University of Dhaka

Curriculum for Master of Science (MS)
in
Biochemistry and Molecular Biology

Sessions: 2022-23 and onwards

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

MASTER OF SCIENCE (MS)
IN
BIOCHEMISTRY AND MOLECULAR BIOLOGY
UNIVERSITY OF DHAKA

Sessions: 2022-23 and onwards

Student Admission:

Students will be admitted in the MS program in the department under the Faculty of Biological Sciences as per four Year BS results in the Department of Biochemistry and molecular Biology, University of Dhaka, with a minimum CGPA of 2.5 in the scale of 4. However, department may re-fix the minimum CGPA requirement to a higher level and get approved as such by the authorities. Students must be admitted to MS programme within two academic years of completion of BS (Hons) programme.

Duration of the Program:

The duration of MS Program in the Faculty of Biological Sciences will be of 1 (one) academic year and will be a maximum of 52 weeks which will be distributed a fellows

Classes	28 weeks
Preparation Time for Course Final Examination	4 weeks
Course Final Examination (Theory + Practical) if there	4 weeks
Preparation time for thesis submission/ Practical including internship after completion of Final examinations	12 weeks
Results	4 weeks
Total	**52 weeks**

Results of the annual examination should be published within 4 weeks from the date of the last final exam (theory/practical/thesis presentation whichever is the latest).

MS Program Learning Outcomes:

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

1. Research Skills and Proficiency in Laboratory Techniques:

a) Perform cutting-edge research to address fundamental and practical scientific questions by applying core knowledge (achieved from BS learning out comes), laboratory and research skills to solve wide variety of biochemical and molecular problems.
b) Analyze, discuss and create theoretical framework using comprehensive literature mining.
c) Perform literature mining by using available web tools.

d) Conduct research with relevant molecular bioscience protocols together with computational and bioinformatics tools.
e) Qualitatively and quantitatively analyze and interpret scientific data based on sound scientific principles and reasoning.
f) Understand and comply with current policies on the rights of research subjects, copyrights, ethics, malpractice, data ownership and use of animals, hazardous materials and rDNA.
g) Maintain a safe workspace, adhere to lab safety regulations and display responsible conduct in research

2. Effective Writing, Communication and Presentation Skills

a) Produce written documents appropriate for publication, progress reports and thesis.
b) Describe basic biological concepts and principles and underlying chemical, physical and mathematical foundations.
c) Accurately and professionally, present their research in seminar format.
d) Defend research findings in an examination environment.
e) Apply statistical principles to analyze and interpret their results.
f) Understand how to avoid plagiarism.
g) Demonstrate their ability to defend their research findings in an examination environment.
h) Demonstrate the ability to constructively mentor, teach and support others.
i) Present research findings to the public in terms understandable to those without knowledge of the biomedical sciences.

3. Teamwork/Networking skills

a) Develop and maintain good working relationships with colleagues, supervisors and administrative staff at the institution.
b) Establish new connections within their field of research by attending seminars, meetings, symposiums or conferences.
c) Demonstrate the ability to effectively listen and give constructive feedback to others.
d) Show leadership skills and effective team management**.**

4. Professional and Ethical Behavior

a) Work effectively individually or in a group in a multidisciplinary setting.
b) Apply the principles of academic integrity and ethics of scientific research.
c) Demonstrate a good work ethic by setting goals and meeting deadlines.
d) Plan for professional growth and personal development within and beyond the undergraduate program.
e) Become a productive and ethical contributor to scientific research.
f) Efficiently manage own schedule, arriving on time to meetings, classes and other scheduled events

Assignment of Credits:

The entire MS program is covered by a set of theoretical, thesis work, practical (laboratory/field) if there, seminars/project/internship courses.

(a) Theoretical Courses: A minimum of 15 class-hours will constitute 1.0 credit.

(b) Practical courses: A minimum of 60 laboratory-hours will constitute 1.0 credit.

(c) Thesis: The mode of distribution of thesis will be determined by the academic committee of the department in due time; however, the minimum CGPA in BS program should not be less than 3.0 in the scale of 4.0

(d) Seminar course: A set of teachers approved by the departmental academic will assist, monitor and assess student's presentation capabilities for in-course assessment. A student must have to earn minimum 30 credits for successful completion of his/her MS program.

(e) Distribution of credits is as follows:

				Total Credits
Theory	**Thesis**	**Seminar**	**Viva-Voce**	
20	6	2	2	30

Evaluation of Students' Performance:

The total performance of a student in a given course will be evaluated on the basis of a scheme of continuous assessment and course final examinations.

a) For theory courses, the continuous assessment will be made through a set of in-course examinations (formative and summative assessment) and class attendance.
b) Continuous assessment of Practical (laboratory/field) courses will be made through observation of the student at work, *viva-voce*, assignments and evaluation of practical reports.
c) The scheme of continuous assessment for the practical courses will be announced by the teacher on the first day of classes.

d) The distribution of marks for a theoretical and practical course will be as follows:

Class attendance	5%
In-course assessment	35%
Course final examination	60%

e) The distribution of marks for thesis will be as follows:

Thesis presentation	40%
Thesis evaluation by external examiners	60%

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

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

g) In-course Assessment (Theory courses):

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

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

h) The Course Final Examinations:

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

ii. Pattern of question will be decided by the respective academic committee of the department.

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

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

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

vi. Assessment of Seminar: Seminar will be evaluated by a committee involving three internal members of the examination committee and two members nominated by the academic committee of the respective department.

vii. Assessment of Final Laboratory work works for non-thesis students. The final examination on practical works will be conducted by the course teachers to be appointed as examiners along with the external examiner of the examination committee.

viii. Assessment of Thesis: Oral presentation thesis defense will be evaluated by a committee of 5 members of which 4 are from the examination committee of the respective year and 1 is his/her supervisor. The thesis will be evaluated by two external examiners from outside the department. If the difference of marks of two external examiners is more than 20%, there will be a third examiner to examine. Marks of the nearest two examiners will be used to get average marks as final marks.

i) Viva-voce/Oral examination:

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

j) The Grading System:

Marks obtained for each course will be converted to grades. A basic four-point (4.00) grading scale will be followed. The following letter grades and corresponding grade points will be used to determine the student's grade point average (GPA) as approved by the University of Dhaka.

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

Earned Credits:

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

counted for the calculation of credits earned.

Calculation of GPA:

Grade Point Average (GPA) is the weighted average of the grade points obtained in all the courses passed/completed by a student in an academic year. The Grade Point Average (GPA) is computed in the following manner:

$$GPA = \frac{\sum (Grade\ Points \times Credits)}{\sum Credits\ Attempted}$$

The Grade Point Average (GPA) is computed by dividing the total accumulated grade points earned during the MS program by total credit points attempted. For successful completion of MS program, a student must earn 30 credits or more if approved with no F grade in any course. However, this minimum requirement may be raised by any department as per their programme and final GPA will be calculated using all the credits attempted.

Class Attendance:

(a) A student must attend at least 75% of the total classes held in an academic year to be eligible for appearing in the final examination of that year without paying any penalty.
(b) A student attending at least 60% classes but less than 75% classes will be allowed to appear for the examination after paying non-collegiate fees fixed by the university.
(c) A student attending less than 60% classes will not be allowed to appear for final examination for that year.

Retake:

A student can appear in retake examination once only in one course to clear F grade within 6 weeks after announcement of the result and definitely before registration for convocation. His/her in-course assessment marks will be retained.

Readmission:

A student failing to earn the degree may seek readmission with the next batch. For readmission, a student will have to apply within one month after announcement of the result of the concerned year. Readmission will be allowed only after the approval of the departmental academic committee.

On readmission, a student may choose, subject to approval of the Academic Committee of the department, to retain his/her in course marks earned earlier as chosen by him/her. Student must clearly indicate his/her choice on the application for readmission. The Academic committee will determine whether the re-admitted student can undertake any thesis work.

If a student succeeds after taking readmission his/her transcript will bear “R” after GPA with a footnote of mentioning “R means readmission”.

Requirements for successful completion:

A student must earn GPA of 2.50 on 4.00 scale for obtaining MS degree.

Time limits for completion of Master's Degree:

A student must fulfill all the requirements for a Master's degree within a maximum period of two academic years, from the year of enrolment.

Teaching Methodologies:

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

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

☐lectures ☐discussions ☐homework ☐reading text book ☐peer reviewing ☐problem based ☐case studies ☐ presentation ☐Other teaching method (please specify)

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

Structure of Curriculum:

The total number of earned credits for MS degree is 30, of which the number of credits on theory courses to be taken is 20, and for Thesis/Laboratory work will be 6. Two credits have been allocated for Seminar/Paper presentation, while 2 credits have been earmarked for Viva-voce. Each 4-credit theory course will be of 100 marks comprising 60 lecture-hours, and 2-credit theory course will be of 50 marks comprising 30 lecture-hours. The students will choose 20 credits from the list of theory courses BMB-501 to BMB-510.

