA sequencing	5
07.	Application of DNA markers	2
Total classes		**30**

Recommended Books and Readings:

1. Genes X by Lewin, B.
2. Molecular cell biology by Lodish, H, Berk, A, Kaiser, CA, Krieger, M, Scott, MP, Bretscher, A, Ploegh, H, and Matsudaira.
3. Principles of Gene Manipulation and Genomics by S.B. Primrose and R.M. Twyman.

BMB-305: Molecular Genetics 4 Credits

Introduction:

This course intended to provide a genetic knowledge at a general level with an understanding of how genes can be ordered in bacteria and how gene expression is regulated while describing the molecular genetic mechanisms in relation to structure and function of genes using the prokaryotic lac and trp operons as examples. Students will be introduced to how phenotypic changes arise through genetic mutation and recombination. This course will also allow to understand genetic variability and distinguish between the lytic and lysogenic reproductive cycles, with phage lambda as an example.

Objectives:

The objectives of this course are to introduce students to:

- mechanisms which help to understand how gene expression is studied
- knowledge as to how genes work together in biological processes
- mechanisms of genetic alternation, recovery and its effects
- how the relative position between genes can be determined based on the frequency of recombinant gametes and its correlation with the frequency of crossing-over
- genetic variability and the control of gene expression in prokaryotes

Contents:

1. General nature of mutation: Chromosome and gene mutation, Types of mutation, missense, same-sense and nonsense mutation, frame-shift mutations, deletion and lethal mutation and suppressor mutation, physicochemical mutagens, molecular mechanism of mutation, in vitro mutagenesis and site-directed mutagenesis, mutation by transposons and retroposons, mutations induced by radiation, different repair mechanisms in mutation, role of DNA repair enzymes in clinical manifestations, mutation rate and its measurement. Mutations in human - deleterious and recessive. Screening of carcinogens - Ames test.

2. Recombination: Various models for recombination, homologous and non-homologous recombination, RecA protein and its homologs, Holliday junctions, gene conversion, mitotic and meiotic recombination, biochemistry of recombination system and site-specific recombination. Technique to study recombination intermediates: two-dimensional gel electrophoresis.

3. Genetics of viruses, bacteria and fungi: Mechanisms of genetic exchange in bacteria, conjugation - transduction, transformation and transfection; restriction mapping, chromosome

walking, genetics of lambda phage, assembly of T-phages. Evolutionary significance of genetic exchange in bacteria, Drug resistance in bacteria.

4. Linkage and chromosome mapping in higher organism: Recombination and crossing over, exception to Mendelian principles of independent assortment, frequency of recombination, crossing over, chiasma and time of crossing over, recombination with two and three point cross over, recombination frequency and genetic map distance, linkage analysis in chromosome (human), gene and pedigree patterns. Linkage disequilibrium.

5. Cytogenetics: Analysis of mitotic chromosome, karyotype and its applications, chromosome aberration and associated diseases like Down syndrome, Turner syndrome, Klinefelter syndrome, Edward's syndrome, Cri du chat syndrome, etc., Genetic basis of autosomal and sex-linked dominant and recessive disorders like Huntington disease, cystic fibrosis, sickle cell disease, thalassemia, hemophilia, invasive and non-invasive prenatal diagnosis, possible treatment options; genetic counseling. Polyploidy.

6. Gene expression: Constitutive, inducible and repressible gene expression, positive and negative control of gene expression, attenuation of trp operon, autogenous regulation of λ operon. The lac and trp operons, control of gene expression for both prokaryotic and eukaryotic systems. Autogenous regulation of gene expression.

Intended Learning Outcome:

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

- Understand the difference between spontaneous and induced genetic mutations along with their effects on the living objects.
- Describe the various mechanisms of how mutations can arise spontaneously within a cell or can be induced and the consequences of the genetic change
- Identify the various kinds of DNA mutations (point mutation, insertion, deletion, nonsense, nonsense suppressor, frameshift and reversion) and how these might affect the resultant mRNA transcript or protein product as well as the phenotype.
- Understand the relationship between nonsense and frameshift mutations.
- Demonstrate the application of mutation in the field of modern biotechnology
- Explain the basic understanding of the carcinogen testing, DNA repair mechanisms and the mutagenic effects of disease outcomes.
- Describe DNA recombination, restriction mapping analysis and their applications.
- Explain the general principles of concept of in vivo and ex vivo genetic exchange

- Understand how transcription and translation are coupled in bacteria
- Understand and describe some examples of gene regulation by attenuation
- Understand the difference between specific gene regulation and global gene regulation
- Understand how the phenotype of specific mutants can be used to determine the mechanisms of gene expression and regulation in bacteria
- Understand the temporal regulation of gene expression in lambda virus
- Describe the molecular events that occur in the lysogenic and lytic phases of lambda
- Understand the differences between generalized and specialized transduction and the applications of each in bacterial genetics
- Understand the underlying molecular events of recombination in bacteria
- Define linkage and explain why linkage interferes with independent assortment
- Distinguish between parental and recombinant phenotypes
- Explain how crossing over can unlink genes
- Map a linear sequence of genes on a chromosome using given recombination frequencies from experimental crosses.
- Understand the basics of cytogenetics
- Understand how numerical and structural chromosome abnormalities occur and the clinical syndromes which can result from these abnormalities
- Demonstrate and understanding of how structurally rearranged chromosomes can result in the production of gametes with unbalanced chromosome constitutions.
- Understand how recombination is an efficient mechanism of DNA damage repair.
- Understand the differences and similarities between prokaryotic and eukaryotic recombination.
- Understand why genetic counseling and prenatal diagnosis is important.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	General nature of mutation	10
02.	Recombination	12
03.	Genetics of viruses, bacteria and fungi	10
04.	Linkage and chromosome mapping in higher organism	10
05.	Cytogenetics	8
06.	Gene expression	10
Total classes		**60**

Recommended Books and Readings:

1. Human Molecular Genetics by Tom Strachan.
2. Molecular Biology of the Gene. J.D. Watson, NH, Hopkins, J. W. Roberts, J.A. Steit, A.M. Weiner, 3rd Edition. *W. A. Benjamin, Inc*.

3. Cell and Molecular Biology. E.D.P. DeRobertis and E.M.F. DeRobertis. *Wavertev*.
4. Molecular Biology of the Cell. Bruce. Alberts, Denneis Bray, Julian Lewis, Martin Raff, Keith, Roberts, James, D. Watson. *Garland Publishing Inc*.
5. Principles of Genetics by Peter Snustad and Michael Simmons.

BMB-306: Plant Biochemistry 2 Credits

Introduction:

This course focuses on the various aspects of cellular organization, plant metabolism, plant physiology and the crucial processes behind it, major biosynthetic process occurring in plant, plant growth regulating components that can be either plant hormones or secondary metabolites, etc.

Objectives:

- Students will have knowledge of cellular metabolism, understand the principles and importance of metabolic control, and understand how different control mechanisms may be integrated to coordinate cell metabolism and function.
- They will learn to identify the reactants and products of photosynthesis, understand how light energy is packaged and how its absorption is related to wavelength, understand how photosystem I and photosystem II in plants produce ATP and NADH.
- They will study the three phases of the Calvin cycle and how the products of the Calvin cycle are used to form the other molecules found in plants.
- They will understand how photorespiration affects C3 photosynthesis and will study the comparison between C4 and CAM photosynthesis and how they combat photorespiration.
- Moreover, students will know how carbohydrates can help to maintain the plant structure and how they play important roles in stress tolerance.
- They will have the knowledge of plant respiration specialities which include cyanide insensitive respiration and glyoxylate cycle.
- They will learn the process of nitrogen fixation, nitrogen and sulfur assimilation in details including the underlying mechanisms.
- They will find out how the phytohormones and the secondary metabolites produced by the plants can regulate their growth and metabolism.

Content:

1. **Plant cell and metabolism specialties:** Cellular and sub-cellular compartmentation plant cell and organelle structure, role of compartmentation in regulation of metabolism, unique aspects of plant metabolism and their impact on metabolic flux, transporters in metabolic flux.
2. **Photosynthesis:** Light reactions, electron transport, dark reactions, Calvin cycle and regulation, photorespiration, C3, C4 and CAM metabolism and their comparison. Role of carbohydrate metabolism in plants in normal and stress conditions.
3. **Plant respiration specialties:** Cyanide insensitive respiration; glyoxylate cycle.

4. **Nitrogen and sulfur assimilation and metabolism:** role of transporters.
5. **Plant hormones:** Physiology and importance of auxins, cytokinins, gibberellins, abscisic acid, ethylene, brassin steroids and polyamines. Basic concepts of plant cell signaling and stress physiology. Role of jasmonic acid, salicylic acid, nitric oxide and phospholipids.
6. **Secondary metabolites in context of plant growth and metabolism:** Alkaloids and plant Phenolics; their distribution and site of production in plant. Role of Alkaloids and Phenolics in plant growth and function. Medicinal plants and their uses.

Intended Learning Outcome:

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

- Describe the main mechanisms through which metabolic processes are controlled.
- Demonstrate the light dependent reactions that take place during photosynthesis, identify the light-independent reactions in photosynthesis.
- Explain the Calvin cycle in plants, including the significance of ATP and NADH and the ultimate product(s) of the reaction.
- Compare and contrast photosynthesis and respiration, and their relationship in the global carbon and oxygen cycles.
- Discuss the observations that led to the discovery of photorespiration, will able to comprehend the need of photorespiration and the dual nature of Rubisco.
- Elucidate the energy cost involved in photorespiration and the concept of compartmentalization of the photorespiratory pathway.
- Contrast C_3, C_4, and CAM photosynthesis and explain how different photosynthetic modes allow plants to adapt to a particular environment.
- Identify specific points of the process which are critical for molecular level manipulation to accelerate the fixation and assimilation process.
- Explain plant hormones and secondary metabolites and their potential role in plant growth and metabolism.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Plant cell and metabolism specialties	5
02.	Photosynthesis	5
03.	Plant respiration specialties	5
04.	Nitrogen and sulfur assimilation and metabolism	5
05.	Plant hormones	5
06.	Secondary metabolites	5
Total classes		**30**

Recommended Books and Readings:

1. Plant biochemistry by Hans-Walter Heldt.
2. Introduction to Plant Biochemistry. T.W. Goodwin and E.I. Mercer. *Pergamon Press*.
3. Plant Biochemistry and Molecular Biology. Hans-Water, Heldt *Oxford University Press*.

4. Plant Hormones And Their Role in Plant Growth And Development. P.J. Davies. *Khuwer Academic Publishers.*

BMB-307: Basic Immunology 2 Credits

Introduction:

This course will introduce the students with the immune system, which is made up of special cells called the leukocytes, proteins (antibodies, cytokines, complement), tissues, and organs that work together to defend our body against attacks by microorganisms or other foreign invaders.

Objectives:

This course has the following objectives:

- To give the students in-depth understanding that the immune system can recognize and remember millions of different pathogens, and produce soluble mediators and cells to fight against them.
- To explain that an immunization (by a vaccine) introduces the body to an antigen in a way that doesn't make someone sick, but does allow the immune system to produce antibodies that will protect the person from future attack by the pathogen.
- Phagocytes comprising of the neutrophils and monocytes engulf the invading organisms by the innate immune response, and the lymphocytes remember and recognize previous invaders and help the body destroy them by the adaptive immune response.
- To describe morphology, markers and functions of T and B lymphocytes.
- Introduce the students with the structures of different antibodies that can neutralize toxins produced by different pathogens.
- To introduce how complement proteins assist the immune system.
- To explain diagnostic application of immunochemical techniques.

Contents:

1. Introduction to immunology: Innate and adaptive immunity, features of adaptive immune responses; cells and soluble mediators of immunity - complement, cytokines and antibodies; antigens, phases of adaptive immune responses - recognition of antigens, clonal selection and activation of lymphocytes, effector phase of immune responses, homeostasis; inflammation, chemotaxis, phagocytosis, defenses against extracellular and intracellular pathogens, vaccination, immunopathology.

2. Cells of the immune system:

i) Cells of the innate immune system: Mononuclear phagocytes and polymorphonuclear granulocytes, morphology and functions of phagocytes, neutrophils, eosinophils, basophils and mast cells, platelets, natural killer cells.

ii) Cells of the adaptive immune system: Antigen presenting cells, lymphocytes, morphological heterogeneity of lymphocytes, resting blood T and B cells, characteristic morphological heterogeneity of lymphocytes, resting blood T and B cells, characteristic surface markers of

lymphocytes, cluster designation (CD), families of cell surface markers, T-cell antigen receptor complex, B-cell differentiation, lymphoid tissues.

3. Immunoglobulins: Distribution of major human immunoglobulins, immunoglobulin classes and subclasses, physicochemical properties and functions of human immunoglobulin classes, general properties of immunoglobulins, molecular structure of antibodies - general feature, variable and constant regions, association between heavy and light chains; antibody effector functions; structure of immunoglobulin in relation to function - enzymatic cleavage of human IgG1, structure in relation to antigen binding, genetic basis of antibody diversity - isotype, allotype, idiotype.

