Syllabus for 4-Year Bachelor of Science (BS)
in
Biochemistry and Molecular Biology
University of Dhaka

Sessions: 2018-2019 and onwards

- Each 4-credit theory course will be of 100 marks, comprising 60 lecture-hours, 3-credit theory course of 75 marks comprising 45 lecture-hours and 2-credit theory course will be of 50 marks comprising 30 lecture-hours.

- Each 4-credit practical course will be of 100 marks comprising 180 hours of laboratory work with 40% marks for continuous assessment and 60% marks for final examination.

- Examination (assessment and final) rules, allotment of marks etc. are given in the Rules and Guidelines for the BS (Honors) degree program under the Grading System.

- As per university rules a student must earn 128 credits 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).

1st Year BS (Honors)

Departmental courses:

BMB-101	Biophysical Chemistry	2 Credits
BMB-102	Bioorganic Chemistry	4 Credits
BMB-103	Cells and Biomolecules	2 Credits
BMB-104	Peptides and Proteins	2 Credits
BMB-105	Molecular Biology-I	2 Credits
BMB-106	Laboratory Work	4 Credits
BMB-107	Viva-voce	2 Credits

Extra-departmental courses:

BMB-151	Foundation Course in English	2 Credits
BMB-152	Basic Microbiology	2 Credits
BMB-153	Basic Biology and Biodiversity	2 Credits
BMB-154	Introduction to Applied Biology	2 Credits

Total Credits in 1st Year BS (Honors): 26 Credits

2nd Year BS (Honors)

Departmental courses:

BMB-201	Enzyme	4 Credits
BMB-202	Carbohydrate Metabolism	4 Credits
BMB-203	Biological Membrane and Lipid Metabolism	2 Credits
BMB-204	Endocrinology	2 Credits
BMB-205	Molecular Biology-II	4 Credits
BMB-206	Laboratory Work	4 Credits
BMB-207	Viva-voce	2 Credits

Extra-departmental courses:

BMB-251	Human Physiology	4 Credits
BMB-252	Computer Basics and Data Analysis	4 Credits

Total Credits in 2nd Year BS (Honors): 30 Credits

3rd Year BS (Honors)

Departmental courses:

BMB-301	Metabolism of Nitrogenous Compounds	3 Credits
BMB-302	Biochemistry of Natural Products	2 Credits
BMB-303	Human Nutrition	2 Credits
BMB-304	Molecular Biology-III	2 Credits
BMB-305	Molecular Genetics	3 Credits
BMB-306	Plant Biochemistry	2 Credits
BMB-307	Basic Immunology	2 Credits
BMB-308	Clinical Biochemistry	2 Credits
BMB-309	Laboratory Work	8 Credits
BMB-310	Viva-voce	2 Credits

Extra-departmental courses:

BMB-351	Applied Biostatistics	4 Credits
BMB-352	Microbiology	2 Credits

Total Credits in 3rd Year BS (Honors): 34 Credits

4th Year BS (Honors)

Departmental courses:

BMB-401	Cell Biology	4 Credits
BMB-402	Plant Biotechnology	2 Credits

BMB-403`	Pharmaceutical and Food Biotechnology	4 Credits
BMB-404	Molecular Biology-IV	2 Credits
BMB-405	Biochemistry of Cancer	2 Credits
BMB-406	Virology	2 Credits
BMB-407	Immunology	4 Credits
BMB-408	Biochemistry of Drugs	2 Credits
BMB-409	Neurobiochemistry	2 Credits
BMB-410	Applied Human Nutrition	2 Credits
BMB-411	Basic Bioinformatics	2 Credits
BMB-412	Laboratory Work	8 Credits
BMB-413	Viva-voce	2 Credits

Total Credits in 4th Year BS (Honors): 38 Credits

Grand total for BS (Honors) program: 128 Credits.

