MASTER OF SCIENCE IN BIOCHEMISTRY

A Two-Year Full Time Programme
(Rules, Regulations and Course Contents)

June 2009

Department of Biochemistry
Faculty of Interdisciplinary and Applied Sciences
University of Delhi South Campus
Benito Juarez Road
New Delhi-110021

MASTER OF SCIENCE IN BIOCHEMISTRY

Two-Year Full Time Programme

(2009 onwards)

The Masters' programme in Biochemistry endeavours to provide the students with excellent training in Biochemistry emphasizing on solid background of basic concepts as well as rapid advancement in the field. In addition to theoretical knowledge, considerable emphasis is also given to offer the students hands on experience in the forefront areas of Biochemistry.

The two years programme is prescribed according to the semester system of Delhi University for the post-graduate courses beginning 2009 and is divided into four semesters. The programme has 16 papers in total, 4 in each semester. Each paper has a maximum marks of 100 (4 credits). These 16 papers include 2 multidisciplinary papers and 2 special papers based on the seminars to be delivered by the students. In addition, semester 1 and 2 would have practicals (maximum marks 200, 8 credits) for each semester. In Semester 3 and 4, the practicals would be replaced by dissertation work (maximum marks 200, 8 credits) for each semester.

Thus, the programme will comprise of 2400 marks in total.

16 Theory papers of 100 marks each with 30% allocated for internal assessment	=	1600
Practicals / dissertation work with 30% allocated for internal assessment	=	800
Total	=	2400

Two multidisciplinary courses have been included to leverage the advantage to students keeping in mind the interdisciplinary nature of the faculty and repertoire of expertise available. Two papers on seminars by the students (one paper each year) have been part of our current M.Sc. programme also, for which students deliver open seminars on important scientific topics and are collectively evaluated by the departmental faculty members. In our experience, it is tremendously beneficial to students in terms of learning how to critically review the scientific literature, to churn out the best of the available information and present it in a concise and clear manner. It also gives them experience of public speaking and instills confidence. Hence, we have continued with this practice in our new syllabus.

Besides, an important feature of this programme pertains to the dissertation carried out by every student during the second year in the supervision of a mentor. The past experience of the department is that this provides the students with tremendous opportunity for hands on training in research. It exposes them to various aspects pertaining to research including the habit of scientific reading, research methodology, analytical ability, organizational capability, independent thinking and scientific writing. Thus, they are well trained to join any laboratory of modern biology and start right away without much lag period. Over the years, the department has received tremendous positive feedback in this regard from the students as well as from various institutions, wherever the students have joined after completing M.Sc. from this department. Hence, we have persisted with the dissertation during the Part II. However, for this exercise to be meaningful, it has to be given enough time as considerable period in the beginning has to be devoted for review of literature, discussions with the mentor, planning of the research project and standardization of methods etc. Hence, the dissertation would have to continue throughout Part II i.e. Semester

3 and 4 and would be evaluated by the faculty members at the end of Semester 4 as prescribed in the scheme of examinations.

The syllabus for each theory paper is appended with a list of suggested readings. Students would also consult the latest editions of the books prescribed. In addition, this list for every course would be further supplemented with other books and scientific papers every year in consultation with the teacher concerned and would be modified as new advancements in a particular area are made.

In addition, the department regularly organizes seminars by national and international researchers to expose the students to a repertoire of scientific areas and scientific methodology. The department also runs a journal club in which students (both Ph.D. and M.Sc.) regularly present scientific papers throughout the year. Although summer training is not a compulsory part of the curriculum, students are encouraged to undergo summer training in other institutions during summer vacation. The faculty members help the students in making these arrangements.

UNIVERSITY OF DELHI
Examination Branch

Course: **M. Sc. Biochemistry**

Check list of New Course Evaluation for AC consideration

S.No.	Parameters	Status
1.	Affiliation	Included
2.	Programme structure	Included
3.	Codification of papers	Included
4.	Scheme of examinations	Included
5.	Pass percentage	Included
6.	Promotion criteria	Included
7.	Division criteria	Included
8.	Qualifying papers	Not applicable
9.	Span period	Included
10.	Attendance requirements	Included
11.	Course content for each paper	Included
12	List of readings	Included

MASTER OF SCIENCE IN BIOCHEMISTRY

TWO-YEAR FULL TIME PROGRAMME

AFFILIATION

The proposed programme shall be governed by the Department of Biochemistry, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus, New Delhi-110021.

PROGRAMME STRUCTURE

Part I	Semesters	Title of papers	Total (Theory/ Internal Assessment)
	Semester 1		
	BIOCHEM 0701	Proteins – Structure, Folding and Engineering	100 (70/30)
	BIOCHEM 0702	Cell Biology – I	100 (70/30)
	BIOCHEM 0703	Membrane Biology	100 (70/30)
	BIOCHEM 0704	Seminar Paper	100 (70/30)
	BIOCHEM 0705	Practicals	200 (140/60)
			Total marks : 600 Theory : 400 Practical : 200
	Semester 2		
	BIOCHEM 0801	Enzymes and Techniques in Biochemistry	100 (70/30)
	BIOCHEM 0802	Cell Biology - II (Cellular Signalling)	100 (70/30)
	BIOCHEM 0803	Immunology and Immunotechniques	100 (70/30)
	PMBB 0804	*Bioinformatics	100 (70/30)
	BIOCHEM 0805	Practicals	200 (140/60)
			Total marks : 600 Theory : 400 Practical : 200
Part II	**Semester 3**		
	BIOCHEM 0901	Molecular Biology - I	100 (70/30)
	BIOCHEM 0902	Recombinant DNA Technology and Applications - I	100 (70/30)
	BIOCHEM 0903	Applications of Proteomics and Metabolomics	100 (70/30)
	BIOCHEM 0904	Developmental Biology	100 (70/30)
	BIOCHEM 0905	Dissertation**	200 (140/60)
			Total marks : 600 Theory : 400 Dissertation : 200

	Semester 4		
	BIOCHEM 1001	Molecular Biology – II	100 (70/30)
	BIOCHEM 1002	Recombinant DNA Technology and Applications – II	100 (70/30)
	MICROB 0803	***Microbial Pathogenicity	100 (70/30)
	BIOCHEM 1004	Seminar Paper	100 (70/30)
	BIOCHEM 1005	**Dissertation	200 (140/60)
			Total marks : 600 Theory : 400 Dissertation : 200

**multi-disciplinary course to be offered by the Department of Plant Molecular Biology and Biotechnology.*

*** As described in the preamble to the programme, the dissertation work will begin at the start of semester 3 and complete at the end of semester 4. The evaluation would be carried out at the end of semester 4.*

****multi-disciplinary course to be offered by the Department of Microbiology*

SCHEME OF EXAMINATIONS

1. English shall be the medium of instruction and examination.

2. Examinations shall be conducted at the end of each Semester as per the Academic Calendar notified by the University of Delhi.

3. The system of evaluation shall be as follows:

   3.1 Each theory paper will carry 100 marks of which 30% marks shall be reserved for internal assessment based on classroom participation, seminar, term courses, tests, viva-voce and attendance. The weightage given to each of these components shall be decided and announced at the beginning of the semester by the individual teacher responsible for the course. Any student who fails to participate in classes, seminars, term courses, test and viva-voce will be debarred from appearing in the end-semester examination in the specific course and no internal assessment marks will be awarded. His/her internal assessment marks will be awarded as and when he/she attends regular classes in the courses in the next applicable semester. No special classes will be conducted for him/her during other semesters. The duration of written examination for each paper shall be three hours.

   3.2 Examinations for practicals for each semester 1 and 2 will comprise of 200 marks of which 30% marks will be reserved for internal assessment. Practical examination for each semester 1 and 2 would be for 8 hours duration in total.

   3.3 Dissertation work would comprise of research work carried out by each student during the semesters 3 and 4 in the supervision of a particular faculty member. Each student will be assigned to a particular faculty member (mentor) at the beginning of semester 3 to plan and execute a research project. The student would carry out the review of literature on the topic of research

and formulate the plan of work in consultation and in the supervision of the mentor. The student would then conduct the research experiments for the remaining part of semester 3 and total duration of semester 4 in the supervision of the mentor. Towards the end of semester 4, the student will compile the research work including review of literature, aims and objectives, methodology and results and discussion in the form of a dissertation in the supervision of the mentor. At the end of semester 4, students would make presentations in the presence of all faculty members and would be collectively judged by the faculty members. Marks will be assigned to each student collectively by the faculty based on his/her performance, work and continuous assessment throughout the year by the mentor.