4. Antigens: Chemical basis of antigenicity, immunogenicity, antigenic determinants, haptens, antigen-antibody binding, antibody affinity and avidity, antibody specificity and cross-reactivity; physiological significance of high and low affinity antibodies.

5. The complement system: Complement proteins, activation and regulation of complement pathways - classical, alternative and lectin pathways; membrane attack complex (MAC), biological effects of complement

6. Techniques in antigen-antibody interactions: Precipitation reactions, agglutination reactions, simple immunodiffusion, double immunodiffusion, immunoelectrophoresis, counterimmuno-electrophoresis, two-dimensional immunoelectrophoresis, complement fixation, radioimmunoassay (RIA), enzyme-linked immunosorbent assay (ELISA), imunofluorescence, agglutination of bacteria, hemagglutination, nephelometry.

Intended Learning Outcome:

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

- Demonstrate an understanding of the functions of leukocytes in the innate and adaptive immune responses that defend our body against foreign invaders.
- Develop confidence and skills to apply their acquired knowledge that the B lymphocytes secrete antibodies for defenses against pathogens while T cells specifically recognize the invaders and destroy them, and also provide signals (cytokines) to help other cells.
- Elucidate that some small regions in the structure of all antibodies are extremely variable, allowing millions of antibodies with slightly different structures, to exist which give them enormous diversity to recognize a wide variety of antigens.
- Explain the functions of the complement system in killing bacteria, viruses, or infected cells and help removal of immune-complexes from the circulation.
- Describe different immune effector mechanisms.
- Explain the roles of antigens in immune response, antigen-antibody interactions.
- Interpret the principles, methodologies and applications of immunoelectrophoresis, immunodiffusion, RIA, complement fixation, ELISA techniques.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Introduction to immunology	6
02.	Cells of the immune system	5
03.	Immunoglobulins	6
04.	Antigens	3
05.	The complement system	4
06.	Techniques in antigen-antibody interactions	6
Total classes		**30**

Recommended Books and Readings:

1. Immunology, 6th Edn., by Ivan Roitt, Jonathan Brostoff, David Male
2. Basic & Clinical Immunology, 6th Edn., by Daniel P. Stites, John D. Stobo, J. Vivian Wells
3. Fundamentals of Immunology by O. G. Bier, W. D. De Silva, D. Gotze, I. Mota
4. Kuby Immunology by Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne
5. Essential Immunology, 9th Edn., by Ivan M. Roitt
6. Biochemistry by Lubert Stryer

BMB-308: Laboratory Science and Clinical Biochemistry 4 Credits

Introduction:

This course provides a detailed knowledge and understanding of the clinical laboratory practices, services and tests that are needed for the diagnosis, prognosis and treatment of disease along with basic understanding of common human diseases. This course describes common clinical diagnostic procedures and the course curriculum is concerned with methodology and interpretation of a wide range of in vitro chemical and biochemical tests performed on body fluids and tissues, to support diagnosis, treatment and monitoring of disease. Students will also gain knowledge about the interpretation of patient results in a variety of clinical settings. They will also learn biochemical interpretation of some common diseases. They will also learn basic laboratory practices to maintain biosafety and biosecurity in laboratory environment along with basic knowledge regarding maintaining quality of laboratory works.

Objectives:

The objectives of this course are to introduce students to:

1. In this course, the students will be introduced to some basic aspects of a clinical diagnostic laboratory. These aspects include clinical laboratory safety and security, quality control and quality assurance of tests, knowledge of common clinical laboratory

instruments, test specimen collection and preservation, diagnostic assay principle, interpretation of test results, significance of diagnostic tests, biochemistry of some common diseases, biological waste management etc.

2. Provide students with a broad and balanced foundation of clinical laboratory knowledge and practical skills; performing effectively in clinical diagnostic services, academics and quality assurance; and function independently or in collaboration with other members of the health team in the care of individuals and groups at all levels of health care.
3. Another objective of this course is to introduce the students with good clinical practices that includes maintaining bio-safety in the lab environment as well as learning about proper biological waste management in order to prevent biohazards in the environment.
4. Identify the important parameters in the design of a laboratory to conduct the most commonly-used diagnostics protocols and ensure quality analysis of tests and other procedures.
5. Become proficient in the techniques required in order to perform the most commonly-used diagnostics protocols.
6. Use critical thinking skills to trouble shoot problems as they occur and determine possible causes.

Contents:

1. Introduction to Laboratory Biosafety and Biosecurity: Definition, risk analysis (risk assessment, risk management and risk communication), biological hazards and chain of infection, classification of microorganisms by risk group, common pathogenic agents of research animals and zoonosis, biosafety from airborne microorganisms; biocontainment (biosafety levels, hierarchy of control, engineering control, administrative control, safety equipment, PPE and good laboratory practices) standard precautions for handling human specimens, packing and shipping biological materials, biosecurity.

2. i) Quality control and quality assurance system in clinical diagnostics: Internal quality control and external quality assurance system, common pre-analytical and analytical errors. Characteristics of laboratory data (accuracy and precision), establishment and use of reference values, concept of reference values and reference state, unexpected test results, sensitivity and specificity, standardization of assay methods. Standard operating procedure (SOP), good clinical laboratory practice (GCLP).

ii) Introduction to common laboratory instruments: Principle and use of common instruments like spectrophotometer, biochemistry analyzer, electrolyte analyzer, hormone analyzer, ELISA reader and thermocycler.

3. Specimen collection and preservation for diagnostic tests: Collection and

preservation of specimen in laboratory, use of preservatives.

4. Clinical application of enzymes and metabolites as diagnostic tools: Preference of enzymes as diagnostic tools, serum/plasma enzymes, factors considered in enzyme diagnosis.

5. i) Disease and its Diagnosis: Diseases, causes of diseases, parameters of diseases (symptoms, sign, and lesion), Significance of diagnostic test, hazards in diagnostic tests.

ii) Diagnosis of organ specific diseases: (assay principle, assay procedure and diagnostic importance of different enzymes and biomarkers):

a) Regulation of blood glucose and diabetes: Normal plasma glucose levels, factors maintaining blood glucose, effects of hormones on glucose level, types of diabetes, diagnosis of diabetes, Metabolic derangements in diabetes.
b) Diagnosis of pancreatic diseases: Acute pancreatitis, assay principle and procedure of lipase, amylase.
c) Cardiovascular diseases and hyperlipidemia: Hyperlipidemias, Atherosclerosis and coronary artery disease, Risk factors for coronary artery disease, Pathogenesis of atherosclerosis. Diagnosis of Myocardial Infarction; assay procedure and diagnostic importance of different biomarkers like creatine kinase (CK-MB), AST, LDH and cardiac troponin I.
d) Liver and Gastric function tests: (Tests of hepatic excretory function)
   Serum – Bilirubin; total, conjugated, and unconjugated. Urine – Bile pigments, bile salts and urobilinogen.
   Liver enzyme panel (markers of liver injury/cholestasis) Alanine amino transferase (ALT), Aspartate amino transferase (AST), Alkaline phosphatase (ALP), Gamma glutamyl transferase (GGT).
   Plasma proteins (Tests for synthetic function of liver) Total proteins, serum albumin, globulins, A/G ratio, Prothrombin time
   Special tests: Ceruloplasmin, Alpha-1-antitrypsin (AAT), Alpha- fetoprotein (AFP).
e) Kidney Function tests: Glomerular and tubular functions, abnormal constituents of urine, clearance tests (inulin, urea, creatinine).
f) Prostate function test: Acid phosphatase and Prostate specific antigen (PSA) tests.
g) Anemia: Hemoglobin, iron, transferrin, TIBC, and ferritin.
h) Some special biomarkers: D-dimer, procalcitonin, C-reactive protein (CRP), CA 15-3, CA 125, CA 27.29 and Carcinoembryonic antigen (CEA).

iii) Serum electrolytes: Specimen processing and methods for determination of serum electrolytes and blood gases (Na^+, K^+, Cl^-, $HCO3^-$).

6. Biochemistry of some common diseases: Biochemical interpretation of the causes, diagnosis, and possible treatment options of Hyperuricemia, Gout, Rheumatoid arthritis, Malabsorption syndrome, Acidosis and alkalosis, and Obesity.

7. Biological waste management: Biological waste management including blood and related products, cultures decontamination and disinfection options; disposable procedure for liquid, sharp radioactive and mixed wastes, etc.

Intended Learning Outcome:

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

1. Identify the hazards and risks in a clinical laboratory and maintain precautions to minimize the hazards.
2. Demonstrate which parameters can affect the analytical results of a specimen since it is collected until it is processed.
3. They will gain knowledge to carry out various laboratory analyses on clinical samples.
4. Explain laboratory data, parameters of diseases and interpret reference value, significance of clinical diagnostic tests.
5. Elucidate quality control and quality assurance system.
6. Integrate the knowledge gained on Biochemistry, Anatomy and Physiology, in order to understand the pathophysiology of disease processes and their correlation in the study of body functions.
7. Interpret causes and possible treatment options of some common diseases including diabetes, atherosclerosis, acidosis and alkalosis etc.
8. They will be able to ensure that the lab processes and operations run efficiently and guarantees the production of accurate and reproducible results
9. They will gain more ability to understand and carry out clinical scientific research.
10. Gain Knowledge to efficiently use and operate various laboratory equipment.
11. Ability to work as part of a team among the medical setting.
12. Ability to apply appropriate specific safety measures when dealing with clinical samples and patients.
13. Ability to apply appropriate general laboratory safety measures and utilize protective equipment.
14. Gain knowledge to identify issues and troubleshoot them should they arise among the laboratory setting.
15. Ability to apply quality control and quality assurance measures and protocols in the laboratory setting and apply proper biological waste management system in laboratory set up.

Required Number of Classes:

No	Title of the unit	Number of classes
1.	Introduction to Laboratory Biosafety and Biosecurity	5
2.	Quality control and quality assurance system	4
3.	Introduction to common laboratory instruments	4
4.	Specimen collection and preservation for diagnostic tests	5
5.	Clinical application of enzymes and metabolites as diagnostic tools	5
6.	Disease and its Diagnosis	5
7.	Diagnosis of organ specific diseases	20
8.	Serum electrolytes	4
9.	Biochemistry of some common diseases	4
10.	Biological waste management	4
Total Classes		**60**

Recommended Books and Readings:

1. Clinical Chemistry by Lawrence A. Kaplan.
2. Applied Biochemistry of Clinical Disorders. A. Gernell. *Lippincott*.
3. Clinical Chemistry. Principles & Techniques. Edited by Richard J. Henry, Donald C. Cannon. James, W. Winkelman. *Harper & Row Publishers*.
4. Clinical Chemistry. Interpretation & Techniques. Alex Kaplan & Laverne L. Szabo.

BMB-309: Laboratory Work 8 Credits

Introduction:

This course is designed for hands-on-training of different techniques in biochemistry and molecular biology. The students will learn the principles of these techniques and then perform laboratory experiment. As part of their continuous laboratory skill development, the students will be able to practice basic molecular biology techniques including but not limited to plasmid isolation, PCR, gel electrophoresis, selection of clone of interest and genetic transformation. In addition, the students will also learn and perform experiments in enzymology, TLC and estimation of active compounds in drugs (such as acetaminophen and salicylate).

Objectives:

This course has the following objectives:

- To provide the students with a platform for practical experiments using advanced biochemistry and basic molecular biology techniques.

- To introduce the molecular biology experiments including extraction of nucleic acid, performing polymerase chain reaction (PCR), and gel electrophoresis.
- To train the students on plasmid isolation and selection of desired clones using antibiotic resistance gene as a means of selection.
- To enable the students with analytics ability on enzyme kinetics and influence of different factors on enzymatic activity.
- To train the students on basic chromatographic techniques for separating small molecules.
- To provide practical training on estimation of active compounds in drugs (such as acetaminophen and salicylate).
- To perform laboratory experiments on nutritional biochemistry (e.g. estimation of glycogen).

Contents:

(A) Study on the solubility and precipitation of proteins:

1. Effect of ionic strength on protein solubility.
2. Determination of total globulin in serum by precipitation.
3. Effect of pH on protein solubility (precipitation of serum albumin and globulin at their respective pI).

(B) Clinical Biochemistry:

1. Assay of bovine kidney alkaline phosphatase activity and determination of K_m and Vmax.
2. Determination of serum acid phosphatase activity.
3. Assay of muscle lactate dehydrogenase and coenzyme NAD^+.
4. Assay of pancreatic lipase.
5. Determination of serum cholesterol.
6. Estimation of acetaminophen in serum.
7. Estimation of salicylate in serum.