1st Year BS (Honors)

Departmental courses:

BMB-101	Biophysical Chemistry	2 Credits
BMB-102	Bioorganic Chemistry	4 Credits
BMB-103	Cells and Biomolecules	2 Credits
BMB-104	Peptides and Proteins	2 Credits
BMB-105	Molecular Biology-I	2 Credits
BMB-106	Laboratory Work	4 Credits
BMB-107	Viva-voce	2 Credits

Extra-departmental courses:

BMB-151	Foundation Course in English	2 Credits
BMB-152	Basic Microbiology	2 Credits
BMB-153	Basic Biology and Biodiversity	2 Credits
BMB-154	Introduction to Applied Biology	2 Credits

Total Credits in 1st Year BS (Honors): 26 Credits

BMB-101: Biophysical Chemistry 2 Credits

1. **Thermodynamics:**
   i) First law of thermodynamics: Introduction, definitions, nature of heat and work, PV work, maximum work, first law of thermodynamics - internal energy, enthalpy, molar heat capacities, isothermal and adiabatic expansion.

   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.
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, 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 concept, strengths of acids, strong and weak acids and bases, pH, buffer solutions. Henderson-Hasselbalch equation, buffering against pH changes in biological systems, maintaining the pH of blood, acid-base indicators, acid-base titration, choice of a suitable indicator.

5. **Properties of liquids (brief treatment):** Introduction – kinetic molecular description, intermolecular forces in liquids, dielectric constant, surface tension, viscosity, diffusion, osmotic pressure, phase rule, phase diagram of water, ionization of water, water as a reactant.

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

References:

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

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. **Stereochemistry and 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.

References:

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

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.

References:

1. Lehninger Principles of Biochemistry by David L. Nelson, Michael M. Cox
2. Textbook of Biochemistry by Edward Staunton West, Wilbert R Todd, Howard S Mason, John T Van Bruggen
3. Text Book of Biochemistry with Clinical Correlations, 4th Edn., by Thomas M. Devlin.
4. 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**

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.

References:

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

BMB-105: Molecular Biology-I 2 Credits

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).

References:

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

1. Use of electronic balances and preparation of standard solutions.
2. Standardization of HCl by titrimetric method.
3. Estimation of acetic acid content of vinegar by titrimetric method.
4. Estimation of calcium from milk by titrimetric method.
5. Estimation of iron from Mohr's salt and commercial iron tablets by dichromate method.
6. Estimation of ascorbic acid content of biological samples and vitamin C tablets by Bessel's titrimetric method.
7. Identification of organic compounds (elements and functional groups including Nitrogen, Sulphur, Halogen, aldehydes, ketones, carboxylic acids, phenols, amines and amides); Molisch test.
8. Determination of saponification number of fat or oil.
9. Determination of iodine number of fat or oil.
10. Determination of lactose content of milk by Benedict's method.
11. Determination of λ-max and verification of Beer-Lambert law by using Spectrophotometer.
12. Determination of serum protein content by the biuret method.
13. Determination of glucose content of serum by Nelson - Somogyi method.
14. Estimation of copper content of a solution by iodometric method.

BMB-107: Viva-voce 2 Credits

Extra-departmental courses:

BMB-151: Foundation Course in English 2 Credits

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 response s.

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.

References:

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**

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 microscope - 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 of a 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

References:

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**

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**: 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.

References:

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. Bangshagati Bidyar Mulkatha 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 **2 Credits**

Theory: 40 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; biotech for crop improvement. Renewable energy**:** waste management, biofuels, reduction green-house gases. Soil health: conservation agriculture, ecological intensification, fertilizer and PGPRs. Biotechnology in animal improvement.

3. **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.

4. **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. Food chains, food web and pyramids of biomass and energy and their effect on human preferences.

Practical: 10 Marks

1. Assignment/Field Visit

References:

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)

Departmental courses:

BMB-201	Enzyme	4 Credits
BMB-202	Carbohydrate Metabolism	4 Credits
BMB-203	Biological Membrane and Lipid Metabolism	2 Credits
BMB-204	Endocrinology	2 Credits
BMB-205	Molecular Biology-II	4 Credits
BMB-206	Laboratory Work	4 Credits
BMB-207	Viva-voce	2 Credits

Extra-departmental courses:

BMB-251	Human Physiology	4 Credits
BMB-252	Computer Basics and Data Analysis	4 Credits

Total Credits in 2nd Year BS (Honors): 30 Credits

BMB-201: Enzymes 4 Credits

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).

