UNIVERSITY OF CALCUTTA

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Ref.No : CUS/ 215 (cir.)/18
Dated the 20th April, 2018

To
The Principals/T.I.C.
of all the Undergraduate Colleges
offering B.Sc. in Molecular Biology (General)
affiliated to the University of Calcutta

Sir/Madam,

The undersigned is to inform you that the proposed **revised semesterised draft Syllabus for Molecular Biology (General)** Courses of Studies under **CBCS has been uploaded in the Calcutta University website (www.caluniv.ac.in).**

The said syllabus has been prepared by the **U.G. Board of Studies in Molecular Biology, C.U.**, suppose to be implemented from the academic session 2018-2019

You are requested kindly to go through it and send your feedback within 30th April, 2018.

In this regard you may send your observation/ suggestion to the **Department of U.G. Councils, C.U**. or through email (u.g.councilsc.u@gmail.com), and you also may contact **Prof. Anshuman Lahiri,** Department of **Molecular Biology** through e-mail **(ahbmbg@caluniv.ac.in/ lahiri.ansuman@gmail.com).**

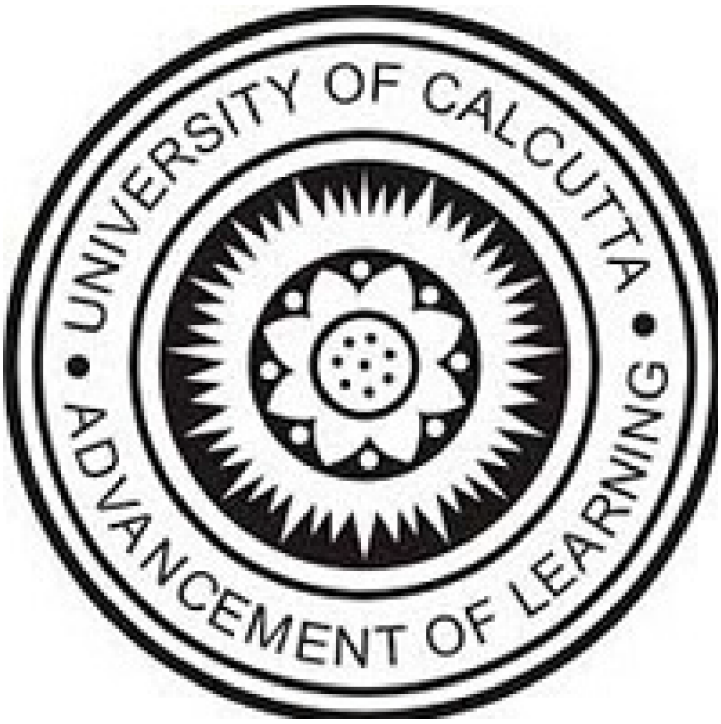
Your cooperation in this regard will be highly appreciated. Kindly treat the matter as urgent.

Thanking you,

Yours faithfully,

20/04/18

Secretary



University of Calcutta

Revised Draft Syllabus for three-year B.Sc. in Molecular Biology

(General)

under

CBCS System

2018

SCHEME AND SYLLABUS FOR CHOICE BASED CREDIT SYSTEM IN B.SC. (GENERAL) MOLECULAR BIOLOGY

Semester **(20 credits each)**	**Discipline Specific** **Core Course** **DSC** **(6 credits each)**	**Ability** **Enhancement** **Compulsory Course** **AECC** **(2 credits each)**	**Skill** **Enhancement** **Course** **SEC** **(2 credits each)**	**Discipline** **Specific Elective Course** **DSE** **(6 credits each)**
I	**DSC-MLBG-1A** Cell Biology - Principles and Techniques	English/ Hindi/Mil communication/ Environment Sc.		
II	**DSC-MLBG-1B** Basics of biomolecules	English/ Hindi/Mil communication/ Environment Sc.		
III	**DSC-MLBG-1C** Concepts of Molecular Biology		**SEC-1** ECS/ General Interest / Hobby/ Sports / NCC/ NSS /Related courses on its own. **(Radiation Biology)**	
IV	**DSC-MLBG-1D** Biophysical Techniques		**SEC-2** ECS/ General Interest / Hobby/ Sports / NCC/ NSS /Related courses on its own. **(Biomedical Instrumentation)**	