(C) Nutritional Biochemistry:

1. Extraction and estimation liver glycogen.
2. Determination of brain phospholipid.
3. Thin layer chromatographic separation of amino acids.
4. Separation of components of a lipid mixture by TLC.
5. Determination of total fatty acids in a lipid extract.
6. Determination of proximate composition of foodstuff.

(D) Molecular Biology:

1. Isolation of plant DNA from onion by chemical method.

2. Isolation of plasmid DNA from *E. coli*.
3. Transformation of *E. coli* with plasmid DNA.
4. Agarose gel electrophoresis of DNA.
5. Isolation and assay of bacteriophage lamda, amplification of DNA by polymerase chain reaction (PCR).
6. Polyacrylamide gel electrophoresis of proteins.

(E) Assignment:
Out of 200 marks of this course, 20 marks are allotted for an assignment. For which, every student will be assigned a separate project and will be asked to use library, internet etc. to dig out information and submit a short report on the project.

Intended Learning Outcome:

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

- Prepare different consumables and buffer solutions for laboratory use.
- Perform TLC for the separation and identification of sugars and amino acids.
- Perform PCR for the amplification of target gene and gel electrophoresis of the PCR products.
- Estimate the active compounds in different drugs.
- Perform genetic transformation and selection of desired clones.
- Analyze the enzymatic activity of a target enzymes.
- Estimate glycogen and phospholipid content from tissue samples.

Required Number of Classes:
For laboratory work, students will have to complete 3-4 experiments per credit that consists of theory lecture for each experiment and laboratory work. To complete an experiment, approximately one hour of theory lecture and 4-6 hours of laboratory work are required.

No	**Title of the unit**	**Number of experiments**
1.	Study on the solubility and precipitation of proteins	3
2.	Clinical Biochemistry	7
3.	Nutritional Biochemistry	6
4.	Molecular Biology	6
Total experiments		**22**

Recommended Books and Readings:
1. Laboratory manuals.

BMB-310: Viva-voce **2 Credits**

Introduction:

This course is designed to assess the overall depth and clarity of knowledge gained in relevant courses during the current academic session. This course will provide a platform for the students to showcase their basic understanding of the overarching goals and approaches of different courses taught during the academic session.

Objectives:

The objective of the viva-voce exam is to:

- assess the overall knowledge of a student on a particular academic topic.
- enable them the platform to develop their interpersonal communication skills.
- provide a foundation for formal discussion on an academic topic with the current peers (in this case, the examiners of the examination committee).

Contents:

The content of the viva-voce exam includes all the topics taught in the theory and practical courses, throughout the academic year.

Intended Learning Outcome (ILOs):

By participating in the Viva-voce exam, the students will be able to –

- Develop basic communication skills
- Express their depth and clarity of knowledge on an academic topic.
- Showcase and improve on their scientific discussion skill.

Extra-departmental courses:

BMB-351: Applied Biostatistics **4 Credits**

Introduction:

This course is designed to assist the students with statistical concepts and thoughts including introduction to the statistics, sampling technique, classification, diagrammatic and graphical representation, measures of central tendency, measures of dispersion, correlation analysis, regression analysis, probability and test of hypothesis. Generally, this course focuses on the basics and essentials of statistics, which may be broadly described as the techniques to collect, clarify, summarize, organize, analyze and interpret numerical information in the biological field.

Objectives:

The specific objectives of this course for the students of Biochemistry and Molecular Biology are to:

- procure knowledge and information about the elementary and fundamental statistical terms, data collection procedure, analyze and interpret the data through basic statistical theories.
- learn about the basics of R-language.

Contents:

Theory (50 Marks):

1. **Introduction**: Definition, population, sample, parameter, variable, data; biostatistics - definition and applications, scope of biostatistics in applied field.
2. **Sampling techniques:** Basic idea about sampling and concept about simple random sampling.
3. **Classification:** Definition and different types of classification, frequency distribution, cumulative frequency distribution.
4. **Measures of central tendency**: Definition, different types of measures of central tendency, arithmetic mean, weighted arithmetic mean, median, quartiles, deciles, percentiles, mode.
5. **Measures of dispersion:** Definition, absolute measures of dispersion- range, quartile deviation, mean deviation, variance, standard deviation; relative measures of dispersion-

coefficient of range, coefficient of quartile deviation, coefficient of mean deviation, coefficient of variation, box and whiskers plot.

6. **Correlation analysis:** Definition, types of correlation, methods of studying correlation, properties of correlation coefficient, rank correlation coefficient.

7. **Regression analysis:** Definition of regression analysis, application of the least square method, goodness of fit in regression.

8. **Probability:** Understanding probability, theorems on probability, independence of events, conditional probability, random variable, probability distribution,Bernoulli distribution, binomial distribution, Poisson distribution, normal distribution.

9. **Test of hypothesis:** Concepts, hypothesis, test of hypothesis, statistical hypothesis, null hypothesis, alternative hypothesis, level of significance, type I error, type II error, critical region, test statistic, testing procedure, p-value, confidence interval; different types of tests: i) test of a specified value of a single mean, ii) test of equality of two means, iii) test of equality of several means, iv) paired t-test, Chi-squared (χ^2) test,

Practical (50 Marks):

- Introduction to R programming and SPSS.
- Descriptive Statistical analysis.
- Correlation analysis.
- Regression analysis
- Test of hypothesis.

Intended Learning Outcome:

After completion of the course students are expected to be able to:

- How to define the terms say, population, sample, parameter, statistics and so on.
- How to define and differentiate among different types of scales of measurements say, nominal, ordinal, interval and ratio scale of measurements.
- How to create and interpret frequency tables, histograms, cumulative frequency tables, stem and leaf plots and scatter plots manually and by using the most popular statistical software named SPSS.
- How to calculate and apply measures of central tendency and measures of dispersion to the data by hand and by SPSS.
- How to calculate and interpret the correlation coefficients and regression lines.
- How to apply discrete and continuous probability distributions to numerous problems.
- How to draw a sample by hand and through SPSS.
- How to formulate the hypotheses.

- How to perform test of hypothesis manually and by SPSS.
- How to make relevant conclusions and interpretations.
- How to calculate and interpret the confidence interval.
- How to use properly the knowledge of statistics to the data of Biochemistry and Molecular Biology.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Introduction	3
02.	Sampling Technique	3
03.	Classification	3
04	Measures of Central Tendency	2
05	Measures of Dispersion	2
06	Correlation Analysis	2
07	Regression Analysis	2
08	Probability	6
09	Test of Hypothesis	7
Total classes		**30**

Recommended Books and Readings:

1. An introduction to Statistics and Probability by Islam M. N.
2. Basic Statistics by Jalil, A. and Ferdous, R.
3. Methods of Statistics by Mostafa, M. G.
4. Elementary Statistics by Larson, R. And Feber, B.
5. Biostatistics: A Foundation For Analysis In the Health Sciences by Wayne W. Daniel

BMB-352: Microbiology **2 Credits**

Introduction:

Microbiology deals with the study of various types of both prokaryotic and eukaryotic microbes for instance bacteria, virus fungus and protozoa. Microbes and their activities are very important in our daily life because they affect every aspect of our lives. This advance Microbiology course (BMB-352) mostly covers host-pathogen interaction in various diseases, metabolism and control of pathogens and the uses of microbes in diverse area of Microbiology including food, industry, agriculture and environment. The course is appropriate for the students who had taken the basic Microbiology (BMB-152) course at 1st year and gained an understanding of the fundamental concepts of microbes and diseases.

Objectives:

This course has the following objectives:

- Know the processes of bacterial metabolism, fermentation and uses of bacteria for production of primary metabolites including ethanol, vinegar, butanol and citric acid.
- Understand in details the host-pathogen interaction during disease condition including virulence factors, pathophysiology, mode of transmission, symptoms, diagnosis and prevention of some common bacterial diseases.
- Know the mechanism of how the bacterial diseases can be treated / prevented.
- Learn about some food and waterborne diseases including typhoid, dysentery etc.
- Know the processes of using bacteria for food production (yogurt, cheese etc) and preservation.
- Learn how to transfer bacteria from laboratory to industry for large scale production of primary and secondary metabolites including various antibiotics and drugs.
- Understand the mechanism of plant-microbes interaction and the role of microbes on turnover of nitrogen, carbon and sulfur in soil.
- Know the process of biogas production and microbial degradation of industrial effluents.
- Learn in details about biocontrol agents e.g. *Bacillus thuringiensis* toxin and baculoviruses.

Contents:

(Theory: 40 Marks)

1. **Microbial metabolism:** Aerobic and anaerobic metabolism; fermentation; microbial fermentation for production of ethanol, acetic acid or vinegar, butanol, citric acid.

2. **Host-microbe interaction:** Normal microbial population of healthy human body - skin, mouth, respiratory tract, urino-genital tract, eye; pathogenicity, colonization and growth,

virulence; virulence factors - exotoxins, enterotoxins, endotoxins, neurotoxins; entry of pathogens into the host; mechanism of bacterial pathogenicity; avoidance of host defense mechanisms by microbes and host's innate resistance to infection; brief idea about morphology, biochemical characteristics, mode of transmission, disease symptoms and diagnosis of diseases mediated by pathogenic microbes like *V. cholerae*, *S. typhi*, *H. pylori*, *C. albicans.*

3. **Control of pathogens (very brief idea):** Definition and classification of antibiotics on the basis of structure and mode of action; antibodies and antibiotics; semi-synthetic and new generation of antibiotics; mode of action of common antibiotics used; bacterial resistance to antibiotics; chemotherapeutic agents like sulfa drugs.

4. **Food Microbiology:** Microbes in food spoilage and contamination; food and water borne diseases like food poisoning, typhoid, dysentery etc.; brief idea about food preservation – pasteurization, high and low temperature; drying, salt etc.; food produced by microbes like yogurt, cheese, etc.

5. **Industrial microbiology:** Concepts of transferring bacteria from lab to industries; examples of industrially important microbes and their products; primary and secondary metabolites.

6. **Agricultural and environmental microbiology:** Microbes in soil fertility; symbiotic and non-symbiotic nitrogen fixation with mechanism; microbes in nitrogen cycle, carbon cycle, sulfur cycle; methanogenic bacteria and methane production (biogas); brief idea about microbial degradation of industrial effluents; bioleaching, bioaugmentation.

7. **Microbial toxins and insecticides:** Insecticidal toxin of *B. thuringiensis*, mode of action and use, engineering of *B. thuringiensis* toxin gene, baculoviruses as biocontrol agents.

Laboratory Work (10 Marks):

1. Enumeration of bacteria from water sample.
2. Bacterial growth curve.
3. Screening of amylase producing bacteria from environmental samples.

Intended Learning Outcome:

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

- Acquainted with the fermentation process along with production of important primary metabolites through aerobic/anaerobic metabolism.

- Acquire detail knowledge on host-microbe interaction, pathophysiology of microbial infection: transmission, disease symptoms and diagnosis of diseases.
- Explain about antibiotics and their detail mode of action for controlling bacterial infection.
- Illustrate the knowledge of transferring a microbe from a laboratory to the industry.
- Demonstrate how to protect foods from microbial spoilage and the use of bacteria in food industry for large-scale production of yogurt, cheese etc.
- Identify techniques used in the different phases of industrial microbiology: discovery, production (including fermentation and scale-up), bioprocessing.
- Apply knowledge on application of microbiology in the field of food, industrial, agricultural and environmental microbiology.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Microbial metabolism	4
02.	Host-microbe interaction	4
03.	Control of pathogens (very brief idea)	4
04.	Food Microbiology	3
05.	Industrial microbiology	3
06.	Agricultural and environmental microbiology	3
07.	Microbial toxins and insecticides	3
Total classes		**24**

Recommended Books and Readings:

1. Microbiology by E.C.S. Chan, Michael J. Pelczar, Jr.,Noel R. Krieg
2. Microbiology, An introduction. by Tortora, Funke, Case
3. Prescott's Microbiology by Joanne Willey, Linda Sherwood, Chris Woolverton
4. Industrial Microbiology by Prescott & Dunn's
5. Microbiology by Nester Roberts, Lidstrom, Pearsall, Nester.

****

4th year BS Honors

Total Credits in 4th Year BS (Honors): 40 Credits

Course No.	Name of the course	Credits
Departmental courses:		
BMB-401	Cell Biology	4
BMB-402	Plant Biotechnology	2
BMB-403	Pharmaceutical and Food Biotechnology	4
BMB-404	Molecular Biology-IV	2
BMB-405	Biochemistry of Cancer	2
BMB-406	Virology	2
BMB-407	Immunology	4
BMB-408	Biochemistry of Drugs	2
BMB-409	Neurobiochemistry	2
BMB-410	Applied Human Nutrition	2
BMB-411	Basic Bioinformatics	2
BMB-412	Research Methodology	2
BMB-413	Laboratory Work	8
BMB-414	Viva-voce	2
	Total	**40**

BMB-401: Cell Biology **4 Credits**

Introduction:

This course focuses on structural components of cells and fundamental cellular processes including cell division, cell cycle, membrane dynamics, vesicle trafficking, stem cells and tissue maintenance. We will also discuss the technical and analytical tools utilized in cell biology as well as translational aspects of current cell biological research.