References:

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

BMB-202: Carbohydrate Metabolism 4 Credits

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).

References:

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

BMB-203: Biological Membrane and Lipid Metabolism 2 Credits

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.

References:

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

BMB-204: Endocrinology **2 Credits**

1. **Characteristics of the hormone system :** Introduction, function of hormones, endocrine glands, target gland concept, negative and positive feedback, hormone receptors and its abnormalities, classification of hormones, intracellular messengers.

2. **Pituitary and hypothalamic hormones, thyroid and parathyroid hormones:** Structure, synthesis, physiological and biochemical actions.

3. **Hormones of the adrenal cortex, adrenal medulla, gonads and pancreas:** Structure, biosynthesis, regulation, transport, mechanism of action and pathophysiology.

4. **Gastrointestinal hormones:** Gastrin, cholecystokinin (CCK), secretin, glucagon, gastric inhibitory polypeptide (GIP), vasoactive intestinal sp polypeptide (VIP), glicentin, neurotensin, substance P and somatostatin.

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

References:

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

BMB-205: Molecular Biology-II **4 Credits**

1. **Structure and properties of DNA:** Different physicochemical properties; different conformations of DNA, tandem sequence, palindrome sequence, cruciform structure, hybridization kinetics, $C_o t$ 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.

References:

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

BMB-206: Laboratory Work **4 Credits**

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 pKa 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 olorimetric method.
8. Estimation of inorganic phosphate by colorimetric method.
9. Determination of the acid neutralizing capacity of a commercial antacid tablet.
10. Estimation of chlorophil content in plant *(Basella alba)* leaves
11. Measurement of salivary amylase activity.

12. Assay of heart succinic dehydrogenase and cytochrome oxidase.
13. Measurment of a microbial enzyme activity (dehydrogenase).
14. Determination of serum ALT and AST activity by colorimetric method.
15. Separation of serum and plasma from whole blood and determination of serum plasma glucose by glucose oxidase method.

BMB-207: Viva-voce 2 Credits

Extra-departmental courses:

BMB-251: Human Physiology 4 Credits

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.

References:

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

BMB-252: Computer Basics and Data Analysis 4 Credits

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

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

References:

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

3rd Year BS (Honors)

Departmental courses:

BMB-301	Metabolism of Nitrogenous Compounds	3 Credits
BMB-302	Biochemistry of Natural Products	2 Credits
BMB-303	Human Nutrition	2 Credits
BMB-304	Molecular Biology-III	2 Credits
BMB-305	Molecular Genetics	3 Credits
BMB-306	Plant Biochemistry	2 Credits
BMB-307	Basic Immunology	2 Credits
BMB-308	Clinical Biochemistry	2 Credits
BMB-309	Laboratory Work	8 Credits
BMB-310	Viva-voce	2 Credits

Extra-departmental courses:

BMB-351	Applied Biostatistics	4 Credits
BMB-352	Microbiology	2 Credits

Total Credits in 3rd Year BS (Honors): 34 Credits

BMB-301: Metabolism of Nitrogenous Compounds 3 Credits

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, antimetabolities 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:** Modification of transportation, central and specific pathways.

References:

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

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 spectrium, 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 penicillins, 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).

References:

1. Organic Chemistry by Finar.
2. Chemistry of Organic Natural Products, Vol. 1. .P Agrwal *Goel Publishing*.
3. Natural Products Chemistry. K. Nakanishi, T. Goto, S. Ito, S. Natori and $. Nozoe. *Academic Press, Inc.*
4. Introduction to Alkaloids. Biogenic Approach. *G.A. Cordill.*
5. Antibiotics and Antimicrobial Action. S.M. Hammond and P.A. Lambert. *Edward Arnold.*

BMB-303: Human Nutrition **2 Credits**

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

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

3. **Role of proteins in human nutrition:** Function of proteins, 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 vitamins A, D, E and K - their sources, biological functions, deficiency symptoms and recommended daily allowances (RDA); water soluble vitamins thiamine, riboflavin, niacin, pyridoxine, lipoic acid, folic acid, ascorbic acid (vitamin C) –
   their sources, biological function, deficiency symptoms, RDA, and coenzyme activities.