Course No.	Name of the course	Credits
BMB-501	Advanced Molecular Biology	4
BMB-502	Advanced Bioinformatics	2
BMB-503	Drug Designing and Pharmacogenomics	4
BMB-504	Advanced Molecular Diagnostics	2
BMB-505	Agricultural Biochemistry	2
BMB-506	Environmental Biochemistry	2
BMB-507	Clinical Immunology and Immunodiagnostics	4
BMB-508	Applied Nutrition and Nutritional Biochemistry	4
BMB-509	Biochemistry of Natural Products	2
BMB-510	Biotechnology Business Management	2
BMB-511	Advanced Forensic Sciences	2
BMB-512	Laboratory Work (For Group A)	6
BMB-512	Thesis (For Group B)	6
BMB-513	Seminar / Paper Presentation	2
BMB-514	Viva-voce	2

Structure of Courses:

BMB-501: Advanced Molecular Biology **4 Credits**

Introduction:

This course focuses on the regulation of gene expression at the post-transcriptional level, particularly by small RNAs and describes the outcomes of the human genome project. It will also discuss the advancement of our understanding about human genome in the post-genomic era. Finally, this course will elaborate various proteomic tools and their applications in understanding the genomes and proteomes.

Objectives:

The objectives of this course are to:

- Explain gene regulation occur post-transcriptionally by small RNAs.
- Understand technological basis of human genome project.
- Understand outcomes and impacts of human genome project.
- Describe proteomics techniques and their applications.

Contents:

1. **Gene regulation by small RNAs:** Small RNAs and insights into a new level of gene regulation. Posttranscriptional gene silencing (PTGS) – RNA interference (RNAi) gene silencing; role of dsRNA in triggering PTGS/RNAi; formation of dsRNA; role of Dicer and RISC (RNA Induced Silencing Complex) in RNAi gene silencing system. Micro-RNA (miRNA)

structure, biogenesis, mechanism of action, regulation of gene expression and role in diseases. Small-interfering RNA (siRNA) synthesis, role in RNA interference, use of siRNA as therapeutics, siRNA delivery. Piwi-interacting RNA (piRNA) biogenesis and role in genome stability and to counter foreign sequences; long non-coding RNA.
Application of epigenetics in chromosome inheritance and human diseases.

2. **Genomics:** Human Genome Project - brief mention of others. Minimal Genome Project, Synthetic genome, synthetic strain.
Physical mapping and sequencing of the whole genome; sequence analysis and annotations; linkage analysis; physical map-based cloning and mapping in silico; comparative homologies, evolutionary changes and single nucleotide polymorphism, Whole Genome Association studies, Genome editing.

DNA microarray, preparation of microarray slides, hybridization, interpretation and application.

3. **Proteomics:** Area and scope, experimental approaches to proteomics: "classical proteomics" 2-D gel electrophoresis; Protein engineering, Mass spectrometry; functional characterization of proteins: differential display, phage display, use of GFP to visualize proteins in live tissues. Human proteomics initiative: annotation of all human proteins in SWISSPROT and beyond. Role of proteomics in disease.

Intended learning outcomes (ILOs):

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

- Compare the difference between transcriptional and post-transcriptional gene regulations.
- Elucidate the biogenesis of small RNAs such as miRNAs, siRNAs, piRNAs in eukaryotic system and their roles in RNA interference for developmental programs.
- Identify the roles of catalytic proteins and RISC in RNAi gene silencing system.
- Explain the roles of small RNAs in communicable and non-communicable diseases.
- Demonstrate the design, application and prospect of small RNA-therapeutics.
- Familiar with human genome project and its technological aspects.
- Explain the findings of the human genome project.
- Elucidate the advancement and impacts of the human genome project in health and disease.
- Illustrate different proteomics tools such as mass spectrometry, phage display and yeast two-hybrid systems and their applications in health and diseases.

Required number of classes:

No	Title of the unit	Number of classes
01.	Gene regulation by small RNAs	20
02.	Genomics	20
03.	Proteomics	20
	Total	**30**

Recommended books and readings:

1. Genetics - A Conceptual Approach by Benjamin A Pierce.
2. RNAi - A Guide to Gene Silencing by Gregory J. Hannon.
3. RNA Interference in Practice: Principle, Basics and Methods for Gene Silencing. in *C. elegans*, Drosophila and Mammals by Ute Schepers.
4. Discovering Genomics, Proteomics and Bioinformatics by A Malcolm Campbell and Laurie J Heyer.
5. Introduction to Genomics, 2nd edition by Arthur M. Lesk.
6. Introducing Proteomics: From Concepts to Sample Separation, Mass Spectrometry and Data Analysis by Josip Lovric.
7. A First Course in Systems Biology, 1st edition by Eberhard Voit.
8. Proteomics in Systems Biology by Jörg Reinders.
9. Epigenetic Regulation and Epigenomics by Robert A. Meyers (Editor).

BMB-502: BMB-502: Advanced Bioinformatics 2 Credits

Introduction:

This course is designed to familiarize the students with the theoretical concepts behind the different applications of bioinformatics. The course will assist the students to appreciate how the multi-disciplinary concepts of mathematics, statistics, computer science and biology can successfully be amalgamated. The course will encourage students to apply the core bioinformatics knowledge – gained from this course to solve various biological questions.

Objectives:

This course has the following objectives:

- Students should become familiar with the structure and organization of Specialized bioinformatics databases such as ENCODE, NONCODE, TCGA, GOBP, SNPdb, GOBP, GOMP, GOCC.
- Students will be encouraged to use different biological databases for data retrieval and analysis in order to answer scientific research question.
- Students will gather knowledge on genomics and transcriptomics data analysis.
- Student should understand the concept of microarray data analysis.
- Students should have an understanding regarding the principles of epitope based vaccine design.
- Students should be familiar with the basic principles of next generation DNA sequencing techniques and data analysis.
- Students should comprehend the basic principle of gene expression analysis techniques such as microarray and RNA seq and should be familiar with different gene expression databases.

- Students should be familiar with the different quantitative proteomics techniques and databases.

Contents:

1. **Specialized Bioinformatics databases:** Structure, organization and usage of various specialized bioinformatics databases. ENCODE: Encyclopedia of DNA Elements. NONCODE: Database dedicated to non-coding RNAs (excluding tRNAs and rRNAs), TCGA: The cancer genome atlas, Roadmap Epigenomics Project.
   Basic concept of GO enrichment, Classification of GO terms: Gene- ontology Biological Process (GOBP), Gene-ontology Molecular Function (GOMP) and Gene-ontology Cellular Component (GOCC).

2. **Analysis of transcriptomics data**: The basic principle of microarray. Familiarization with different large-scale gene expression projects and data repository platforms such as expression Atlas, GTEx, FANTOM and Illumina body Map. Understanding the basic features of gene expression dataset and determination of differentially expressed genes in the RNA-seq and microarray datasets.

3. **Protein Analysis and Proteomics**
   Protein Databases; Four Perspectives on Proteins: Protein Domains and Motifs, Physical Properties of Proteins, Protein Localization, Protein Function; Protein Data Bank (PDB); Protein Structure Prediction: Homology Modeling (Comparative Modeling), Fold Recognition (Threading), Ab Initio Prediction (Template-Free Modeling), Introduction and application of computational proteomics. Use of different proteomics databases for the Interpretation of different proteomics parameters such as peptide coverage, identity score, MS/MS spectra quality, peptide/protein intensity. Molecular docking: Protein-protein docking using online server such as ClusPro, Docking using PyRx.

4. **Analysis of Next-Generation Sequence Data**: DNA Sequencing Technologies, the basic principle of next generation sequencing techniques (DNAseq and RNAseq), Experimental Design and Sample Preparation, From Generating Sequence Data to FASTQ, Genome Assembly, Sequence Alignment, Variant Calling: Single-Nucleotide Variants and Indels, Visualizing and Tabulating Next-Generation Sequence Data, Storing Data in Repositories

5. **Biological network**: Basic concept of biological network. Structure and properties of biological network. Different types of biological network: Protein-Protein interaction network, Gene-regulatory network, Biochemical pathway network. Building up biological network using bioinformatics tools such as STRING and STICH.

6. **Immunoinformatics**: Basic knowledge about the basic mechanism of antigen presentation. Familiarization with different immunoinformatics websites and tools. B-cell

epitope prediction, Prediction of T cell epitopes and MHC binding, analysis of HLA-epitope interaction, understanding of principles of epitope-based vaccine design. Continuous and discontinuous epitope, multiepitope vaccine construction and role of linker sequences and adjuvant, in silico cloning of the vaccine construct using SnapGene or related tool.