Objectives:

The objectives of this course are listed below:

- Discuss the structural and functional basis of cytoskeletal structures.
- Explain the membrane structure and its role in cell communication.
- Elaborate the mechanisms of cell cycle regulation.
- Describe intricate relationship between various cellular components and their trafficking.
- Discuss the cellular signaling pathways and their implications in cellular homeostasis and in different diseases.
- Describe the characteristics of stem cells and the process of tissue maintenance.

Contents:

1. **The cytoskeleton:** Muscle contraction, ciliary movement, general features of microtubules and actin filaments as dynamic assemblies, microtubule organizing centers and microtubule associated proteins, actin filaments and actin binding proteins in nonmuscle cells, intermediate filaments, organization of the cytoskeleton and cell behavior.

2. **Membrane targeting of proteins:** The secretory pathway, signal sequences to target for translocation, translocation of protein coupled to translation, post-translation translocation, transmembrane translocation, processing of proteins for translocation, the endoplasmic reticulum, the ER membrane, signal sequences associated with transport into and out of mitochondria.

3. **Protein trafficking between membranes:** Exocytic and endocytic pathways, vesicle mediated protein transport, signal mediated and bulk flow transport, transport from ER to the Golgi apparatus and from Golgi apparatus to ER, Rab GTPases, tethers, SNARE proteins, clathrin coated vesicles.

4. **Germ cells and fertilization**: Meiosis, primordial germ cells and determination of gender in mammals, eggs, sperm and fertilization.

5. **Development of multicellular organisms**: Universal mechanisms of animal development, patterning of the anterior posterior axes, organogenesis and pattering of appendages, cell movements and shaping of the vertebrate body, neural development.

6. **Cells in their social context:** Cell-cell junctions, cell adhesion and the extracellular matrix of animals, integrins.

7. **Cell growth and cell division:** Control of cell division, tumor viruses as a tool for studying the control of the cycle events in the S phase, the logic of the cycle, cell division. Regulation of cell cycle by CDK and associated proteins, cell cycle check points, regulation of passage through check points, effects of cell cycle deregulation.

8. **Cell Signaling/Cell communication:** General features of cell signaling, PI3-kinase regulated signaling, signaling through ion channels, G-protein controlled signaling, growth factor/ receptor tyrosine kinase mediated signaling, the wnt pathway regulated signaling, Src protein kinase mediated signaling, mitogen activated protein kinase (MAPK) signaling, Notch and hedgehog signaling.

9. **Differentiated cells and the maintenance of tissues:** Maintenance of differentiated state, tissues with permanent cells, renewal by simple duplication, renewal by stem cells, epidermis, renewal by pluripotent stem cells, blood cell formation, quiescent stem cells, skeletal muscle, soft cells and tough matrix, growth turnover, repair of skeletal connective tissue, territorial stability in the adult body. Applications of stem cells.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Describe cytoskeletons and various cytoskeletal and functional aspects of microtubules, actin filaments and intermediate filaments.
- Relate interaction of cytoskeletons with different motor proteins.
- Explain cellular processes including ciliary and flagellar movement, muscle contraction and diseases associated with them.

- Describe relationships between cellular membrane and transport mechanisms.
- Relate structure, locations and functions of different biological transport mechanisms including symporters, antiporters, uniporters, aquaporins and ATPases
- Describe cell division, cell cycle and its regulation and the effects of cell cycle deregulation.
- Explain cell renewal and maintenance of tissues with special emphasis on stem cells.

Required Number of Classes:

No	Title of the unit	Number of classes
01	Membrane and transport mechanisms	10
02	Membrane targeting of proteins	6
03	Protein trafficking between membranes	7
04	Microtubules and associated motor proteins	7
05	Actin filaments and associated myosin molecules	6
06	Intermediate filaments	6
07	Cell division	5
08	Cell cycle and its regulation	6
09	Differentiated cells and maintenance of tissues	7
Total classes		**60**

Recommended Books and Readings:

1. Cell Biology, by Gerald Karp.
2. Molecular Biology of the Cell, by Bruce Alberts, Alexander Johnson and Julian Lewis.
3. Lewin's Cell, by Lynne Cassimeris, Vishwanath R. Lingappa and Benjamin Lewin.
4. Molecular Cell Biology, by Harvey Lodish et. al.

BMB-402: Plant Biotechnology **2 Credits**

Introduction:

Agriculture is the mainstay of Bangladesh. Molecular tools have shown the way to obtain precise and accelerated crop improvement. The students will be introduced to these modern biotechnological tools, which can lead to the production of superior crops and ensure food security for the future.

Objectives:

- This course deals with the application of modern tools of Biochemistry, Biotechnology and Molecular Biology for Crop Improvement.
- With the advances in knowledge about cell, organ, tissue and plant physiology, the sequencing of many genomes and stress-specific gene-expression, many biotechnological tools have become available for application in crop improvement programs. The students will learn about these tools and how these can be used in specific crop improvement programs.

Contents:

1. **Plant cell culture and applications:** Manipulation at cellular level, totipotency of plant cells, somatic embryogenesis, organogenesis, recalcitrant plants, micropropagation and applications, disease-free plants, protoplast culture and fusion with reference to cybrids and cytoplasmic male sterility, anther culture and applications for breeding, commercialization of tissue culture technology, plant tissue culture as a basis for genetic engineering.

2. **DNA markers and application for breeding:** Fingerprinting for assessment of germplasm, concept of polymorphism, mapping and breeding populations, linkage of marker to trait of interest, marker-aided selection for breeding.

3. **Plant genetic transformation – prospects and potential:** Current status, characters transformed, techniques for plant transformation such as agrobacterium-mediated and biolistics, use of constitutive, tissue-specific and stress-specific promoters for transformation, molecular assessment of transgenic status and inheritance of transgenes, gene silencing, current status of chloroplast transformation and advantages, plants as bioreactors and vaccine production systems, biosafety issues, GM crops.

4. **Discovery/cloning of plant genes:** Probe-based-screening, genomic and proteomic approaches, map-based cloning, transposon tagging, isolation by T-DNA insertion, functional characterization by gene mutagenesis/silencing.

Intended Learning Outcome:
After successful completion of the course, students will be able to:

- Elucidate how to culture plants in vitro for multiplication of unique genotypes for ornamentation, commercial output, disease-free material or re-forestation and genetic manipulation.
- Explain the need for biodiversity and seed banks for searching useful genes for targeted introgression into commercial varieties.
- Identify, clone and express useful genes in plants systems using Biochemistry, Bioinformatics and Molecular Biology Principles. They will have knowledge about production of stress-tolerant varieties anduse of latest technologies to monitor transgene utility, function and safety in environment.
- Describe the principles of DNA markers as applied to genetic linkage mapping and establishing DNA-trait linkage for precise breeding and gene pyramiding to speed up and make breeding more efficient. They will be understand the use of Single nucleotide polymorphism and the concept of genome wide association mapping or GWAS.

Required Number of Classes:

No.	**Title of the unit**	**Number of classes**
01.	Plant cell culture and applications	9
02.	DNA markers and application for breeding	7
03.	Plant genetic transformation – prospects and potential	8
04.	Discovery/cloning of plant genes	6
Total classes		**30**

Recommended Readings

1. Plant Biotechnology by J Hammond, P McGarvey and V Yummond
2. In vitro culture of higher plants-Pierik
3. Plant Biotechnology-Chawla
4. Plant Biotechnology by Slater, Scott and Fowler
5. Plant Development and Biotechnology: Trigiano and Gray
6. Plant Biotechnology-a laboratory manual-by Purohit.
7. Plant Biotechnology and Genetics by Stewart.

BMB 403: Pharmaceutical and Food Biotechnology **4 Credits**

Introduction:

This course provides an overview of different aspects of pharmaceutical and food biotechnology. It will specifically provide knowledge of current technology and processes using in those industrial setups. It also provides fundamental insights to exploit enzymes, microbes and whole cell for the manufacturing of products, which have a huge industrial significance. In addition, this course will also provide an overview of the processes involved in food processing and the ethical perspective of food biotechnology

Objectives:

The course aims exposing students to various topics of pharmaceutical and food biotechnology.

- It will give an understanding about industrial production of biotechnology-derived products and the approval processes.
- Students will understand the use of living cells such as bacteria, yeast, algae or component of cells like enzymes from plants and animal origin to generate industrial products and processes. They will also study various techniques for strain improvement of microorganism to improve yield.
- Students will develop the basic skills for vertebrate cell culture, maintenance of cell lines and in vitro application of cell and molecular techniques and also to understand the principles of animal cloning and its applications.
- This course will also provide basic knowledge about food processing, preservation techniques, food quality and analysis and food safety laws.

Contents:

1. **Fermentation technology:** Principles of microbial growth kinetics; different types of fermentation; different types of fermenters, stages of fermentation process; upstream, downstream processing and product purification, analysis of finished products, formulation and filling; isolation, preservation and improvement of industrially important microorganisms; production of amino acids and organic acids; production of single cell protein.

2. **Production of specific pharmaceuticals:** Current status and future prospect of biopharmaceuticals; traditional pharmaceuticals of plant, animal and microbial origin. Guide to good manufacturing practice (GMP), role of regulatory authorities - FDA, European regulation; International pharmacopeia (USP, BP, EP).

   i) Hormones and growth factors: Insulin production; recombinant insulin and its formulation; engineered insulin; IGF, EGP, PDGF.

   ii) Antibiotics: Screening of antibiotic producers; cultural and semi-synthetic antibiotic production e.g. penicillin, cephalosporin, streptomycin, tetracycline etc.

   iii) Vaccines: Traditional vaccine technology involving attenuated, inactivated antigen etc.;

recombinant vaccine-peptide vaccine, adjuvant technology and its use, development of vaccine against hepatitis, cholera, FMD etc.

iv) Enzymes and nucleic acid therapeutics: DNase, alginate lyase; gene therapy and its application in various diseased conditions e.g. genetic diseases, cancer etc.

3. **Animal cell culture:** Animal cell culture characteristics, culture design and significance, hybridoma technology, monoclonal and polyclonal antibody production, antibody engineering. Manipulation of reproduction in animals– artificial insemination, embryo transfer technology, *in vitro* fertilization (IVF) technology, embryo cloning. Stem cells and their applications. Production of transgenic animals.

4. **Enzyme immobilization:** Different types of biocatalysts; different immobilization processes of biocatalysts - adsorption, covalent binding, entrapment, encapsulation; application of immobilized biocatalysts; multi-enzyme system.

5. **Food biotechnology:** Fermented food; dairy products, oriental fermentation; food ingredients; Food derived from lactic, ethanolic fermentation.

(i) Alcohol production: Technological trends in modern brewing; classic and modern malting process, wine production.

ii) Bread: Technology of baker's and forages yeast; pressed and dry yeast; anabiose of dry yeast cell.

iii) Dairy products: Biotechnological aspects of milk production; biological methods of shelf life elongation; technology of cheeses production; whey processing and butter production.

iv) Poultry products: Biotechnology of animal originated foods, biochemistry of meat maturation; processing of butcher by-products, processing of poultry, eggs, wild animals and fish.

v) Sweeteners production: Biotechnological aspects of saccharide processing - sugar, honey, cacao, chocolate, starch processing; modified and substituted starches production of high glucose corn syrup, artificial sweeteners.

vi) Probiotics: Production and uses.

6. **Food toxicology:** Introduction to food toxicology; toxicity testing; natural toxicants present in foods (plants, animals, marine and microbial toxins).

7. **Food processing and control:** Food preservation by heating, chilling, freezing, dehydration and ionizing radiation; food packaging and packaging materials; food laws and standards, prevention of food borne disease; concepts of food quality and safety - food hazards, risk assessment, process control, application of principles of food hygiene and relevant codes of practice/guidelines to ensure quality and safety, adulteration, elements of national food control system; food flavors, additives and supplements.

8. **Ethical perspective of food biotechnology:** Environmental impact; animal welfare; consumer perceptions; industry perspectives; producer perspective around the world; regulation of food biotechnology.

Intended Learning Outcome:
After successful completion of the course, students will be able to:

- Explain the fundamental insights to exploit enzymes and microbes for the manufacturing of products which have a huge industrial significance.
- Blend the science and engineering with various biochemical processes to obtain products of diverse fields such as chemicals, food, bioenergy etc.
- Illustrate the basic design of industrial scale fermentation processes using different bioreactors.
- Explain differences between upstream and downstream processing of industrial fermentation processes.
- Exhibit skills in the variety of fermentation, the principles of product recovery and subsequent processing approaches available for the manufacture of biological products.
- Describe and evaluate methods for enzyme immobilization and for characterization of the properties of immobilized enzyme.
- Demonstrate knowledge of basic cell culture techniques, establishment of cell lines and their maintenance, demonstrate knowledge on design and use the cell culture facilities, discuss the advantages and limitations of primary cell culture compared to immortalized or transformed cell lines.
- Explain the benefits and limitations (scientific and ethical) of producing processed foods and be able to recommend, justify and critique commonly used methods of food processing.