6. **Mineral and trace elements:** Functions and importance of minerals – calcium, iron, potassium, magnesium, zinc, phosphorus, sodium; function and importance of trace elements in human body - copper, selenium, manganese, iodine etc.

References:

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**

1. **Inhibition of protein synthesis and post-translational modifications:** Inhibition of protein synthesis: role of antibiotics and other chemicals. Different types of processing

of nascent polypeptides; role of chaperons; synthesis of exportable proteins in eukaryotes.

2 **Assaying macromolecular interactions:** DNA-protein interactions (DNase footprinting, chromatin immunoprecipitation (ChIP), protein-protein interactions (in brief), interaction of RNA with other macromolecules (SELEX).

3. **Regulation of gene expression:** Chromatin remodeling and gene regulation, genome editing tools (in brief), 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.

4. **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.

5. **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.

6. **DNA sequencing:** Sanger's method, Maxam and Gilbert's method, next generation sequencing methods.

7. **Application of DNA markers:** RFLP, AFLP, SSR, RAPD and SNP.

References:

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.
4. Molecular Biology of the Cell. Bruce. Alberts, Denneis Bray, Julian Lewis, Martin Raff, Keith, Roberts, James, D. Watson. *Garland Publishing Inc*.

BMB-305: Molecular Genetics **3 Credits**

1. **General nature of 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, biochemistry of recombination system and site-specific recombination.
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.
4. **Linkage and chromosome mapping in higher organism:** Recombination and crossing over, exception to Mendelian principles of independent assorment, 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.
5. **Cytogenetics:** Analysis of mitotic chromosome, karyotype and its applications, chromosome aberration and associated diseases like Down syndrome, turner syndrome, Kleinfelter syndrome etc., Genetic basis of autosomal and sex-linked dominant and recessive disorders, invasive and non-invasive prenatal diagnosis, possible treatment options; genetic counseling.
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. Autogeneous regulation of gene expression.

References:

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*.

BMB-306: Plant Biochemistry **2 Credits**

1. **Plant cell and metabolism specialities:** 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, abscisicacid, ethylene, brassinsteroids 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.

References:

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

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.

References:

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: Clinical Biochemistry **2 Credits**

1. **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), reference value and reference state, unexpected test results, sensitivity and specificity, standardization of assay methods. Introduction to good clinical laboratory practice (GCLP).

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

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. Assay principle and diagnostic importance of:

i) Enzymes/proteins: creatine kinase (CK), alanine amino transferase (ALT), aspartate amino transferase (AST), lactate dehydrogenase (LDH), acid phosphatase (ACP), alkaline phosphatase (ALP), amylase, lipase, serum total protein, albumin, globulin, A/G ratio.
ii) Metabolites: Bilirubin, Cholesterol, Uric acid, Creatinine, CCR, Urea/BUN,
iii) Serum electrolytes: Na^+, K^+, Cl^-, $HCO3^-$

5. **Biochemistry of some common diseases:** Biochemical interpretation of the causes, diagnosis, and possible treatment options of diabetes, atherosclerosis, hyperuricemia and gout, rheumatoid arthritis, malabsorption syndrome, acidosis and alkalosis, obesity.

References:

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**

(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 acetoaminophen 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.

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

Extra-departmental courses:

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

Theory: 60 Marks

1. **Introduction**: Definition, characteristics, uses and importance of statistics, nature of statistics, population, sample, parameter, variable, data; biostatistics - definition and applications, scope of biostatistics in applied field.

2. **Sampling techniques:** Basic idea about sampling and sample survey, detailed study about simple random sampling, concept of cluster sampling, stratified sampling and systematic sampling with examples.

3. **Classification:** Definition and different types of classification, general rules of classification, frequency distribution, construction of a frequency distribution, cumulative frequency distribution.

4. **Measures of central tendency**: Definition, different types of measures of central tendency, arithmetic mean, geometric mean, harmonic mean, weighted arithmetic mean, median, quartiles, deciles, percentiles, mode, computing median and mode graphically.