V			**SEC-3** ECS/ General Interest / Hobby/ Sports / NCC/ NSS /Related courses on its own. **(Biostatistics)**	**DSE-MLBG-1A** Recombinant DNA Technology **DSE-MLBG-2A** Genomics
VI			**SEC-4** ECS/ General Interest / Hobby/ Sports / NCC/ NSS /Related courses on its own. **(Bioinformatics)**	**DSE-MLBG-1B** Sensory Processes in Biophysics / **DSE-MLBG-2B** Clinical Biochemistry

Course Details

DSC-MLBG-1A: Cell Biology - Principles and Techniques (4 + 2 = 6 credits)

Theory (4 credits/50 marks)

Unit1: Cell Biology (12 hours)

Cells as basic functional unit of living body, cellular classification (3 domains, i.e. eubacteria, archaebacteria, eukaryotes), (2 hrs)

Prokaryotic cell organization (Prokaryotic cell structure, Bacterial cell walls), (2 hrs)

Eukaryotic cell organization (Brief idea of structure and function of --- Plasma membrane, Nucleus, Endoplasmic reticulum, Golgi apparatus, Mitochondria, Chloroplast, Lysosome, Peroxisome, cytosol, Plant cell wall, Plant cell vacuole,) (6 hrs)

Brief idea of cell cycle (recapitulation of mitosis and meiosis) (2 hrs)

Unit2. Molecules of Life 1 (28 hours)

Importance of carbon molecule (valency, chiral carbon, types of isomer) (2hrs)

Concept of intra- and intermolecular interaction (covalent bond, ionic bond, hydrogen bond, hydrophobic interaction, van der Waals interaction), (3 hrs)

Structure and Water, Henderson-Hasselbalch equation & its significance, Concept of pH / pKa , isoelectric pH (pI) and Buffer. (5hrs)

Carbohydrate: Structure, Function and properties of Monosaccharides (Hexoses and pentoses), Disaccharides (sucrose, lactose, maltose), storage & structural polysaccharide (glycogen, starch and cellulose).(8hrs)

Lipids : Definition and classification of lipids, Structure and function of fatty acid, storage lipids, structural lipids . (4 hrs)

Roles of lipid in Membrane structure, fluid Mosaic model of membrane structure, Transport of small molecules (Passive and active transport), Transport of macromolecules (exocytosis, endocytosis, phagocytosis, pinocytosis). (6hrs)

Unit 3: Microscopy Techniques (10 hours)

Optical microscopy, the nature of light—its particle and wave character. Ray diagrams and image formation.(4 hours)

Simple and compound microscopes, Applications of optical microscopes, Numerical Aperture (NA) Resolution, Contrast, depth of field and depth of focus, Angular magnification, Spherical aberration, Chromatic aberration of optical system (definitions only). Mathematical expression for limit of resolution in terms of Rayleigh criteria. Empty magnification.(6 hours)

Basic principles of oil immersion microscope. Limitations of optical microscopes.(2 hours)

Electron microscopy---basic working principle, advantages of electron microscope over optical microscope, Optical Microscopy vs. TEM, Electrostatics and magnetostatics electron microscopes, Relation between the applied voltage and wavelength of electrons.(10 hours)

Very short discussions on preparation of thin samples, Positive and negative staining.Very short introduction on fixation and fixatives. (3 hours).

Practical (2 credits/25 marks)

1. Determination of refractive index of a given biological sample by travelling microscope
2. Determination of relative sizes of nucleus and cytoplasm of squamous cells
3. Preparation of phosphate buffer and measurement of pH
4. Qualitative tests for reducing sugar, non-reducing sugar, polysaccharide, lipid
5. Separation of lipids by TLC.
6. Quantitative estimation of glucose .