Required Number of Classes:

No.	**Title of the unit**	**Number of classes**
01.	Fermentation technology	10
02.	Production of specific pharmaceuticals	10
03.	Animal cell culture	7
04.	Enzyme immobilization	6
05.	Food biotechnology	10
06.	Food toxicology	10
07.	Food processing and control	5
08.	Ethical perspective of food biotechnology	2
Total classes		**60**

Recommended Books and Readings:

1. Molecular Biotechnology: Principles and Applications of Recombinant DNA. Textbook by Bernard R. Glick and Jack J. Pasternak
2. A Textbook of Biotechnology By R C Dubey.
3. Industrial Biotechnology by Varun Shastri.

BMB-404: Molecular Biology- IV **2 Credits**

Introduction:

This 2-credit course is intended for the students to understand the general process of control of initiation of transcription in eukaryotes and the mechanisms of post-transcriptional regulatory processing and the role of this process in control of gene expression. Students will also gain experience in gene structure and function, gene regulation, protein localization in relation to its function, genomics with reference to mobile genetic elements, chromatin structure and its relation to transcription and the epigenetics underpinning the developmental processes.

Objectives:

The objectives of this course are to introduce students to:

- Cis and trans regulators of eukaryotic gene expression and a distinction between them
- How differential post-transcriptional processing (alternative splicing or RNA editing) is used to modify gene expression in eukaryotes.
- A distinction between spatial and temporal control of gene expression
- the functions of proteins in the context of compartments that organize them in the cellular environment
- How DNA methylation and histone acetylation affects chromatin structure and the regulation of transcription
- How methylation of genes can result in gene imprinting and silencing.

Contents:

1. **Gene structure:** Interrupted genes, organization of exons and introns, distribution of genes, organization of gene families, variations in individual genomes, and organization of genes in the organelles. Repetitive genes, special features of metaphase chromosome, DNA-protein interaction in centromere and telomere.
2. **Mechanism of DNA loss and amplification:** Gene regulation, DNA rearrangement and gene shuffling.
3. **Mobile genetic elements:** Transposons and retroposons - characteristics and functions, evolution of these elements.
4. **Gene expression:** Tissue specific expression of proteins and messenger RNAs, post transcriptional events.
5. **Regulation at the transcriptional level:** Regulation of RNA splicing, RNA editing, regulation of RNA transport, stability and translation.

6. **Transcriptional control of DNA sequence elements:** Short sequence elements located within or adjacent to the gene promoter, enhancers, negative-acting sequence elements, locus control regions. Regulation by RNA pol I and III, DNA binding transcription factors.
7. **Transcription control of chromatin structure:** Changes in DNA methylation, alteration in histones, changes in chromatin structure**.**
8. **Protein localization**: Introduction, passage across membrane, protein translocation, chaperons, signals sequences of translocation.
9. **Epigenetics:** Epigenetics and chromatin dynamics, silencing, transcriptional landscapes and genomes, memory of transcriptional states, stem cells and reprogramming, maintenance of (Epi) genome integrity. Epigenetics and cancer.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Delineate a general understanding of the current knowledge of the molecular structure of eukaryotic genes
- Describe gene and genome organization.
- Discuss the molecular aspects of chromosome and gene structure, and how genes are replicated, expressed, and regulated.
- Describe Transposable elements as immobilized derivatives which account for a large fraction of eukaryotic genomes.
- Describe how transposable elements can affect nearby gene activity
- Demonstrate gene expression and regulation mechanisms.
- Explain the mechanism by which transcription is initiated in eukaryotic cells.
- Illustrate methods to identify key regulatory elements within a eukaryotic promoter.
- Explain cis and trans regulators, distinguish between them, and explain their interactions.
- Explain how transcriptional control is achieved through alterations in chromatin structure and methylation.
- Outline the mechanisms by which post-transcriptional control is achieved.
- Explain the structure, formation and function of microRNAs.
- Discuss the range of non-coding RNAs in the genome, including their annotation and function in gene expression regulation.
- Recognize and explain examples of transcriptional activation and inhibition.
- Predict the effects on gene expression resulting from regulatory perturbations.
- Delineate genetic variability resulting from polymorphisms and epigenetics.
- Demonstrate an understanding of how phenotype is affected by both genetic and epigenetic factors.

- Recognize epigenetic alterations as heritable changes persisting through cell division.
- Explain how some genes are activated and others silenced through histone modifications.
- Illustrate protein translocation into the endoplasmic reticulum.
- Recognize protein trafficking as a consequence of increased cellular complexity

Required Number of Classes:

No.	Title of the unit	Number of classes
01.	Gene structure	3
02.	Mechanism of DNA loss and amplification	2
03.	Mobile genetic elements	5
04.	Gene expression	2
05.	Regulation at the transcriptional level	4
06.	Transcriptional control of DNA sequence elements	3
07.	Transcription control of chromatin structure	4
08.	Protein localization	4
09.	Epigenetics	3
Total classes		**30**

Recommended Books and Readings:

1. Regulation of gene expression in the genomic context: Taylor J Atkinson , Marc S Halfon
2. Transcriptional Regulatory Elements in the Human Genome: Glenn A. Maston, Sara K. Evans, and Michael R. Green
3. CpG islands and the regulation of transcription: Aimee M. Deaton and Adrian Bird
4. Regulated functional alternative splicing in Drosophila: Julian P. Venables, Jamal Tazi and Francois Juge
5. Targeting the histone orthography of cancer: drugs for writers, erasers and readers Laia Simó-Riudalbas and Manel Esteller

BMB-405: Biochemistry of Cancer **2 Credits**

Introduction:

The course is designed to generate insights on the molecular processes that enable a normal cell to attain the hall-marks of cancer. This course encompasses different fields including biochemistry, molecular biology, cell biology, epigenetics, and immunology with respect to cancer. Through a series of combined lecture/literature review/discussion, this course presents how processes within the body, whether normal or perturbed in some way, are involved in carcinogenesis, tumor progression and molecular aberrations underlying the manifestations, epigenetic regulation of them, and the response to anti-cancer therapy.

Objectives:

- Students should be aware of the basic concept and functionality of Oncogenes, proto-oncogenes and tumor suppressor genes in the cancer context.
- Students should understand the difference between germ line and somatic mutation and their implications in cancer.
- Students should be familiar with the molecular mechanism of metastasis.
- Students should be familiar with the mechanisms of cell cycle regulation and how aberrant cell cycle regulation can lead to cancer.
- Students should understand the role of p53 tumor suppressor gene in cancer, DNA damage and apoptosis.
- Students should be familiar with the concept of DNA tumor viruses mediated cancer incidence.
- Students should understand the basic epigenomic regulations such as DNA methylation, histone modifications in mammalian systems.
- Students should be familiar with the existing therapeutic interventions for cancer such as chemotherapy, radiotherapy, mAB and small molecule based targeted therapy, immunotherapy and combination therapy.

Contents:

1. **Introduction and overview of cancer:** Oncogenes and proto-oncogenes, tumor suppressor genes and hereditary cancer, basic mechanisms of cell cycle regulation, targeted ubiquitination, mammalian cell cycle regulation. Cyclins and cyclin-dependent kinases, inhibitors of cyclin-dependent kinases.

2. **The molecular biology of cancer:** The retinoblastoma tumor suppressor gene, regulation of E2F transcription factors, transcription regulation by RB/E2F, p53 tumor suppressor gene, regulation of p53 response, DNA damage and cell cycle response, apoptosis, DNA tumor viruses, growth factors and receptors, non-receptor tyrosine kinases, Ras signalling and adapter proteins, cancer regression by senescence.

3. **Cancer as an epigenetic disease:** DNA methylation in cancer, gene silencing and cancer, methyl CpG binding proteins and cancer.

4. **Cancer treatment:** Effective cancer therapy through immunomodulation, dynamics of treatment, pharmacogenetics in cancer treatment, cellular senescence in cancer treatment, treating cancer's kinase addiction.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Identify the malignant and benign cancer by analyzing the clinical data and applying the core knowledge of cancer hallmarks.
- Illustrate differentiation between oncogene and tumor suppressor genes by analyzing their functions.
- Distinguish between familial and sporadic cancer by applying their knowledge of germ line and somatic mutations.
- Identify the regulatory check points in cell cycle which can potentially be aberrant in cancer context.
- Outline possible therapeutic interventions for cancer with the help of their knowledge regarding cell cycle regulations.
- Differentiate different mode of molecular aberrations such as point mutation, gene amplifications, large deletions and microsatellite instability.
- Explain the role of tumor suppressor gene such as p53 in cancer.
- Delineate how the p53 induced apoptotic response in inhibited in cancer cells.
- Dissect the molecular mechanism of different cancer by applying their core knowledge on growth factors and receptors (EGFR), non-receptor tyrosine kinases, Ras signalling and adapter proteins.
- Explain the hall marks of cancer by molecular events occur in cancer cells.
- Differentiate between different modes of epigenetic regulation such as DNA methylation and histone modifications.
- Correlate with the promoter-methylation of tumor suppressor genes and cancer progression.

- Distinguish the role of the methyl CpG binding proteins in cancer.
- Identify the aberrant histone marks that are commonly associated with different types of cancer.
- Differentiate different therapeutic approach by delineating their strength and weaknesses.
- Distinguish the therapeutic interventions that are applicable for different cancer types and different stages of cancer.
- Explore a strategy to overcome the chemo resistance features of certain cancer.
- Explain why certain therapy may not work for a particular cancer type or stage.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Introduction and overview of cancer	8
02.	The molecular biology of cancer	8
03	Cancer as an epigenetic disease	8
04	Cancer treatment	6
Total classes		**30**

Recommended Books and Readings:

1. Hallmarks of Cancer: The Next Generation: cell, by Douglas Hanahan, Robert A. Weinberg.
2. Robbins & Cotran Pathologic Basis of Disease, by Vinay Kumar, Abul K. Abbas, Jon C. Aster.
3. Robbins and Cotran Pathologic Basis of Disease, by Stanley L Robbins.
4. Epigenetic Cancer Therapy, by Steven Gray.

BMB-406: Virology **2 Credits**

Introduction:

The Virology course is designed to describe at the molecular level the replication strategies of representative DNA and RNA viruses and the effects of virus infection on cell growth control and survival. Emphasis is placed on developing an understanding of the experimental systems used to elucidate individual steps in virus life cycles and their interactions with host cells. Host cell-virus interactions leading to production of progeny virus and interactions involved in establishing and maintaining long term interactions, such as latency and oncogenesis, are discussed in detail.

Objectives:

The course is designed to address the following objectives:

- To describe the structure and replication strategies of the individual viruses discussed, including the processes of entry into cells, control of gene transcription and where relevant translation and gene product stability, control of and mechanism(s) of genome replication, virion assembly and egress from the cell.
- To define the process of virus latency and describe in molecular terms control of the process and activation of viral genomes during reactivation.
- To describe the growth behavior differences between normal cells and cells transformed by oncogenic DNA and RNA viruses.
- To describe the processes of senescence and apoptosis and discuss the impact of oncogenic viruses (and specific viral gene products or activities) on these processes.
- To integrate experimental strategies learned in the context of individual viral systems into the design of experiments involving other systems.

Contents:

1. **Classification of viruses:** Bacterial, plant and animal viruses with their nomenclature and classification.

2. **Virus cultivation, detection and genetics:** Cultivation of virus - cell culture, embryonated eggs, laboratory animals. Detection sp of virus in hosts - measurement of infectious units, measurement of virus particles and their component, serological and molecular detection, plaque assay (PFU), infectious center assay, one-hit kinetic and two-hit kinetics of virus cultivations. Genetic analysis of virus - classical genetic methods, engineering mutations into viruses, engineering viral genomes, viral vectors.

3. **Host virus interaction:** Attachment, entry and uncoating, replication, assembly and maturation, exit of virus from host cells. Mechanism of viral interation with cell.

4. **Animal virus:** Classification based on gene expression, studies on virion structure, infectivity, mode of gene expression and virus assembly of representative member of each class – herpes virus, papovavirus, hepatitis virus (HBV and HCV), picornavirus, vesicular stomatitis virus (VSV), rabies virus, reovirus, retrovirus (HIV), white spot syndrome virus (WSSV) of shrimp, bird flu, swine flu, SARS, ROTA virus.

5. **Effect of animal viruses on host cells:** Cytolytic effects, morphological and biochemical observations, inhibition of protein, RNA and DNA synthesis, pattern of viral infection - acute, chronic, persistent and latent viral infection.