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, probable error, 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, some idea and discussion about non-parametric test difference between parametric and non-parametric test.

Practical: 40 Marks

1. **Introduction to statistical software:** Familiarization with commonly used statistical software such as SPSS, GraphPad and R.

2. **Diagrammatic and graphical representation**: Determination of sample size and distribution, bar diagram, pie chart, line graph, stem and leaf plot, histogram, frequency polygon, frequency curve, cumulative frequency curve.

3. **Descriptive statistics:** Column statistics - The column statistics analysis computes descriptive statistics (and normality tests) for each data set; Frequency distribution - This section explains how to generate a frequency distribution (table and graph) from raw data.

4. **Compare two groups:**
   a) **Unpaired t test from raw data:** To investigate the likelihood that the difference between the means of the two groups could have been caused by chance.

   b) **Unpaired t test from averaged data:** To compare the means of two unmatched groups, assuming that the values follow a Gaussian distribution.

   c) **Paired t test:** To compare the means of two matched groups, assuming that the distribution of the before-after differences follows a Gaussian distribution.

   d) **Chi-squared test:** Observed frequencies for two or more groups are compared with expected frequencies by chance.

5. **Compare three or more groups:**
   a) **One-way ANOVA:** To determine whether there are any statistically significant differences between the means of two or more independent (unrelated) groups.

   b) **Two-way ANOVA:** To compare the mean differences between groups that have been split on two independent variables.

c) **Multiple comparisons:** Post hoc test to confirm where the differences occurred between groups.

6. **Correlation analysis:** Compute correlation between two specific columns:
   a) **Pearson correlation:** Measure of the strength of linear relationship between two variables.

   b) **Spearman rank correlation**: Non-parametric measure of correlation, using ranks to calculate the correlation.

   c) **Regression analysis:** Useful for exploring relationships among variables and understand which among the independent variables are related to dependent variable.

References:

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**

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.

Practical: 10 Marks

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

References:

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)

Departmental courses:

BMB-401	Cell Biology	4 Credits
BMB-402	Plant Biotechnology	2 Credits
BMB-403`	Pharmaceutical and Food Biotechnology	4 Credits
BMB-404	Molecular Biology-IV	2 Credits
BMB-405	Biochemistry of Cancer	2 Credits
BMB-406	Virology	2 Credits
BMB-407	Immunology	4 Credits
BMB-408	Biochemistry of Drugs	2 Credits
BMB-409	Neurobiochemistry	2 Credits
BMB-410	Applied Human Nutrition	2 Credits
BMB-411	Basic Bioinformatics	2 Credits
BMB-412	Laboratory Work	8 Credits
BMB-413	Viva-voce	2 Credits

Total Credits in 4th Year BS (Honors): 38 Credits

BMB-401: Cell Biology 4 Credits

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**: The benefits of sex, meiosis, pri-mordial germ cells and sex determination 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 tyrosin 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.

References:

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

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 - genotyping:** Markers including SNP, SNP validation and conversion to PCR-based markers, Genotyping by sequencing, mapping and breeding populations, linkage of marker to trait of interest, marker-aided selection for breeding, genome wide association mapping.
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, genome editing technologies, specially CRISPR-mediated transformation,

chloroplast transformation plants as bioreactors and vaccine production systems, biosafety issues, GM crops.

4. **Discovery and 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.

References

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

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.

References:

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**

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.

References:

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**

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.

References:

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**

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.

References:

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.
4. Fundamental Virology. B.N. Fields, B.M. Knipe. *Raven Press*

BMB-407: Immunology **4 Credits**

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.

References:

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

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

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.

References:

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

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.

References:

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

1. **Nutrition and energy metabolism:** Energy balance, respiratory quotient, basal metabolic

rate, energy requirement and energy expenditure, thermic effect or specific dynamic action (SDA) of food, measurement of energy expenditure and requirement.

2. **Life cycle nutrition:** Importance and function of nutrients in different stages of pregnancy, relationship of low birth weight baby with maternal nutrition, nutrition of lactating mother and infant, nutrition during childhood, adolescence and old age.