DSC-MLBG-1B Basics of biomolecules (4 + 2 = 6 credits)

Theory (4 credits/50 marks)

Unit 1 : Molecules of life (20 hours)

Amino acids: structure of twenty amino acids,classification, titration curve of amino acids, concept of zwitterionic structure, physical and chemical properties. (8 hours)

Proteins : classification of proteins on the basis of composition, conformation and function, different level of structural organization of proteins(primary, secondary, tertiary &

quaternary), forces stabilizing protein structure and shape, physical and chemical properties. (10 hours)

Enzymes : classification and nomenclature, Holoenzyme, apoenzyme, cofactors , coenzyme, prosthetic groups, activation energy, and transition state, enzyme, activity, enzyme unit, specific activity, concept of active sites, Kinetics of enzyme catalysed reactions - Michaelis-Menten Equation, Lineweaver Burk Plot, Determination of K_m and V_{max}, significance of K_m and V_{max}, Factors influencing the enzyme reaction, and Enzyme inhibition (competitive, noncompetitive and uncompetitive inhibitions, Preliminary concept of allosteric enzyme. (12 hours)

Unit 2 : Bioenergetics and metabolism of biomolecules (30 hours)

Glycolysis (4 hours)

Fate of pyruvate under aerobic and anaerobic condition, TCA cycle, electron transport chain, oxidative phosphorylation, role of inhibitors and uncouplers. (8 hours)

Glycogenesis, Glycogenolysis, Gluconeogenesis, Pentose phosphate pathway (8 hours)

β-oxidation of saturated fatty acid, (4 hours)

Transamination, oxidative deamination, and urea cycle. (6 hours)

Practical (2 credits/25 marks)

1. Qualitative tests for amino acid, protein.
2. Identification of unknown compounds (from sugars, polysaccharide,lipid,amino acid and protein)
3. Estimation of protein by Lowry method using UV-Visible spectrophotometer or colorimeter.
4. Calculation of R_f value and separation of unknown amino acid by TLC or paper chromatography.
5. Estimation of amino acid by formol titration

DSC-MLBG-1C: Concepts of Molecular Biology (4+2 credits)

Theory (4 credits/50 marks)

Unit 1: Basic Concepts of genome and its organisation (20 hrs)

Nucleic acid as the genetic material (Griffith's experiment, Avery, MacLeod and McCarty's experiment, Hershey-Chase experiment), Importance of Molecular Biology, Central Dogma of Molecular Biology, Model organisms for studying Molecular Biology. (5 hrs)

Structure and functions of Nucleic acids: Nucleosides & Nucleotides, purines and pyrimidines. Biologically important nucleotides, (5 hrs)

Watson and Crick model of DNA structure, A, B & Z forms of DNA, Supercoiled and relaxed DNA, denaturation and renaturation of DNA, melting temperature (Tm), hyperchromic effect.(5 hrs)

Genome and its organisation : (idea about gene, coding sequence, regulatory sequence, intron, exon, Nucleosome structure and packaging of DNA into higher order structures, brief idea of chloroplast DNA and Mitochondrial DNA).(5 hrs)

Unit 2: Replication of DNA in prokaryotes (8 hrs)

3.2.1 Features of DNA Replication, Proof of semiconservative nature of DNA replication, Features of bidirectional DNA replication. (4 hrs)

3.2.2 Mechanism of bidirectional DNA replication (4 hrs)

UNIT 3: Gene expression (17 hrs)

RNA structure and types of RNA, Transcription in prokaryotes with E. Coli as model system: Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains, (4 hrs)

Genetic code, properties of genetic code, Wobble hypothesis (2 hrs)

Components of Protein synthesis machinery : Messenger RNA, tRNA structure and function, Charging of tRNA, aminoacyl tRNA synthetases, ribosome structure and assembly , Mechanism of protein synthesis in prokaryotes : initiation, elongation and termination. (7 hrs)

Principles of gene regulation, negative and positive regulation, concept of operons, Regulation of gene expression in bacteria : lac operon concept. (4 hrs)

Unit 4: Damage, Repair and Mutation (15 hrs)

Causes (spontaneous, chemical agent, radiation) and types of DNA damage (3hrs)