Intended learning outcomes (ILOs):

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

- Distinguish different types of biological data such as molecular data: sequence data, protein modification data and protein-protein interaction data etc. quantitative data: gene expression, RNAseq, protein intensities etc. metadata: linking gene to corresponding mRNA and protein sequences.
- Retrieve biological data from different biological databases and should be able to distinguish different formats of datasets such as genebank format, FASTA format etc.
- Distinguish among different output parameters such as e-value, alignment score, homology percentage etc.
- Distinguish different bioinformatics algorithms and their strength and weaknesses.
- Predict the conserved domains of proteins via structure-function analysis.
- Understand large scale gene expresion data repository platforms.
- Identify basic features of gene expresion dataset.
- Determine differentially expressed genes in the RNA-seq and microarray datasets
- Understand homology modeling, fold recognition, ab initio prediction
- Understand next generation sequences data analysis, genome assembly and alignment
- Run web-based immunoinformatics tools.
- Identify the proteasomal cleavage sites by using computational tools.
- Analyze HLA-epitope interaction.
- Retrieve gene expression data from various databases such as expression atlas.
- Understand biological networking.
- Build biological network based on proteomics data.
- Interpret different proteomics parameters.

Required number of classes:

No	Title of the unit	Number of classes
01.	Introduction to bioinformatics database	4
02.	Analysis of transcriptomics data	5
03.	Protein Analysis and Proteomics	5
04.	Analysis of Next-Generation Sequence Data	6
05.	Biological network	5
06.	Immunoinformatics	5
	Total	**30**

Recommended books and readings:

1. Bioinformatics and Functional Genomics, Third edition, Jonathan Pevsner
2. Applied Bioinformatics: An Introduction, by PM Selzer, RJ Marhöfer, A Rohwer
3. Bioinformatics, 4th Edition, By Andreas D. Baxevanis, Gary D. Bader, David S. Wishart

BMB-503: Drug Designing and Pharmacogenomics 4 Credits

Introduction:

This course provides knowledge of the basics of drug development. It will discuss about the long processes and different techniques between the thinking of a researcher in the laboratory to development of a drug against a specific disease and the final approval of the drug for therapeutic use. An introduction to pharmacogenomics is included in relation to the development of new drug development.

Objectives:

The objectives of this course are to:

- Understand the process of drug development, from target identification to final drug registration.
- Present drug development as a process involving target selection, lead discovery using computer-based methods and combinatorial chemistry/high-throughput screening.
- Explain safety evaluation, bioavailability, clinical trials, and the essentials of patent law.
- Learn about molecular recognition, computer aided drug design, and toxicology as applied to the development of new medicines.
- Understand basic principles of pharmacology and genomics as they pertain to pharmacogenomics and distinguish the different considerations applying to genes involved in pharmacokinetics versus pharmacodynamics.
- Provide an understanding using several specific examples of important pharmacogenomics and their implementation in clinical practice.

Course Contents:

1. **Drug receptors:** The evolution of the receptor concept, General principle of drug action, Receptor families, Drug Receptor interaction, Non-receptor mediated actions of drugs, Regulation of receptors.
2. **Drug transporters:** Drug transporters and drug response, transporter super families, genetic variation in transporters, transporters and pharmacokinetics.
3. **Drug design:** Basic concepts; study of lead compounds-modification and identification; target validation; high throughput technologies; molecular modeling, molecular docking and

dynamics; physicochemical factors e.g. thermodynamic, electrostatic, and stearic factors; molecular interaction and kinetics; molecular method of drug design and development; screening of libraries of compounds; serendipitous observation; combinatorial chemistry in drug design.

4. **Biologic drug development and approval:** Pre-clinical and clinical trials, methodological and organizational considerations and the principle of trial conduct and reporting, sample size, delivery and assessment of clinical trials, genetic basis of drug designing.
5. **Structure activity relationship of drugs:** Quantitative structure activity relationship (QSAR), Structure activity relationship of some selected drugs-sulfa drugs, antihistamine drugs, antidepressant drugs.
6. **Designing of selected drugs:** TB drugs, novel topoisomerase inhibitors, tyrosine kinase inhibitors, androgen receptor antagonists.
7. **Advanced drug delivery:** Basic principles, controlled and sustained release, polymer based drug carriers, lipid membrane based drug carriers, permeation enhancement, molecular approach of drug delivery.
8. **Mechanism of action of some specialized drugs:** Chemotherapeutics, drugs affecting renal and cardiovascular functions, drug therapy for inflammation, drugs affecting gastrointestinal functions, chemotherapy for protozoal infections, chemotherapy for microbial infections, antiviral agents, anticancer drugs.
9. **Pharmacogenomics:** Pharmacogenetics as the future of drug therapy; genetic polymorphism of major drug metabolizing enzymes, allelic variation in drug metabolizing enzymes, pharmacological consequences of genetic polymorphism in the drug metabolizing enzymes, potential clinical applications of pharmacogenetics.

Intended Learning Outcomes (ILOs):

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

- Elucidate drug discovery process from target identification and validation through to filing of a compound and the approximate timescale for these processes.
- Illustrate the steps pharmaceutical company or university research groups consider to follow to initiate the identification of a lead compound.
- Molecular modeling, molecular docking, serendipity and combinatorial chemistry principles to find a lead compound with appropriate example.
- Explain the target of a drug and how to choose a drug target along with examples of target specificity and selectivity.
- Demonstrate the target validation techniques, their advantages and disadvantages.
- Identify a bioassay system for test validity; like high throughput screening (HTS) etc.
- Explain about basic mode of action, approach to design the TB drugs, novel topoisomerase inhibitors, tyrosine kinase inhibitors, androgen receptor antagonists.
- Differentiate between drugs and biologics, to understand about Biologic License Establishment.
- Illustrate drug approval processes, FDA approval process, orphan drug acts, the preclinical and clinical trials of drugs and biologics.

- Identify the limitations of the delivery of peptide and protein drugs and the principles of the novel approaches for biologic drugs with their advantages and disadvantages.
- Elucidate the drug transporters and their role in pharmacokinetics. Tissue distribution of transporter superfamilies, how the genetic variation in transporters affect the drug action.
- Describe the mode of action and the structure activity relationship of sulfa drugs, antihistamine and antidepressant drugs.
- Illustrate the structural features of different classes of drug receptors and their modes of action.
- Describe drug receptor interaction with examples and drug actions without specific receptors.
- Explain concept of pharmacogenetics and how this concept can be applied to drug therapy.
- Explicate how the genetic polymorphisms and allelic variations in drug metabolizing enzymes can alter the effects of drugs.
- Clarify the potential clinical applications of pharmacogenetics.
- Illustrate the mechanism of actions of drugs affecting renal and cardiovascular functions, inflammation, gastrointestinal functions, protozoal infections, and microbial infections.
- Demonstrate the mechanism of actions of beta-lactam antibiotics, aminoglycosides, protein synthesis inhibitors and antibacterial and antiviral agents.

Number of Lecture Hours:

No	Title of the unit	Number of classes
01.	Drug design	12
02.	Biologic drug development and approval	5
03.	Designing of selected drugs	5
04.	Advanced drug delivery	5
05.	Drug transporters	5
06.	Structure activity relationship of drugs	7
07.	Drug receptors	7
08.	Pharmacogenomics	6
09.	Mechanism of action of some specialized drugs	8
	Total	**60**

Recommended books and readings:

1. **Gooman & Gillman's Pharmacological Basis of Therapeutics,** Edited by Laurance Brunton and Bruce Chabner
2. **Biotechnology and Pharmaceuticals - Transforming Proteins and Gene into Drugs,** Edited by Rodney J.Y HO
3. **Principles of Drug Action**, Edited by Avran Goldstein, Lewis Aronew and Sumner M. Kalman
4. **Pharmaceutical Biotechnology, Drug Discovery and Clinical Applications**; Edited by O. Kayser and R. H. Muller.
5. **Biopharmaceuticals: Biochemistry and Biotechnology**, Edited by Gary Walsh
6. **Pharmacogenomics**, Edited by James Swarbrick

BMB- 504: Advanced Molecular Diagnostics 2 Credits

Introduction:

This course describes molecular diagnostic procedures, about the most commonly utilized molecular diagnostic testing protocols and molecular testing to the most commonly performed applications in the clinical laboratories such as: nucleic acid extraction, resolution and detection, analysis and characterization of nucleic acids and proteins, nucleic acid amplification and DNA sequencing.

Objectives:

The objectives of this course are to introduce students to:

- Identify the important parameters in the design of a laboratory to conduct the most commonly-used molecular diagnostics protocols.
- Identify the important parameters in the design of a quality system for molecular analyses.
- Become proficient in the techniques required in order to perform the most commonly-used molecular diagnostics protocols.
- Identify the important parameters in the design of a molecular diagnostic test.
- Identify the components of a well-controlled diagnostic test.
- Use critical thinking skills to trouble shoot problems as they occur and determine possible causes.