3.4 Total marks for dissertation shall be 400 and evaluation will be as follows:

Continuous evaluation (IA)[$]	=	140 marks
Content and organization	=	140 marks
Presentation including viva-voce	=	120 marks
Total	=	400 marks

[$]*Continuous evaluation / internal assessment will be based on attendance, intellectual ability, creativity, independent thinking, motivation, record keeping, laboratory discipline and planning & execution of experiments.*

4. Examinations for courses shall be conducted only in the respective odd and even Semesters as per the Scheme of Examination. Regular as well as Ex-Students shall be permitted to appear/reappear/improve in courses of odd semesters only at the end of odd semesters and for even semester with the even.

PASS PERCENTAGE

Students are required to pass separately both in theory and practical examinations. Minimum marks for passing the examination shall be 45% in aggregate in theory courses, 45% in practical courses and 45% marks in dissertation (if applicable) by scoring at least 40% in each theory paper.

PROMOTION CRITERIA

SEMESTER TO SEMESTER: Within the same Part, the candidate will be promoted from a Semester to the next Semester (Semester 1 to Semester 2 and Semester 3 to Semester 4), provided the candidate has passed at least two of the papers of the current semester by securing at least 40% marks in each paper.

Note:

1. A candidate will be permitted only 2 attempts to pass a theory paper. A candidate who does not appear in a theory paper will be allowed ONLY ONE more attempt to pass the paper. No further attempts for improvement will be allowed.

2. A candidate will not be allowed to reappear (even if he/she is absent) in the practical examination.

PART I TO PART II: Admission to Part II of the program shall be open to only those students who have fulfilled the following criteria:

1. have scored at least 45% marks in the practical papers of Semester 1 and 2 taken together,
2. have passed at least 75% of the theory papers (6 papers) offered in courses of Part I comprising of Semester 1 and Semester 2 by securing at least 40% marks in each of these six papers and
3. have secured at least 45% in aggregate of all theory papers of Part I.

Note:

1. The candidate, however, will have to clear the remaining papers while studying in Part II of the programme.

AWARD OF DEGREE

A candidate will be awarded M.Sc. degree at the end of Semester 4 provided he/she has:

1. passed all the theory papers of Part I (Semester 1&2) and Part II (Semester 3&4) by securing at least 40% marks in each paper and has also obtained at least 45% in aggregate of Part I & Part II,
2. passed the practical examination by securing at least 45% in aggregate of Part I and Part II, separately and
3. passed dissertation (if applicable) by securing at least 45% marks.

Candidates who have fulfilled criteria 2 and 3 (wherever applicable) but not criteria 1:

1. Can reappear for theory papers as per University rules. A candidate must pass the M.Sc. examination within span period.
2. No candidate shall be allowed to reappear for practical or dissertation.

SCOPE FOR IMPROVEMENT – As per University rules.

DIVISION CRITERIA

Successful candidates will be classified on the basis of the combined results of Part I and Part II examinations as follows:

Candidates securing 60% and above	:	1st Division
Candidates securing 50% and above but less than 60%	:	2nd Division
Candidates securing 45% and above but less than 50%	:	Pass

SPAN PERIOD

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of **four years** from the date of admission to the Part I/Semester 1 of the M.Sc. program.

ATTENDANCE REQUIREMENT

No student shall be considered to have pursued a regular course of study and be eligible to take examination unless he/she has attended 75% of the total number of lectures, tutorials, seminars and practicals conducted in each semester, during his/her course of study. Under special circumstances, the Head of the Department may allow students with at least 65% attendance to take the examination.

Part I – Semester 1

BIOCHEM 0701

Proteins – Structure, Folding and Engineering

1. Introduction: Genesis; History; Importance and Significance of proteins; Functional diversity, Ubiquity, Classes and Dynamism; Structure-function relationship; Key Features.

2. Amino acids as constituents: Acid/Base properties, Bifunctional monomers, Polarity, Classification, Chirality & Stereochemistry, pK_a, Codes, Ways of representation, Essential, Non-essential, Non-standard & Non-proteinogenic amino acids.

3. Physico-chemical interactions in biological systems: Covalent & non-covalent interactions, Importance of water, Accessible surface area, Importance of weak interactions.

4. Levels of protein structure: *Primary structure*: Importance of amino acid sequence, Peptide bond and polypeptide – polarity, direction, backbone and side chains, Importance of H-bonding, Cross-linking in polypeptides, Flexibility and conformational restrictions, Characteristics of peptide bond, Trans- and cis-peptide bonds, Rotation of adjacent peptide bonds, Dihedral angles – phi and si, Ramachandran plot, Thermodynamic considerations. *Secondary structure*: H-bonding scheme, Alpha-helices, Screw sense, Diversity in alpha-helices, Alpha-helical wheel, Helix capping, Beta-stand and sheet, Types of beta-sheet, Ramachandran plots, Turns and loops, Importance of loops. *Tertiary structure*: General properties and characteristics, Myoglobin structure as model, Supersecondary structures, Protein Data Bank (PDB). *Quaternary structure*: Concept of subunits and protomers, Kinds of subunit association, Importance of quaternary structure, Various examples.

5. Fibrous and Globular proteins, Structural Features of Membrane proteins

6. Protein Classification and Structure Prediction: Importance, Assumptions, Classes and Databases; Terminologies like domains, motifs, folds, architecture, active site, Examples; Secondary structure prediction; Theories and tools; Tertiary structure prediction (Modeling).

7. Protein Folding: Genesis and definition; The "protein folding problem"; Terminologies; Denaturants and their mode of action; Anfinsen's classical experiment; Propensities of amino acids to form secondary structure; Folding curves and transitions; Cooperative protein folding; Equilibrium and kinetic intermediates; Models and Theories of protein folding; Assisted protein folding (Chaperones); Misfolding and diseases; Current status.

8. Protein Engineering: Basic principles; Types and Methods; Strategies in protein engineering (Directed evolution, Comparative design, Rational design); Applications.

9. Solvent Engineering, Solubility / stability of proteins in solutions: Interaction of protein, water and solvent; Importance of solvents; Factors affecting aqueous solubility; Physical basis for protein denaturation/ stability; Effect of primary structure on stabilization; Preferential binding and preferential hydration models; Thermodynamics of unfolding; Rationalizing stabilities of folded conformations; Various stabilizers.

10. Techniques to investigate protein conformation and folding: *Spectroscopic methods* : Absorbance, Fluorescence, Circular dichroism; *Electrophoretic methods* : Limited proteolysis and SDS-PAGE, Transverse Urea gradient gel electrophoresis; *Hydrodynamic methods* : gel filtration, analytical ultracentrifugation; Calorimetric methods – Differential Scanning Calorimetry (DSC); *Structural methods* : NMR; *Mass spectrometry*.

Suggested study material

1. D. Sheehan. 2009. Physical Biochemistry: Principles and Applications, John Wiley and Sons Ltd, Chichester, England.
2. C. Branden, T. Tooze. 1999. Introduction to Protein Structure, Garland Publishing, New York, USA.
3. T.E. Creighton. 2002. Proteins: Structures and Molecular Properties, W.H. Freeman and Company, New York, USA.
4. A. M. Lesk. 2004. Introduction to Protein Science: Architecture, Function and Genomics, Oxford University Press, Oxford, England.
5. R. Pain. 2000. Mechanisms of Protein Folding, Oxford University Press, Oxford, England.
6. M. Arai, K. Kuwajima. 2000. Advances in Protein Chemistry, Academic Press, New York, USA.
7. J. Cavanagh, W.J. Fairbrother, A.G. Palmer III, M. Rance, N. J. Skelton. 2007. Protein NMR Spectroscopy: Principles and Practice, Academic Press, San Diego, USA.
8. S. Lutz, U. W. Bornschesser. 2008. Protein Engineering Handbook, Wiley-VCH, Weinheim, Germany.
9. D. W. Mount. 2004. Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory, Plainview, New York, USA.
10. V. N. Uversky, A.L. Fink. 2006. Protein Misfolding, Aggregation and Conformational Diseases: Part A: Protein Aggregation and Conformational Diseases (Protein Reviews), Springer, New York, USA.