6. **Plant virus:** Structure, genomic organization and molecular aspects of tobacco mosaic virus (TMV), cotton leaf curl gemini virus (CLCuV) and potato virus Y.

7. **Prevention and control of viral infection:** General prevention strategies, immunization with vaccines and antiviral drugs, mechanisms of action and limitations of use of these drugs. Interferon and its modification.

Intended Learning Outcome:

After successful completion of the course, students will be able to learn the essential concepts of virology which include the structure of different viruses, properties, replication, types of infection, how viruses cause disease, immune response to infection, treatment and the inhibitory action of the antiviral chemotherapy and laboratory diagnosis. In addition, the students will be able to:

- Critically assess virological cause of disease and able to correlate between different diseases and viruses associated.
- Select the suitable sample and the suitable laboratory test for diagnosis
- Choose the required measurements for prevention and control of viral diseases.
- Work safely in a medical laboratory.
- Understand different methods of laboratory diagnosis.
- Practice different methods used for isolation of viruses and their identification.
- Learn about molecular techniques used for virus detection.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Classification of viruses	4
02.	Virus cultivation, detection and genetics	4
03.	Host virus interaction	6
04.	Animal virus	4
05.	Effect of animal viruses on host cells	4
06.	Plant virus	4
07.	Prevention and control of viral infection	4
Total classes		**30**

Recommended Books and Readings:

1. Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses by S. Jane Flint.
2. Principles of molecular virology by Alan Cann

3. Fundamentals of Molecular Virology by Nicholas H. Acheson

BMB-407: Immunology **4 Credits**

Introduction:

This course aims to offer a fresh and stimulating approach to introduce the students how the immune system is developed to combat a great variety of infectious microbes and discriminate between self and non-self, which are crucial for an effective immune response. From the development of the immune system, through immunogenetics, the major histocompatibility complex, regulation of immune responses, immunological tolerance, vaccination etc., this course will cover all major areas of immunology to give a solid background to the students on this fascinating subject of biological science.

Objectives:

This course has the following objectives:

- To give the students an exciting understanding on the development of the immune system.
- To present how cytokines, activated T and B lymphocytes and antibodies produced by an immune response ultimately determine its outcome and regulate the system.
- To explain how lymphocytes are educated to show tolerance to self-components.
- To provide comprehensive knowledge how the immune system acts against various pathogens - bacteria, fungi, viruses, parasites.
- To explain principles of vaccination and how vaccines are developed to give protection against infectious microbes and boost the immune response.
- To introduce methodologies based on antigen-antibody interactions the students will be made aware how FACS, surface plasmon resonance, ELISPOT, monoclonal antibody production, TUNEL assay methods can be applied in future research.

Contents:

1. **Development of the immune system:** Development of immune cells in bone marrow, thymus, lymph nodes and spleen, development of memory B cells, cutaneous immune system, mucosal immune system, lymphocyte recirculation and homing.

2. **Cytokines:** General properties of cytokines, cytokine receptors and signaling, functions of signature cytokines: cytokines in innate immunity - TNF, IL-6, IL-12, IFN-α and IFN-β, IL-10, chemokines; cytokines in adaptive immunity – IL-2, IL-4, IL-5, IFN-γ, TGF-β, IL-13, cytokines of T_H17 cells and T_{regs}; cytokines in pathogenesis; cytokine-based therapies.

3. **Innate and cell-mediated immunity:** Components of innate immunity (brief

treatment), antimicrobial peptides, toll-like receptors (TLR), TLR signaling pathways, connections between innate and adaptive immunity, effector mechanisms of cell-mediated immunity - T-cell mediated activation of macrophages and other leukocytes, CTL and NK cell-mediated killing of infected cells.

4. **Major histocompatibility complex (MHC):** Production of inbred mouse strains, arrangement of H2 and HLA complexes, genetic map, structure of class I and II MHC molecules, peptide-MHC interactions, antigen processing and presentation, tissue typing, transplantation and rejection, association of MHCs with diseases.

5. **Activation of T and B cells:** Antigen receptors and accessory molecules of T cells, antigen recognition, MHC-restriction of T cells, cell cooperation in the antibody response, role of cytokines and co-stimulatory molecules in B and T cells activation; signaling pathways of T and B cell activation.

6. **Immunogenetics**: Immunoglobulin (Ig) gene structure, mechanism and regulation of Ig gene recombination and expression, generation of antibody diversity, class switching.

7. **Regulation of immune responses:** Factors governing the outcome of immune responses - regulation by APCs, antigen and Ig, regulation by T cells; apoptosis, activation induced cell death (AICD), passive cell death (PCD); neuroendocrine regulation of immune responses; influence of genetic factors - MHC-linked and non-MHC linked immune responses.

8. **Immunological tolerance:** General features and mechanisms of immunological tolerance, T and B cells tolerance to self-antigens, tolerance of T and B cells, tolerance induced by T_{regs}, tolerance induced by foreign antigens, artificially induced tolerance; therapeutic applications of tolerance.

9. **Immunity to microbes:**

   i) Immunity to bacteria: Bacterial mechanisms of pathogenicity; non-specific antimicrobial defense mechanisms; lymphocyte-independent bacterial recognition pathways; antigen-specific protection by antibody; bactericidal functions of phagocytes−oxygen-dependent and oxygen-independent killing mechanisms, other antimicrobial mechanisms, cytotoxicity; immune evasion mechanisms of pathogenic bacteria; immunological tissue damage by bacteria - endotoxin shock, superantigens, heat-shock proteins.
   ii) Immunity to fungi: Categories of fungal infection, cell mediated immunity against fungal infections.
   iii) Immunity to viruses: Modes of virus infection, viroids, prions; virus receptors

on host cells; different types of virus infection; innate immune responses to virus; host defence against virus and virus-infected cells

iv) Immunity to protozoa and worms: Features of parasitic infections; effector mechanisms against parasite infection− first line of defense by macrophages, neutrophils, eosinophils and platelets; role of T cells in the development of immunity to protozoa and worms.

10. **Vaccination:** Active and passive immunization, live attenuated vaccines, inactivated or killed vaccines, subunit vaccines, conjugate vaccines, DNA vaccines, recombinant vector vaccines, edible vaccines, prime-boost strategies.

11. **Immunotechniques:** Production of monoclonal antibodies, antibody engineering, chimeric and humanized monoclonal antibodies, transgenic mice with human Ig loci, phage display libraries in the derivation of monoclonal antibodies, immunoblotting, immunohistochemistry, isolation of lymphocyte populations and subpopulations - Ficoll-Hypaque gradient, flow cytometry and FACS analysis, antibody-coated magnetic beads, ELISPOT assay, TUNEL assay, assay for cytotoxic T and $CD4^+$ T cells, surface plasmon resonance (SPR), immunoelectron microscopy.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Acquire scientific skills to understand and describe the events in the development of the immune system.
- Discuss how the cellular and soluble components of the immune system determine its outcome - whether to feed back into, suppress or promote the response and why an underactive or overactive reaction to antigens may be deleterious.
- Explain self-tolerance by the immune system and how the system distinguishes between self and foreign antigens to make the decision between tolerance and immunity.
- Interpret why effectiveness of the immune mechanisms to be different against bacteria, fungi, viruses, parasites, depending on the pathogenic mechanism of the infectious agent.
- Illustrate application of immunological principles in the production of vaccines against tuberculosis, tetanus, measles, diphtheria, polio, rabies and explain different strategies followed to prepare these vaccines, and how future vaccines will use genes and vectors to deliver antigens.
- Demonstrate their knowledge and skills on immunotechniques while pursuing research or professional career.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Development of the immune system	5
02.	Cytokines	5
03.	Innate and cell-mediated immunity	4
04.	Major histocompatibility complex (MHC)	5
05.	Activation of T and B cells	5
06.	Immunogenetics	5
07.	Regulation of immune responses	5
08.	Immunological tolerance	4
09.	Immunity to microbes	8
10.	Vaccination	5
11.	Immunotechniques	9
Total classes		**60**

Recommended Books and Readings:

1. Immunology, 6th Edn., by Ivan Roitt, Jonathan Brostoff, David Male
2. Kuby Immunology by Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne
3. Essential Immunology, 9th Edn., by Ivan M. Roitt
4. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman

BMB 408: Biochemistry of Drugs **2 Credits**

Introduction:

This course will provide a general and broad knowledge about drug administration, distribution and actions in human body and how drugs produce therapeutic effects in the body. It also discusses how drugs are metabolized and excreted through the body.

Objectives:

This course has the following objectives:

- the basic features and classification of drugs
- the pharmacokinetic properties of drugs [how drugs are absorbed, distributed, excreted and metabolized in human body
- the molecular basis of drug actions [what are the dose-response relationships and ligand-receptor interactions]
- the causes of drug resistance

- adverse drug reactions like drug toxicity and drug allergy.

Contents:

1. **Introduction:** Drugs; basic features**,** broad classification with specific examples
2. **Administration/absorption:** Different routes of drug administration, their advantages and disadvantages. Passage of drugs across biological membranes; diffusion, active transport, physicochemical characteristics influencing their biotransport; primary mechanism of drug absorption in stomach and in intestine.
3. **Distribution:** General principles (compartments of drug distribution), binding of drugs with protein, volume of distribution, passage of drugs through biological membranes, central nervous system (CNS), and placenta, factors affecting drug distribution.
4. **Metabolism:** Biotransformation, Phase I and Phase II reactions, inhibition and induction of drug metabolizing pathways**.**
5. **Excretion/elimination:** Excretion of drugs through renal and biliary systems.
6. **Mechanism of drug action:** Basic aspects**,** drug receptors and their characteristics**,** non-receptor mediated drugs.
7. **Drug resistance:** Intrinsic and acquired drug resistance, transfer of resistance. Biochemical mechanisms of resistance development.
8. **Drug toxicity:** Evaluation of drug toxicity drug allergy and test for its prediction.

Intended Learning Outcome:

After successful completion of the course, students will be able to:

- Describe basic feature and broad classification of drugs. Physicochemical properties of drugs.
- Elucidate the qualitative factors like routes of administration, passage of drugs across biological membranes, and the mechanism of absorption in stomach and in intestine.
- Demonstrate quantitative aspects like excretion of drugs by different roots, clearance, volume of distribution, bioavailability, half-lives, steady state, etc) of drug pharmacokinetics.
- Illustrate the design and optimization of dosage regimens (therapeutic window), maintenance dose, loading dose etc.
- Discuss phase I and phase II metabolism of drugs, major reactions in drug metabolism, factors affecting drug metabolism.

- Describe different classes of drug receptors, the terms and principles for different modes of drug-receptor interactions (agonist, antagonist etc), the molecular interactions between drugs and their receptors and nonreceptor mediated drug action.
- Explicate mechanisms responsible for transfer of drug resistance, pattern of emergence, Biochemical mechanisms of drug resistance development with example.
- Explain the history of drug toxicity, different types of drug toxicity, evaluation of drug toxicity, principles of nonspecific therapy, principle of antidote treatment of drug toxicity with example, drug allergy; manifestations of drug allergy, frequency of allergic reactions, methods of predicting allergic sensitivity, methods of desensitization, and the management of allergic reactions.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Introduction	3
02.	Administration/absorption	4
03.	Distribution	4
04.	Metabolism	4
05.	Excretion/elimination	4
06.	Mechanism of drug action	4
07.	Drug resistance	4
08.	Drug toxicity	3
Total classes		**30**

Recommended Books and Readings:

1. Goodman & Gilman's The Pharmacological Basis of Therapeutics by Hardman JG & Limbird LE.
2. Lippincott’s Illustrated Reviews: Pharmacology, by Richard Finkel, Luigi X Cubeddu and Michelle A Clark
3. Goodman & Gilman's The Pharmacological Basis of Therapeutics by Laurence L Brunton, Jhon S Lazo and Keith L Parker
4. Will’s Biochemical Basis of Medicine. B. Gillman, D.K. Papachristodoulou, and J.H. Thomas. Butterworth-Heinemann.

BMB 409: Neurobiochemistry **2 Credits**

Introduction:

This course provides a broad introduction to the mammalian nervous system with a particular focus on the structure and function of the human brain. Neurons have a special cellular chemistry related to their ability to send and receive chemical signals. The course comprises the biochemistry of the nervous system including the role of different axon guidance proteins; nerve impulse generation; neurotransmitter synthesis; molecular mechanism of neurotransmission; brain growth and development; different types of brain diseases. It also gives an overview of short-term & long-term memory of the human brain.

Objectives:

In this course students will:

- learn anatomical structure and function of the human brain.
- enrich knowledge on structural, chemical and metabolic peculiarities of the brain; axon guidance proteins, and their role to make a functional neuron; ionic basis of action potential;
- understand the mechanism of nerve impulse conduction along myelinated and unmyelinated nerve fibers; molecular mechanism of neurotransmission; pain perception pathway; brain growth and development; metabolism of the developing brain during normal and malnutrition state; different types of brain diseases.
- have an understanding of memory formations and its functions.