Mechanism of DNA repair: Direct repair, base excision repair, nucleotide excision repair, mismatch repair, recombination repair. (6 hrs)

Molecular basis of mutation, types of mutation (missense mutation, nonsense mutation, silent mutation, point mutation, frameshift mutation). (6 hrs)

Practical (2 credits/25 marks)

1. Determination of absorption spectra of DNA and protein using UV-Visible spectrophotometer.
2. Study of DNA melting using UV-Visible spectrophotometer
3. Extraction of DNA from plant cells
4. Estimation of DNA by diphenylamine reaction.
5. Estimation of RNA by orcinol method

DSC-MLBG-1D: Biophysical techniques (4 + 2 = 6 credits)

Theory (4 credits/50 marks)

Unit 1: Diffusion (6 hours)

Boyle's law, Charles' law, Gas laws (Ideal gas and real gas equation)Dalton's law of partial pressure. Diffusion in fluids,Fick's laws(Statement and explanation) Facilitated diffusion e.g. gas exchanges in lungs.

Unit 2: Osmosis (4 hours)

Definition,contrast with diffusion,Tonicity and isotonic solutions.Effect of tonicity on R.B.C. Cell nutrition.

Unit 3:Viscosity (10 hours)

Definition,Laminar and turbulent flow, Concept of Reynolds number,
Newton's law of viscosity,Newtonian and non- Newtonian fluids, Coefficient of viscosity, Relative viscosity and fluidity. Measurement by Ostwald's viscometer. Dependence of viscosity on temperature and other factors e.g. size and shape of solutes (general idea)Viscosity of human blood (general idea).

Unit 4: Centrifugation (5 hours)

Theory of ultracentrifugation, Relative centrifugal force (RCF),Sedimentation rate sedimentation coefficient, Isopycnic (equilibrium) sedimentation, (discussion with example e.g. Meselson and Stahl Experiment)

Unit 5: Spectrophotometry and other methods (10 hours)

Absorption of light, Transmittance, Absorbance(Optical density), Lambert-beer law, Method of determining Absorption spectrum of chlorophyll by spectrophotometer. A brief idea on Dialysis,Chromatography(Gel filtration,Ion exchange), Electrophoresis.

Unit 6: Immunology (25 hrs.)

Immune Response - An overview, Primary and secondary immune response, components of mammalian immune system, (6 hrs)

Basic concept on Molecular structure of Immunoglobulin or Antibodies, Humoral & Cellular immune responses, T-lymphocytes & immune response (cytotoxic T-cell, helper T-cell, suppressor T-cells. (12 hrs)

Basic concept in Autoimmune diseases, Immunodeficiency-AIDS and vaccination. Introduction to immunodiagnostics – RIA, ELISA. (7 hrs)

Practical (2 credits/25 marks)

1. Human blood group determination.
2. Measurement of viscosity/fluidity of DNA by Ostwald viscometer.

3. Separation of nucleosides by paper chromatography

DSE-MLBG-1A: Recombinant DNA Technology (4+2 = 6 credits)

Theory (4 credits/50 marks)

Cloning: Cloning vectors (pBR. 322, pUC8I9. YACs), Bacteriophage lambda and M13 based vectors. Cosmids, Ti plasmid as transformation vector. Use of linkers and adaptors Restriction and Modification enzymes. (12 hours)

Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering, Restriction Mapping. (8 hours)

Enzymes used in Recombinant DNA techniques: DNA ligase. Polynucleotide Kinase. DNA Polymerase, Reverse Transcriptase. (10 hours)

Polymerase Chain Reaction & qPCR, Electrophoresis & Blotting Techniques, Site- Directed Mutagenesis, DNA Sequencing, Reporter Gene Assays, DNA-Protein Interaction Assays, Protein-Protein Interaction Assays, DNA Fingerprinting. (20 hours)

Practical (2 credits/25 marks)

1. Restriction enzyme digestion of plasmid DNA
2. Gel purification of RE digested DNA
3. Ligation of DNA fragments with cloning vectors pBR322
4. Preparation of competent cells and transformation of E. coli with recombinant vectors
5. Primer design for PCR and amplification of DNA by PCR