BIOCHEM 0702

Cell Biology – I

1. The Cell Theory of Life: Historical background, Difference between Prokaryotic and Eukaryotic cells.
2. Sub-Cellular organelles: Isolation and characterization of sub-cellular organelles. Structure and function of sub-cellular organelles.
3. Cell Culture: Primary culture and secondary culture, Monolayer and suspension culture, Preparation of primary culture from tissues or organs, counting of mammalian cells, cell freezing and reconstitution. Dye exclusion test for cell viability assay.
4. Cell lines, a clone of mammalian cells, cloning of mammalian cells- importance of cloning, Hybridization of mammalian cells, Application of hybrid cells. Marker proteins on mammalian cells.
5. Cytoskeleton: Role in control of cell shape and motility, role in intracellular transport, mitosis. Structure and movement of cilia and flagella. Microtubules, structure and dynamics.
6. Extracellular Matrix: Assembly of various extracellular matrix and their role in integrating cells into tissues and cell-cell interactions.
7. Cell cycles: G_0, G_1, S, G_2 and M-phases of cell cycles-Characteristics of each phase of cell cycles. Restriction point of cell cycle and Quiescent cells, Synchronization of mammalian cells-its importance. Determination of the length of each phase of cell cycle.
8. Control of cell cycle in yeast and mammalian cells. Role of various cycle-CDK complexes in the transition of various check point of cell cycle. Role of ubiquitin-protein ligase –SCF and APC/C in the control of cell cycle.
9. Mitosis: Different stages of mitosis- prophase, metaphase, anaphase and telophase and molecular mechanism of each stage of mitosis.
10. Transport across cell membranes: Understanding membrane transport phenomenon using artificial membrane (Liposomes). Preparation of liposomes –hand shaken and detergent dialysis methods for membrane transport studies, Passive and active transport, comparison of a carrier protein with membrane bound enzymes, Symport, uniport and antiport.
11. Endocytosis:-Classification of endocytosis, phagocytosis and pinocytosis, clathrin-independent endocytosis, receptor-mediated endocytosis. Mechanism of formation clathrin coated pits and vesicles, role of assembly particles in receptor-mediated endocytosis. Caveosomes and dynamics of caveolae and the kinases involved in regulation.
12. Endosome-endosome fusion assay. Identification and mechanism of action of various molecular factors (like Rab5, PI-3-Kinase) involved in endosome-endosome fusion.
13. Transport of cholesterol in mammalian cells: LDL-receptor structure adopted for its function. Signal/key for entry into clathrin coated pits. Regulation of cellular level of cholesterol in mammalian cells. Transport of iron into mammalian cells.
14. Polypeptide toxins: Source of polypeptide toxins, Structure and mechanism of action of plant and bacterial toxins. Retrograde transport of ricin from TGN to ER.
15. Protein targeting: Historical background, Protein translocation across ER-membrane. Modification and quality control of protein in ER: Golgi vesicular traffic, Biogenesis of sub-cellular organelles.
16. Glycosylation in mammalian cells, origin, nature and types of Glycosylation. Role of Glycosylation in protein stability and folding with reference to ER exit.

Suggested study materials

1. H. Lodish, A. Berk, C.A. Kaiser, M. Kreiger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaria. 2008. Molecular Cell Biology, W.H. Freeman and Company, New York., USA.

2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P Walter. 2002. Molecular Biology of the Cell, Garland Publishing, Inc. New York. USA.

3. G.M. Cooper. 2000. The Cell: Molecular Approach, ASM Press, Washington, D.C. USA.

4. M. Butler. 2004. Animal Cell Culture and Technology, BIOS Scientific Publishers, Taylor and Francis Group. U. K.

5. R.I. Freshney. 1989. Animal Cell Culture: A Practical Approach, IRL Press, Oxford. U.K.

6. J.M. Graham and R. Rickwood. 1997. Subcellular Fractionation: A Practical Approach, IRL Press, Oxford University Press. U.K.

7. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.

8. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York.

9. G. Zubey. 1993. Biochemistry, Wm. C. Brown Publishers, Oxford. U.K.

BIOCHEM 0703

Membrane Biology

1. Historical development of the lipid bilayer model of biological membrane. Salient features of bio-membrane, comparison with model membrane/liposome. Detection of phospholipid bilayer microheterogenity and domains by fluorescence spectroscopy. Role of cholesterol and fatty acid composition in membrane fluidity. Supramolecular membrane structure. Live cell microscopy, FRAP and dynamics of cell surface receptors using TIRFM and confocal microscopy.
2. Liposome technology and its application in biotechnology. Preparation of liposomes. Charecterization of liposomes. Covalent attachment of protein/ligand to liposome surface. Biophysical study of methods of liposome membrane. Liposome in biological systems and its application in Biotechnology such as targeted drug delivery.
3. The molecular assembly of biomembranes. Structures of membrane proteins in normal and cancer cells. Interchange of proteins between membranes and their soluble environment. Studies on membrane fluidity. Membrane receptors and responses. Membranes in cancer. Membrane biology of glycolipids in normal and neoplastic cells.
4. Membrane permeability. Metabolite transport in normal and cancer cells. Bioenergetics of transport. Active transport by ATP-powered pumps. Membrane transport and tumor therapy. Electron transport in membranes with special emphasis in mitochondrial and chloroplast membranes. Cell contact and cell recognition.
5. Structure and function of various biological membranes. Lipid- protein and protein-protein interactions, dynamics of lipid-protein interactions, driving forces. Molecular and patch-clamp approaches to the structure function relationship of voltage gated channels. Ion channels in cancer cells. Membrane technology applied to laboratory diagnosis. Membrane rafts in normal and disease conditions. Detail of various classes of membrane proteins and their role in normal/abnormal cell physiology.
6. Structure and function of various enveloped animal viruses. Their entry mechanisms, use as a probe in cell biology. Use of fluorescence probes in membrane fusion. Detail studies on Influenza virus hemagglutinin (HA) and Sendai virus fusion (F) protein as a model. Kinetics of viral envelope protein-induced cell fusion by continuous monitoring of fluorescent dyes. Their applications in targeted drug/gene delivery.
7. Structure-function interplay of some typical membrane receptors like ASGP-R, LDL, Ferritin etc. Membrane biology of receptor-mediated endocytosis. Role of cytoskeletal components in membrane structure/organization.
8. Membrane asymmetry and its significance in membrane structure and function. Various techniques to determine asymmetry. Its implications in health and disease. Its role in membrane signalling.
9. The structural organization of Gap Junction. Role of complement proteins in making membrane pores. Mechanism of complement-mediated lysis of membrane. Structure and function of various hemolysins. Hemolysins and membrane active peptides in therapeutics.

Suggested study material

1. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, WH Freeman and Company, New York and England.
2. R. Verna. 1989. Membrane Technology, Raven Press, New York., USA**.**
3. H. Lodish, A. Berk, S.L. Zipursky, P. Matsudaira, D. Baltimore, J. Darnell. 2000. Molecular Cell Biology, WH Freeman and Company, NY and England
4. H.R. Petty. 1993. Molecular Biology of Membranes Structure and Function, Plenum Press, New York, USA and London.
5. D.F.H. Wallach. 1975. Membrane Molecular Biology of Neoplastic Cells, Elsevier Scientific Publishing Company, Amsterdam, Oxford and New York., USA**.**
6. R.R.C. New. 1990. Liposomes a Practical Approach, IRL Press, Oxford, New York., USA**.** and Tokyo.
7. A.L. Lehninger, D.L. Nelson, M.M. Cox. 1993. Principles of Biochemistry, Worth Publisher, New York., USA**.**
8. A. Azzi, L. Masotti, A. Vecli. 1986. Membrane Proteins Isolation and Characterization, Spriger-Verlag, New York, USA**.**

BIOCHEM 0704

Seminar Paper

(Students, in this paper, would present open seminars on important scientific topics, which would be collectively evaluated by the departmental faculty).