Contents:

1. **Brain as a specialized tissue:** Structural, chemical and metabolic peculiarities - difference between growing and adult brain.
2. **Gross and fine structure of the brain:**

   i) Gross structure: different parts of the brain, their functions and growth characteristics (brief treatment).

   ii) Fine structure and functions**:** cells of the brain, classification of neurons and glia, their structure, location, function and axon *guidance molecules such as netrin, draxin, slit, semaphorin, ephrin, etc*.; myelination, myelin composition and maturation.
3. **Synapse:** Structure, their types – chemical and electrical, chemistry of neurotransmission (brief treatment), nerve impulse, action potential, its ionic basis, sodium channel; conduction of nerve impulse, mechanism of conduction along myelinated and

unmyelinated nerve fibers, comparison of conduction velocity along myelinated fibers; neurotransmission, neurotransmitters, their metabolism, storage and release; calcium channel, post synaptic receptors - their modulation with agonists and antagonists, neuropeptides.

4. **Brain growth and development:** Species, structural and cell type differences, neurogenesis and gliogenesis, neuronal death and nervous system development; metabolism of the developing brain, energy metabolism, changes during development, susceptibility of developing and adult brain to energy supply.

5. **Brain development during malnutrition:** Effect on cell proliferation, myelination and synaptogenesis; malnutrition and brain metabolism - energy metabolism, protein and lipid metabolism.

6. **Biochemistry of memory:** Types of memory processing in the brain, short-term memory, long-term memory, retrograde and anterograde amnesia, relation between retroactive interference and sleep, role of intense emotion on memories.

7. **Brain diseases:** Parkinson's, Wilson's, Huntington's disease, Schizophrenia, Sleeping beauty syndrome, and Alzheimer's diseases.

Intended Learning Outcome:

After successful completion of this course, student will be able to understand-

- Structural, chemical and metabolic peculiarities of brain
- Difference between growing and adult brain
- Gross and fine structure of brain
- Structure, their types – chemical and electrical, chemistry of neurotransmission
- Action potential, its ionic basis, sodium channel
- Myelin composition and maturation
- Mechanism of conduction along myelinated and unmyelinated nerve fibres
- Comparison of conduction velocity along myelinated and unmyelinated fibers
- Neurotransmitters, their metabolism, storage and release
- Role of calcium channel
- Post synaptic receptors and their modulation with agonists and antagonists
- Role of neuropeptides
- Species, structural and cell type differences, neurogenesis and gliogenesis, neuronal death and nervous system development
- Energy metabolism and its changes during development
- Susceptibility of developing and adult brain to energy supply
- Effect on cell proliferation, myelination and synaptogenesis
- Parkinson's, Wilson's, Huntington's and Alzheimer's diseases
- Short-term memory, long-term memory

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Brain as a specialized tissue	2
02.	Gross and fine structure of the brain	4
03.	Synapse	6
04.	Brain growth and development	6
05.	Brain development during malnutrition	5
06.	Biochemistry of memory	3
07.	Brain diseases	4
Total classes		**30**

Recommended Books and Readings:

1. Understanding the Brain and Its Development: A Chemical Approach by Harun K. M. Yusuf.
2. Basic Neurochemistry: Principles of Molecular, Cellular, and Medical Neurobiology by R. Wayne Albers, George J. Siegel, Scott Brady.
3. Basic Neurochemistry: Molecular, Cellular and Medical Aspects by Scott Brady, George Siegel, R. Wayne Albers, Donald Price.
4. Biochemistry of Brain. S. Kumar. *Pergamon Press*.

BMB-410: Applied Human Nutrition **2 Credits**

Introduction:

This course provides a comprehensive understanding of the role of nutrition in human health and focuses on the practical application of nutrition principles. Students will explore the concepts of functional foods, nutraceuticals, prebiotic and probiotic foods, and nutritional management of various diseases. Additionally, they will learn about different methods for assessing nutritional status and interpreting dietary data.

Objectives:

The objective of this course is to:

- equip students with the knowledge and skills necessary to apply the principles of human nutrition in real-life situations.
- enable the students with a deep understanding of the benefits of functional foods, nutraceuticals, prebiotic and probiotic foods, and the nutritional management of common diseases.

- provide proficiency in assessing nutritional status using various techniques and interpreting dietary data accurately.

Content:

1. **Role of functional foods in human health:** Benefits of functional foods, applications of herbs to functional foods. Concept of free radicals and antioxidants; nutritive and non-nutritive food components with potential health effects, effect of processing on nutrients, functional foods for diseases prevention.

2. **Introduction to Nutraceuticals:** Classifications and properties, applied aspects of the nutraceutical science. Sources of nutraceuticals, efficacy and toxicity, metabolism and regulation, brief idea about some nutraceutical rich supplements e.g. bee pollen, caffeine, green tea, lecithin, mushroom, extract, chlorophyll, kelp and spirulina etc.

3. **Prebiotic and Probiotic foods:** Understanding about prebiotic and probiotic foods, Characteristics, spectrum of activity and health claim, health and medical benefits and safety. Health benefits of synbiotics, anti-nutritional factors present in foods, Types of inhibitors present in various foods and its inactivation.

4. **Causes, Symptoms and Nutritional Management of diseases:** Diseases of the GI tract (Gastric and peptic ulcer, Diarrhoea, Constipation, Intestinal Fistula, Malabsorption Syndrome, Inflammatory Bowel syndrome, Gluten Induced enteropathy), Diabetes, Liver diseases, Kidney diseases, Gout, Atherosclerosis and Cancer.

5. **Assessment of nutritional status**: objectives and importance. Types of assessment anthropometry clinical & biochemical assessment. Dietary assessment as part of nutritional status. Types & methods of dietary surveys. Analysis and interpretation.

Intended Learning Outcome:

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

- Explain the role of functional foods in promoting human health and describe the benefits and applications of herbs in functional foods.
- Understand the concepts of free radicals and antioxidants and their implications for human health.

- Identify and analyze nutritive and non-nutritive food components with potential health effects and explain how processing affects nutrient content.
- Evaluate the use of functional foods for the prevention and management of various diseases.
- Classify nutraceuticals based on their properties and understand their sources, efficacy, toxicity, metabolism, and regulatory considerations.
- Assess the health benefits of prebiotic and probiotic foods and explain their role in maintaining gut health.
- Recognize the presence of anti-nutritional factors in foods and understand methods for their inactivation.
- Identify and describe the causes, symptoms, and nutritional management strategies for diseases such as gastrointestinal disorders, diabetes, liver diseases, kidney diseases, gout, atherosclerosis, and cancer.
- Demonstrate the ability to assess nutritional status through anthropometry, clinical and biochemical assessments, and interpret the results.
- Apply various dietary assessment methods and analyze dietary surveys to evaluate the nutritional adequacy of individuals or populations.

Required Number of Classes:

No	**Title of the unit**	**Number of classes**
01.	Role of functional foods in human health	6
02.	Introduction to Nutraceuticals	6
03.	Prebiotic and Probiotic foods	6
04.	Causes, Symptoms and Nutritional Management in diseases	6
05.	Assessment of nutritional status	6
Total classes		**30**

Recommended Books and Readings:

1. Human Nutrition and Dietetics by Davidson and Passmore
2. Lehninger Principles of Biochemistry by Michael M. Cox, David L. Nelson
3. Harper's illustrated Biochemistry by Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil.
4. Human Nutrition & Dietetics. J.S. Garrow, W.P T. James, A. Ralph. *Churchill Livingstone*.
5. Essentials of Nutrition and Diet Therapy. S.R. Williams. *Times/ Mirror/ Mosby College Publishing*.

BMB-411: Basic Bioinformatics **2 Credits**

Introduction:

The field of bioinformatics harnesses computational tools and databases to extract meaningful insights from large-scale biological data. Bioinformatics plays a crucial role in modern biological, medical, and agricultural sciences. This introductory course in bioinformatics aims to provide students with a comprehensive overview of bioinformatics, its applications, and the fundamental tools and databases used in the field. Students will gain practical skills in data retrieval, analysis, and interpretation, enabling them to address scientific research questions effectively.

Objectives:

The objectives of this course are to:

- Understand the significance of bioinformatics in biological, medical, and agricultural sciences.
- Familiarize students with the structure, organization, and applications of bioinformatics databases such as NCBI, ENSEMBL etc.
- Introduce specialized databases and their applications, including Uniprot, PDB, dbSNP, Haploreg, RegulomeDB, ENCODE, and cBIOPORTAL.
- Explore resources available at the SBI's Expasy portal for predicting post-translational modifications, glycosylation, and transmembrane helix of protein sequences.
- Gain proficiency in pairwise sequence alignment using various types of BLAST tools.
- Learn multiple sequence alignment techniques using Clustal W and MUSCLE.
- Acquire knowledge of gene prediction and codon optimization tools.
- Introduce basic algorithms in bioinformatics, with a focus on Hidden Markov Model (HMM) and its applications.
- Explore molecular phylogenetics and evolutionary bioinformatics, including phylogenetic tree construction using the MEGA software.
- Understand the importance of structural bioinformatics in deciphering the structure-function relationships of biomolecules, and perform three-dimensional structure prediction of unknown protein sequences using template-dependent and template-independent approaches.

Contents:

1. **Introduction to bioinformatics:** Definition and application of bioinformatics in various fields, including biological, medical and agricultural sciences.

2. **Biological databases and tools:**
   (i) **Basic databases:** Structure and organization of various bioinformatics databases such as NCBI, ENSEMBL. 1000 Genome Browser. Usage and practical

exploration of these databases for data retrieval and analysis in order to answer scientific research question.

(ii) **Specialized databases and their usage:** Uniprot, PDB, dbSNP, Haploreg, RegulomeDB, ENCODE and cBIOPORTAL. Use of the resources at the Expasy for the prediction of post-translational modification, glycosylation and transmembrane helix of a protein sequence.

3. **Sequence homology:**
   (i) **Pairwise sequence alignment:** different types of BLAST (BLASTP, BLASTN, PSI-BLAST, BLASTx, tBLASTn) and their applications. Explaining different features of a BLAST output and interpretation of statistical values.
   (ii) **Multiple sequence alignment:** Familiarization with the commonly used bioinformatics tools such as Clustal W, MUSCLE etc for multiple sequence alignment.

4. **Gene prediction and codon optimization tools:** ORF finder, GENSCAN, Codon usage bias, codon adaptation index and its application, codon frequency, Codon optimization tools (e.g. JCAT).

5. **Basic algorithms and their uses in computational Biology:** Introduction of the basic principle of bioinformatics algorithm such as Hidden Markov Model algorithm. Applications of Hidden Markov Model**.**

6. **Molecular phylogenetics and evolutionary bioinformatics:** Basic knowledge about the principles behind evolutionary bioinformatics such as phylogenetic trees and nucleotide substitution rates etc. The usage of different parameters to interpret evolutionary bioinformatics analysis such as non-synonymous vs synonymous substitution (Ka/Ks) etc. Rooted and unrooted tree representation. Bootstrapping strategies. Evolutionary analysis using MEGA.

7. **Structural bioinformatics:** The importance of the structural features of different types of biomolecules (RNAs and proteins) and understand the structure-function relationships. Three-dimensional structure prediction of an unknown protein sequence using template dependent (e.g. SWISS-MODEL) and template independent (e.g. I-TASSER) approaches. Use of various tools to validate and refine the predicted 3D structure of a protein.

Intended Learning Outcome:

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

- Explain the definition and applications of bioinformatics in biological, medical, and agricultural sciences.
- Navigate and utilize essential bioinformatics databases, retrieving and analyzing data.
- Employ specialized databases and resources to predict protein sequence properties and post-translational modifications.

- Perform pairwise sequence alignments using different BLAST algorithms.
- Apply multiple sequence alignment tools for comparing and aligning multiple biological sequences.
- Utilize gene prediction tools and analyze codon usage bias to optimize gene expression.
- Understand the basic principles of Hidden Markov Model (HMM), and its applications.
- Conduct evolutionary analysis using molecular phylogenetics tools and interpret results based on evolutionary parameters.
- Predict the three-dimensional structure of unknown protein sequences using template-dependent and template-independent approaches.
- Validate and refine predicted protein structures using appropriate bioinformatics tools.