Contents:

1. **Molecular diagnostics:**
   a) Introduction to molecular diagnosis (MD) and molecular diagnostic laboratory, appropriate clinical specimen for MD.
   b) Isolation and characterization of DNA/RNA from different clinical specimens - basic principle of DNA extraction by organic method, chelex method, spin columns, magnetic beads etc.
   c) Overview of the application of molecular methods for diagnosis of genetic disorders, infectious diseases and cancer.
   d) PCR in molecular diagnostics - conventional PCR and real time PCR, qualitative and quantitative PCR, PCR-ELISA.
   e) Molecular diagnosis of viral disease - HBV, HCV, HCMV, HIV and HPV.
   f) Molecular diagnosis of bacterial disease - MTB and STDs.
   g) Molecular diagnosis of cancer - hematological cancer and solid cancer.
   h) Molecular HLA Typing - SSP, SSOP and SBT methods for typing HLA Class I and Class II.

2. POCT based clinical diagnostics:

a) Micro-nanofluids and future diagnostics –
Introduction to microfluidic/nanofluidic technology and their applications in diagnostics and life sciences.
Microfabrication and miniaturization - a basic understanding of principle and processes of microfluidic device fabrication, testing and characterization:
Lab-on-a-chip
Manufacturing technologies and development cycle of a microfluidic device from the design to the ready-to-use device.
Applications of microfluidics in point-of-care and clinical diagnostics, analytical and synthetic chemistry, biotechnology and cell biology.

b) Quality control and quality assurance system in clinical diagnostics –
Internal quality control system, External quality assessment system, Common pre-analytical errors, Common analytical errors.

c) Regulatory issues and compliances in clinical diagnostics -
Overview of IVD regulation, Regulatory compliance - FDA, CE, CLIA.

Intended Learning Outcomes (ILOs):

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

- Apply critical analysis to the molecular methodologies in use and under development at the forefront of microbiological diagnosis, treatment and research, and develop a creative approach to applying such methodology within the discipline
- Demonstrate knowledge and critical understanding of the use of internal and external quality assurance systems in health service laboratories
- Integrate theory and practice with respect to disease
- Critically evaluate the performance of new analytical technologies in the context of the specific requirements of the health service
- Explain how tests for molecular diagnostics are evaluated and how standard operating procedures are formulated
- Communicate effectively in a variety of settings with a range of individual

Required Number of classes:

No	Title of the unit	Number of classes
01.	Molecular diagnostics	10
02.	POCT based clinical diagnostics	20
	Total	**30**

Recommended books and readings:

1. Molecular Diagnostics 3rd Edition by George Patrinos Wilhelm Ansorge Phillip B. Danielson
2. Molecular Diagnostics for the Clinical Laboratorian, by Coleman, William B., Tsongalis, Gregory J. (Eds.).

BMB-505: Agricultural Biochemistry 2 credits

Introduction:

The course will introduce the tools of high throughput biology to produce information on DNA sequence, RNA expression, proteomics and metabolomics and the use of databases to aid in crop improvement. The course will specifically provide knowledge about the Physiology of Plant Adaptation to Biotic and Abiotic stresses and how this knowledge has been used to provide proof of concept for the function of identified genes in order to provide tolerant plants. Some successful examples of commercially released varieties using modern tools will also be provided.

Objectives:

The objectives of this course are to introduce students to:

- The concept of Integrated Databases for plants to mine information of useful traits and the consequences of sequence information.
- The detailed molecular biology of plants with respect to diseases and pests, nutrition and as well as abiotic stresses such as flooding, salt and drought, mineral deficiencies and toxicities and their remediation.
- The molecular biology of enhancing yield in cereals.
- The use of a plant as an industrial processor for production of pharmaceuticals or vaccines, biodegradable plastic, and bioremediation.

Contents:

1. **Responses to plant pathogenesis:**
   a) Ways in which plant pathogenesis cause disease, b) Plant defense systems,
   c) Genetic basis of plant-pathogen interactions, biochemistry of plant defense reactions,
   d) Systemic plant defense responses,
   e) Control of plant pathogen by genetic engineering.
2. **Responses to abiotic stresses:**
   a) Plant responses to abiotic stresses.
   b) Stresses involving water deficit.
   c) Osmotic adjustment and its role in tolerance to drought and salinity.
   d) Impact of water deficit and salinity on transport across plant.
   e) Additional genes induced by water stress.
   f) Freezing stress.

g) Flooding and oxygen deficit.
h) Oxidative stress.
i) Heat stress.

3. **Mineral nutrient acquisition, transport, and utilization:**
   a) Overview of essential mineral elements
   b) Mechanisms and regulation of plant K^+ transport
   c) Phosphorus nutrition and transport
   d) The molecular physiology of micronutrient acquisition
   e) Plant responses to mineral toxicity, plants as bioreactors.

4. **Crop improvement, yield enhancement and uses of novel plant products:** Uses and modifications of fatty acids & lipids, plants as sources of biodegradable plastics, plants as factories for chemical drug.

Intended learning outcomes (ILOs):

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

- Explain how NGS sequence technologies, genotyping by sequencing, genome wide association studies, and use of sequence information and different databases are being used for application in crop improvement for tolerance to biotic, abiotic as well as high yields.
- Acquire knowledge about pathogens and pests, their mode of operation and resistance. How plants fight back or become susceptible. How a plant can be bred or engineered to be resistant to bacteria, fungus, virus and well as insects. They will know about broad spectrum resistance to pests and diseases.
- Elucidate the physiology of salt, drought and flooding stress and molecular strategies for mitigating these stresses. They will know about regulatory and other genes and their effect in reducing stress after specific transformation events.
- Explain the molecular strategies for yield enhancement in cereals.
- Demonstrate transporters and their manipulations for specific rate-limiting nutrients, such as potassium and phosphorous and the detrimental effects of arsenic and its mitigation in plants.
- Illustrate the use of plants as bioreactors.

Required number of classes:

No	Title of the unit	Number of classes
01.	Responses to plant pathogenesis	8
02.	Responses to abiotic stresses	10
03.	Mineral nutrient acquisition, transport, and utilization	7
04.	Crop improvement, yield enhancement and uses of novel plant products	5
	Total	**30**

Recommended books and readings:

1. Biochemistry and Molecular Biology of Plants, 2nd Edition by Bob B. Buchanan (Editor), Wilhelm Gruissem (Editor), Russell L. Jones (Editor)
2. Plant Biotechnology: The genetic manipulation of plants, Second Edition by Adrian Slater, Nigel Scott, and Mark Fowler.
3. Plant Biotechnology and Agriculture: Prospects for the 21st Century, 1st Edition by Arie Altman Paul Hasegawa.
4. The Molecular Life of Plants, 1st Edition by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland.
5. Journals with recent articles on topics covered: Nature, Nature Biotechnology, PNAS, Plant Physiology, Nature Scientific Reports, Frontiers in Plant Sciences. Specific articles or references will be provided as and when published and where relevant

BMB-506: Environmental Biochemistry **2 Credits**

Introduction:

This is a course aimed to make students understand a couple of environmental concepts, consequences of major environmental problems in Bangladesh and the recommended basic solutions to manage these issues/challenges.

Objectives:

The objectives of this course are to introduce students to:

- Some environmental concepts (ecology and ecosystem, environmental genetics and bioengineered foods)
- The reasons and consequences of major environmental problems in their surrounding areas (environmental pollution)
- Basic solutions to prevent/reduce/manage major environmental issues (waste water treatment, waste management, bioremediation and wasteland)

Contents:

1. **Introduction to ecology and ecosystem:** Brief treatment.
2. **Environmental pollution (water, soil and air):** Noise and thermal pollution, their sources and effects. Pollution due to arsenic, tannery and textile industry waste, lead and sulphur- rich coal.
3. **Wastewater (sewage and industrial effluents) treatments:** Anaerobic and aerobic treatment, conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria-technical process and conditions, emerging biotechnological processes in waste - water.
4. **Solid waste management:** Landfills, composting, earthworm treatment, recycling and processing of organic residues. Treatment of heavy metal wastes, development of industrial waste treatment system. Anaerobic digestion of agroindustrial byproducts and wastes.
5. **Bioremediations:** Biotransformation of toxic wastes to harmless products.
6. **Wasteland:** Uses and management, bioremediation and biorestoration of contaminated lands.
7. **Environmental genetics:** Degradative plasmids, release of genetically engineered microbes in environment. Environmentally friendly biofertilizers and biopesticides, biofuels and biogas.
8. **Bioengineered foods:** GM foods; Regulation and safety.

Intended learning outcomes (ILOs):

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

- Explain how the biotic and abiotic components interact with each other on the earth.
- Demonstrate various types and mode of remediation of environmental pollution (air, water, soil etc) that exist in Bangladesh.
- Illustrate the strategy of waste water (sewage and industry) treatment.
- Comprehend management protocols for both biological and non-biological waste.
- Decipher the mechanism of waste degradation in soil through biological methods including bioremediation.
- Demonstrate the importance of bioremediation and bio-restoration.
- Explain the microbes in the soil can be modified genetically for production of biofertilizers and biopesticides, biofuels and biogas.
- Explain Genetically Modified Foods along with its regulation and safety.