Part I – Semester 1

BIOCHEM 0705

Practicals

1. **Buffers: theory and practice**. **Preparation of protein stock solutions**: Concept of buffers and pH, Importance of buffers, Buffering capacity, Henderson-Hasselbach equation, Concept of pKa, Choice of best buffers based on pKa, Preparation of buffers in the laboratory over a pH range (2 to 11), Ionic strength of buffers, Storage of buffers, Additives to be added to buffers, Use of pH meters. Handling of proteins, storage concerns.

2. **Protein quantitation**: Estimation of protein by Lowry's and Bradford's method – Theory, concept of standards, sensitivity, precautions. Use of spectrophotometer, extinction coefficient and Lambert-Beer's law for accurate determination of protein concentrations, Concept and various units of extinction coefficient. Extinction coefficient by *in silico* methods.

3. **Protein folding / stability / denaturation: Hemoglobin, Trypsin, Lysozyme as model systems**: Preparation of chemical denaturants like GuHCl and urea, strategy and experimental design, Selection of measurement probe – absorption (hemoglobin), fluorescence (lysozyme/ hemoglobin), activity assays (trypsin), circular dichroism. Generation of transition curves, Concept of native (N), Intermediate (I) and Unfolded (U) states, Calculation of transition midpoints – quantitative measure of stability, Concept of normalization – fraction unfolded / folded – for ready comparison, Calculation of ΔG, Concept of molten globule; Refolding by stopped-flow.

4. ***In Silico* Protein Structure Analysis.** Introduction to protein structures; Mining and retrieval of structures from PDB; Sequence Alignment; Prediction of physical parameters; Homology modeling – modeling, validation and visualization.

5. **Estimation of Biomolecules**

   (A) Estimation of inorganic phosphate by Fiske-Subbarow's method-known and unknown sample.

   (B) Estimation of phospholipids by acid digestion and by estimating inorganic phosphate.

   (C) Estimation of carbohydrate using Phenol-Sulphuric method- known and unknown sample.

   (D) Estimation of protein and sugar content of a glycoprotein.

   (E) Estimation of phospholipids by Stewart's method.

6. **Sub-cellular fractionation** of liver homogenate by differential centrifugation method and identification of the organelles by measuring marker enzymes.

7. **Enzyme Assays and Inhibition Studies**

   (A) Determination of specific activity of Succinate dehydrogenase, Lactate dehydrogenase and Acid phosphatase from mouse liver extract.

   (B) Inhibition studies of Succinate dehydrogenase by malonic acid.

8. **Expression of β-galactosidase.** Preparation of media, Autoclaving, Inoculation of culture, Harvesting of cells, Sonication, Estimation of protein in the cell-free extract. Preparation of reagents for the assay of β-galactosidase, standardization of assay (linearity of the activity during assay period, substrate concentration). Induction of β-

galactosidase at 42^{o}C (using recombinant *E. coli* containing plasmid carrying the heat liable repressor for the control of expression). Optimization of induction period for maximum yield of the enzyme activity. Growing large volume cultures and harvesting the cells for enzyme purification.

9. **Purification of enzyme.** Purification of β-galactosidase involving preparation of cell-free extract, ammonium sulphate precipitation, dialysis, ion exchange chromatography, gel filtration, evaluation of purification by SDS-gel electrophoresis.

10. **Measurement of kinetic parameters.** Determination of K_m, determination of optimal pH, determination of effect of temperature on the stability and activity of the enzyme.

Part I - Semester 2

BIOCHEM 0801

Enzymes and Techniques in Biochemistry

1. Enzymology: Introduction, General characteristics of enzymes, Activation energy, Coupled reactions, Active site and its importance, Factors influencing catalytic efficiency.
2. Enzyme kinetics: Rapid Equilibrium, Henry-Michaelis-Menten's equations, Steady State approach, Significance of K_m, Haldane equation, Velocity vs Substrate concentration curves.
3. Methods of plotting enzyme kinetics data: Lineweaver-Burk, Hanes-Woolf, Woolf-Augustinsson-Hofstee, Eadie-Scatchard; Advantages and disadvantages of the methods, Comparisons and applications; Integrated form of the Henry-Michaelis-Menten equation.
4. Equilibrium dialysis, Scatchard plot for equilibrium binding, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability, Arrhenius equation.
5. Formation of E. S covalent intermediates, transient kinetics, flow techniques (cont., stopped, quenched), Temp-Jump.
6. General mechanistic principles: Role of proximity effect, bound distortion, multistep catalysis, bi-functional catalysis and solvent effects.
7. Regulation of enzyme activity: Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylase, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity.
8. Enzyme Inhibition, Models and types of inhibition.
9. Applied enzymology: Application of enzymes in analytical labs. (Clin. And indust.), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, Assay of enzyme activities for diagnostic purposes, Abzymes, Recent developments.
10. Enzyme purification & Chromatography: Gel filtration, ion-exchange, hydrophobic interaction chromatography, hydroxyapatite and affinity chromatography, FPLC HPLC
11. Chemiluminescance & Phosphoresence
12. Hydrodynamic methods, Centrifugation Sedimentation, partial specific volume and diffusion co-efficient, Viscosity
13. Molecular spectroscopy, IR, ESR, FRET, Biomolecular fluorescence complementation assay
14. X-ray Crystallography: Methods of crystallization, X-ray diffraction and Bragg's Law, Crystallographic parameters; Phase problem; Electron Density Calculations; Model building.
15. Radioisotope and their use in biology, autoradiography, radioactive labeling of biological macromolecules.

Suggested study material

1. P. F. Cook, W.W. Cleland. 2007. Enzyme Kinetics and Mechanism, Garland Science Publishing, London, England and New York, USA.
2. K. Buchholz, V. Kasche, U.T. Bornscheuer. 2005. Biocatalysts and Enzyme Technology, Wiley-VCH, Weinheim, Germany.
3. Trevor Palmer. 2001. Enzymes: Biochemistry, Biotechnology, Clinical Chemistry, Horwood Publishing House, Chichester, England.
4. Irwin Segel. 2004. Biochemical Calculations, John Wiley and Sons, California, USA.
5. A.S. Bommarius, B.R. Riebel. 2004. Biocatalysis – Fundamentals and Applications, Wiley-VCH, Weinheim, Germany
6. P.C. Engel. 1996. Enzymology – LABFAX, BIOS Scientific Publishers, Academic Press, San Diego, USA.
7. U. Brodbeck. 1980. Enzyme Inhibitors, Verlag Chemie, Weinheim, Germany
8. M. P. Deutcher. 1993. Guide to Protein Purification, Academic Press, San Diego, USA.
9. David Sheehan. 2009. Physical Biochemistry: Principles and Applicatons, John Wiley and Sons Ltd, Chichester, England
10. Gale Rhodes. 2006. Crystallography Made Crystal Clear, Academic Press, Burlington, USA.