DSE-MLBG-2A: Genomics ((4 + 2 = 6 credits)

Theory (4 credits/50 marks)

Genomes and Gene Structure: Gene families, Functional domains; Transcriptomics; Proteomics; Biological databases. (5 hours)

Genome sequencing techniques and applications: Sequencing strategies and the shotgun method; Massively parallel sequencing and its applications; Next-Generation sequencers. (15 hours)

Genome assembly and annotation: Gene finding; Promoter identification; Transcription factor binding site analysis. (10 hours)

Comparative genomics: Comparative and evolutionary genomics; Gene duplication; Genome duplication; Paralogous and orthologous genes; Neofunctionalization. (10 hours)

Ecological genomics: Ecology; Phenotypic plasticity; Molecular Markers, Model Organisms. (10 hours)

Practical (2 credits/25 marks)

1. Using genomic dotplot for comparing genomes
2. Using genomic dotplot for detecting internal repeats in a genome
3. Using GENSCAN to predict protein coding genes in a genome
4. Using the Ensembl genome browser for genome analysis

DSE-MLBG -1B: Biophysics of Sensory Processes (4+2 - 6 credits)

Neurobiophysics Description and function of neurons. Origin of membrane potential (Gibbs-Donnan effect; Membrane transport—relevant points; Nernst potential). Voltage clamp method (brief idea). Threshold potential. Action potential and its characteristics.Axonal conduction and speed of propagation.Synaptic transmission (chemical**). 8hours**

Electrical signals from the heart – Electrocardiogram (ECG) Physical basis of electrocardiography. Recording of ECG. Mention of heart problems that can be detected.4 **hours**

Physics of vision
Nature of light.Eye lens and refraction.Accommodation of the eye.Errors of refraction (myopia, hyperopia, astigmatism) and their correction (qualitative). Optical elements of the human eye. Binocular vision.Visual acuity and its testing.Retina and photoreceptors.Photoreceptors and fibre optics (salient points).Mechanism of rod vision (brief discussion).Colour vision. Colour blindness (salient points). **8hours**

Physics of audition
Nature of sound.Values of sound velocity in air, water, iron, human body. Energy, power and intensity of sound wave (definitions only). Sound impedance (qualitative idea).Loudness, pitch and quality of sound(definitions).

Intensity level. Values of intensity level of some standard sounds. Noise pollution – main causes and important effects on humans.

Human ear and the process of hearing. Doppler effect (basic idea) and its important applications in the medical field. Echolocation by bats (qualitative discussion). **8hours**

Physics of cardiovascular system
Action of the heart as a double pump. Blood pressure – systolic and diastolic. Measurement of blood pressure. **2 hours**

Practical (2 credits/25 marks)

1. Determination of blood pressure with the help of mercury or aneroid sphygmomanometer.
2. Verification of Nernst's equation

DSE-MLBG-2B: Clinical Biochemistry (4 + 2 = 6 credits)

Theory (4 credits/50 marks)

Unit 1 (15 hours)

Idea about the features of pathogenic and non-pathogenic microorganisms. General properties of synthetic and naturally occurring antimicrobial drugs: selective toxicity, and modes of action, of Penicillin, Chloramphenicol and Streptomycin. Antibiotic resistance.: mechanism of drug resistance, origin & transmission of drug resistance in microbes.

Unit 2 (15 hours)

Mechanism of Bacterial Pathogenicity: entry, colonization, pathogenicity, course of infectious disease, duration of symptoms

Mechanism of damage of host cell Exo-and endotoxins - definition and general properties.

General properties and importance of clinically important enzymes like SGOP, SGPT, Alkaline phosphatase and Creatinine kinase, lactate dehydrogenase

Unit 3 (20 hours)

Disorders of thyroid, pituitary, adrenal, hypothalamic, ovarian, testicular and renal hormones;

Use of tumour markers in oncology

Iron status, protein abnormalities, therapeutic drug monitoring and drugs of abuse testing and the genetic basis of disease.