Required number of classes:

No	Title of the unit	Number of classes
01.	Introduction to ecology and ecosystem	2
02.	Environmental pollution (water, soil and air)	4
03.	Wastewater (sewage and industrial effluents) treatments	5
04.	Solid waste management	5
05.	Bioremediations	3
06.	Wasteland	3
07.	Environmental genetics	5
08.	Bioengineered foods	3
	Total	**30**

Recommended books and readings:

1. Environmental Science by Daniel B. Botkin and Edward A Keller.
2. Microbial Biodegradation and Bioremediation, by Surajit Das.
3. Biodegradation and Bioremediation by Martin Alexander.
4. Environmental Microbiology by Ian L Pepper, Charles P Gerba, Terry J Gentry.
5. Soil and Water Contamination by Marcel van der Perk. Environmental Science by Daniel B Botkin and Edward A Keller.

BMB-507: Clinical Immunology and Immunodiagnostics 4 Credits

Introduction:

This course aims to focus on diseases caused by disorders of the immune system which are also very challenging in the context of modern medicine. The diseases fall into broad categories - autoimmunity, hypersensitivity, transplant rejection, immunodeficiency etc. The course will cover how the immune system attacks its own cells and tissues such as rheumatoid arthritis, responds inappropriately to harmless compounds for example in asthma and allergies, or fails to provide an adequate response to pathogens as in HIV AIDS. The course will also deal with tumor immunology, immunoassays for diagnosis of highly infectious viral diseases, transfusion reactions, hemoglobinopathy, immunotherapy etc. This course has an immense impact in understanding immunopathology, design drug delivery, management and treatment of diseases.

Objectives:

This course has the following objectives:

- To explain how immunological tolerance to self-break down and autoimmunity develops.
- To make students aware of the causes of primary and secondary immunodeficiencies.

- To present the pathophysiology and treatment option, if any, of the immunodeficiency syndromes.
- To explain how the immune system may respond aggressively against pollens or dust mites as in allergic reactions.
- To present the theories and mechanisms of allograft rejections.
- To provide comprehensive knowledge as to how cancer cells differ from the normal cells and explain immune responses against tumors.
- For designing assay protocols for immunodiagnosis of infectious diseases or detection of hormones at nanomolar concentrations.
- To provide comprehensive knowledge on flow cytometry methods with working principles.

Contents:

1. **Autoimmunity and autoimmune disease**: Characteristics, pathogenesis, genetic susceptibility to autoimmunity; role of infection in autoimmunity; pathogenic role of autoantibodies; control mechanisms; treatment of autoimmune diseases like autoimmune diabetes, autoimmune hemolytic anemia, rheumatoid arthritis, hereditary angioneurotic edema etc; diagnostic and prognostic value of autoantibodies.
2. **Allergy and hypersensitivity**: Coombs and Gell classification.

i) Type I- Immediate hypersensitivity - induction and effector mechanisms; allergens, atopy; IgE involvement, control of IgE production; immune response to inhalant allergens; role of mast cells, mediators and the reactions involved; genetic susceptibility and immunopathology; diagnosis; skin prick test; immunotherapy and new approaches for treatment.

ii) Type II- Antibody dependent cytotoxicity - mechanism of tissue damage; reactionsinvolving hemolytic diseases in newborn, autoimmune hemolytic anemia and hyperacute graft rejection; treatment.

iii) Type III- Immune complex mediated hypersensitivity - types of immune complex diseases; inflammatory mechanisms involved; experimental models to study; persistence of deposition and detection of immune complexes,

iv) Type IV- Delayed hypersensitivity - contact hypersensitivity; tuberculin-type and granulomatous hypersensitivity; cellular reactions and disease manifestation in delayed hypersensitivity.

3. **Transplantation immunology**: Immunology of allogenic transplantation; recognition of alloantigens; activation of alloreactive T cells; effector mechanisms of allograft rejection hyperacute, acute and chronic rejection; prevention and treatment - immunosuppression, inducing donor-specific tolerance or suppression; xenogeneic transplantation; blood transfusion; bone marrow transplantation - graft-versus-host disease.
4. **Tumor immunology**: Immune surveillance; tumor antigens; tumor associated antigens; immune responses to tumors; immune evasion by tumors; immunodiagnosis; immunotherapy for tumors.
5. **Immunodeficiencies**: Primary (congenital) immunodeficiencies; B and T cell deficiencies - SCIDs, X-LA; selective IgA and IgG deficiencies, hyper IgM syndrome; common variable

immunodeficiency; X-linked immunoproliferarive disease; defective class I and II MHC expression; Wiskott-Aldrich syndrome; ataxia-telangiectasia; chronic granulomatous disease,leukocyte adhesion deficiency; defects in complement proteins; defects in phagocytosis; therapeutic approaches. Acquired (secondary) immunodeficiency - HIV and AIDS, treatment and prevention.

6. **Immunoassays:** Enzyme immuno assays, MEIA for detection of anti-HCV, immunoassay for HIV envelope proteins, detection of HBsAg, HBeAg, IgM-anti-HBc, anti-HBe, immunoelectrophoresis, radioimmunoassay for hormones - insulin, hCG, etc. immunoturbidometry, microtiter-haemagglutination, detection and quantitation of immunecomplexes, cancer markers. Complement deficiencies, hemolitic assays for complement, hereditary angioneurotic edema, flow cytometry and FACS analysis
7. **Diagnostic application of monoclonal antibodies**: Progression of treatment, side effects of antibody therapy
8. **Immunohematology:** Full blood count, clinical utility of ESR determination, hemoglobinopathy, glycosylated hemoglobin (HbA1c), blood transfusion, transfusion reactions, acute kidney shutdown, haemostasis, cross-matching, tissue typing.

Intended Learning Outcomes (ILOs):

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

- Explain the regulatory mechanisms controlling autoimmunity, and effects of alteration of immunological status on disease outcome in animal model;
- Compare different types of hypersensitivity reactions with mechanisms of tissue damage, immunotherapy with allergen extracts and other treatment options;
- Interpret type of transplants and laws of transplantations with deviation;
- Elucidate and interpret principles and methods to assess histocompatibility between donors and recipients of grafts;
- Identify and explain tumor antigens and immune evasion by tumors;
- Classify immunodeficiency disorders and evaluate the consequences of the various immunodeficiency syndromes;
- Identify and interpret causes, mechanisms, immune responses and treatment of acquired immunodeficiency syndrome;
- Describe immunoassays for HIV envelope proteins, detection of HBsAg, anti-HCV;
- Evaluate use of monoclonal antibodies for diagnostic and therapeutic purposes; Explain clinical utility of CBC, HbA1c, ESR.
- Explain clinical utility of complete blood count (CBC), glycosylated hemoglobin, ESR.
- Explain cross-matching, blood transfusion and consequences of transfusion reactions.

Required number of classes:

No	Title of the unit	Number of classes
01.	Autoimmunity and autoimmune disease	8
02.	Allergy and hypersensitivity	12
03.	Transplantation immunology:	7
04.	Tumor immunology	6
05.	Immunodeficiencies	7
06.	Immunoassays	10
07.	Diagnostic application of monoclonal antibodies	4
08.	Immunohematology	6
	Total	**60**

Recommended books and readings:

1. Cellular and Molecular Immunology by Abul K Abbas, Andrew H Lichtman and Shiv Pillai.
2. Immunology, 7th edition by David Male, Jonathan Brostoff, David B Roth and Ivan Roitt.
3. Essential Immunology by Ivan Roitt.
4. Kuby Immunology by Thomas J Kindt, Richard A Goldsby and Barbara A Osborne.
5. Immunology by Ian R Tizard.
6. Basic and Clinical Immunology by Daniel P Stites, John D Stobo, H H Fudenberg and J V Wells.
7. Manual of Clinical Laboratory Immunology by Noel R Rose, Herman Friedman and John I Fahey.

BMB-508: Applied Nutrition and Nutritional Biochemistry 4 Credits

Introduction:

This course is designed to provide a basic, fundamental understanding of the effect of host nutrition on the immune response. It focuses on nutrigenomics, the effect of diet on gene expression, and nutrigenetics, how genetic differences affect nutrient uptake and metabolism, and how diet and underlying genetics interact to affect molecular phenotypes and ultimately susceptibility to diseases. This course covers nutrient-drug interactions, role of IT on nutrition education, malnutrition and psychological development, eating disorders, nutrition in emergencies, nutritional enhancement of plant food, nutrition in chronic non-communicable diseases, low birth weight, nutrition and HIV/AIDS, street food and nutrition intervention programs in Bangladesh.