BIOCHEM 0802

Cell Biology (Cellular Signaling) - II

1. Cellular Signaling: General principles of signaling by cell surface receptors, endocrine, paracrine and autocrine signaling, types of cellular responses induced by signaling molecules, components of intracellular signal-transudation pathways.
2. Short Term Signaling: G-protein coupled receptor system, General mechanism of the activation of effectors molecules associated with G-protein-coupled receptors, G-protein coupled receptors that activate or inhibit adenylate cyclase, G-protein coupled receptors that activate phospholipase C, and G-protein coupled receptors that regulate ion channels.
3. Long Term Signaling: Signaling of growth factors (EGF and Insulin) via activation of receptor tyrosine kinases. Signaling of TGFβ by direct activating Smad proteins. Cytokine signaling via JAK/STAT pathway.
4. Cell Survival and Death Signal: Programmed cell death and role of Caspase protein in apoptosis. Various pro-apoptotic and anti-apoptotic regulators and pathways.
5. Signal for Protein Sorting: Road map of biosynthetic protein traffic. Dynamics of protein trafficking. Experimental evidences of protein translocation across ER-membrane.
6. Signal Recognition Particles: Characteristics and importance of SRP. Characterization and function of SRP-receptor, signal peptide and signal peptidase. Mechanism of movement of polypeptide through ER-membrane into the ER lumen.
7. Protein Modification in ER: GRP, PERK, Unfolded response pathway, eiF2a, PDI roles in survival and death. Role of PDI and Bip in protein maturation in ER. Biosynthesis of O-linked and N-linked sugars, Golgi antiport. Role of Dolicol-phosphate in the biosynthesis of precursor N-linked oligosaccharides.
8. Sorting of protein in Golgi: Evidences for three compartments for Golgi stack, Mapping of Golgi enzymes in stack, Sorting of resident ER-protein from other proteins, targeting of lysosomal enzymes and specificity of lysosomal enzymes phosphorylation.
9. Golgi vesicular Transport: Coated and uncoated vesicle, Composition of coated vesicles, Role of ARF and coatomer in the formation of coated bud and vesicles. Mechanisms of targeting and fusion of Golgi-derived transport vesicles to the correct target site. Role of NSF, SNAPs and SNAREs.
10. Protein Import in Mitochondria: Characteristics of signal sequences, nature of receptors, accessories proteins, co-receptors for import of mitochondrial proteins, mechanism.
11. Protein Import in Peroxisomes: Characteristics of signal sequences, nature of receptors, accessories proteins, co-receptors. Mechanism of entry of proteins into the peroxisomal matrix and insertion into peroxisomal membranes.
12. Signal for Import and Export of Macromolecules from Nucleus: Characteristics of signal sequences, nature of importins and exportins. Mechanism of entry and exit of macromolecules from nucleus. Mechanism of entry of large and small molecules into nucleus via Nucler-Pore-Complex.

Suggested Study Material

1. L. Harvey, B. Arnold, Z.S. Lawrence, M. Paul, D. Baltimore, J.E. Darnell. 1999. Molecular Cell Biology, W. H. Freeman & Co, New York, USA.
2. G.M. Cooper. 2000. The Cell - A Molecular Approach, Sunderland (MA), Sinauer Associates, Inc. USA.
3. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 2000. Molecular Biology of The Cell, Garland Science, New York and London.
4. J.G. Siegel, B. W. Agranoff, A. R. Wayne, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott,Williams & Wilkins, Philadelphia, USA.
5. A. Varki, R.D. Cummings, J.D Esko, H.H. Freeze, P. Stanley, C.R. Bertozzi, G.W Hart, M.E. Etzler. 2008. Essentials Of Glycobiology, Cold Spring Harbor Laboratory Press. Plainview, New York, USA.
6. J.M. Coffin, S.H. Hughes, H.E. Varmus. 1997. Retroviruses, Cold Spring Harbor Laboratory Press, Plainview, New York, USA.
7. T. Strachan, A. P. Andrew. 1999. Human Molecular Genetics, Garland Science, New York and London.
8. D. W. Kufe, R.E Pollock, R. R. Weichselbaum, R.C.J. Bast, S.H. Gansler, J. F. F. Ted, Emil. 2003. Cancer Medicine, BC Decker Inc, Hamilton, Canada.

BIOCHEM 0803

Immunology and Immunotechniques

1. Historical development of the branch "Immunology". Integration of all disciplines of modern biology in full understanding of Immunology.
2. Overview of the immune system. Cells and organs involved in immunity. Hematopoiesis, Concepts of vaccines.
3. Discovery of immunoglobulins, blood group substances. Structure and function of various classes of immunoglobulins. Humoral immune response, Concept of neutralizing antibodies. Epitope mapping, Development of monoclonal antibodies, single chain antibodies. Applications of antibodies in diagnostics and routine laboratory assay systems. Agglutination reaction, principles of western blots, radioimmunoassay, ELISA, immunohistochemistry, immunoelectron microscopy, Flow cytometry.
4. Generation of B and T cells Responses. Antigens, Immunogens, Haptens, Epitopes. Antigen-Antibody interactions.
5. T-cell receptors, maturation, activation and differentiation. B-cell activation and differentiation, B-cell receptor and the immunoglobulin superfamily.
6. Immune response to infectious diseases, AIDS, Transplantation immunology.
7. Various immunocytes, their identification/purification and function, cell mediated immunity, MHC restriction and mechanism of antigen presentation.
8. Allergy, Cell biology of hypersensitivity reactions, development of vaccines against various infectious diseases with special emphasis on tuberculosis, malaria, leishmania etc.
9. Immunogenetics, Generation of antibody diversity, class switching among constant-region genes
10. Immune effector mechanisms. Properties of cytokines, receptors, secretion by T_{H1} and T_{H2} subsets.
11. The complement systems, mechanism of complement activation, pathology related to complement proteins.
12. Regulatory T cells and its role in immune response. Immunological memory.
13. Designing vaccines for active immunization, whole-organism vaccines, recombinant vaccines, DNA vaccine, synthetic peptide and multivalent sub unit vaccines. Vaccine delivery.
14. Tumor antigens and cancer immunotherapy.
15. Mechanisms of induction of autoimmunity, treatment of autoimmune diseases

Suggested study material

1. R.A. Goldsby, T.J. Kindt, B.A. Osborne. 2007. Kuby Immunology, W.H. Freeman and Company, New York.
2. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York and England**.**
3. F. Loor, G.E. Roelants. 1977. B and T cells in Immune Recognition, John Wiley & Sons, London, New York, Sydney, Toronto.
4. I. Roitt, J. Brostoff, D.M. Mosby. 1993. Immunology, St. Louis, Baltimore, Toronto.
5. D. Male, B. Champion, A. Cooke. 1987. Advanced Immunology, JB Lippincott Company, Philadelphia.
6. C.A. Janeway, P. Travers. 1994. Immunobiology, Blackwell Scientific Publications, Oxford.
7. S. Pathak, U. Palan. 2005. Immunology Essential and Fundamental, Capital Publishing Company, New Delhi, Kolkata and Bangalore.
8. I.R. Tizard. 1995. Immunology and Introduction, Saunders College Publishing, Harcourt Brace College Publishers, New York, Tokyo.
9. K. Landsteiner. 1962. The Specificity of Serological Reactions, Dover Publications, Inc. New York.

PMBB 0804

Introduction to Bioinformatics*

1. **Introduction to Computers and Bioinformatics** -- Types of operating systems, concept of networking and remote login, basic fundamentals of working with Unix.

2. **Biological Databases** -- Overview, modes of database search, mode of data storage (Flat file format, db-tables), flat-file formats of GenBank, EMBL, DDBJ, PDB.

3. **Sequence Alignment** -- Concept of local and global sequence alignment; Pairwise sequence alignment, scoring an alignment, substitution matrices, multiple sequence alignment.

4. **Phylogenetic Analysis** -- Basic concept of phylogenetic analysis, rooted/uprooted trees, approaches for phylogenetic tree construction (UPGMA, neighbour joining, maximum parsimony, maximum likelihood).

5. **Generation and Analysis of High Throughput Sequence Data** -- Assembly pipeline for clustering of HTGS data, format of '.ace' file, quality assessment of genomic assemblies; International norms for sequence data quality; Clustering of EST sequences, concept of Unigene.

6. **Annotation Procedures for High Through-put Sequence Data** -- Identification of various genomic elements (protein coding genes, repeat elements); Strategies for annotation of whole genome; Functional annotation of EST clusters, gene ontology (GO) consortium, phylogenomics.

7. **Structure Predictions for Nucleic Acids and Proteins** -- Approaches for prediction of RNA secondary and tertiary predictions, energy minimization and base covariance models; Basic approaches for protein structure predictions, comparative modeling, fold recognition/ 'threading', and *ab- initio* prediction.

**multi-disciplinary course to be offered by the Department of Plant Molecular Biology and Biotechnology.*

Suggested study material

1. A.D. Baxevanis, B.F.F. Ouellette. 2005. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley and Son Inc., USA.
2. D.W. Mount. 2004. Bioinformatics Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press, USA.
3. A. Tramontano. 2007. Introduction to Bioinformatics, Chapman & Hall/CRC, USA.
4. M. Zvelebil, J.O. Baum. 2008. Understanding Bioinformatics, Taylor and Francis, USA.