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Introduction to bioinformatics	1
02.	Biological databases and tools	7
03.	Sequence homology	6
04.	Gene prediction and codon optimization tools	3
05.	Basic algorithms and their uses in computational Biology	3
06.	Molecular phylogenetics and evolutionary bioinformatics	5
07.	Structural bioinformatics	5
Total classes		**30**

Recommended Books and Readings:

1. Structural Bioinformatics Edited By Philip E. Bourne San Diego and Helge Weissig University of California San Diego La Jolla, CA.
2. Bioinformatics (A Practical Guide to the Analysis of Genes and Proteins) Andreas D. Baxevanis and B. F. Francis A JOHN WILEY & SONS, INC., PUBLICATION
3. Bioinformatics for Dummies by Jean-Michel Claverie and Cedric Notredame Published by Wiley Publishing, Inc. 111 River Street Hoboken, NJ 07030-5774

BMB-412: Research Methodology **2 Credits**

Introduction

This course aims to guide the 4th year BS Honors students towards achieving competence and proficiency in the theory of and practice to research. This fundamental objective can be realised through helping the students to develop the subject of their research, encourage the formation of higher level of trained intellectual ability, critical analysis, rigour, and independence of thought, foster individual judgement, and skill in the application of research theory and methods, and develop skills required in writing research proposals, reports, and dissertation.

Objectives:

After completion of this course, students will be

- familiar with the principles behind research work
- acquainted with practical knowledge of research work and
- able to perform a research work in their field independently or in collaboration

Intended Learning Outcome:

- Enable students understand what research is and what is not.
- Raise awareness of crucial aspect of the nature of knowledge and the value of scientific method.
- Introduce the concept at the heart of every research project - the research problem- and to discuss what a researchable problem is.
- Evaluate literature, form a variety of sources, pertinent to the research objectives.
- Identify and justify the basic components of the research framework, relevant to the tackled research problem.
- Explain and justify how researchers will collect research data.
- Put forward a credible research proposal.

Content:

1. **Introduction to research methodology**: Meaning of research, objectives of research, motivations in research, types of research, research approaches, significance of research, research methods vs methodology, criteria of good research.
2. **Basic types of researches**: Fundamental/applied research, descriptive/analytical research, quantitative/qualitative research, conceptual/empirical research, diagnostic/hypothesis testing research, conclusion oriented/decision-oriented research, theoretical/action research, longitudinal/cross sectional research.

3. **Research design**: Exploratory research design - concept, types and uses; descriptive research designs - concept, types and uses; experimental design: concept of independent & dependent variables.
4. **Sampling**: Concepts of statistical population, sample, sampling frame, sampling error, sample size, non-response. characteristics of a good sample. probability sample - simple random sample, systematic sample, stratified random sample & multi-stage sampling. Determining size of the sample - practical considerations in sampling and sample size
5. **Data analysis and synthesis**: Data preparation - univariate analysis (frequency tables, bar charts, pie charts, percentages); bivariate analysis - cross tabulations and chi-square test including testing hypothesis of association; synthesis - meaning and introduction, logical generalization and statistical generalization
6. **Task of writing in research**
   (i) Research Proposal: Meaning and purpose of research proposal, academic/ project/ case study proposals, steps for preparing proposal, framework and arrangement of sub heading in research proposal; writing research proposal for academic programme; common mistakes in proposal writing.
   (ii) Thesis/Dissertation: Introduction, features of thesis, structure of thesis, steps in thesis writing, documentation of a thesis/dissertation.
7. **Research Ethics**: Ethics-ethical issues, plagiarism and self-plagiarism, IPR- intellectual property rights and patent law

Required Number of Classes:

No	Title of the unit	Number of classes
01.	Introduction to research methodology	2
02.	Basic types of researches	4
03.	Research design	6
04.	Sampling	6
05.	Data analysis and synthesis	5
06.	Task of writing in research	3
07.	Research Ethics	4
Total classes		**30**

Recommended Books and Readings:

1. Research Methodology – C. R. Kothari
2. Kumar, R. (2011). Research Methodology: a step-by-step guide for beginners (3rd edition). London, UK: TJ International Ltd, Padstow, Corwall.
3. Singh, Y. K. (2006). Fundamental of Research Methodology and Statistics. New Delhi. New International (P) Limited, Publishers.
4. Robert E. Slavin (1994). Research Methodology in Education: A practical guide, prentice Hall.

BMB-413 Laboratory Work 8 Credits

Introduction:

This course is designed to introduce students to hands-on experience in molecular biology, immunology, microbiology, and analytical biochemistry-related research techniques. It focuses on plant DNA extraction, plasmid isolation, restriction digestion, total and differential white blood cell count, and cell viability. The course also covers antibiotic resistance of microbes as well as analytic techniques including thin-layer chromatography and gel filtration. In addition, the course arranges industrial tours and research laboratory visits which enlightens the students about the pharmaceutical industry and research facilities of the country.

Objectives:

- To develop an understanding of procedural knowledge.
- To develop the ability to elucidate the processes and applications related to biochemistry and molecular biology.
- To develop the ability to handle the apparatus carefully, and use the resources wisely.
- To develop the ability to work together.
- To develop an ability to express themselves coherently and logically.
- To isolate quality DNA from plant and bacterial sources for molecular weight determination and polymorphism analysis using the RFLP method.
- To develop skills to study metabolic channeling and cell signaling using protein marker.
- To develop an understanding of immunology of the human body focusing on blood cells.
- To develop knowledge of isolating bacteria from environmental sources for its identification, and characterization.
- To develop an understanding of basic protein separation techniques
- To determine the active pharmaceutical ingredient of a drug molecule.

Contents:

❖ **DNA related experiments:**

1. Preparation of standard solutions
2. Isolation and quantitation of plant DNA
3. Isolation of plasmid and amplification of specific gene after primer design
4. Characterization of the pGLO plasmid.
5. Isolation of plasmid by alkaline lysis method and determination of molecular size.
6. Restriction enzyme analysis of DNA.

❖ **Blood and Immunology experiment:**

1. Collection of serum and plasma
2. Identification of blood groups.

3. Determination of the erythrocyte sedimentation rate (ESR).
4. Separation of blood leukocytes
5. Total white blood cell count
6. Differential white blood cell count
7. Test of blood cell viability
8. Phagocytosis by neutrophils
9. ELISA for the detection of antibodies against cholera toxin B subunit in human serum samples.

❖ **Microbiology experiments:**

1. Total bacterial count in environmental sample
2. Presumptive test for coliform bacteria in environmental water sample
3. Test of antibiotic susceptibility of microorganisms isolated from environmental samples

❖ **Analytical experiments:**

1. The identification of sugars in fruit juices using thin layer chromatography.
2. Assay of streptomycin from a given unknown sample
3. Ion-exchange chromatography to separate a mixture of standard proteins
4. Gel filtration to separate a mixture of proteins
5. Polyacrylamide gel electrophoresis of miscellaneous proteins using denaturing (SDS) and non-denaturing gels

Intended Learning Outcome:

At the end of this course, the students shall be able to

- Develop and establish procedures for collecting, processing, and analyzing DNA specimens.
- Explain different molecular biology techniques such as DNA extraction, plasmid extraction, agarose gel electrophoresis, restriction enzyme digestion.
- Explain what differential count is.
- Perform differential white blood cell count and reporting differential leucocyte count.
- Define erythrocyte sedimentation rate, discuss the factors that affect ESR and indicate the normal values of ESR and explain the clinical implications of ESR determination.
- Explain how cell viability can be tested.
- Explain how neutrophils perform phagocytosis.
- Define antibiotic resistance and MIC.
- Define what a presumptive test for coliform bacteria is and how to perform the test.
- Define different culture media for bacterial growth.
- Understand different analytical techniques such as TLC, GFC and their uses.
- Explain what research areas our pharmaceutical industries are engaged in
- Explain the major activities of a leading pharmaceutical industry of our country

- Conduct experiments according to laboratory protocol and recognize factors interfering with test results and take corrective action.
- Interpret laboratory data results using quality control measures.
- Apply scientific principles, such as immunology, biochemistry, molecular biology, genetics, microbiology, laboratory principles, and methodology to both the research and clinical settings.
- Comply with established laboratory safety regulations.
- Communicate through oral and written skills, effectively and professionally to enable consultative interactions.

Required Number of Classes:

For laboratory work, students will have to complete 3-4 experiments per credit that consists of theory lecture for each experiment and laboratory work. To complete an experiment, approximately one hour of theory lecture and 4-6 hours of laboratory work are required.

No	**Title of the unit**	**Number of Experiments**
01.	DNA related experiments	6
02.	Blood and Immunology experiment	9
03.	Microbiology experiment	3
04.	Analytical experiment	5
Total experiments		**23**

Recommended Books and Readings:

1. Laboratory manuals and protocol sheets.

BMB-414: Viva-voce **2 Credits**

Introduction:

This course is designed to assess the overall depth and clarity of knowledge gained in relevant courses during the current academic session. This course will provide a platform for the students to showcase their basic understanding of the overarching goals and approaches of different courses taught during the academic session.

Objectives:

The objective of the viva-voce exam is to:

- assess the overall knowledge of a student on a particular academic topic.
- enable them the platform to develop their interpersonal communication skills.
- provide a foundation for formal discussion on an academic topic with the current peers (in this case, the examiners of the examination committee).

Contents:

The content of the viva-voce exam includes all the topics taught in the theory and practical courses, throughout the academic year.

Intended Learning Outcome:

By participating in the Viva-voce exam, the students will be able to –

- Develop basic communication skills
- Express their depth and clarity of knowledge on an academic topic.
- Showcase and improve on their scientific discussion skill.

****

EXTRA-DEPARTMENTAL COURSES

BMB-11: Basic Biochemistry-I **4 Credits**

Theory: 80 Marks

Group A:

1. **Acid, base, and buffer:** Ion product of water, acid, base, pH, pH indicators, buffer solution and buffer capacity.

2. **Thermodynamics:** First law of thermodynamics, enthalpy, Hess's law; second law of thermodynamics, entropy, free energy, standard states; spontaneous, reversible, irreversible and non-equilibrium reactions; steady state.

3. **Cell:** Cell, sub-cellular particles and their functions.

4. **Carbohydrates:** Nomenclature, classification, optical properties, general reactions, color tests and methods of estimation, isolation from natural sources and representative examples of each class with a note on characteristics.

5. **Lipids:** Nomenclature, classification, reactions of fatty acids, sterols and methods of estimation, structure and biological functions of different classes of lipids.

Group B:

1. **Amino acids and peptides:** Structural features, optical activity and classification of amino acids, ionization in solution, isoelectric behavior, color tests, isolation of amino acids from protein hydrolysates, peptide bonds and biologically important peptides.

2. **Proteins:** General introduction, classification based on shape, structure and biological properties, isolation from natural sources, different levels of structural organization (in brief).

3. **Enzymes:** Chemical nature, effect of substrate, temperature and pH on its activity, K_m and V_{max}, enzyme inhibition, digestive enzymes.

4. **Nucleosides and nucleotides:** Basic chemistry of nucleosides and nucleotides, polynucleotides.

5. **Vitamins:** Classification, occurrence, deficiency symptoms, biological functions, vitamins as coenzymes.

Practical: 20 Marks

1. Preparation of standard solution and standardization of HCl.
2. Estimation of calcium in biological sample.
3. Determination of ascorbic acid content of a biological sample.
4. Color tests for biomolecules.
5. Determination of lactose content of milk.
6. Determination of phosphorus content of the supplied solution.

References:

1. Essentials of Physical Chemistry by Arun Bahl, B.S. Bahl and G.D. Tuli
2. Physical Chemistry for the Biosciences by Raymond Chang
3. Lehninger Principles of Biochemistry by David L. Nelson, Michael M. Cox
4. Biochemistry by Lubert Stryer, John L. Tymoczko, Jeremy Mark Berg

BMB-12: Basic Biochemistry-II **4 Credits**

Theory: 80 Marks

1. **Carbohydrate metabolism:** Glycolysis, pentose phosphate pathway, glucuronic acid pathway, oxidation reduction reactions and redox potential, electron transport chain, oxidative phosphorylation, inhibition and uncoupling of oxidative phosphoorylation, citric acid cycle, gluconeogenesis, glycogenolysis, and glycogen synthesis.

2. **Lipid metabolism:** β-oxidation and the related energetics, basic concept of lipoproteins, synthesis of fatty acids, ketone bodies and their formation.

3. **Amino acid metabolism:** Different methods for the degradation of amino acids, transamination, deamination, decarboxylation and synthesis of single carbon unit, synthesis of biologically active molecules from amino acids, urea cycle.

4. **Central dogma:** DNA as genetic material, replication of DNA, transcription, different types of RNAs, protein synthesis and inhibitors of protein synthesis.

5. **Nutrition:** Basic concept, protein, fat and carbohydrates as nutrients, basic concept on micronutrients like iodine, zinc, magnesium and iron.

Practical: 20 Marks

1. Determination of saponification number of oil.
2. Determination of iodine number of oil.
3. Determination λ-max and verification of Beer-Lambert's law.
4. Estimation of total protein content of serum.
5. Determination of serum glucose content.
6. Determination of cholesterol content of serum.
7. Determination of creatine content urine.

References:

1. Lehninger's Principles of Biochemistry by David L. Nelson and Michael M. Cox
2. Biochemistry by Dr. U Satyanarayana
3. Lippincott Illustrated Reviews: Biochemistry by Denise R. Ferrier