Practical (2 credits/25 marks)

1. Blood glucose estimation
2. Impact of subinhibitory antibiotic concentrations on bacterial growth (testing kanamycin, tetracyclin, gentimycin, chloramphenicol etc.)
3. Fungal inhibition assay of streptomyces

SEC-1: Radiation Biology (2 credits/25 marks)

Radiation quantities: Exposure; absorbed dose; equivalent dose; effective dose; activity; linear energy transfer. (5 hours)

Cellular response to radiation: Radiolysis of water and radical formation; indirect and direct action; time scale of radiation effects; cell kinetics, mitotic death and apoptosis; DNA damage and chromosomal aberrations; radiation sensitivity; sublethal damage and cell survival curves; dose-rate effect; oxygen effect; relative biological effectiveness; radioprotectors and radiosensitizers. (10 hours)

Sources of radiation to the human populations; radiation carcinogenesis; whole-body radiation effects; doses and risks associated with medical radiology; radiation protection. (10 hours)

SEC-2: Biomedical Instrumentation (2 credits/25 marks)

Measurement of blood pressure, Cardiac output , Heart rate, Heart sound , Pulmonary function measurements, spirometer, Blood Gas analysers, pH of blood – measurement of blood pCO2, pO2, finger-tip oxymeter, ESR, GSR measurements. (7 hours)

Electrodes, Limb electrodes, floating electrodes, pregelled disposable electrodes, Micro, needle and surface electrodes, Amplifiers, Preamplifiers, differential amplifiers, chopper amplifiers, Isolation amplifier, ECG, EEG, EMG, ERG, Lead systems and recording methods, Typical waveforms, Electrical safety in medical environment, shock hazards, leakage current-Instruments for checking safety parameters of biomedical equipments. (7 hours)

Radiographic and fluoroscopic techniques, Computer tomography, MRI, Ultrasonography, Endoscopy, Thermography, Different types of biotelemetry systems, Retinal Imaging, Imaging application in Biometric systems, Analysis of digital images. (7 hours)

Pacemakers, Defibrillators, Ventilators, Nerve and muscle stimulators, Diathermy, Heart – Lung machine, Audio meters, Dialysers, Lithotripsy, ICCU patient monitoring system, Nano Robots, Robotic surgery, Advanced 3D surgical techniques, Orthopedic prostheses fixation. (4 hours)

SEC-3 Biostatistics skills (2 credits/25 marks)

Keywords and terms used in biostatistics. Concept of frequency distribution (frequency distribution table, simple and group frequency distribution, data presentation), mean, median, mode, standard deviation; Simple problems on mean, median, mode and standard deviation. (10 hours)

Correlation and Regression analysis: Relation between two variables, scatter diagram, definition of correlations, curve fitting, principles of least squares, Two regression lines, Pearson's coefficient of correlation, Rank correlation, Tied ranks. (5 hours)

Probability theory: Random variable (discrete and continuous), Probability density function (discrete and continuous), Distribution function for discrete random variable. Distribution function for continuous random variable, Joint probability distribution, Conditional and marginal distribution. The expected value of a random variable, moments, Moment generating functions, Product moments, Conditional expectations. (5 hours)

Standard distributions: Uniform distribution. Exponential distribution, Gamma distribution, Beta distribution. Binomial distribution, Poisson distribution, Normal and standard normal distributions. (5 hours)

SEC-4 Bioinformatics (2 credits/25 marks)

Nucleic acid and protein sequences; sequence databases and information retrieval; pairwise sequence comparisons; PAM and BLOSUM scoring matrices; global and local alignment algorithms; statistical significance of pairwise alignments; BLAST and FASTA. (7 hours)

Multiple sequence alignments (MSA) - hierarchical and non-hierarchical methods; tools for MSA. (3 hours)

Molecular phylogenetic analysis: Introduction to molecular evolution, the molecular clock hypothesis and neutral evolution; tree nomenclature and structure; tree-building methods - neighbour joining (NJ), maximum parsimony (MP), maximum likelihood (ML) methods; tree-evaluation methods; bootstrapping. (10 hours)

Protein and nucleic acid structure databases; The Protein Data Bank (PDB); structure comparison; SCOP and CATH. (5 hours)