Part I – Semester 2

BIOCHEM 0805

Practicals

1. **Introduction to Sendai virus**. Determination of Viral activity (host-virus interaction/membrane fusion) by Hemagglutination and Hemolysis.
2. **Kinetics of Membrane fusion** (by hemolytic) induced by Sendai virus. Effect of pH and Temperature
3. **Electrophoresis and Western Blotting.** SDS-PAGE analysis of Sendai virus proteins. Visualization of protein bands by CB and Silver staining. Western blot analysis of the viral proteins with anti-Sendai antibodies. Development by DAB and ECL
4. **Competent cells and Transformation**. Laboratory preparation of Competent cells (DH 5α). Transformation of circularized plasmid and calculation of transformation efficiency.
5. **Plasmid Isolation**. Isolation of plasmid (midi-prep) and estimation of DNA amount and yield.
6. **Animal Tissue Culture**. Introduction to animal tissue culture and various requirements. Growing mammalian cells, trypsinization, plating, cryofreezing and general maintenance of cells. Cell counting using Hemocytometer and compare confluency.
7. **Transfection and In cell Visualization of the Ectopically Expressed Protein**. Preparation of DNA Transfection Reagents. Introduction of foreign DNA (plasmid expressing GFP) into mammalian cells. Visualization of the GFP expression in live cells using fluorescent microscope.
8. **Overexpression Analysis**. Preparation of total cell lysate of the transfected cells and Western Blot analysis of the over expressed GFP protein.
9. **Introduction to Basic Molecular Biology**. Plating, streaking and isolation of single bacterial colony from glycerol stock. Isolation of plasmid DNA by alkaline lysis and Phenol-Chloroform methods. Isolation of plasmid DNA by commercial columns. Restriction digestion analysis of purified plasmid sample
10. ***In silico* Genomics**. Application of bioinformatics tools in genomics and recombinant DNA technology
11. **Amplification of a gene by PCR**. Strategies, Optimization, Interpretation.
12. **Cloning**. Cloning of a gene into expression vector to produce recombinant protein (Isolation of Vector, Restriction digestion, extraction of DNA from gel, Ligation, Transformation). Screening of positive clones by colony PCR and restriction digestion analysis. Confirmation of sequence of cloned amplicon by DNA sequencing (Only One Sample)- Analysis and interpretation of sequencing result.
13. **Expression of Recombinant Protein**. Expression and characterization of recombinant protein.
14. **Bacteriophages (Lambda and Filamentous):** Isolating single plaque of Lambda phage by titering serial dilutions, Growing small scale Lambda phage culture, Isolating single plaque of filamentous phage by titering serial dilutions, Preparation and titration of phage particles from phagemid vectors using Helper phage, Preparing Single stranded phage DNA from M13 derived vectors, Preparing double stranded Replicating-Form DNA, Preparing single stranded DNA from M13 derived vectors and phagemids.

Part II - Semester 3

BIOCHEM 0901

Molecular Biology - I

1. Introduction: Characteristics of living beings, brief historical review
2. Genetic code: Relationship between genes and proteins, concept of tRNA, triplet nature of genetic code, concept of mRNA, development of cell free system for protein synthesis by Nirenberg, discovery of 1st codon for phenyl alanine, discovery of codons for other amino acids.
3. Triplet binding assay, Hargobind Khorana's work on genetic code, discovery of initiation and termination codons, universality of genetic code, colinearity of genes and proteins, Wobble hypothesis and exceptions, degeneracy of genetic code, mitochondrial genetic code.
4. Protein synthesis in prokaryotes and eukaryotes: Complexity of protein synthesis and general features of the process, direction of protein synthesis, direction of mRNA translation, activation of amino acids, fidelity of protein synthesis.
5. Initiation: Special features of initiator tRNAs, RBS and its interactions with 16S rRNA in bacteria, initiation complex formation, role of bacterial and eukaryotic initiation factors, regulation at initiation.
6. Elongation: Elongation factors in prokaryotes and eukaryotes, entry of amino acyl tRNA to A site, peptide bond formation, nature of peptidyl transferase, translocation, translocation factors in prokaryotes and eukaryotes.
7. Role of antibiotics in understanding protein synthesis, recognition of cognate amino acyl tRNA, mechanism of action of elongation factors, allosteric control between A and E sites and its implications.
8. Termination: Recognition of termination codons by release factors, role of molecular mimicry, mechanism of peptidyl tRNA hydrolysis, ribosome release factors, differences between prokaryotes and eukaryotes
9. Mode of action of various antibiotics in the inhibition of protein synthesis.
10. Biosynthesis of RNA (Transcription) in prokaryotes: General features of the process, transience of bacterial mRNA, coupling of transcription and translation in prokaryotes, direction of transcription, various stages of the process.
11. Discovery and assay of RNA polymerase, Phage RNA polymerases – the minimal apparatus, Bacterial RNA polymerase - core and holoenzyme, Importance of sigma factor in initiation.
12. Isolation and characterization of promoters, consensus sequences, up and down mutations. Role of -10 and -35 sequences in open complex formation. Conserved regions of sigma factors and their role in DNA binding. Control of transcription by substitution of sigma factors
13. Elongation, RNA polymerase – structure and function
14. Termination of transcription, intrinsic and rho dependent termination, mechanism of action of rho. Anti-termination and gene regulation, role of anti-termination proteins and their interaction with RNA polymerase, mechanism of anti-termination.

Suggested study material

1. D.L. Nelson, M.M. Cox. 2008. Lehninger Principles of Biochemistry, W.H. Freeman and Company, New York, USA.

2. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York, USA.

3. B. Lewin. 2007. Gene IX, Jones and Bartlett Publishers, Sudbury, Massachusetts, USA.

4. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2007. Molecular Cell Biology, W.H. Freeman, New York, USA.

5. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter. 2007. Molecular Biology of the Cell, Garland Science, New York and London.

6. J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levin, R. Losick. 2007. Molecular Biology of the Gene, Benjamin Cummings, San Francisco, USA.

7. W.M. Becker, L.J. Kleinsmith, J. Hardin, G.P. Bertoni. 2008. The World of the Cell, Benjamin Cummings, San Francisco, USA.

8. R.F. Weaver. 2007. Molecular Biology, McGraw Hill. New York. USA.

BIOCHEM 0902

Recombinant DNA Technology and Applications - I

1. Restriction and Modification systems in *E. coli* and their use in recombinant library constructions.
2. Restriction and Modification enzymes and their uses.
3. Basic techniques for RDT including Agarose gel electrophoresis, PAGE, Pulse field electrophoresis.
4. Basic Biology of plasmids including their replication, copy number, Incompatibility of Plasmids, and development of Plasmid Vectors. Vectors for making RNA probes.
5. Biology of filamentous phages, development of phage and phagemid vectors.
6. Biology of Bacteriophage lambda, Promoters and control circuits, phage assembly and In vitro packaging and development of vectors for different types of Libraries.
7. Vectors for cloning large fragments of DNA, (Cosmid, PAC, YAC and BAC) and strategies for cloning large DNA fragments.
8. Basic DNA sequencing methods, Maxam and Gilbert's chemical and Sanger's chain termination methods, and automated DNA sequencing, Pyrosequencing, Array based methods of DNA Sequencing, Base calling and sequencing accuracy.
9. Polymerase chain reaction and its application in research including cloning of PCR amplified fragments, mutagenesis and construction of Libraries. Real time/quantitative PCR
10. Oligonucleotide synthesis, purification, and its application in screening of libraries, cloning and mutagenesis.
11. Strategies for constructing cDNA libraries and screening using Nucleic acid and antibody probes. Subtractive Libraries, Expression based strategies for cloning of functional genes, Differential mRNA display.
12. Strategies for constructing Genomic libraries and screening using Nucleic acid probes.
13. Understanding of Operons Lac, Trp, Arabinose, Tetracycline and their applications in studying biological processes and development of Vectors. Use of Tags to aid solubility and Purification.
14. Vectors and strategies for expressing heterogonous proteins in *E. coli*, Yeast, Baculovirus, vaccinia virus and mammalian Cells.
15. DNA safety guidelines and regulatory aspects.