3. **Dietary management of diseases:** Diets for patients suffering from diabetes mellitus, **g**out, atherosclerosis, jaundice and other liver diseases, obesity and cancer.

4. **Role of functional foods in human health:** Significance, claims for functional foods, important functional foods.

5. **Protein energy malnutrition:** Aetiology, characteristics and symptoms of kwashiorkor, marasmus and their management, effect of protein energy malnutrition on fetal brain development.

6. **Assessment of nutritional status of a population:** Community nutrition, nutritional problems of Bangladesh and their possible remedies.

References:

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**

Theory: 30 Marks

1. **Introduction to bioinformatics:** Definition and application of bioinformatics in various fields. Introduction to biological data format and sequence alignment. Substitution matrices, scoring matrices – PAM and BLOSUM. Multiple sequence alignment, Local and Global alignment concepts and interpretation of statistical values. Familiarization with the commonly used bioinformatics tools such as BLAST, Clustal W, and Codon optimization tools.

2. **Biological database:** Structure and organization of various bioinformatics databases such as NCBI, ENSEMBL and Uniprot. Usage of different biological databases for data retrieval and analysis in order to answer scientific research question.

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

Diversity of different biological algorithms that are used to execute variety of bioinformatics tools. Applications of the algorithms commonly used in Bioinformatics**.**

4. **Molecular phylogenetics and evolutionary bioinformatcis:** 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.

5. **Structural bioinformatics:** The importance of the structural features of different types of biomolecules (RNAs and proteins) and understand the structure-function relationships.

Practical/Projects: 20 Marks

a) Multiple sequence alignment and inference
b) Phylogenetic tree construction and analyses
c) Prediction of secondary structure of RNAs and proteins
d) Three dimensional structure prediction of an unknown protein sequence
e) Use of various tools to validate a predicted 3D structure of a protein
f) Prediction of post-translational modification and glycosylation of a predicted protein
g) Prediction of a transmembrane helix of a protein sequence
h) Familiarization with PDB tools

References:

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: Laboratory Work **8 Credits**

(A) Molecular Biology

1. Isolation and quantitation of DNA from plant tissue.
2. Isolation of plasmid DNA by alkaline lysis method.
3. Agarose gel electrophoresis of DNA.
4. Characterization of pGLO plasmid.
5. PCR/Restriction digestion of DNA.

(B) **Biochemical and Pharmaceutical Techniques**

1. Thin layer chromatography (TLC) of fruit juices for identification of sugars.
2. Gel filtration chromatography for separation of known proteins from a mixture.
3. Estimation of streptomycin.
4. Ion exchange chromatography of known proteins and checking for separation by gel electrophoresis.
5. Estimation of vitamin A by HPLC.

(C) **Cellular and Clinical Immunology**

1. Identification of blood groups and Rh antigen.
2. Total and differential white cell counts.
3. Separation of blood leucocytes.
4. Determination of white cell viability.
5. Demonstration of phagocytosis by neutrophils.
6. Assay of human serum immunoglobulins.

(D) **Environmental Microbiology**

1. Water quality determination by presumptive test for coliform.
2. Determination of bacterial load, lactose fermenting and nonfermenting coliform counts from environmental samples.
3. Test of antibiotic susceptibility of microorganisms isolated from environmental samples.
4. Isolation and enumeration of bacteriophage.

(E) **Bioinformatics and its Application**

1. Introduction to bioinformatics.
2. Familiarization with database: NCBI, PubMed, Nucleotide and protein database, OMIM,
   etc.
3. Analysis with BLAST, multiple sequence alignment, primer design.
4. Phylogenetic analysis: Introduction to MEGA software.
5. Applications of bioinformatics: SNPs, proteomics – protein analysis by EXPASY tools, transmembrane helix determination, secondary and 3D structure prediction.

(F) **Assignment:**

Out of 200 marks of this course, 20 marks are allotted for an assignment. In this, every student will be required to participate in practical training/orientation course during the summer vacation in pharmaceutical, clinical and research establishments and submit a short report.

BMB-413: Viva-voce **2**

Credits

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