Objectives:

This course has the following objectives:

- Comprehend the importance of nutritional adequacy in immunity.
- Understand the interaction between nutrition and drug, nutrition and genomics.
- Identify the importance of IT in nutrition education and gaining nutrition knowledge.
- Recognize the effects of malnutrition on psychological and cognitive development.
- Gain knowledge about eating disorders, total parental nutrition and low birth weight in relation to nutrition.
- Critically evaluate the role of nutrition in emergencies, globalization and nutrition, nutrition and poverty, nutrition and HIV/AIDS, nutrition intervention programs in Bangladesh.
- Identify the relationship between diet, nutrition and lifestyle related to chronic non-communicable diseases and what modifications can be made in the diet to reduce the risk for these diseases.
- Understand the sports nutrition, street food and nutritional enhancement of plant foods.

Contents:

1. **Malnutrition and immunity:** Role of nutrition in immune response to infection, malnutrition and immunity, nutrition and immunodeficiency disorders, dietary modification in infection.
2. **Nutrition and genomics:** Genetic and environmental variations and nutrient composition of foods, role of nutrients in gene expression and regulation,
3. **Nutrient–drug interaction:** Effect of Food on drug pharmacokinetics, effects of drugs on nutrition: drugs which affect food intake, absorption, metabolism and excretion.
4. **Nutrition and IT:** Nutrition Information, Education and communication – IT offers a new approach, IT & Nutritional support for patients with chronic illnesses.
5. **Malnutrition and psychosocial development:** Introduction: Definition of terms, impact of PEM on brain development and psychosocial development, nutritional rehabilitation and mental development, malnutrition and cognitive development - a multifaceted problem
6. **Current topics in nutrition:** Eating disorders; Anorexia nervosa and Bulimia nervosa, total parenteral nutrition (TPN), sports nutrition, poverty and nutrition, nutrition in emergencies - famine, war, flood and natural disasters, international nutrition - nutrition in developing economies, globalization and nutrition, nutritional enhancement of plant foods
7. **Applied nutrition:** Diet, nutrition and lifestyle-related chronic non-communicable diseases (NCDs), low birth weight - increased risk of morbidity, mortality and retarded cognitive development, nutrition and HIV/AIDS, street food as meal of millions, nutrition intervention programs in Bangladesh.

Intended Learning Outcomes (ILOs):

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

- Explain the role of nutrition in immune response to infection, concept of immunodeficiency disorders and relationship between malnutrition and immunity.
- Elucidate the basic concepts of genes, genomes, nutrigenetics and nutrigenomics and interpret the relationship between the genetic factors and nutrition.
- Describe diseases resulting from changes in one or more human gene and explain the molecular mechanisms of interaction of genes and nutrients and nutrient consumption and genotypes.
- Explain how food components regulate gene expression and how an individual's genotype influence phenotype with respect to chronic disease and human health and identify the role of nutrition in preventing genome pathology.
- Demonstrate the ability to interpret the drug-nutrient interaction in terms of effect of food on drug pharmacokinetics and effect of drugs on nutrition.
- Explain how to utilize it for nutrition information and education in relation to nutritional support for patients with chronic illnesses and health.
- Elucidate the basic biological concepts of relationship between malnutrition with cognitive and psychological development.
- Demonstrate knowledge of fundamental concepts of current and applied topics in nutrition such as nutritional enhancement of plant foods, street food, eating disorders, total parental nutrition (TPN), poverty and nutrition, sports nutrition, nutrition in low birth weight and HIV/AIDS.
- Apply knowledge of diet, nutrition and lifestyle choices related to chronic non-communicable diseases (NCDS) to develop interventions to affect change and enhance wellness in diverse individuals and groups.
- Explain the nutrition requirement in emergencies and able to implement nutrition intervention programs.
- Communicate nutrition information and scientific concepts to a variety of audiences.

Required number of classes:

No	Title of the unit	Number of classes
01.	Malnutrition and immunity	9
02.	Nutrition and genomics	8
03.	Nutrient–drug interaction	8
04.	Nutrition and IT	5
05.	Malnutrition and psychosocial development	10
06.	Current topics in nutrition	10
07.	Applied nutrition	10
	Total	**60**

Recommended books and readings:

1. Essential of Nutrition and Diet Therapy (8^{th} or 12^{th} Edition) by S R Williams and E D Schlenker.
2. Understanding the Brain and Its Development: A Chemical Approach (1^{st} Edition) by Harun K M Yusuf.
3. Basic Neurochemistry, by G J Siegel, R W Albers, B W Agranoff and R Katzman.
4. Human Nutrition and Dietetics (10^{th} Edition) by J S Garrow, W P T Jones, A Ralph.
5. Children's Thinking: Cognitive Development and Individual Differences by David F Bjorklund and Kayla B Causey.
6. Recent Trends in Agriculture and Food Security in Bangladesh. FAO, Bangladesh, Spijkers, Ad 2009.
7. Genetic – Nutritioneering by Jeffrey S. Bland, 1999.
8. Nutritional Genomics Edited by Jim Kaput and Raymond L. Rodriguez. 2006.
9. Genetic Nutrition by A. P. Simopoulos, Victor Herbert and Beverly Jacobson. 1993.
10. Nutrient-Gene Interactions in Health and Disease Edited by Naima Moustaid-Moussa and Carolyn D. Berdanier, CRC Press. 2001.
11. Nutritional Biochemistry and Metabolism with Clinical Applications. Edited by Maria C. Linder. Lsevier Science Publishing Company Inc., New York, 1985.
12. Textbook of Human Nutrition. Editors: Mahtab S. Bamji, N. Pralhad Rao and Vonodini Reddy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 1996.
13. Advanced Textbook on Food and Nutrition. Volume I, by M. Swaminathan, 1998.

BMB-509: Biochemistry of Natural Products 2 Credits

Introduction:

This course discusses the knowledge regarding one- and two-dimensional NMR spectroscopic technique and their uses in biochemistry and medicines. It also provides understanding the molecular mechanisms of drug actions of biologically and medicinally active alkaloids, antibiotics, steroids and flavonoids and synthesis of semisynthetic antibiotics.

Objectives:

The objectives of this course are to:

- Familiarize spectroscopic technique NMR elaborately and its applications to determine the structures of natural products.
- Study the chemical and biological properties of alkaloids, antibiotics, steroids and flavonoids, synthesis of medicinally important natural products.
- Develop medicines from plant sources which will be cheaper and with low side effects.

Contents:

1. **NMR:** Spectroscopy, chemical shifts, factors affecting the chemical shift, coupling constants: vicinal coupling, geminal coupling, long range coupling, use of coupling constant values in the determination of stereochemistry of some important natural and

biochemical substances. AB and ABX system, two dimensional NMR:NOE,COSY, Use of NMR in Biochemistry and Molecular Biology: use of 13C NMR in the elucidation of biochemical pathways including the biosynthesis of cephalosporin, bikaverin, penicillin, chlorophyll and Vitamin B12; use of NMR in the determination of 3 dimensional structure of proteins, enzymes, DNA, RNA and protein signaling; Use of NMR in Designing lead compounds (drugs): Use of NMR in drug screening. Clinical use of 31P NMR – Detection of abnormalities in different organs by the use of 31P NMR. Magnetic resonance tomography (MR) – use of MR to locates tumors, vascular dilations and many other pathological abnormalities.

2. **Mass spectroscopy:** Mass fragmentation of some important natural products.
3. **Structure determination of some medicinally important alkaloids:** Quinine, atrophine, morphine by synthetic and degradative methods. Biosynthesis of some complex alkaloids.
4. **Molecular mechanism of actions of some selective antibiotics and prodrugs:** Advantages of prodrugs, semisynthetic antibiotics, synthesis of antibiotics, mechanism of antibiotic action, allergic reactions. Chemical synthesis of some medicinal steroids progesterone, cortisol, *v*itamin D.
5. **Structure of vitamins:** Vitamin B12, Biological reactions with participation of vitamin B12 and coenzyme of B12. Chemical synthesis of vitamin E - α-tocopherol and β-tocopherol.

Intended learning outcomes (ILOs):

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

- Explain various types of NMR techniques including one- and two-dimensional NMR, structure determination of various compounds by the use ofthis spectroscopic technique and application of NMR in biochemistry and medicines.
- Demonstrate synthesis of medicinally important alkaloids, antibiotics, steroids and flavonoids.
- Illustrate molecular mechanisms of action of medicinally important natural products and vitamins.

Required number of classes:

No	Title of the unit	Number of classes
01.	NMR: Spectroscopy	10
02.	Mass spectroscopy	5
03.	Structure determination of some medicinally important alkaloids	5
04.	Molecular mechanism of actions of some selective antibiotics and prodrugs	6
05.	Structure of vitamins	4
	Total	**30**

Recommended books and readings:

1. Spectroscopic Methods in Organic Chemistry by I. Fleming
2. Basic One- and Two-dimensional NMR by Friebulin
3. Natural Products vol. 2 by I. Finar
4. Natural Products Chemistry vol. 1 & 2 by O.P. Agarwal
5. The Antibiotics by Betina.