Suggested study material

1. F.M. Ausubel *et al.*, 2007. Current Protocols in Molecular Biology, John Wiley and Sons, Inc., USA.
2. J. Sambrooks, D.W. Russell. 2001. Molecular cloning, A Laboratory Manual Vol. I-III. Cold Spring Harbor Laboratory Press, USA
3. J.D. Watson, M. Gilman, J. Witkowski, M. Gilman, M. Zoller. 2008. Recombinant DNA, W.H. Freeman and Company, USA
4. J.D. Watson, R.M. Myers, A.A. Caudy, J. Witkowski. 1990. Recombinant DNA, Genes and Genomes – A Short Course, Cold Spring Harbor Laboratory Press, USA
5. R. Abe *et al*., 2007. Current Protocols in Immunology, John Wiley and Sons, USA
6. S.B. Primrose, R.M. Twyman. 2003. Principles of Genome Analysis and Genomics, Blackwell Publishing, USA
7. S.B. Primrose, R.M. Twyman, R.W. Old. 2001. Principle of Gene Manipulation. Blackwell Science, USA
8. T.A. Brown. 2007. Genomes 3. Garland Science, USA

BIOCHEM 0903

Proteomics and Metabolomics

1. Introduction to proteome, proteomics technology and importance of proteomics.

2. Principles and applications of the separation technology (Electrophoresis, Centrifugation, Chromatography etc) in proteomics. Mass spectrometry (Ionizers, analyzers and detectors) technology and its application in proteomics.

3. General workflow for the 2-D Gel Electrophoreses, sample preparation, evolution of D PAGE, experimental details for the 2-D gel and high throughput 2-D PAGE.

4. Application of two-dimension gel electrophoreses in proteomics. Importance of 2-D fluorescence difference gel electrophoresis for comparative proteomics. Two-dimensional gel electrophoresis for biomarker discovery

5. Proteomic profiling for host-pathogen interaction. Sample treatment for labeling, 2D LC-MS/MS analysis, database search and relative quantification, analysis and interpretation.

6. Protein-Protein Interaction (PPI) and its application in proteomics. Methods to study PPI.

7. Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology

8. Introduction to metabolomics world. Highthroughput screening systems and utility. Lessons from metabolites, metabolic fingerprinting, and metabolic profiling. Biotechnological potentials of metabolomics.

9. Proteomics approaches in metabolomics. Analysis of differential protein expression, post-translational modifications and protein activity for metabolomics.

10. HPLC and FPLC based approaches in metabolomics. Criteria for the selection of chromatography methods and their importance in metabolomics.

11. Application for cellular metabolomics for metabolic pathway structure. Size of metabolome, metabolite identification, pathway identification and pathway integration.

12. Metabolite profiling for infectious disease.

13. Application of metabolite profiling in heart disease. Metabolic signature and metabolite profiling in heart disease.

14. Metabonomics in preclinical pharmaceutical discovery and development. Analytical considerations, and biological aspects and applications.

15. Prospects of metabolic profiling in plant science.

Suggested Study Material

1. T. Palzkill. 2002. Proteomics, Kluwer Academic Publishers, New York, USA.
2. E.D. Hoffmann, V. Stroobant. 2007. Mass Spectrometry: Principles and Applications, John Wiley & Sons Ltd. The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England.
3. D. Kambhampati. 2004. Protein Microarray Technology, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.
4. E. Fung. Methods in Molecular Biology, Volume 264: Protein Arrays, Humana Press Inc., Totowa, NJ.
5. S.G. Villas-Boas. 2007. Metabolome Analysis: An Introduction, Wiley-Blackwell, USA.
6. B. J. Nikolau. 2007. Concepts in Plant Metabolomics, Wurtele, Eve Syrkin, Springer, USA.
7. J. Lindon, J. Nicholson, E. Holmes. 2006. The Handbook of Metabonomics and Metabolomics, Elsevier B.V., Netherlands.

Paper 0904

Developmental Biology

1. History and basic concepts of development, modification of development in evolution, identification of developmental genes.
2. Gametogenesis, fetilization, generation of multicellular embryo, formation of germ layers, patterning of vertebrate body plan.
3. Morphogenesis: Cell adhesion, cleavage and formation of blastula, ganstrulation, neural tube formation and cell migration.
4. Model systems
   A. *C. elegans*: Study of cell lineage, mosaic development and organogenesis (vulva formation).
   B. Drosophila: Pattern formation, polarily determination of embryo by maternal genes, formation of body segments, Homeotic genes.
   C. Mouse: Vertebrate development, determining function of genes during development by generation of knockout and knock-in models.
5. Development of nervous system : Specification of cell identity in the nervous system, Axonal guidance, Neuronal survival, synapse formation, Neurotransmitters and Synaptic transmission. Psychological disorders like depression, bipolar disorder, Schizophrenia, Parkinson etc. Discussion about latest research interests in this field.
6. Cell-cell communication in development : Concepts of induction and competence, epithelial-mesenchymal interactions, role of FGF-RTK pathway, JAK-STAT, Hedgehog family, Wnt family, TGF-β superfamily, Notch pathway and developmental signals from extracellular matrix.
7. Stem cells in development : Definition, types and properties of stem cells, cultivation of stem cells, adult stem cells, cancer stem cells, stem cell markers, role of stem cells in development and applications of stem cells.
8. Medical implications of developmental biology : Genetic errors of human development, gene expression and human diseases, in-vitro fertilization, environmental assaults on human development, design of future medicines like gene therapy, therapeutic cloning and regeneration therapy.

Suggested study material

1. S. F. Gilbert. 2006. Developmental Biology, Sinauer Associates, Inc., MA, USA.
2. D.L. Riddle, T. Blumenthal, B.J. Meyer, J.R. Priess. 1997. *C. elegans* II. Cold Spring Harbor Laboratory Press, New York, USA.
3. Worm Book: The Online Review of *C. elegans* Biology. 2005. The *C. elegans* Research Community, Pasadena, USA. (www.wormbook.org)
4. G.J. Siegel, B.W. Agranoff, R.W. Alberts, S.K. Fisher, M.D. Uhler. 1999. Basic Neurochemistry: Molecular, Cellular, and Medical Aspects, Lippincott, Williams & Wilkins, New York, USA.
5. P.A. Lawrence. 1992. The making of a fly: the genetics of animal design, Blackwell Publishers, Oxford, UK.
6. L. Wolpert, R. Beddington, T. Jessell. 2001. Principles of Development, Oxford University Press, New York, USA.
7. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira. 2003. Molecular Cell Biology, W.H. Freeman, New York, USA.
8. A. Nagy, M. Gertsenstein, K Vintersten, R. Behringer. 2003. Manipulating the mouse embryo: a laboratory manual, Cold spring Harbor Press, New York, USA.

BIOCHEM 0905

Dissertation

As described in the scheme of examinations, dissertation will start at the beginning of semester 3, continue through semester 4, and will be assessed at the end of semester 4.

Part II - Semester 4

Paper 1001

Molecular Biology - II

1. DNA Replication in prokaryote and eukaryotic systems : Semiconservative nature of replication, classic experiments of Meselson and Stahl, origin of replication, types of replicons, isolation and mapping of replication origins, relationship between genome size and number of origins. Regulation of replication initiation by methylation and licensing factors. Various modes of replication, mode of action of reverse transcriptase, discovery, properties and general structure of DNA polymerases, synthesis of leading and lagging strands, role of okazaki fragments and termination of replication.
2. DNA Repair : Different types of DNA damages, requirement of repair systems, recognition of DNA damage, types of DNA repair systems including excision repair, base flipping, mismatch repair, recombination repair, conserved repair systems in eukaryotes and diseases associated with DNA repair problems.
3. Eukaryotic Transcription : General introduction, characteristics of promoters and enhancer elements. Activators and repressors of transcription, different DNA binding domains like zinc finger, helix-turn-helix, leucine zipper, helix-loop-helix. Properties of eukaryotic RNA polymerases and their mode of action, assembly of basal transcription apparatus at the promoter, initiation, elongation and termination of transcription. General techniques used to study binding and activity of transcription factors and coactivators in eukaryotes.
4. RNA Splicing and Processing : Splice junctions, Lariat structure, role of sn RNA in splicing, Spliceosome formation, Alternative splicing and tRNA splicing. Processing and maturation of RNA.
5. Catalytic roles of RNA : Self splicing introns , catalytic activities of Ribozymes, RnaseP, Viroids and mechanisms of RNA editing.
6. Gene Silencing : Mechanism of action of RNAi and micro-RNA. Role of DNA-Methylation, Acetylation and Deacetylation in gene expression. Recent advances and applications of gene silencing.