BMB-510: Biotechnology Business Management 2 credits

Introduction:

This course would help the students to become successful entrepreneurs. By starting and effectively managing businesses they would not only be able to establish themselves but also would be able to contribute to the economic development of the country. This course would also help a lot to attain the efficiency of working in a project and would play an important role in analyzing and searching markets for a certain biotech product and also in ensuring effective distribution of the product so produced.

Objectives:

The objectives of this course are to:

- Be able to start a new business as an entrepreneur
- Plan, implement, and manage a project effectively
- Learn the decision making techniques
- Manage the marketing and distribution activities
- Understand intellectual property rights and take legal action(s) in retaining the rights

Contents:

1. **Business Management:** The Company, its environment, stakeholders; corporate strategies; some basic economic principle (e.g. profit maximization, shareholder value); business planning and decision making processes and supporting tools, methods of business analysis. Introduction to technology development; procurement; operational management; marketing and sales.
2. **Project management:** Fundamentals of project management; project life cycle (definition, planning, execution and controlling; close out); tools and methods of project management e.g. planning methods, problem solving methods, social competence in project management (team work, communication).
3. **Commercialization, marketing and management of products:** Fundamentals of marketing and sales of products, creating and marketing the image of the company; positioning of the company name and products; the art of negotiation; workable marketing and the strength of

distribution; effective advertising and marketing, opportunities of international marketing, steps involved in commercialization of biotechnology products.

4. **Intellectual property rights:** Introduction, general introduction, patent claims; legal decision making process, ownership of intellectual property, basic requirements of patentability, patentable subject matters, novelty and the public domain, special issues in biotechnology patents, disclosure requirements, collaborative research, competitive research, foreign patents, patent litigation, substantive aspects and procedural aspects of patent litigation, recent development in patent system and patentability of biotechnological invention.

Intended learning outcomes (ILOs):

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

- Start a new business as an entrepreneur and attain the desired success of effective management.
- Get a thorough idea about a project and also attain the efficiency of planning, implementing, and managing a project effectively.
- Gain the efficiency of effective communication and management of marketing and distribution.
- Obtain an ability to grasp the art of effective negotiation in engaging contracts and in resolving conflicts.
- Know the ins and outs of the intellectual property rights and the strategies of keeping the rights and also the process of taking legal action in retaining the same.

Required number of classes:

No	Title of the unit	Number of classes
01.	Business Management	8
02.	Project Management	8
03.	Commercialization, Marketing, and Management of Products	7
04.	Intellectual Property Rights	7
	Total	**30**

Recommended books and readings:

1. BUSINESS for the 21st century, Steven J. and M. Ivancevich 2003, Richard D. Irwin, Inc.
2. Building Biotechnology: Biotechnology Business, regulations, patents, Law, policy and Science, Yali Friedman, Logos press (USA), 4th Edition 2014.
3. Projects- *Planning, Analysis, Selection, financing, Implementation, and Review,* Prasanna Chandra, McGraw Hill Education (India) Private Limited.
4. Marketing Management, Philip kotler, kenin Lane Keller, and Abraham Koshy, MithileshwarJha, Pearson edition, (Latest Edition).

5. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies, Craig D. Shimasaki, Springer USA, 1st Ediion, 2014.
6. The Business of Bioscience: What goes into making a biotechnology product, Craig D. Shimasaki, Springer USA, 2014.

BMB-511: Advanced Forensic Sciences **2 credits**

Introduction

DNA is often described as the blueprint for living beings – it contains the code that allows one to build all the various molecules that an organism needs to function. Since the introduction of DNA technology a few decades ago, forensic science has been revolutionized. In forensic science, the main use of DNA is as an identification technique where we aim to match a DNA sample found at, for instance, a crime scene, to a specific individual.

DNA Forensic Science course aims to explain the scientific principles and techniques behind the work of forensic scientists and will be illustrated with numerous case studies. As the field of forensic science and in particular DNA profiling moves onwards at a rapid pace, there are few introductory sections that cover the current state of this science. Afterwards, the students will be taken through the process of DNA profiling from collecting biological evidence to evaluating and presenting genetic evidence. The emphasis is on the use of short tandem repeat (STR) loci in human identification as this is currently the preferred technique. Following the process of generating a DNA profile, students will also gain an idea of how a DNA profile is interpreted and evaluated. In addition, they will be introduced to databases of DNA profiles, lineage markers, single nucleotide polymorphisms (SNPs), and DNA profiling of non-human species, as well.

Objectives

- To introduce students to forensic genetics
- To show how genetics can be used by forensic scientists
- To introduce students to case studies that will delve into real-life examples of criminal investigations where biological evidence, genetics, and forensic DNA analysis were used to solve the investigation and also where genetics and forensic DNA analysis were used to exonerate people who have been imprisoned for a crime they did not commit
- To show students how genetics has changed over the years and the effects that this has had on forensic investigations

Contents:

1. Basics of forensic science:
Forensic science in historical perspectives, forensic science development in Bangladesh, forensic science laboratories and their utilization in Police work, facilities offered by various divisions of the laboratory, forensic samples and their collection & utilization.

2. DNA polymorphism: Minisatellite sequences or Variable Number of Tandem Repeats (VNTRs), Microsatellite sequences or Short Tandem Repeats (STRs), Biology and nomenclature of STR markers, Combined DNA Index System (CODIS) and the use of DNA databases, Single Nucleotide Polymorphism (SNPs), SINEs and LINEs, Mitochondrial DNA variations, Y-Chromosome STRs, X-Chromosome STRs, Amelogenin: the sex typing marker, Non-human DNA testing and microbial forensics

3. DNA typing methods: DNA profile - definition (DNA fingerprinting/DNA testing), Restriction Fragment Length polymorphism (RFLP), Single locus and multi-locus DNA typing, Allele specific oligonucleotides (ASO), Polymerase Chain Reaction (PCR): An overview, Analysis of minisatellites by PCR, STR analysis by PCR, DNA detection methods - silver staining, fluorescent dyes, Capillary electrophoresis, principles and Instrument platform for capillary electrophoresis e.g. 310/3100 Genetic analyzer, Statistical interpretation of STR profiles, Estimating the frequencies of STR profiles, Approaches to statistical analysis of mixtures and degraded DNA.

4. DNA extraction and quantitation from forensic samples: DNA extraction from liquid blood, soft tissues, bone, teeth, buccal cells, semen, blood stains, and semen stains etc., FTA card, Differential extraction, DNA quantitation by - Spectrophotometry, Fluorometry, Slot-blot, Real-time PCR.

5. Applications of DNA profiling: Identity test, Parentage test, Kinship test, Mass disaster DNA victim identification

Intended learning Outcomes:
At the end of this course, students will

- Demonstrate a basic understanding of forensic science and the role of a forensic scientist
- Demonstrate an understanding of the role of genetics in forensic science
- Understand how DNA can be identified at a crime scene and which samples might contain DNA (human DNA, plant DNA, animal DNA)
- Understand how DNA can be collected from a crime scene and examined in the laboratory
- Demonstrate an understanding of the use of mitochondrial DNA in forensic cases involving the identification
- Demonstrate knowledge of the types of analysis which can be completed using DNA
    - Polymerase chain reaction
    - Restriction fragment length polymorphism

- Understand how to analyze a DNA profile and the use of statistical analysis relating to DNA profiles
- Show an understanding of the differences in DNA between unrelated individuals and family members
- Demonstrate an understanding of the information contained within the DNA database
- Be able to describe how mitochondrial DNA can be used to identify unknown human remains
- Be able to explain why nuclear DNA is used to identify the criminal suspect(s) rather than mitochondrial DNA
- Be able to differentiate between Restrictive Fragment Length Polymorphism (RFLP) and Polymerase Chain Reaction (PCR) DNA print analysis techniques
- Be able to explain why criminal DNA evidence is supported by population frequency values
- Demonstrate knowledge about lineage markers

Required number of classes

Title of the Unit	Number of classes
1. Basics of forensic science	02
2. DNA polymorphism	10
3. DNA typing methods	08
4. DNA extraction and quantitation from forensic samples	05
5. Applications of DNA profiling	05
Total	**30**

Books and References:

1. An Introduction to Forensic Genetics. William Goodwin, Adrian Linacre, Sibte Hadi
2. Forensic DNA Typing. John M. Butler

BMB 512: Laboratory Work (For Group A) **6 Credits**

Course description:

This course is designed to anticipate hands on experience about the advanced biochemical and molecular research techniques to the students. It focuses on the Human DNA profiling, DNA isolation from human blood and microbes, Restriction digestion, Real time PCR, HPLC and gel electrophoresis. This course also covers ELISA, drug potency determination, enzymatic activity determination from microbes, dissection of rat brain and basic bioinformatics. In addition, the course also enlightens students with writing research proposal and presenting scientific papers. Lastly, this course also places students in different research organization or pharmaceutical companies for 4 weeks in internship program.