Suggested study material

1. J.M. Berg, J.L. Tymoczko, L. Stryer. 2008. Biochemistry, W.H. Freeman and Company, New York, USA.

2. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P.Walter. 2008. Molecular Biology of the Cell, Garland Science, New York, USA.

3. H. Lodish, B. Harvey, Arnold, S. Zipursky, S.Lawrence, P. Matsudaira, D. Baltimore, J. Darnell, E. James. 2003. Molecular Cell Biology, W.H. Freeman and Company, New York, USA.

4. G. M.Cooper. 2000. The Cell: A Molecular Approach, Sinauer Associates, Inc. Massachusetts, USA.

5. M.M. Cox, D.L. Nelson. 2008. Lehninger's Principles of Biochemistry, W.H. Freeman and Company, New York, USA.

6. B. Lewin. 2006. Genes, Jones and Bartlett Publishers, Massachusetts, USA.

7. J.D. Watson, T.A. Baker, S.P. Bell, A. Bann, M. Levine, R. Losick. 2004. Molecular Biology of the Gene, Benjamin Cummings, California, USA.

8. R.H. Garrett**,** C.M**.** Grisham**.** 2000**.** Biochemistry, Saunders College Publishers, Texas, USA.

BIOCHEM 1002

Recombinant DNA Technology and Application - II

1. Mutagenesis: Chemical, random, site-directed and Newer methods and strategies for protein engineering such as DNA shuffling to produce better variants and to study their functions.
2. Regulated vectors for controlled expression of multiple genes to study gene function in different hosts.
3. Determining the Function of Individual genes. Gene deletion, over-expression and complementation. Genome-wide Insertional mutagenesis.
4. Recombinant DNA strategies to study protein interactions. Yeast 2-hybrid system, Bacterial-2 hybrid system, Phage display, Ribosome Display, Cell Display, Protein fragment complementation.
5. Gene transfer and expression in plant.
6. Gene transfer in animals and human and applications.
7. Fundamentals of Whole-Genome Sequencing. Sequencing of Phage, Viral and Bacterial Genomes, Human Genome sequencing, and comparative genomics.
8. High throughput genome-wide cloning and protein expression strategies and applications.
9. Antibody gene cloning and Engineering, Humanization and Human antibodies.
10. Strategies for large-scale expression of recombinant proteins in heterogonous hosts. Purification and downstream processing to produce Therapeutic grade recombinant proteins and regulatory aspects.
11. Micro/si RNA technology and applications in studying gene functions.
12. Microarray techniques for DNA, Proteins and Antibodies. Global expression profiling

Suggested study material

1. E. Golemis. 2002. Proteins–Protein Interaction. A Molecular Cloning Manual, Cold Spring Harbor Laboratory Press, USA
2. F.M. Ausubel *et al.*, 2007. Current Protocols in Molecular Biology, John Wiley and Sons, Inc., USA
3. J. Sambrooks, D.W. Russell. 2001. Molecular cloning, A Laboratory Manual Vol. I-III. Cold Spring Harbor Laboratory Press, USA
4. J.D. Watson, M. Gilman, J. Witkowski, M. Gilman, M. Zoller. 1992. Recombinant DNA, W.H. Freeman and Company, USA
5. J.D. Watson, R.M. Myers, A.A. Caudy, J. Witkowski. 2008. Recombinant DNA, Genes and Genomes – A Short Course, Cold Spring Harbor Laboratory Press, US
6. J.E. Coligan *et al.*, 2007. Current Protocols in Current Protocols in Protein Science, John Wiley and Sons, USA
7. R. Abe *et al*., 2007. Current Protocols in Immunology, John Wiley and Sons, USA
8. S.B. Primrose, R.M. Twyman. 2003. Principles of Genome Analysis and Genomics, Blackwell Publishing, USA
9. S.B. Primrose, R.M. Twyman. 2005. Genomics-Applications in Human Biology, Blackwell Publishing, USA
10. T.A. Brown. 2007. Genomes 3, Garland Science, USA

MICROB 0803

Microbial Pathogenicity*

1. **Classical view of microbial pathogenicity**: Define pathogenicity and virulence; Quantitative measures of virulence: minimal lethal dose (MLD), LD_{50}, ID_{50}, $TCID_{50}$. Virulence determinants: colonization, toxins, enzymes and invasiveness. Facultative / obligate intracellular pathogens.

2. **Molecular microbial pathogenicity:** Molecular Koch's postulates, multiplicity of virulence features, coordinated regulation of virulence genes, two component signal transudation systems and environmental regulation of virulence determinants, antigenic variation; clonal and panmictic nature of microbial pathogens, type 1-IV secretion systems, biofilms and quorum sensing.

3. **Emerging and re-emerging pathogens:** Illustrate emerging and re-emerging pathogens using *V. cholerae* 0139, X-MDR *M. tuberculosis, Helicobacter pylori*, Enterohaemorrhagic *E. coli* (EHEC), *Cryptosoridium parvum*, Lyme disease, SARS virus, Bird flu, prions, AIDS, Dengue Hemorrhagic Fever, and *Chlamydiae*, opportunistic fungal pathogens. Mechanisms of emergence of new pathogens: microbial change and adaptation, horizontal gene transfer (HGT), pathogenicity islands (PAI), role of integrons.

4. **Molecular microbial epidemiology:** Objectives of microbial epidemiology. Biochemical and Immunological tools - biotyping, serotyping, phage typing, FAME, Curie Point PyMS, protein profiling, multilocus enzyme electrophoresis (MLEE); Molecular typing: RFLP (ribotyping, IS based), RAPD, 16S-23S IGS, ARDRA, rep (REP, ERIC, BOX)-PCR, PFGE, AFLP, MLST, MVLST, VNTR, SNP, Microarry and whole genome sequence; GIS

5. **Environmental change and infectious diseases:** Global warming lead increase in vector-borne and water-borne infectious diseases; Impact of increasing urbanization, international travel and trade on infectious diseases.

6. **Antimicrobial resistance:** Recent concepts – Multidrug efflux pumps, extended spectrum β-lactamases (ESBL), X-MDR *M. tuberculosis*, Methacillin-resistant *S. aureus* (MRSA).

7. **Newer vaccines:** Recombinant vaccines, subunit vaccines, DNA vaccines, Vaccinia, BCG and HIV– vector based vaccines

8. **Rapid diagnostic principles:** Nucleic acid probes in diagnostic microbiology, nucleic acid amplification methods, Real-time PCR, diagnostic sequencing and mutation detection, molecular typing methods, array technology.

**multi-disciplinary course to be offered by the Department of Microbiology.*

Suggested Study Material

1. G.F. Brooks, J.S. Butel, S.A. Morse, J.L. Melnick, E. Jawetz, E.A. Adelberg. 2004. Jawetz, Melnick & Adelberg's Medical Microbiology, Lange Publication. USA

2. P. Cossart, P. Boquet, S. Normark, R. Rappuoli. 2005. Cellular Microbiology, American Society for Microbiology Press. USA

3. A.A. Salyers, D.D. Whitt. 2002. Bacterial Pathogenesis: A molecular approach. American Society for Microbiology Press, Washington, DC USA.

4. J. Hacker, U. Dorbindt. 2006. Pathogenomics: Genome analysis of pathogenic microbes, Wiley-VCH. Germany

5. D.H. Persing, F.C. Tenover, J. Versalovic, Y. Tang, E.R. Unger, D.A. Relman, T.J. White. 2004. Molecular Microbiology: Diagnostic Principles and Practice, American Society for Microbiology Press. USA

6. K.E. Nelson, C.M. Williams, N.M.H. Graham. 2001. Infectious Disease Epidemiology: Theory and Practice, An Aspen Publication. USA

BIOCHEM 1004

Seminar Paper

(Students, in this paper, would present open seminars on important scientific topics assigned to them, which would be collectively evaluated by the departmental faculty).

BIOCHEM 1005

Dissertation (continuation from Semester III - BIOCHEM 0905)

As described in the scheme of examinations, dissertation will be carried out for one full year comprising of semester 3 and semester 4. The complete work carried out during the dissertation will be evaluated at the end of semester 4. The marks would be assigned as described in the programme structure.