Objectives:

1. To introduce students to assess quantitative or analytical chemistry of drugs.
2. To enable students to efficiently use and operate HPLC in order to separate a mixture of compounds.
3. To introduce some basic molecular biology techniques like DNA isolation from different biological samples, its purity determination, quantification, gel electrophoresis, Polymerase Chain reaction (PCR), Real-time PCR, restriction digestion of plasmid, Human DNA Profiling, etc.
4. To introduce to some basic aspects of protein biochemical techniques like Taq polymerase isolation, SDS-PAGE for protein separation, and the determination of different types of enzymatic activities like protease, cellulase, and creatine kinase.
5. To perform dissection of rat brain to explore the internal structure and function of basic mammalian anatomy.
6. To enable students to efficiently use and operate ELISA.
7. To teach students about different bioinformatics tools, for primer designing, drug designing and molecular characterization.
8. To enable students writing Research proposals.
9. To improve students' presentation skills by conducting a scientific paper presentation.
10. To provide internship opportunities to students in different research organizations or pharmaceutical companies.

Course content:

S.I.	Name of experiments	Day/Time
1.	Quantitative estimation of Diclofenac from given samples.	01 Day
2.	Assay for the determination of the potency of Diclofenac	01 Day
3.	Determination of Metronidazole from solid dosage forms.	01 Day
4.	Assay for the determination of comparative potency of commercially available Metronidazole.	01 Day
5.	Isolation of secondary metabolites from microbial samples and separation using chromatographic methods.	07 Days
6.	Determination of paclitaxel from the fungal extract by HPLC method.	02 Days
7.	Determination of vitamin D from serum by HPLC method	02 Days
8.	Isolation and quantification of plasmid DNA from bacteria.	03 Days
9.	Restriction digestion of plasmid DNA.	02 Days
10.	Isolation and quantification of chromosomal DNA from bacteria.	02 Days

11.	PCR amplification of a specific bacterial gene and determination of the amplified PCR product size.	02 Days
12.	Genomic DNA isolation and quantification from Human whole blood samples and PCR amplification of different human genes.	04 Days
13.	Human DNA Profiling.	02 Days
14.	Differential expression analysis by Real-time PCR.	02 Days
15.	Isolation and purification of Taq polymerase enzyme.	07-10 Days
16.	Separation of proteins by SDS –PAGE.	02 Days
17.	Determination of protease activity from microbial samples.	01 Day
18.	Determination of cellulase activity from microbial samples.	
19.	Determination of Ag or Ab from serum sample using ELISA.	02 Days
20.	Gel electrophoresis of proteins from normal and stressed plants.	(7/8) Days
21.	Dissection of rat brain and identification of different anatomical structures.	(02-03) Days
22.	Quantitative determination of creatine kinase activity in human serum.	01 Day
23.	Bioinformatics:	
	a) Introduction to basic Bioinformatics tools.	03 Days
	b) Designing primers for specific genes and analyzing the quality of the primers.	01 Day
	c) Molecular identification of microbial strains from given DNA sequences and phylogenetic analysis.	01 Day
	d) Molecular docking for drug designing.	
24.	Research proposal writing	
25.	Paper Presentation	
26.	Internship	4 weeks

Intended Learning outcomes (ILOs):

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

1) Follow experimental procedures independently, including locating materials and equipment and practice good lab procedures.
2) Analyze experimental results, differentiate between expected and unexpected results, troubleshooting, interpret results and make conclusions.
3) Able to perform quantitative analysis of drugs with appropriate assay controls.
4) Able to use and operate HPLC machine efficiently and perform the separation of analytes in different biological samples.

5) Perform chromosomal DNA extraction from various biological samples and assess the purity and quantification of the isolated DNA samples.
6) Able to perform DNA extraction from bacterial plasmid DNA followed by quantification.
7) Design and perform PCR and gel electrophoresis with appropriate assay controls as well as interpret gel image and conclude the findings.
8) Design and perform restriction digestion of plasmid DNA followed by size prediction and interpreting the result.
9) Design and perform SDS-PAGE for the separation and detection of proteins in biological samples with appropriate controls.
10) Perform the techniques for the isolation of Taq polymerase and assess different types of enzymatic activities like protease, cellulase, and creatine kinase.
11) Able to perform ELISA technique for the quantification of specific antigen or antibody in biological samples with appropriate positive and negative controls.
12) Perform the dissection rat brain to explore the internal structures of the mammalian brain.
13) Able to perform different basic Bioinformatics analyses, including primer design, building and interpreting phylogenetic trees representing evolutionary relationships among organisms.
14) Able to generate idea and write scientific research proposals to secure funds for conducting proposed research projects.
15) Present scientific research papers and address intellectual questions from peers.
16) Evaluate the internship experience in terms of their personal, educational and career needs and apply appropriate workplace behaviors in professional settings.

BMB 512: Thesis (For Group B) **6 Credits**

Thesis provides opportunities for students to plan, complete, interpret, and report research. The thesis's overall goal is to demonstrate the capability and attitude required for independent work. This course will help to develop skills so that they can apply their theoretical knowledge to practical experience. It will provide opportunities for advance research that will prepare a student as a team member. The areas of the research work will be selected by the respective supervisors. After completion of research works, a student must submit a complete dissertation according to the guideline set by the academic committee of the department and he/she must present his/her activities in front of the examination committee. At the end of the thesis research work, a student should submit a dissertation according to the guideline set by the academic committee of the department.

At the end of the research works, the student must demonstrate the following learning outcomes

- An in-depth understanding on the research activities he/she performed and current research activities in other major advanced laboratories

- The ability to contribute in research
- The ability to design, formulate and perform a new research topic with a holistic approach
- The ability to analyze, troubleshoot and evaluate findings of a research output
- The ability to integrate knowledge critically and methodically
- Should develop awareness about biosafety and biosecurity issues during laboratory work
- Capable of developing skills of arguing logically
- Develop awareness regarding ethics in research

BMB 513: Seminar / Paper Presentation 2 Credits

Introduction:

Presentation of scientific findings through using PowerPoint and/or any other relevant software have become an integral part for science communication. This course is designed to introduce the concept of scientific communication through oral presentation to generate appreciation for the importance of presentation in science.

Objectives:

The objectives of this course are to:

- Enable students to understand the importance of an effective presentation in science communication.
- Generate appreciation on each section of a typical scientific paper: background, methods, results/discussion and significance of biochemistry and molecular biology related scientific studies.
- Familiarize the students with different utilities of Microsoft PowerPoint tool that are required to prepare a standard scientific presentation.
- Make the students acquainted with different strategies to present different section (background, methods, results/discussion and significance) of a typical research article.

Contents:

1. **Introduction:** General introduction to scientific articles and their classifications (Research article, Review article, Case-report, Clinical trial, Short-communication etc.)
2. **Segments of a typical research articles:** Background, Methods and Materials, Results, Discussion, Significance, Conclusion and Future outlook.
3. **General structure of a standard scientific presentation:** Typically, a scientific presentation may include but not limited to background, methods, results/discussion and significance/conclusion. Organization of the slides representing these sections can vary according to the nature of presentation.

4. **Concept of schematic diagram and flowcharts:** The underlying concept of presenting

scientific topic and methods by means of schematic diagrams and flowcharts respectively.

5. **Visualization of results:** Scientific results are often difficult to present in meaningful manner in a presentation. To simplify the complicated data in a biological intuitive manner, different visualization strategies can be applied such as graphs, heatmaps, sematic-diagrams, venn-diagrams, tables etc.

6. **Significance of a scientific study and future direction:** Basic understanding of the significance of a scientific study is essential for presentation. Interpretation of the results in a biologically meaningful way is the key to present the significance of the scientific study/article. It is also important to present the future outlook o a particular study to give the impression of a continuous progression of a scientific topic.

Intended learning outcomes (ILOs):

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

- Use the Microsoft PowerPoint tool to develop and prepare a standard scientific presentation.
- Assess the different relative importance of each section of a scientific presentation (Background, methods, results/discussion and significance) in the context of a whole story.
- Demonstrate their capacity in making flowchart and schematic diagrams to describe methods and biological phenomenon.
- Exhibit their presentation skill.

Required number of classes:

No	Title of the unit	Number of classes
01.	Introduction	5
02.	Segments of a typical research articles	5
03.	General structure of a standard scientific presentation	5
04.	Concept of schematic diagram and flowcharts	5
05.	Visualization of results	5
06.	Significance of a scientific study and future direction	5
	Total	**30**

Recommended books and readings:

1. **Journals having a certain impact factor** (List of journals will be provided by the respective examination committee).

BMB-514: Viva-voce **2 Credits**

Introduction:

A viva is a university examination in which a student answers questions in speech rather than writing. This form of oral assessment helps students develop valuable communication skills.

Objectives:

The objective of the viva-voce exam is to:

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

Content:

The whole theoretical syllabi that have been studied during MS program.

Intended Learning Outcome:

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

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